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Final

Remedial Investigation/ Feasibility Study Work Plan for Operable Unit No. 10 (Site 35)

Marine Corps Base, Camp Lejeune, North Carolina

Prepared For:

Department of the Navy
Atlantic Division
Naval Facilities
Engineering Command

Norfolk, Virginia

Under the

LANTDIV CLEAN Program

Comprehensive Long-Term
Environmental Action Navy

Reference:
Contract
N62470-89-D-4814

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December 1993

Baker
Baker Environmental, Inc

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WESTON
MANAGERS DESIGNERS/CONSULTANTS

FINAL

REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN

FOR OPERABLE UNIT NO. 10
(SITE 35 - CAMP GEIGER AREA FUEL FARM)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0160

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
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ENGINEERING COMMAND
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Prepared by:

BAKER ENVIRONMENTAL, INC.
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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
AST	aboveground storage tanks
ATEC	ATEC Associates, Inc.
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	below ground surface
BOD	biological oxygen demand
BRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COD	chemical oxygen demand
COPC	contaminants of potential concern
CRP	Community Relations Plan
CS	Confirmation Study
CSA	Comprehensive Site Assessment
1,2-DCE	1,2-Dichloroethene
DoN	Department of the Navy
DQOs	data quality objectives
EDB	ethylene dibromide
EPA	United States Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
FSAP	Field Sampling and Analysis Plan
FFA	Federal Facilities Agreement
FFS	Focused Feasibility Study
FS	Feasibility Study
GC	gas chromatograph
IAS	Initial Assessment Study
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
LAW	Law Engineering, Inc.
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
msl	mean sea level
MTBE	methyl tertiary butyl ether
NCDEHNR	North Carolina Department of Environment, Health and Natural Resources
NCWQS	North Carolina Water Quality Standard

NPL	National Priorities List
OU	Operable Unit
ppb	parts per billion
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SVOCs	Semivolatile Organic Compounds
TAL	Target Analyte List
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TSS	total suspended solids
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRC	Technical Review Committee
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VOCs	volatile organic compounds
WAR	Water and Air Research, Inc.

1.0 INTRODUCTION

Marine Corps Base (MCB), Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), National Priorities List (NPL) effective November 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NCDEHNR), and the United States Department of the Navy (DoN) entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect the public health, welfare and the environment (FFA, 1989).

The scope of the FFA included the implementation of a Remedial Investigation/Feasibility Study (RI/FS) at 23 sites throughout MCB, Camp Lejeune. Remedial investigations will be implemented at these sites to determine fully the nature and extent of the threat to the public health and welfare, or to the environment caused by the release and threatened release of hazardous substances, pollutants, contaminants or constituents at the site and to establish requirements for the performance of feasibility studies. Feasibility studies will be conducted to identify, evaluate, and select alternatives for the appropriate CERCLA responses to prevent, mitigate, or abate the release or threatened release of hazardous substances, pollutants, contaminants, or constituents at the site in accordance with CERCLA/Superfund Amendments and Reauthorization Act (SARA) and applicable state law (FFA, 1989).

This RI/FS Work Plan has been prepared by Baker Environmental, Inc. (Baker) and addresses 1 of the 23 sites at MCB, Camp Lejeune: Site 35 - Camp Geiger Fuel Farm (also referred to as Operable Unit No. 10, or OU No. 10).

1.1 Objective of RI/FS Work Plan

The objective of this RI/FS Work Plan is to identify the tasks required to implement an RI/FS for Site 35 at MCB, Camp Lejeune. The Work Plan documents the scope and objectives of the individual RI/FS activities required to collect the appropriate data. It serves as a tool for assigning responsibilities and establishing the project schedule and cost. The preparation and contents of the RI/FS Work Plan are based on the scoping process, which is described below.

1.2 RI/FS Scoping

Scoping is the initial planning stage of the RI/FS and of site remediation. The result or outcome of the scoping process is documented in the RI/FS Work Plan. Scoping begins once the background information is reviewed and evaluated and consists of the following activities:

- Assessing human health and environmental risks.
- Identifying interim actions to mitigate immediate potential threats to the public health and the environment.
- Identifying potential contaminant migration pathways.
- Identifying contaminants of concern.
- Identifying Federal and State Applicable or Relevant and Appropriate Requirements (ARARs).
- Identifying potential technologies/alternatives for mitigating site problems.
- Determining the type, amount, and data quality objectives (DQOs) to assess human health and environmental risks, and to effectively evaluate feasible technologies/alternatives.
- Identifying the remedial alternatives suitable to site conditions.
- Defining the optimum remedial alternative.

The background information available for this process included a number of existing environmental assessment reports, which are identified in Section 8 (References), and information collected during planning visits to the site.

As part of the scoping process, project meetings were conducted with the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), EPA Region IV, and the NCDEHNR to discuss the proposed RI/FS scope of work for Site 35, and to obtain technical and administrative input from LANTDIV.

2.0 BACKGROUND AND SETTING

The purpose of this section is to summarize and evaluate existing information pertaining to MCB, Camp Lejeune, and Site 35. The analysis of existing information will serve to provide an understanding of the nature and extent of contamination in order to aid in the design of RI tasks.

This section specifically addresses the location and setting of the sites, historical events associated with past usage or disposal activities, topography and surface drainage, regional geology and hydrogeology, site-specific geology and hydrogeology, surface water hydrology, climatology, natural resources and ecological features, and land use.

Additional information can be found in the following documents:

- Initial Assessment Study (IAS) of Marine Corps Base Camp Lejeune, North Carolina (Water and Air Research, 1983)
- Final Site Summary Report, Marine Corps Base, Camp Lejeune (Environmental Science and Engineering, Inc. 1990)
- Draft Field Investigation/Focused Feasibility Study, Camp Geiger Fuel Spill Site, Camp Lejeune, Onslow County, North Carolina (NUS Corporation, 1990)
- Underground Storage Tank Site Check, Investigation Report, Former Mess Hall Heating Plant, Marine Corps Base, Camp Lejeune, North Carolina (ATEC Associates, Inc. 1992)
- Hydrogeology of Aquifers in Cretaceous and Younger Rocks in the Vicinity of Onslow and Southern Jones Counties, North Carolina (U.S. Geological Survey, 1990)
- Continuous Seismic Reflection Profiling of Hydrogeologic Features Beneath New River, Camp Lejeune, North Carolina (U.S. Geological Survey, 1990)
- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina (U.S. Geological Survey, 1989)

- Final Report, Underground Fuel Investigation, Camp Geiger Fuel Farm, Marine Corps Base, Camp Lejeune, North Carolina (Law Engineering, Inc., 1992)

- Underground Storage Tank Investigation Report Former Mess Hall Heating Plant (ATEC, 1992)

- Addendum to Report of Underground Fuel Investigation and Comprehensive Site Assessment (Law Engineering, Inc., 1993)

2.1 Marine Corps Base, Camp Lejeune

This section provides an overview of the physical features associated with MCB, Camp Lejeune.

2.1.1 Location and Setting

MCB, Camp Lejeune is located within the Coastal Plain Physiographic Province in Onslow County, North Carolina. The facility covers approximately 170 square miles and is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean.

The eastern border of MCB, Camp Lejeune is the Atlantic Ocean shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB, Camp Lejeune to the north. MCB, Camp Lejeune is depicted in Figure 2-1.

2.1.2 History

Construction of MCB, Camp Lejeune began in 1941 with the objective of developing the "Worlds Most Complete Amphibious Training Base". Construction of the Base started at Hadnot Point, where the major functions of the Base are centered. Development at the Camp Lejeune complex is primarily in five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area. Site 35 is located in the Camp Geiger Area in the northwest quadrant of the Base.

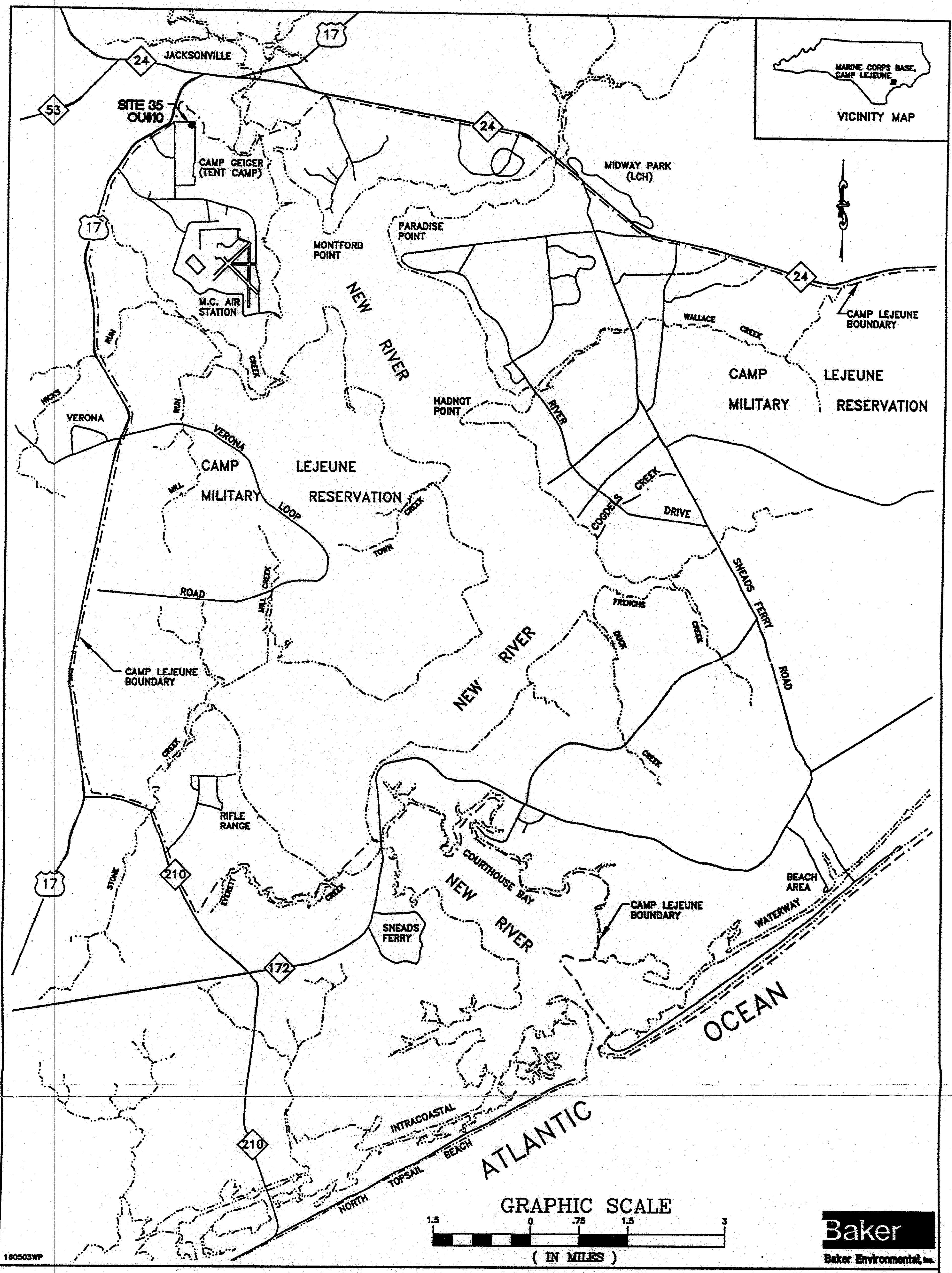

FIGURE 2-1
CAMP LEJEUNE AND SITE 35
LOCATION MAP

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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2.1.3 Topography and Surface Drainage

The generally flat topography of MCB, Camp Lejeune is typical of the seaward portions of the North Carolina Coastal Plain. Elevations on the Base vary from sea level to 72 feet above mean sea level (msl); however, the elevation of most of Camp Lejeune is between 20 and 40 feet above msl.

Drainage at Camp Lejeune is generally toward the New River, except in areas near the coast which drain through the Intracoastal Waterway. In developed areas, natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of Camp Lejeune is in broad, flat interstream areas. Drainage is poor in these areas and the soils are often wet (Water and Air Research, 1983).

The U.S. Army Corps of Engineers has mapped the limits of 100-year floodplain at Camp Lejeune at 7.0 feet above msl in the upper reaches of the New River (Water and Air Research, 1983); this increases downstream to 11 feet above msl near the coastal area (Water and Air Research, 1983). Site 35 does not lie within the 100-year floodplain of the New River.

2.1.4 Regional Geology

MCB, Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone. These sediments lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1991). These sediments were deposited in marine or near-marine environments and range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic basement rocks of pre-Cretaceous age. Figure 2-2 presents a generalized stratigraphic column for this area (ESE, 1991).

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the Base is underlain by seven sand and limestone aquifers separated by confining units of silt and clay. These include the water table (surficial water-bearing layer), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1,500 feet. Less permeable clay and silt beds function as confining units or semi-confining units which separate the aquifers and impede the flow of groundwater between aquifers. A generalized hydrogeologic cross-section (ESE, 1991) illustrates the relationship between the aquifers in this area (see Figure 2-3).

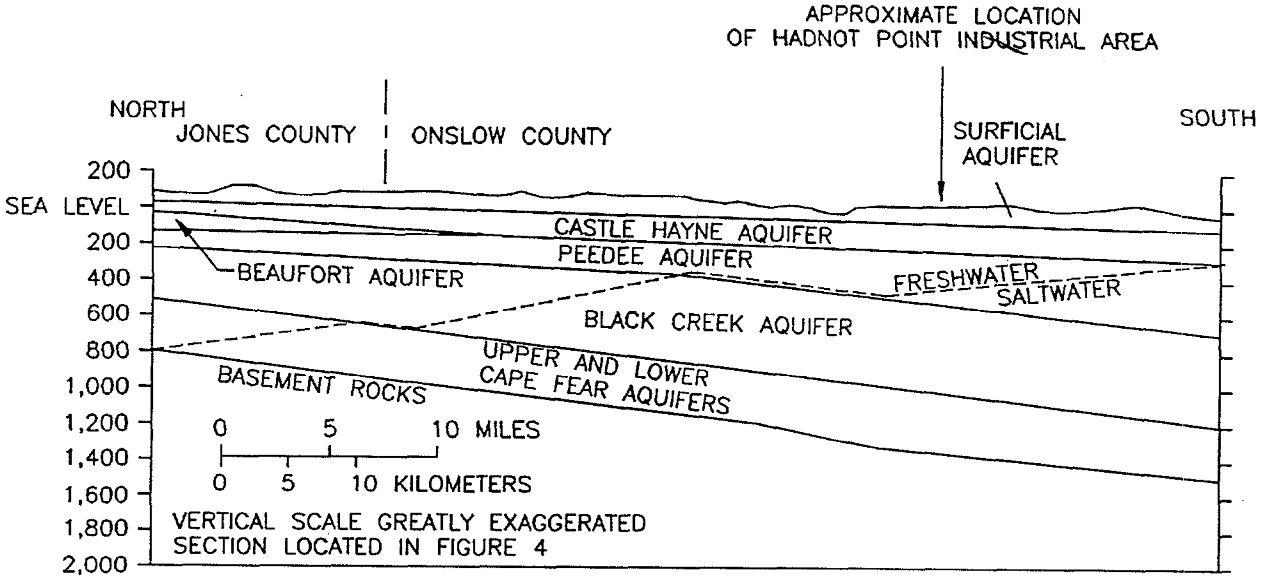
FIGURE 2-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA

GEOLOGIC UNITS			HYDROGEOLOGIC UNITS
System	Series	Formation	Aquifer and Confining Unit
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial aquifer
Tertiary	Pliocene	Yorktown Formation(1)	Yorktown confining unit
			Yorktown aquifer
	Miocene	Eastover Formation(1)	
		Pungo River Formation(1)	Pungo River confining unit
			Pungo River aquifer
		Belgrade Formation(2)	Castle Hayne confining unit
	Oligocene	River Bend Formation	Castle Hayne aquifer
	Eocene	Castle Hayne Formation	Beaufort confining unit(3)
	Paleocene	Beaufort Formation	Beaufort aquifer
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee confining unit
			Peedee aquifer
		Black Creek and Middendorf Formations	Black Creek confining unit
			Black Creek aquifer
		Cape Fear Formation	Upper Cape Fear confining unit
			Upper Cape Fear aquifer
			Lower Cape Fear confining unit
			Lower Cape Fear aquifer
	Lower Cretaceous(1)	Unnamed deposits(1)	Lower Cretaceous confining unit
			Lower Cretaceous aquifer(1)
Pre-Cretaceous basement rocks		--	--

(1) Geologic and hydrologic units probably not present beneath Camp Lejeune.
(2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
(3) Estimated to be confined to deposits of Paleocene age in the study area.

Source: Harned et al., 1989.



Baker
Baker Environmental, Inc.

FIGURE 2-3
GENERALIZED HYDROGEOLOGIC CROSS-SECTION
JONES AND ONSLOW COUNTIES, NORTH CAROLINA

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: ESE, 1991

2.1.5 Regional Hydrogeology

The following summary of regional hydrogeology was originally presented in Harned et al. (1989).

The surficial water-bearing layer is a water table in a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This unit is not used for water supply on the Base.

The principal water-supply aquifer for the Base is found in the series of sand and limestone beds that occur between 50 and 300 feet below land surface. This series of sediments generally is known as the Castle Hayne Formation, associated with the Castle Hayne Aquifer. This aquifer is about 150 to 350 feet thick in the area and is the most productive aquifer in North Carolina.

Onslow County and Camp Lejeune lie in an area where the Castle Hayne Aquifer contains freshwater, although the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Overpumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer contains water having less than 250 mg/L (milligrams per liter) chloride throughout the area of the Base.

The aquifers that lie below the Castle Hayne lie in a thick sequence of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the Camp Lejeune area and are not used.

Rainfall in the Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the water table, which is the top of the saturated zone. In the saturated zone, groundwater flows in the direction of lower hydraulic head, moving through the system to discharge areas like the New River and its tributaries, or the ocean.

The water table varies seasonally. The water table receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter months and lowest in summer or early fall.

In confined aquifers, water is under excess hydraulic pressure (head) and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in a confined or semi-confined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than that in an unconfined aquifer. Some seasonal variation also is common in the water levels of the Castle Hayne Aquifer, but the changes tend to be slower and over a smaller range than for water table wells.

2.1.6 Surface Water Hydrology

The following summary of surface water hydrology was originally presented in the IAS report (Water and Air Research, Inc., 1983).

The dominant surface water feature at MCB, Camp Lejeune is the New River. It receives drainage from most of the base. The New River is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its course, the New River is confined to a relatively narrow channel entrenched in Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays, and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB, Camp Lejeune not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet (Water and Air Research, 1983). The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River inlet.

2.1.7 Climatology

MCB, Camp Lejeune experiences mild winters and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 33 to 53°F in the winter (i.e., January) and 71°F to 88°F in the summer (i.e., July). Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983).

2.1.8 Natural Resources and Ecological Features

The following summary of natural resources and ecological features was obtained from the IAS Report (Water and Air Research, 1983).

The Camp Lejeune complex is predominantly tree-covered with large amounts of softwood [shortleaf, longleaf, pond, and pines (primarily loblolly)] and substantial stands of hardwood species. Approximately 60,000 of the 112,000 acres of Camp Lejeune are under forestry management. Timber producing areas are under even-aged management with the exception of those areas along streams and swamps. These areas are managed to provide both wildlife habitat and erosion control. Forest management provides wood production, increased wildlife populations, enhancement of natural beauty, soil protection, prevention of stream pollution, and protection of endangered species.

Upland game species including black bear, whitetail deer, gray squirrel, fox squirrel, quail, turkey, and migratory waterfowl are abundant and are considered in the wildlife management programs.

Aquatic ecosystems on MCB, Camp Lejeune consist of small lakes, the New River estuary, numerous tributaries, creeks, and part of the Intracoastal Waterway. A wide variety of freshwater and saltwater fish species exist here. Freshwater ponds are under management to produce optimum yields and ensure continued harvest of desirable fish species (Water and Air Research, 1983). Freshwater fish in the streams and ponds include largemouth bass, redbreast sunfish, bluegill, chain pickerel, yellow perch, and catfish. Reptiles include alligators, turtles, and snakes (including venomous).

Wetland ecosystems at MCB, Camp Lejeune can be categorized into five habitat types: (1) pond pine or pocosin; (2) sweet gum/water oak/cypress and tupelo; (3) sweet bay/swamp black gum and red maple; (4) tidal marshes; and, (5) coastal beaches. Pocosins provide excellent habitat for bear and deer because these areas are seldom disturbed by humans. The presence of pocosin-type habitat at Camp Lejeune is primarily responsible for the continued existence of black bear in the area. Many of the pocosins are overgrown with brush and pine species that would not be profitable to harvest. Sweet gum/water oak/cypress and tupelo habitat is found in the rich, moist bottomlands along streams and rivers. This habitat extends to the marine shorelines. Deer, bear, turkey, and waterfowl are commonly found in this type of habitat. Sweet bay/swamp black gum and red maple habitat exist in the floodplain areas of

MCB, Camp Lejeune. Fauna including waterfowl, mink, otter, raccoon, deer, bear, and gray squirrel frequent this habitat. The tidal marsh at the mouth of the New River is one of the few remaining North Carolina coastal areas relatively free from filling or other manmade changes. This habitat, which consists of marsh and aquatic plants such as algae, cattails, saltgrass, cordgrass, bulrush, and spikerush, provides wildlife with food and cover. Migratory waterfowl, alligators, raccoons, and river otter exist in this habitat. Coastal beaches along the intracoastal waterway and along the outer banks of MCB, Camp Lejeune are used for recreation and to house a small military command unit. Basic assault training maneuvers are also conducted along these beaches. Training regulations presently restrict activities that would impact ecologically sensitive coastal barrier dunes. The coastal beaches provide habitat for many shorebirds (Water and Air Research, 1983).

The Natural Resources and Environmental Affairs (NREA) Division of MCB, Camp Lejeune, the U.S. Fish and Wildlife Service, and the North Carolina Wildlife Resource Commission have entered into an agreement for the protection of endangered and threatened species that might inhabit MCB, Camp Lejeune. Habitats are maintained at MCB, Camp Lejeune for the preservation and protection of rare and endangered species through the Base's forest and wildlife management programs. Full protection is provided to such species, and critical habitat is designated in management plans to prevent or mitigate adverse effects of base activities. Special emphasis is placed on habitat and sightings of alligators, osprey, bald eagles, cougars, dusky seaside sparrows, and red-cockaded woodpeckers (Water and Air Research, 1983).

Within 15 miles of MCB, Camp Lejeune are three publicly owned forests: Croatan National Forest; Hofmann Forest; and Camp Davis Forest. The remaining land surrounding MCB, Camp Lejeune is primarily used for agriculture. Typical crops include soybeans, small grains, and tobacco (Water and Air Research, 1983).

2.1.9 Land Use

MCB, Camp Lejeune presently covers an area of approximately 170 square miles. Military and civilian population is approximately 60,000. During World War II, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the recent Gulf War (i.e., Desert Storm). Toward the end of World War II, the Base was designated as a home for the Second

Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

2.2 Site 35 - Camp Geiger Area Fuel Farm

This section addresses the background and setting of Site 35. In addition, a summary of previous investigations is presented.

2.2.1 Site Location and Setting

Camp Geiger is located at the extreme northwest corner of MCB, Camp Lejeune, Onslow County. The main entrance to Camp Geiger is off U.S. Route 17, approximately 3.5 miles southeast of the City of Jacksonville, North Carolina. Site 35, the Camp Geiger Area Fuel Farm refers primarily to five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, and a fuel unloading pad situated within Camp Geiger just north of the intersection of Fourth and "G" Streets. Previous environmental investigations at the site identified underground fuel distribution piping that connect the ASTs to existing and former underground storage tanks (USTs) and expanded the area referred to as Site 35. To date, the Site 35 study area has been roughly bounded on the west by D Street, on the north by Second Street, and on the east by Brinson Creek, and on the south by Fourth Street and Building No. TC-474 (see Figure 2-4).

The ASTs at Site 35 are used to dispense gasoline, diesel and kerosene to government vehicles and to supply USTs in use at Camp Geiger and the nearby New River Marine Corps Air Station. The ASTs are supplied by commercial carrier trucks which deliver product to fill ports located on the fuel unloading pad at the southern end of the facility. Six, short-run (120 feet maximum), underground fuel lines are currently utilized to distribute the product from the unloading pad to the ASTs. Product is dispensed from the ASTs via trucks and underground piping.

The site is underlain by layers of silty sand with interbedded layers of clayey sand, coarse sand and gravel. Investigations performed to date have provided subsurface stratigraphic data to a depth of 44.5 feet. Shallow groundwater is encountered at 8 to 10 feet bgs. Surface topography is characterized as generally flat with a gentle slope to the northeast toward Brinson Creek.

2.2.2 Site History

Construction of Camp Geiger was completed in 1945, four years after construction of MCB, Camp Lejeune was initiated. Available drawings date Site 35 back to at least July 1941. Originally, the ASTs were used for the storage of No. 6 fuel oil, but, were later converted (date unknown) for storage of other petroleum products including unleaded gasoline, diesel fuel, and kerosene. The ASTs currently in use at the site are reported to be the original tanks.

Formerly, the ASTs at Site 35 supplied a gasoline filling station which was located on the northeast corner of the intersection of "F" and Fourth Streets. A leak in the underground line from the ASTs to the dispensing island was reportedly responsible for the loss of roughly 30 gallons per day of gasoline over an unspecified period (Law, 1992). The leaking line was subsequently sealed and replaced.

Reports of a Mogas release in an underground distribution line near one of the ASTs date back to 1957-58 (ESE, 1990). Apparently, the leak occurred as the result of damage to a dispensing pump. At that time the Camp Lejeune Fire Department estimated that thousands of gallons of fuel were released although records of the incident have since been destroyed. The fuel migrated to the east and northeast into Brinson Creek. Interceptor trenches were excavated and the captured fuel was ignited and burned as was the product which discharged into Brinson Creek.

Another abandoned underground distribution line extended from the ASTs to the former Mess Hall Heating Plant, located adjacent to "D" Street, between Third and Fourth Streets. The underground line dispensed No. 6 Fuel Oil to an UST which fueled the Mess Hall boiler. The Mess Hall, located across "D" Street to the west, is believed to have been demolished along with its Heating Plant in the 1960's.

2.2.3 Site Geology and Hydrogeology

The following information has been excerpted from Comprehensive Site Assessment (CSA) Report (Law, 1992). Selected portions of this report are included in Appendix A of this Work Plan for reference.

The soil and stratigraphic borings drilled to date have penetrated three distinctive units. The first unit is a fine- to medium-grained, unconsolidated sand. The thickness of this unit ranges from 15 to 30 feet. Law Engineering selected two samples of this unit to be analyzed for grain-size distribution, including samples from MW-23, collected from a depth of 8.5 to 10.5 feet, and from MW-24, collected from a depth of 13.5 to 15.5 feet. These analyses revealed that the samples generally contain 96 percent sand and 4 percent silt and clay.

The second unit is an oolitic, fossiliferous limestone which ranges in thickness from 6.5 to 20 feet. The fossils consist of fragments of mollusks; the matrix consists of fine-grained sand, fine-grained phosphate grains and lime mud. Under the Folk classification (Blatt et al., 1972), this unit is a biosparite. Mr. Rick Shiver of the Wilmington Regional Office of the DEM stated that this unit is common in the Jacksonville area and is considered part of the unconfined, surficial aquifer. Law Engineering believes this unit is the River Bend Formation.

The third unit is an unconsolidated, dark gray to black silty, clayey sand. Because this unit may be a confining unit separating the surficial and Castle Hayne aquifers, Law Engineering did not attempt to completely penetrate this clayey sand, and therefore, the thickness is not known. This unit was sampled in SB-1, SB-2, SB-3 and MW-19 where it was observed to be up to 4 feet thick in SB-2. Grain-size analysis of a sample from this unit revealed that the sample contained 79 percent fine sand, 9 percent silt and 12 percent clay.

This clayey sand is probably the same described by Harned, et al (1989) as one of the confining units occurring in the surficial aquifer and the Castle Hayne. Baker's experience at Camp Lejeune sites east of the New River is that the unit is not a confining unit in that area because it is thin and discontinuous. The Harned report noted, however, that the unit appears to be thicker and more continuous in the northwestern part of Camp Lejeune, where the Site 35 is located. Law Engineering believes that this clayey sand acts as a confining unit in the study area due to its relatively high percentage of silt and clay. It is believed that this unit separates the surficial aquifer from the underlying Castle Hayne aquifer.

Groundwater in the surficial aquifer generally flows across the project site to the east, towards Brinson Creek. As indicated by comparing water level elevations recorded on September 3, 1991 between "shallow" and "deep" screened intervals, ground water in the surficial aquifer generally moves laterally across the project site with no significant vertical gradient.

The rate or average linear velocity of groundwater movement across the project site is a function of the hydraulic conductivity (K) of the aquifer medium, the effective porosity (n) of the aquifer medium and the hydraulic gradient (dh/dl) that exists in the surficial aquifer. The hydraulic conductivity of the unconsolidated sands within the surficial aquifer was calculated to be approximately 28 feet/day. Law calculated a range of average linear velocities of between 0.99 feet/day (n=25 percent) and 1.66 feet/day (n = 15 percent) using values for effective porosity of 15 percent to 25 percent for fine sand, as estimated by Walton (1984).

2.2.4 Previous Investigations and Findings

Initial Assessment Study (IAS) by WAR

MCB, Camp Lejeune was placed on the National Priority List (NPL) in 1983 after the IAS identified 76 potentially contaminated sites at the base (WAR, 1983). Site 35 was identified in the IAS as one of 21 sites warranting further investigation. No media sampling was included under the IAS.

Confirmation Study (CS) by ESE

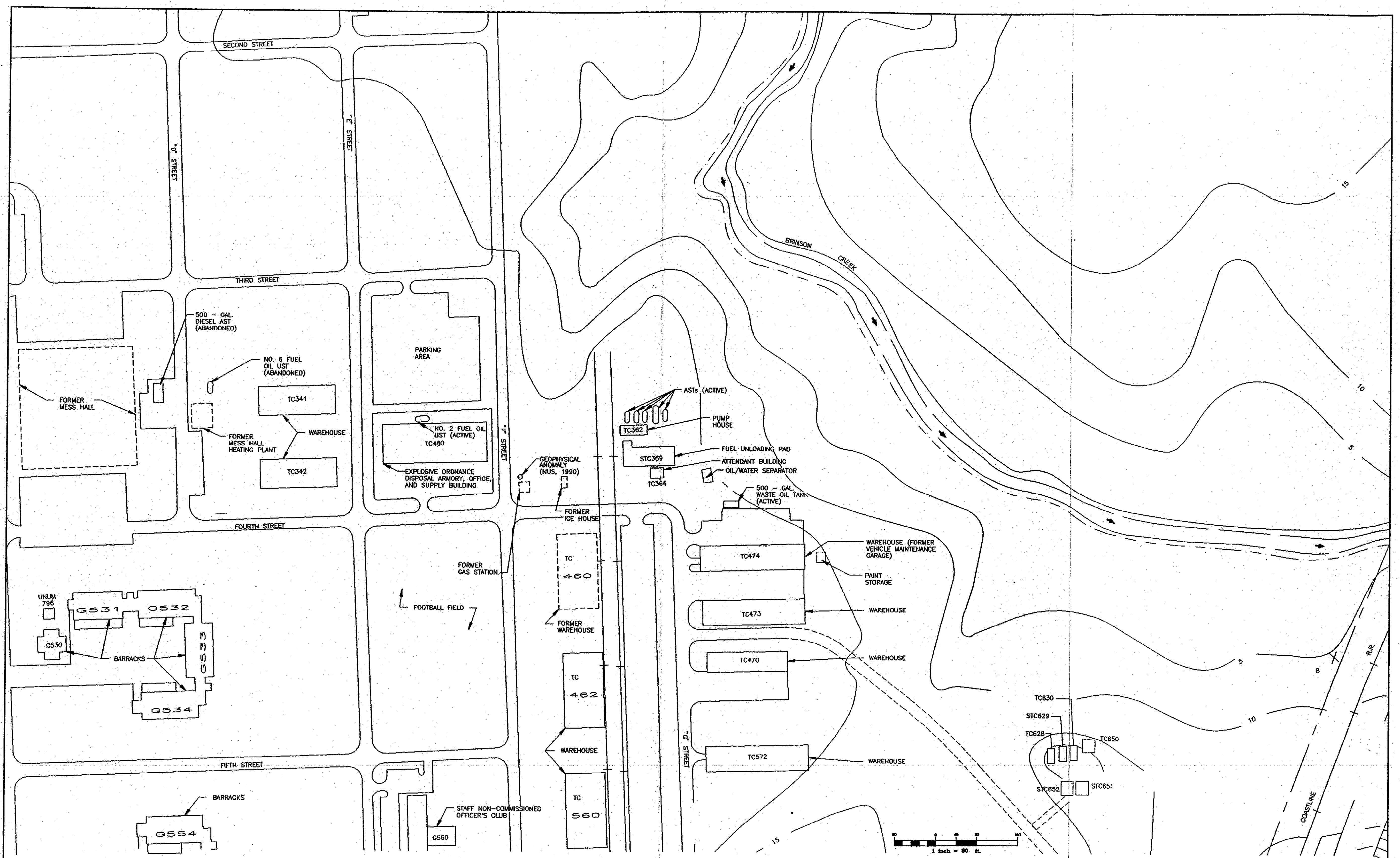
ESE performed Confirmation Studies of the 22 sites requiring further investigation and performed the Fuel Farm study between 1984 and 1987 (ESE, 1990). During this study, ESE advanced three hand-auger borings (35GW-1, -2, and -3), collected groundwater and soil samples from each and documented groundwater contaminated with lead and soil contaminated with lead, oil and grease. In 1986, ESE collected sediment and surface-water samples from Brinson Creek and installed three permanent monitoring wells (EMW-5, -6, and -7), two east of and one west of the Fuel Farm. These wells were sampled after installation and again in 1987. These monitoring well and boring locations are shown on Figure 2-5.

Three soil samples from hand-augered borings were analyzed for:

- Lead (results: 3 detections - 6 to 8 ppm)
- Oil and Grease (results: 3 detections - 40 to 2,200 ppm)

Three groundwater samples from the hand-augered borings were analyzed for:'

- Benzene (results: no detections)
- Trans -1,2-dichloroethene (results: no detections)
- Trichloroethene (results: no detections)
- Methylene Chloride (result: detected in 35GW-1 at 4 ppb)



LEGEND

DATE	OCTOBER 1993
SCALE	1" = 80'
DRAWN	WJH/REL
REVIEWED	DLB
S.O.#	19160-43-SRN
CADD#	106502WP

NORTH

REMEDIAL INVESTIGATION/FEASIBILITY STUDY CTO-0160
MARINE CORPS BASE CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

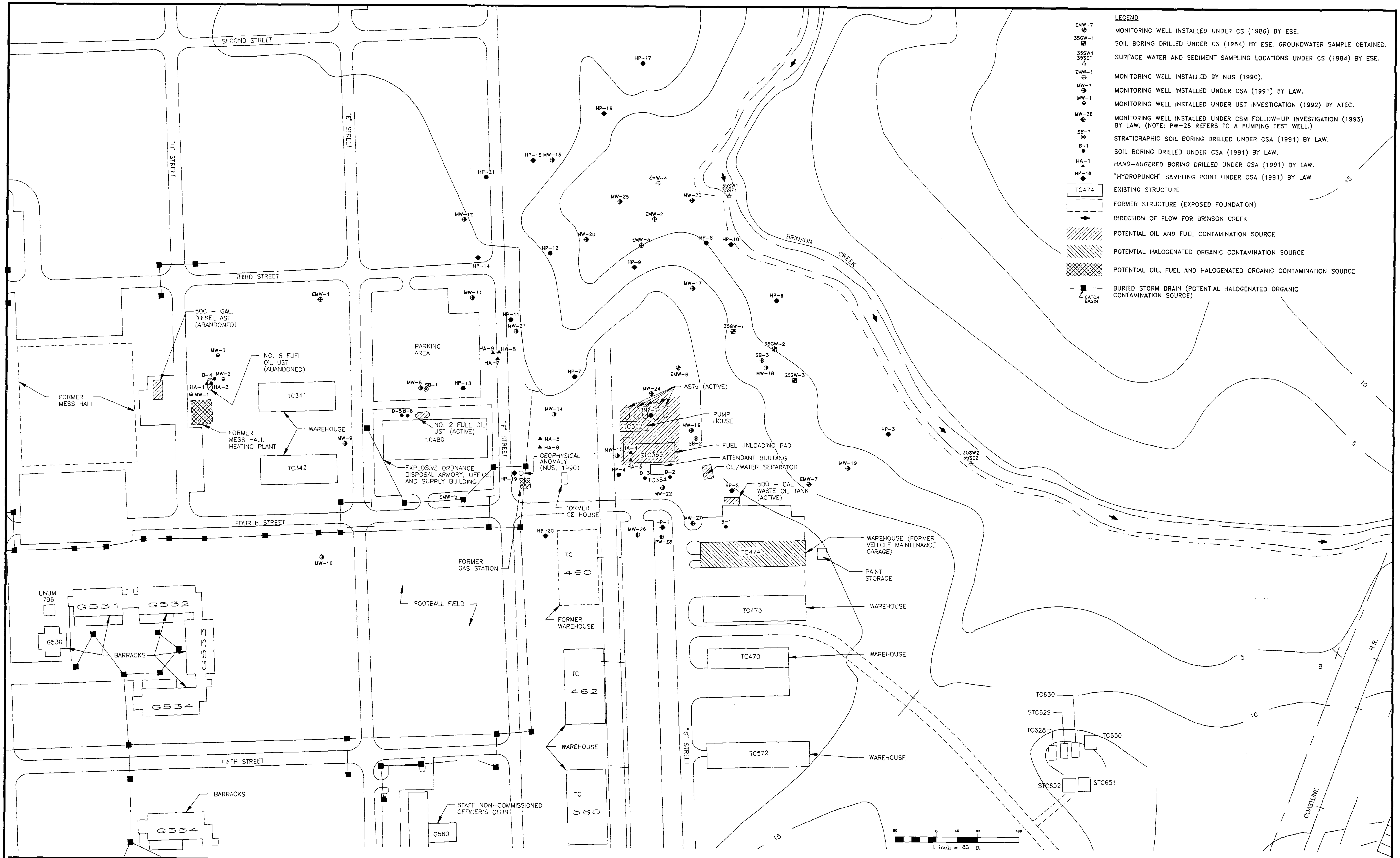
Baker
Baker Environmental, Inc.

SITE PLAN
SITE 35 - CAMP GEIGER AREA FUEL FARM

SCALE 1" = 80'

DATE OCTOBER 1993

FIGURE No.
2-4



LEGEND

DATE	OCTOBER 1993
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DRAWN	WJH/REL
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S.O.#	19160-43-SRN
CADD#	160501WP

NORTH

REMEDIAL INVESTIGATION/FEASIBILITY STUDY CTO-0160
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

EXISTING MONITORING WELLS AND
SAMPLING LOCATIONS
SITE 35 - CAMP GEIGER AREA FUEL FARM

SCALE 1"= 80'
DATE OCTOBER 1993

FIGURE No.
2-5

- Lead (results: 3 detections - 1063 to 3659 ppb)
- Oil and Grease (results: detected in 35GW-2 at 46,000 ppb)

Two surface water samples were obtained from Brinson Creek and analyzed for:

- Lead (results: no detections)
- Oil and Grease (results: no detections)
- Ethylene dibromide (results: no detections)

Two sediment samples were obtained from Brinson Creek at the surface water sampling locations and were analyzed for:

- Lead (results: detected)
- Oil and Grease (results: detected)
- Ethylene dibromide (results: no detections)

Groundwater samples were obtained on two occasions from one upgradient and two downgradient wells and were analyzed for:

- Lead (results: detected once in EMW-6 at 33 µg/L)
- Oil and Grease (results: 6 detections - range 200 µg/L to 12,000 µg/L)
- Benzene (results: 3 detections downgradient - 1.3 to 30 µg/L)
- Trans-1,2-dichloroethene (results: 1 upgradient detections - 3.2 µg/L at EMW-5,2; downgradient detections - 28 and 29 µg/L at EMW-7)
- Trichloroethene (results: 2 downgradient detections of 11 µg/L at EMW-2)
- Methylene Chloride (results: no detections)

Focused Feasibility Study by NUS

A Focused Feasibility Study (FFS) was conducted in 1990 in the area north of the Fuel Farm (NUS, 1990). The investigation included the installation of four groundwater monitoring wells (EMW-1, -2, -3, and -4). Results of laboratory analysis revealed that groundwater in one well and soil cuttings from two borings were contaminated with petroleum hydrocarbons although no free-phase product was observed.

A geophysical investigation was conducted by NUS as part of the 1990 study in an attempt to identify USTs at the site of the former gas station. The results indicated the presence of a geophysical anomaly to the north of the former gas station.

Comprehensive Site Assessment (CSA) by Law Engineering

Recent environmental investigation conducted at the site included a CSA conducted in the fall of 1991 (Law, 1992). The CSA involved the drilling of 18 soil borings to depths ranging from 15 to 44.5 feet. These soil borings were ultimately converted to nested (MW-16 through 25) wells that monitor the water table aquifer along two zones. The shallow or water table zone generally extends from 2.5 to 17.5 feet, below ground surface (bgs). The deeper zone monitored by the nested wells generally ranges from 17.5 to 35 feet bgs. Well MW-20 is the only single well installed by Law that is not a double nested well. It is screened from 3 to 12.5 feet bgs. Five additional soil borings were drilled and nine soil borings were hand-augered to provide data regarding vadose zone soil contamination. Three soil borings (SB-1, -2, -3) were drilled specifically to provide subsurface stratigraphic data. Additional groundwater data was provided via 21 drive-point groundwater or "Hydropunch" samples. A "Tracer" study was also performed to investigate the integrity of the active USTs and underground distribution piping.

Soil and groundwater samples obtained under the CSA were analyzed for both organic and inorganic compounds. Groundwater analyses included purgeable hydrocarbons (EPA 601), purgeable aromatics with MTBE (EPA 602), polynuclear aromatic hydrocarbons (EPA 610), and lead-total (EPA 239.2). Soil analyses included total petroleum hydrocarbons (SW846/5030/3550) and TCLP metals (lead only).

The results of the CSA identified areas of impacted soil and groundwater. The nature of the contamination included both halogenated (i.e., chlorinated) organic compounds and non-halogenated, petroleum-based constituents. The contamination encountered was typically identified in both shallow (2.5 to 17.5 feet bgs) and deep (17.5 to 35 feet bgs) wells. Figures presented in the Law report that depict the results of the CSA have been reproduced and are presented in Appendix A of this Work Plan.

Three areas were identified to be impacted by halogenated organics. The first impacted area is located south of Fourth Street and west of E Street. In this area the analysis of a shallow and deep groundwater samples from monitoring well MW-10 yielded 187 ppb and 810 ppb of TCE, respectively. A second impacted area was identified immediately northeast of Building No. TC-474, a former auto maintenance shop and current warehouse. In this area wells EMW-7 and MW-19 had detectable levels of TCE at 77 ppb and 49 ppb, respectively in the shallow zone and 630 ppb in the deeper zone at MW-19 (well EMW-7 is a single shallow well). A third area was identified to be north of the Fuel Farm ASTs and south of the drainage swale that leads to Brinson Creek. In this area, wells MW-14 and EMW-3 had detectable levels of TCE at 157 ppb and 10 ppb, respectively in the shallow zone and 13 ppb in the deeper zone at MW-14 (EMW-3 is a single shallow well).

The CSA identified three areas impacted by non-halogenated, petroleum-based constituents. The largest area extends from Building No. TC-480 to Brinson Creek, following the natural drainage swales. The second largest area is, for the most part, centered at the Fuel Farm and extends toward Brinson Creek. The smallest impacted area is centered around the abandoned No. 6 fuel oil UST adjacent to the former Mess Hall Heating Plant. The results of a recent investigation at this area performed by ATEC (under a different contract) are presented in Appendix B of this Work Plan.

A follow-up to the CSA was conducted by Law in late 1992. Reported as an Addendum to the CSA (Law, 1993), it was designed to provide further characterization of the southern extent of petroleum contamination resulting from the release. In addition, a pump test was performed to estimate the hydraulic characteristics of the surficial aquifer.

Three wells (MW-26, MW-27, and PW-28) were installed in the southern area of the site. Sampling of groundwater indicated the presence of xylene in one well (MW-26) at levels below the state standards. MTBE (methyl tertiary butyl ether) was also detected in this well but its presence was thought to be unrelated to the tank farm because well MW-26 is located hydraulically upgradient (Law 1993). Law reported that MTBE was detected in several wells across the site, but, in no discernible pattern. Law further indicated their inability to offer an explanation as to other sources of MTBE. The final element of the program was an eight-hour pump test. This test was designed to determine performance characteristics of the well (PW-28) and to estimate hydraulic parameters of the aquifer. An approximate hydraulic conductivity of 100 ft/day was determined for the surficial aquifer.

Interim Remedial Investigation/Feasibility Study (Interim RI/FS) by Baker

Concurrent with the execution of the full RI/FS, Baker is conducting an Interim RI/FS, focused on fuel and oil impacted soil at Site 35. The need for this study was based primarily on the observations of Baker and Camp Lejeune personnel as to the degree of environmental impact of the contaminated soils at the site particularly along the drainage ditches north of the ASTs that discharge into Brinson Creek. The purpose of this Interim RI/FS is to expedite the investigation, evaluation, and remediation of the fuel and oil impacted soils at Site 35.

3.0 EVALUATION OF EXISTING INFORMATION

This section describes the types and volume of known wastes and impacted media at Site 35, potential migration and exposure pathways, preliminary public health and environmental impacts, preliminary ARARs (Applicable or Relevant and Appropriate Requirements) applicable to the site, potential remedial technologies, and data limitations. This summary of information will be used to identify the RI/FS objectives (Section 4.0).

3.1 Types and Volumes of Waste and Impacted Media Present

Information available from previous investigations indicates that Site 35 has been impacted by past releases of oils and fuels associated with the site and by halogenated organic compounds from a source(s) that has yet to be determined. No records are available to document quantities; however, a release of thousands of gallons of gasoline was reported in the late 1950s. More recently, there was a report that a buried fuel line released 30 gallons per day over an unspecified period of time.

Based on the results of the investigations performed to date it is estimated that 35,000 to 60,000 cubic yards of oil and fuel impacted soil are present at the site.

Shallow groundwater plumes impacted with halogenated and non-halogenated compounds are known to extend over an area of approximately 16 acres. The source of the halogenated organic groundwater contamination has yet to be determined. Additional investigation is needed to define the vertical and horizontal extent of halogenated organic contamination in shallow groundwater and attempt a source delineation. The source of the non-halogenated organic shallow groundwater contamination has been determined to be past site operations. The horizontal extent of the non-halogenated organic shallow groundwater contamination has been adequately defined via the results of previous investigation. Additional data is required to define the vertical extent of this contamination.

3.2 Potential Migration and Exposure Pathways

Based on the evaluation of existing conditions at Site 35, the following potential contaminant migration and exposure pathways have been identified.

Transport Pathways

- Overland surface soil runoff to drainage ditches.
- Leaching of contaminants in subsurface soil to groundwater.
- Groundwater discharge to nearby drainage ditches/springs or streams (unnamed tributaries to Brinson Creek, Brinson Creek, and the New River).
- Groundwater infiltration from shallow aquifer to deep aquifer.

Exposure Pathways

- Current military personnel and civilian base employees traversing through the area could be exposed to surface soil, sediments, and standing water.
- Future human residential exposure by incidental soil ingestion.
- Future human residential dermal exposure by direct contact with soil.
- Future potential use of shallow and deep groundwater (shallow impacted groundwater in this area is not currently used as a potable water supply).
- Wildlife (deer, mammals), fish and fowl exposure to surface and subsurface soil and surface water. (Note: Hunting is prohibited in this area.)
- Benthic and pelagic populations on the unnamed tributaries and the New River could be exposed to contaminants.

3.3 Preliminary Public Health and Environmental Health Impacts

Based on existing data, there may be potential human and ecological risk to receptors due to the contamination detected at this site. Military personnel and civilian contractors have been identified as the probable human receptors. The non-human population of receptors includes, but is not limited to, small mammals such as raccoon and fox, deer, birds, reptiles, and aquatic organisms, such as fish.

3.4 Preliminary Identification of ARARs

3.4.1 Chemical-Specific ARARs

Based on the analytical results from the previous sampling activities conducted at Site 35, it appears that the contaminated media include soil and groundwater. Chemical-specific ARARs that may be applicable to Site 35 include the North Carolina Water Quality Standards (NCWQS) and Federal Maximum Contaminant Levels (MCLs) for groundwater established under the Safe Drinking Water Act, Ambient Water Quality Criteria (AWQC), and Sediment Screening Values (SSVs) established by the National Oceanic and Atmospheric Administration (NOAA). There are no North Carolina or Federal ARARs for soil.

Detected concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) and halogenated organics such as trichloroethylene (TCE) and 1,2-dichloroethene (1,2-DCE) exceeded NCWQSs and MCLs at several groundwater monitoring well locations across the site.

3.4.2 Location-Specific ARARs

Location-specific ARARs set restrictions on certain types of activities in wetlands, floodplains, and historical sites. Wetlands ARARs are likely applicable to the Brinson Creek area.

3.4.3 Action-Specific ARARs

Action-specific ARARs are technology-based restrictions triggered by the type of action under consideration. Action-specific ARARs for Site 35 will be identified when potential remedial action technologies have been selected.

3.5 Potential Remedial Technologies

The purpose of this section is to identify potential remedial technologies for each affected medium in order to identify what data may be necessary to evaluate technologies during the Feasibility Study (FS).

3.5.1 Soil

Oil and fuel impacted soils are the focus of an Interim RI/FS currently being executed by Baker under separate portion of this Task Order. Execution of the Interim RI/FS is intended to expedite Site 35 soil remediation.

No other impacted soils have been identified to date.

3.5.2 Sediment

Previous studies have identified elevated levels of lead and oil and grease in two sediment samples obtained from Brinson Creek. Additional sediment sampling will be performed under the RI/FS and all samples will be analyzed for full Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. It is suspected that elevated petroleum hydrocarbon constituents may be present in these sediments. Useful remedial technologies in this case would include both thermal and biological treatment. The applicability of these technologies to impacted sediments will also be considered under the Interim RI/FS.

3.5.3 Groundwater

Previous investigations have detected the presence of non-halogenated and halogenated organic compounds in the shallow aquifer. A number of technologies have been identified as potentially feasible including pumping, containment (via extraction wells), air stripping carbon adsorption, UV/ozone oxidation, and in-situ biological treatment.

These technologies have been preliminarily identified as potentially feasible, based on the limited amount of information available. This listing will be refined as the RI/FS progresses.

Each of the potentially feasible technologies will require specific data in order to evaluate their effectiveness, implementability, and cost. Specific investigatory work elements have been included in the Work Plan to meet these data needs.

3.6 Present Database Limitations

The purpose of this section is to define data limitations with respect to either characterizing the site, assessing human health and environmental risks, or evaluating potential feasible technologies. Site-specific RI/FS objectives and sampling strategies for resolving these data deficiencies are subsequently identified in Sections 4.0 and 5.0 of this RI/FS Work Plan, respectively.

3.6.1 Site Characterization

A review of the data obtained under previous investigations indicates the presence of data gaps which do not afford a full characterization of the nature and extent of contamination at the site. The data gaps include lack of definition of the vertical and horizontal extent of halogenated organic contamination in groundwater, and identification of the possible source(s) of this contamination, and definition of the vertical extent of non-halogenated organic groundwater contamination. Insufficient soil and sediment data also represents a data gap. Existing monitoring wells and sampling locations, the information from which have led to a present site understanding, are depicted on Figure 2-5.

Groundwater

Additional groundwater data is required in the vicinity of monitoring wells MW-10 (near the southwest corner of Fourth and "E" Streets) and monitoring wells EM-7 and MW-19 (located southeast of the ASTs and northeast of Building TC474) to identify the extent of previously identified halogenated organic contamination. In the case of MW-10, where elevated levels of TCE were reported (Law 1992), there is no data available to assess whether a plume extends to the east, south, or west. Similarly, the extent of the TCE plume was not identified south, east, or north of wells EM-7 and MW-19. No data is available to assess the vertical limits of the TCE plume since elevated levels of TCE were identified at several of the deepest wells (i.e., base of well screens set as deep as 35 feet bgs) previously installed including wells MW-10, MW-19, and EM-7.

Additional data is required in the vicinity of monitoring wells MW-2 (at former Mess Hall Heating Plant), MW-21 and MW-25 to assess the vertical extent of non-halogenated organic shallow groundwater contamination. BTEX compounds were detected in samples obtained from the deepest wells previously installed at these locations. In general, sufficient data has been obtained to date to characterize the horizontal extent of the non-halogenated organic contamination in the shallow groundwater.

Groundwater Contamination Sources

Additional soil and groundwater data is required to identify and assess the source of the halogenated organic groundwater contamination. Possible sources include: Building TC474 where vehicle maintenance was performed as late as 1988; the former Mess Hall Heating Plant where solvents may have been used for maintenance; the storm drain conduit system along Fourth Street that may have served as a conveyance system for solvents generated at an unknown off-site location; and any of the past or present buildings whose complete histories of use are not known, but, could have included the handling and storage of solvents.

Soil

The horizontal extent of oil and fuel impacted soils has, for the most part, been sufficiently defined under previous investigations performed at the site. Additional data is required along the drainage channels that extend from "F" Street and the ASTs to Brinson Creek. This data will be obtained under the Interim RI/FS the focus of which will be the oil and fuel impacted soils at this site. The project plans for the Interim RI/FS are being prepared separately under this Task Order.

No soil samples obtained to date at Site 35 have been analyzed for halogenated organic compounds. As a consequence, there is no data pertaining to the possible presence of these compounds at areas where these compounds have been identified in shallow groundwater. Additional soil sampling is required to identify the presence, if any, and extent of halogenated organic compounds in vadose zone soil in the vicinity of the shallow groundwater identified as impacted with these contaminants under previous investigations.

Surface Water and Sediment

To date only two surface water and sediment samples have been obtained from Brinson Creek. These samples were analyzed for lead, EDB, and oil and grease. Laboratory results of the surface water samples indicated no detections while lead and oil and grease were detected in sediment samples. Additional surface water and sediment samples are needed along Brinson Creek at locations upgradient, downgradient, and adjacent to Site 35, to support the baseline risk assessment.

3.6.2 Risk Assessment

No previous investigation performed to date has included the performance of a quantitative baseline human health and ecological risk assessment (RA). The chemical characteristics of surface soil, surface water, groundwater, and sediment samples obtained from throughout Site 35 are the principal data needed to support the baseline human health RA. Additional sampling of selected existing groundwater wells is also needed to provide analytical results for full TAL organics and TCL inorganic parameters across the site. Fish and benthic samples are needed from various locations along Brinson Creek for use in the ecological RA.

3.6.3 Engineering

Engineering data is used to support the evaluation of remedial alternatives under the FS. Typically, this data refers to the engineering characteristics of subsurface soils such as particle size distribution or the hydraulic characteristics of the subsurface aquifer (pump test data). This type of data has been provided in previous reports (Law 1992 and 1993) prepared for Site 35. Pumping tests performed to date have been limited to eight hours and may not provide sufficient data regarding aquifer response to prolonged pumping. If it is determined that such tests are required they will be performed as part of a future pilot-scale test under Task 7.

Additional engineering data required includes information used directly in the design of groundwater treatment systems such as, but not limited to, BOD (biological oxygen demand), COD (chemical oxygen demand), TSS (total suspended solids), TDS (total dissolved solids), TOC (total organic carbon), and iron and manganese concentrations.

4.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY OBJECTIVES

This section presents the objectives of the RI/FS at Site 35. Specifically, the RI objectives are as follows:

- Obtain additional chemical analytical data from Site 35 groundwater, soil, surface water, and sediment to augment the existing database from previous investigations to adequately characterize the nature and extent of contamination.

- Obtain additional groundwater, soil, surface water, sediment, benthic and fish samples to support a baseline human health and ecological risk assessment.

The objective of the FS is to utilize the data obtained to develop and evaluate various alternatives for the remediation of impacted media. (Note: An Interim Remedial Action RI/FS focused specifically on contaminated soils at Site 35 will be conducted concurrently so as to expedite any soil remediation. Project plans for the Interim Remedial Action RI/FS have been prepared separately.)

The data limitations that provide the rationale for these objectives were presented previously in Section 3.6. Specific investigation and sampling strategies proposed to obtain the required data are presented in Section 5.0.

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

This section identifies the tasks and field investigations that will be needed to complete RI/FS activities at Site 35.

5.1 Task 1 - Project Management

Project management activities involved under Task 1 include such activities as daily technical support and guidance; budget and schedule review and tracking; preparation and review of invoices; manpower resources planning and allocation; and communication with LANTDIV and the Activity.

5.2 Task 2 - Subcontract Procurement

Task 2 involves the procurement of subcontractor services such as soil gas and drive-point (hydropunch/geoprobe) groundwater sampling, surveying, drilling, and laboratory analysis. In the event that treatability studies or field pilot-scale demonstrations are warranted, procurement for these services will be performed under this task.

5.3 Task 3 - Field Investigations

The field investigations will be conducted under Task 3 and are intended to provide:

- Data regarding the nature and extent of environmental impact on aquatic and benthic species in Brinson Creek which abuts the eastern boundary of the site.
- Additional soil and groundwater data to support a quantitative, site-wide environmental risk assessment.
- Soil and groundwater data sufficient to afford an evaluation of the source, nature, and extent of previous identified halogenated organic contamination in the shallow groundwater.

An overview of the field investigations to be conducted at Site 35 is presented in the following subsections. Specific activities discussed include site surveying, soil gas and groundwater sample screening, drilling and well installation, and soil, groundwater, surface water, sediment, fish and benthic sampling. Many of the field activities will occur concurrently and are not interdependent. Activities such as surface soil, surface water, sediment, aquatic and benthic sampling may occur at will. Soil gas and groundwater sample screening and the installation of deep monitoring wells (GWD-1 through GWD-5), however, will precede the drilling of soil borings (B-7 through B-19) and the installation of shallow monitoring well clusters (MW-29A,B through MW-33A,B). This is because stratigraphic data from the deep well borings is needed to locate the underlying clay layer which will aid in the placement of the deeper shallow well screens. The results of the soil gas and groundwater sample screening will serve as the basis for locating the soil borings and shallow well clusters.

Details with respect to the investigative and analytical methods are provided in the Field Sampling and Analysis Plan (FSAP) and the Quality Assurance Project Plan (QAPP). The field investigations described below will provide data to meet the overall RI/FS objectives presented in Section 4.0 of this RI/FS Work Plan.

5.3.1 Site Survey

A site survey will be performed to provide for an updating of the available site base map. The survey will include the establishment of topographic contours at 5-foot intervals across the site, the horizontal locations of various site surface features (i.e., structures, foundations, ASTs, USTs, existing and proposed monitoring wells, roads, concrete pads, stormwater catch basins, fire hydrants, manhole covers, utility valve boxes and covers, overhead utility lines, parking lots and miscellaneous concrete slabs). Vertical elevations will be obtained for various monitoring well features including the top of protective well casing, the top of the well casing, and the ground surface elevation adjacent to the well. Vertical and horizontal accuracy will be 0.01 feet and 0.1 feet, respectively. In addition, soil sampling locations (i.e. soil borings and surface sample locations), and surface water/sediment sample locations will be surveyed to a horizontal accuracy of one foot. The nearest USGS horizontal and vertical markers will be utilized for baseline datum reference.

5.3.2 Soil and Groundwater Sample Screening

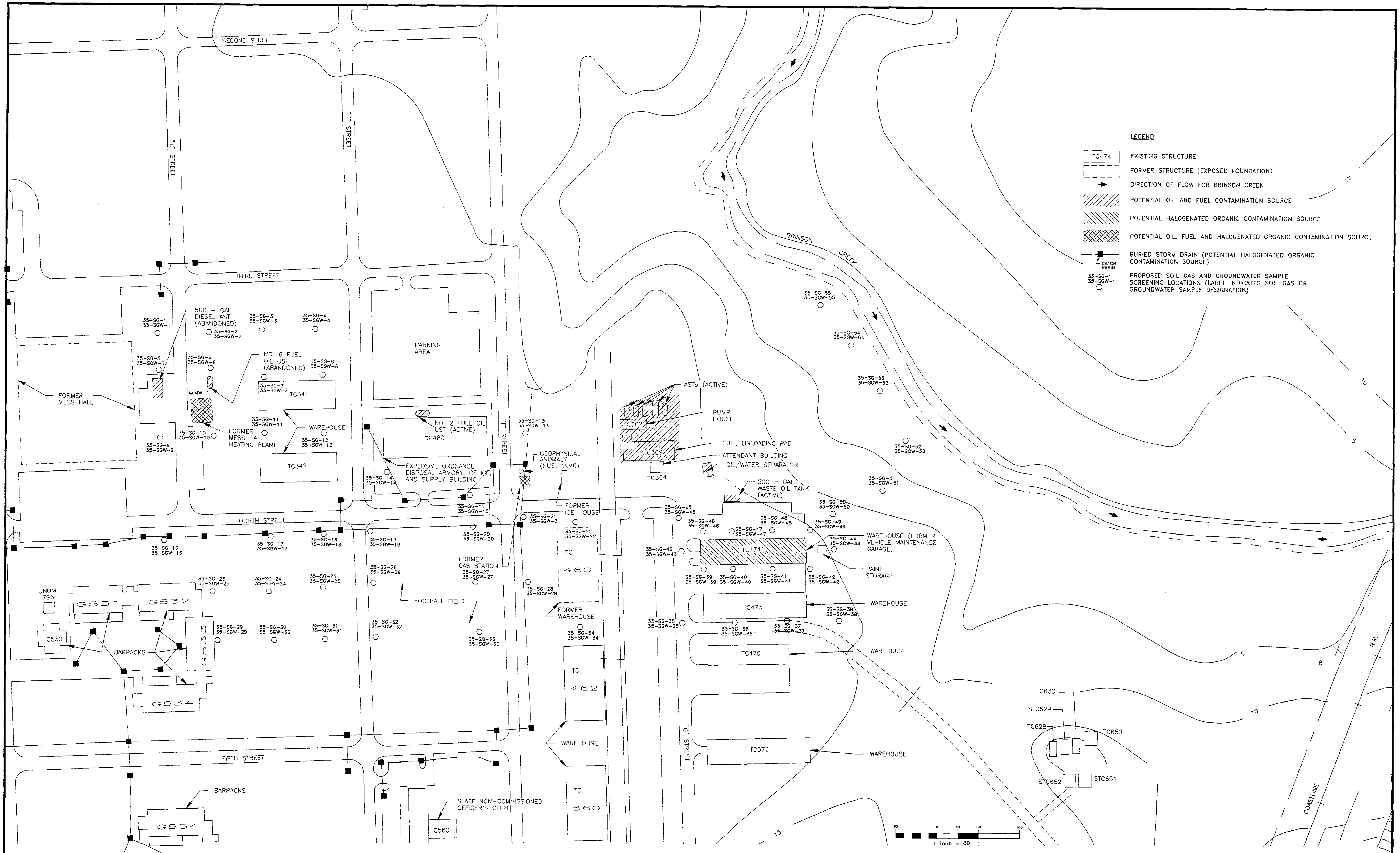
The effort to determine the source, nature and extent of halogenated organic groundwater contamination will be initiated via soil and groundwater sample screening. In this case screening refers to the utilization of soil gas and drive-point (e.g., trade names Hydropunch or Geoprobe) groundwater sampling techniques. The purpose of screening using these techniques is to provide data to afford the optimal placement of soil borings/monitoring wells from which additional soil and groundwater samples can be obtained and shipped off site for analysis.

The focus of the soil and groundwater sample screening will be the areas in the vicinity of: 1) monitoring well MW-10 and the storm drain conduit along Fourth Street; 2) monitoring wells EMW-7 and MW-19, and Building TC-474; and 3) the area surrounding the former Mess Hall Heating Plant (see Figure 2-5 for existing monitoring well locations). A total of 55 locations will comprise the soil and groundwater screening program at the three areas combined, as shown on Figure 5-1 and as discussed below.

The largest area of soil gas and groundwater sample screening is south of Fourth Street from Building G-533 extending east to Building TC-460, including the storm drain conduit along Fourth Street, and north of Fourth Street in the vicinity of the former gas station (see Figure 5-1, sample locations 13 through 34). The concentration of sampling points south of Fourth Street was deemed necessary because, unlike the area north of Fourth Street, very little data was obtained under previous investigations. Previous sampling in this area indicated elevated concentrations of TCE in groundwater samples collected from MW-10, MW-14, and EMW-3. The soil gas and groundwater sample screening program is designed to delineate the horizontal extent of this contamination south of Fourth Street as well as the source, if possible.

Additional soil gas and groundwater sample screening locations may be selected in this area, based on the results of the initial sampling to further define the limits of the soil/groundwater contamination.

A second sampling grid will be used to identify the presence and concentration, if any, of contaminants of concern in soil and groundwater in the vicinity of Building TC-474, monitoring wells EMW-7 and MW-19, and Brinson Creek. Building TC-474 is a warehouse and former auto maintenance facility that is suspected of being the potential source of halogenated organic contamination detected in monitoring wells EMW-7 and MW-19. The initial soil gas and groundwater sample screening grid for this area will consist of 21 sample screening locations (35 through 55) spaced as shown on Figure 5-1. Additional sample screening locations may be selected in this area based on the results of the initial sampling.



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NORTH

REMEDIAL INVESTIGATION/FEASIBILITY STUDY CTO-0160
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc.
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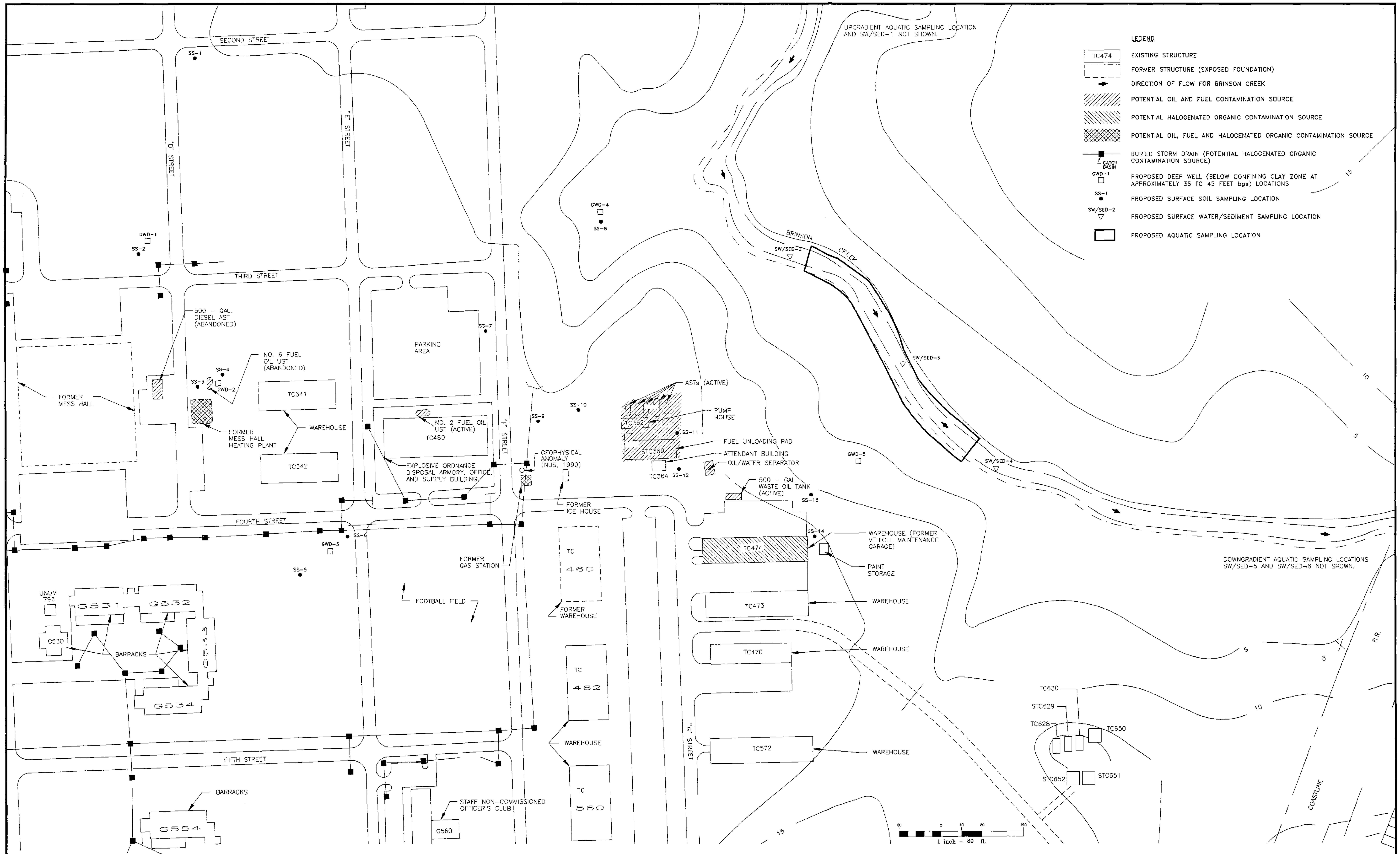
Baker
Baker Environmental, Inc.

PROPOSED SOIL GAS AND GROUNDWATER
SAMPLE SCREENING LOCATIONS
SITE 35 – CAMP GEIGER AREA FUEL FARM

SCALE 1"= 80'

DATE OCTOBER 1993

FIGURE No.
5-1



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REMEDIAL INVESTIGATION/FEASIBILITY STUDY CTO-0160
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

PROPOSED SAMPLING LOCATIONS
SITE 35 – CAMP GEIGER AREA FUEL FARM

SCALE 1"= 80'
DATE OCTOBER 1993

FIGURE No.
5-2

A third sampling grid will be placed in the vicinity of the former Mess Hall Heating Plant because halogenated solvents may have been used at this facility as part of routine maintenance. Elevated concentrations of non-halogenated organic compounds were detected in soil samples collected from boring B-4, adjacent to the abandoned No. 6 fuel oil UST. The initial sampling grid for this area will consist of 12 sampling locations (1 through 12) spaced as shown on Figure 5-1. Additional sample screening locations may be selected in this area based on the results of the initial sampling.

Soil gas and groundwater samples will both be obtained by driving a small diameter stainless steel rod into the unsaturated and saturated zones, respectively. Groundwater samples will be obtained in the saturated zone at or near the shallow groundwater surface. Soil gas samples will be obtained in the unsaturated zone just above the shallow groundwater surface. Collected soil gas and groundwater samples will be analyzed on site using a portable gas chromatograph (GC). Benzene and TCE will be used as the indicator compounds for analysis. TCE is highly volatile (vapor pressure 57.9 mmHGg), is one of the specific halogenated compounds detected under previous investigations at elevated levels in the shallow groundwater, and is likely to be identified as a contaminant of concern under the RA. Benzene is a common volatile component of fuels and is also likely to be identified as a contaminant of concern under the RA.

As indicated above, additional soil gas and groundwater screening samples will be obtained based on the results of the initial sampling until the limits of the impacted areas can be determined.

The results of the soil and groundwater screening will be mapped and used as the basis for placement of soil boring and monitoring wells, as discussed in the following sections.

Detailed sampling procedures are provided in the FSAP and QAPP.

5.3.3 Soil Investigation

Soil sampling at Site 35 will be comprised of two elements including: surface soil sampling across the site to provide data to support the baseline risk assessment; and subsurface soil sampling at soil boring and shallow groundwater monitoring well locations determined via soil gas and groundwater field screening and at deep groundwater monitoring well locations. Each of these elements is discussed below:

5.3.3.1 Surface Soil Sampling

A total of 14 surface soil samples (SS-1 through SS-14), including two background samples (SS-1 and SS-2) will be obtained from the locations depicted on Figure 5-2. Shallow soil samples are defined as those obtained from the interval between the ground surface and 12 inches below the ground surface (bgs). The sampling locations were selected based on the limits of soil and groundwater contamination established via the results of previous investigations (Law, 1992 and ATEC, 1993). Background samples SS-1 and SS-2 are located topographically upslope and hydrogeologically upgradient of previously identified contamination. The area of contamination nearest to the background sample locations is associated with the former Mess Hall Heating Plant situated roughly 150 feet and 350 feet southeast of SS-1 and SS-2, respectively.

The remaining surface soil samples are located within areas where contaminated groundwater and/or soils have been previously identified. Surface soil samples SS-3 and SS-4 are situated in the area of the former Mess Hall Heating Plant where elevated petroleum hydrocarbons were detected in subsurface soil and shallow groundwater samples (Law, 1992 and ATEC, 1993).

Surface soil samples SS-5 and SS-6 are located at the southwest corner of Fourth and "E" Streets where elevated levels of halogenated organics were detected at a monitoring well (MW-10) installed in 1991 by Law.

Surface soil samples SS-7 and SS-8 are located north of Fourth Street. Sample SS-7 is situated between "F" Street and the parking lot for building TC480 while SS-8 is situated near monitoring well MW-25. The locations of these surface soil samples are within an area where elevated petroleum hydrocarbons were previously detected in subsurface soil and shallow groundwater samples (Law, 1992).

Surface soil samples SS-9 and SS-10 are located north of Fourth Street and between "F" Street and the Fuel Farm (TC362 and STC369). The results of previous shallow groundwater sampling and analysis in this area identified elevated levels of halogenated organics (Law, 1992).

Surface soil samples SS-11 and SS-12 are situated in the vicinity of the Fuel Farm (TC362 and STC369) located north of the corner of Fourth and "G" Streets. Elevated levels of petroleum hydrocarbons were detected in shallow groundwater samples previously obtained from this area. Past reported leaks from underground lines in this area make them the primary suspected source of contamination.

Soil samples SS-13 and SS-14 are located east of "G" Street. Sample SS-13 is situated in an area where elevated levels of halogenated organics were detected previously in shallow groundwater samples (MW-19 and EMW-7). Sample SS-14 is situated adjacent to the east wall of building TC474 which previously served as a vehicle maintenance facility and is a suspected source of the groundwater contamination in this area.

Additional samples may be obtained based on the results of soil gas and groundwater sample screening which is being conducted as a tool to aid in defining the limits of the halogenated organic contamination previously detected in shallow groundwater. The locations of these samples, if required, will be established in the field. It is assumed that approximately five additional surface soil samples (SS-15 through SS-19) will be needed. These additional five surface soil samples will be obtained from 5 of the 13 subsurface soil borings (B-7 through B-19) to be drilled under this RI/FS as described in the following subsection.

5.3.3.2 Subsurface Soil Sampling

Subsurface soil samples will be obtained from 28 soil borings drilled under this RI/FS. This includes 13 soil borings drilled exclusively for the purpose of obtaining subsurface soil data and 15 soil borings to be completed as monitoring wells. [Note: Seven additional soil borings (PSB-29 through PSB-35) are to be drilled under the Interim Remedial Action RI/FS to provide subsurface soil data at areas where petroleum-based contamination was identified in soil and/or groundwater under a previous investigation. The detailed rationale for these borings is provided in the Interim Remedial Action RI/FS Project Plan (Baker, 1993)]. It has been assumed that 13 additional soil borings (B-7 through B-19: Borings B-1 through B-6 were installed by Law in 1991), 5 additional two-well cluster shallow groundwater monitoring locations (MW-29A,B through MW-33A,B: monitoring wells MW-1 through MW-27 and pumping well PW-28 were installed by Law in 1991 and 1992) and 5 deep groundwater monitoring wells (GWD-1 through GWD-5) will be included under this RI/FS. Only the deep well locations are depicted on Figure 5-2 because the soil boring and shallow monitoring well cluster locations will be determined by the results of the soil gas and groundwater sample screening.

The locations of the 13 soil borings and 5 two-well cluster shallow groundwater monitoring well locations will be determined based on the results of the soil gas and groundwater sample screening. Sample screening results indicative of both the presence and absence of contamination will be used. That is, it is anticipated that several borings and wells will be positioned in areas where positive soil gas and/or groundwater sampling results are obtained to confirm the presence or absence of contamination in these areas. Several borings and wells will also be positioned in areas where no positive soil gas and/or groundwater sampling results are obtained to confirm the presence or absence of contamination and establish the perimeter of the unimpacted area.

Each subsurface soil boring will be drilled to the top of the shallow groundwater surface (assumed to be 8 to 10 feet bgs based on measurements from existing wells) and sampled at continuous 2-foot intervals via split-spoon using ASTM Method 1586-84. One subsurface sample for laboratory analysis will be obtained from each of the 13 soil borings. Upon opening the split-spoon sampler, each soil sample will be field screened for volatile organic emissions via photoionization detector (PID) or organic vapor analyzer (OVA). The soil sample exhibiting the highest PID or OVA reading will be selected for laboratory analysis. The field geologist can exercise discretion and substitute a visually contaminated sample for the sample exhibiting the highest PID or OVA reading. As indicated in the last paragraph of Section 5.3.3.1, 5 of the 13 soil borings will be selected to provide surface soil (0 to 12 inches bgs) samples for laboratory analysis. The selection of the borings to provide these five surface soil samples will be at the discretion of the field geologist.

Additional subsurface soil samples will be collected at each of the five two-well shallow monitoring well cluster locations and five deep groundwater monitoring well borings. These subsurface soil samples will be obtained from the unsaturated soil interval located immediately above the static groundwater surface. The rationale for obtaining these samples is that it can provide a correlation between soil contamination and groundwater contamination and is likely to be, along with the sample exhibiting the highest PID or OVA reading, the most contaminated sample in the borehole.

Additional soil borings and shallow groundwater monitoring wells may be required based on the results of the soil gas and groundwater sample screening.

5.3.3.3 Soil Analysis

All surface soil samples obtained under this RI/FS will be analyzed for TCL VOAs and SVOAs, and TAL Metals. The data from these samples will be used to support the baseline risk assessment.

Subsurface soil samples obtained from soil borings to be completed as deep groundwater monitoring wells (GWD-1 through GWD-5) will be analyzed for TCL VOAs and SVOAs, and TAL metals. The data from these samples, which will be obtained from areas of previously identified contamination and from areas not previously investigated, will be used to support the baseline risk assessment and to provide additional data pertaining to the presence or absence and vertical extent of soil contamination.

Subsurface soil samples obtained from soil borings (B-7 through B-19) and shallow monitoring well borings (MW-29A,B through MW-33A,B) designed to delineate the nature and extent of the previously identified halogenated organic groundwater contamination will be analyzed only for TCL VOAs.

One undisturbed subsurface soil sample (ASTM D1587-83) will be obtained from the background deep groundwater monitoring well boring GWD-1 and analyzed for engineering parameters including particle size distribution (ASTM D 422-63), Atterberg Limits (ASTM D4943-89), and constant head permeability (ASTM D2434-68). The soil sample will be obtained from the interval corresponding with the underlying clay layer that may be representative of a confining aquitard. It is preferred that the sample be obtained from the background well to ensure an unimpacted sample is sent to the geotechnical laboratory. The performance of the above physical analyses will aid in the classification of the material which, in turn, will afford an empirical estimate of the hydraulic conductivity of this zone that may be compared to the results of the permeability test.

One subsurface soil sample will be obtained from deep groundwater monitoring well boring GWD-3 and analyzed for RCRA hazardous characteristics (i.e., full TCLP, corrosivity, ignitability, reactivity). This well is located in areas where halogenated organic contamination was previously detected in shallow groundwater. In addition, subsurface soil samples will be collected from this boring for the evaluation of other engineering parameters including TOC, phosphorus, nitrogen, and microbial enumeration.

5.3.4 Groundwater Investigation

The groundwater investigation to be conducted under this RI/FS will include the installation of both shallow and deep groundwater monitoring wells. The rationale for the installation of these wells is presented below.

5.3.4.1 Shallow Groundwater Wells

Five, two-well shallow groundwater monitoring clusters (MW-29A,B through MW-33A,B: MW-1 through -27 and pumping well PW-28 were installed by Law in 1991 and 1992) will be installed under this RI/FS to define the horizontal extent of the halogenated organic contamination identified in groundwater samples obtained under previous studies (Law, 1992). Specifically, the extent of this contamination has not been defined south of Fourth Street where elevated levels were encountered at monitoring well MW-10 or in the vicinity of building TC474 where nearby wells MW-19 and EMW-7 exhibited elevated levels of TCE.

The locations of the shallow monitoring well clusters will be determined based on the results of soil gas and groundwater sample screening. Several of the well clusters will be positioned to confirm the presence or absence of shallow groundwater contamination at areas where positive screening results were obtained. Conversely, a couple of the shallow well clusters will be positioned in areas where no positive screening results were obtained so as to delineate the limits of the shallow groundwater contamination.

At each shallow monitoring well cluster location, two 2-inch diameter, schedule 40 PVC wells will be installed. The purpose of the two-well cluster concept is to provide the means for obtaining groundwater data at the shallow groundwater surface and immediately above the underlying confining layer. These intervals are monitored by existing double-nested shallow wells previously installed by Law. According to the results of previous investigations conducted by Law the shallow groundwater surface can be expected to be encountered across the topographically flatter portions of the site at 8 to 10 feet bgs. Data provided by Law indicates the top of the confining layer is located from 35 to 43 feet bgs.

Each well in the two-well clusters will be provided with either an "A" or "B" designation (e.g., MW-29A and MW-29B). The "A" will identify the well screened at the groundwater surface, whereas "B" will identify the well screened at the top of the underlying confining layer. Each well will be constructed with 2-inch diameter, schedule 40 PVC casings and No. 10 slot, 2-inch diameter PVC screens. The groundwater surface monitoring well screened interval will be 10 feet long while a 5-foot long screen will be set in the deeper shallow groundwater well drilled to just above the confining layer. Detailed well construction information and well installation procedures are provided in the FSAP and QAPP.

Additional wells may be required based on the results of the soil gas and groundwater field screening.

5.3.4.2 Deep Groundwater Wells

Five deep groundwater wells (GWD-1 through GWD-5) are to be installed under this RI/FS below the clay layer identified in borings SB-1, SB-2, and SB-3 (Law, 1992) at depths ranging from 35 to 43 feet bgs. This clay layer may represent the confining aquitard that separates the shallow water table aquifer from the regionally significant Castle Hayne formation. The proposed locations are shown on Figure 5-2. The deep well screens will be set immediately below the clay layer. In effect, the screens for these deep wells would be set only a few feet deeper than the deeper shallow groundwater monitoring wells and would be separated only by the underlying clay confining layer.

The purpose of the deep wells is to provide data to define the vertical extent of contamination in areas where analytical results of shallow groundwater samples obtained under previous investigations have identified elevated levels of organic contaminants. One of the five deep wells (GWD-1) will be installed in an area suspected to not have been impacted (i.e., at the northwest corner of the intersection of Third and "D" Streets) to provide background data. Two of the remaining four deep wells (GWD-3 and GWD-5) are located adjacent to existing double-nested wells MW-10 and MW-19 previously installed by Law. Elevated levels of halogenated organics were detected in the lower portions of these double-nested wells that are screened from 25.5 feet to 29.5 feet and from 22.5 feet to 24.5 feet, respectively. The other two deep wells (GWD-2 and GWD-4) are located near wells MW-2 at the former Mess Hall Heating Plant and MW-25 located north of the Fuel Farm (buildings TC362 and STC369). Both of these wells are located in areas where elevated levels of petroleum hydrocarbons were identified in previous studies (ATEC, 1993 and Law, 1992).

The deep wells will be constructed of 2-inch diameter, schedule 40, PVC casings. Well screens will be 5 feet in length and will be constructed of No. 10 slotted PVC. It is assumed that all of the deep wells will be constructed with stick-up (2 to 3 feet) steel casings, locking caps, and protective bollards. Detailed well construction information and well installation procedures are provided in the FSAP and QAPP.

5.3.4.3 Groundwater Sampling and Analysis

One round of groundwater samples will be collected from each well installed under this RI/FS. This will result in 10 samples from newly installed shallow monitoring wells and five samples from the deep wells.

Samples from four of the five shallow groundwater well cluster locations (MW-29A,B through MW-32A,B) will be analyzed for VOAs via EPA Method 601/602 including MTBE (methyl tertiary butyl ether)as these wells will be installed to provide data regarding the source and extent of the previously identified halogenated organic shallow groundwater contamination. The analysis of VOAs via EPA Method 601/602 is preferred because the method detection limits are lower than those provided under TCL organics methodology. The results at lower detection limits are needed for comparison to groundwater MCLs (maximum contaminant levels). In addition, the samples from wells MW-33A and MW-33B will be analyzed for full-scan TCL organics and TAL inorganics.

Samples from four of the five newly-installed deep groundwater monitoring wells (GWD-1 through GWD-4) will be analyzed for VOAs via EPA Method 601/602 including MTBE, TCL SVOAs, and TAL Metals. A sample from well GWD-5 will be analyzed for full-scan TCL organics and TAL inorganics. This data will be used to support the baseline risk assessment and to provide information regarding the vertical extent of groundwater contamination.

In addition to the groundwater samples obtained from the newly installed shallow and deep monitoring wells, a single round of 21 groundwater samples will be obtained from a selected number (12) of existing shallow groundwater monitoring wells to provide comparative data and for use in the baseline risk assessment. The existing wells to be sampled include shallow double-nested wells MW-2, -9, -10, -14, -16, -19, -21, -22, and -25, and single shallow wells EMW-3, -5, and -7. The selection of these 12 wells was based on the results of previous investigations (Law, 1992 and ATEC, 1993). Six of the wells (MW-10, -14, and -19, and EMW-3, -5, and 7) were identified as the only wells exhibiting elevated levels of the halogenated organic compound TCE (trichloroethylene). The remaining six wells (MW-2, -9, -16, -21, -22, and -25) include wells where elevated levels of petroleum hydrocarbons were detected. All of the selected shallow wells are double-nested wells except for EMW-3, -5, and -7 which are single wells.

Each of the samples obtained under this RI/FS from the 12 existing groundwater wells identified above will be analyzed for VOAs via EPA Method 601/602 including MTBE, TCL SVOAs, and TAL metals as this data will be used to support the baseline risk assessment. Both total (unfiltered) and dissolved (filtered) metal analysis samples will be obtained. The risk assessment will be based on total metals analysis results and the dissolved metals analysis results will be used for comparison. In addition, the sample obtained from double-nested well MW-21 will be analyzed for full-scan TCL organics and TAL inorganics in lieu of the above methods and for various engineering parameters including microbial enumeration, TOC, BOD, COD, TSS, TDS, ammonia nitrogen, total phosphorous, and alkalinity.

5.3.4.4 Water Level Measurements

Static water level measurements (minimum two rounds) will be collected from each existing and newly installed monitoring well during the groundwater investigation. Water level measurements shall be collected from all of the wells within a four hour period, if possible. This data will be used to evaluate groundwater flow direction.

5.3.5 Surface Water/Sediment Investigation

Surface water and sediment investigations will be conducted along Brinson Creek to assess possible impacts from Site 35 and to support the baseline risk assessment. Six sampling stations will be established along Brinson Creek including one upstream and five adjacent/downstream locations between the site and the New River. The locations are depicted and described on Figure 5-2. The exact sampling locations are to be determined in the field and are to correspond roughly with aquatic/ecological survey sampling locations. One surface water and two sediment samples (near bank: 0 to 6 inches and 6 to 12 inches below the sediment surfaces) will be obtained from each location. The surface water and sediment samples will be analyzed for TCL organics and TAL metals.

5.3.6 Aquatic/Ecological Survey

Aquatic/ecological surveys will be conducted in Brinson Creek to evaluate the potential ecological impacts from past activities at Site 35. The surveys will include the collection of benthic macroinvertebrate and fish samples to assess environmental stresses posed by Site 35. To assess ecological stresses to the aquatic community posed by stream quality, faunal densities, species richness, and species diversity will be determined for benthic macroinvertebrates at each sampling station. Fish samples will be collected for each of the population statistics and subsequent laboratory analysis of whole body parts and fillets. Crab samples will be collected for subsequent analysis of edible body parts. Each fish sample for chemical analysis will represent different trophic levels, if possible, as follows: top carnivores, forage fish, and bottom feeders. All fish and crab analytical samples will be analyzed for TCL organics and TAL metals.

Benthic macroinvertebrates and fish samples will be collected from three 500-foot stretches (i.e., sampling locations) along Brinson Creek; upgradient of Site 35; roughly adjacent to Site 35; and downgradient of Site 35 (see Figure 5-2). The stations will be located to roughly correspond to the surface water/sediment sampling locations.

Benthic macroinvertebrates will be collected with a Standard Ponar. Fish will be collected utilizing electroshocking procedures, seining, or gill nets and/or other fish collecting techniques.

Specific sampling procedures are detailed in the FSAP and QAPP.

5.4 Task 4 - Sample Analysis and Validation

Task 4 involves efforts relating to the following post-field sampling activities:

- Sample Management
- Laboratory Analysis
- Data Validation

Sample management activities involve coordination with subcontracted laboratories, tracking of analyses received, and tracking of samples submitted and received from a third party validator. Sample management also involves resolving potential problems (reanalysis, resubmission of information, etc.) between Baker, the laboratory, and the validator.

Validation begins when the "raw" laboratory data is received by the validator from Baker. Baker will first receive the data from the laboratory, log it into a database for tracking purposes, and then forward it to the validator. A validation report will be expected within three weeks following receipt of laboratory data packages (Level IV) by the validator. Level IV data will be validated per the CLP criteria as outlined in the following documents:

- EPA, Hazardous Site Control Division, laboratory Data Validation Functional Guidelines for Evaluating Pesticides/PCB Analyses, R-582-5-5-01, May 28, 1985.
- EPA, Hazardous Site Control Division, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, R-582-5-5-01, May 28, 1985.
- EPA, Office of Emergency and Remedial Response., Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, 1985.

5.5 Task 5 - Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. It also involves the evaluation of any field-generated data including: water level measurements, in-situ permeability tests, test boring logs, test pit logs, and other field notes. Efforts under this task will include the tabulation of validated data and field data, generation of test boring logs and monitoring well construction logs, generation of geologic cross-section diagrams, and the generation of other diagrams associated with field notes or data received from the laboratory (e.g., sampling location maps, isoconcentration maps).

5.6 Task 6 - Risk Assessment

This section of the Work Plan will serve as the guideline for the baseline risk assessment (BRA) to be conducted for MCB Camp Lejeune during the RI of Site 35.

Baseline risk assessments evaluate the potential human health and/or ecological impacts that would occur in the absence of any remedial action. The risk assessment will provide the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions.

The risk assessments will be performed in accordance with USEPA guidelines. The primary documents that will be utilized include:

- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part A), EPA 1989.
- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), EPA 1991.
- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives), EPA 1991.
- Risk Assessment Guidance for Superfund: Volume II, Environmental Evaluation Manual, EPA 1989.
- Supplemental Guidance to RAGS: Standard Default Values, EPA 1991a.
- Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992.
- Superfund Exposure Assessment Manual, EPA 1988.
- Exposure Factors Handbook, EPA 1989b.
- Guidance for Data Usability in Risk Assessment, EPA 1990.
- Supplemental Region IV Risk Assessment Guidance, EPA Region IV, 1991.

USEPA Region IV will be consulted for Federal guidance, and the North Carolina DEHNR will be consulted for guidance in the State of North Carolina.

The technical components of the BRA are contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The objectives of the risk assessment process can be accomplished by:

- Characterizing the toxicity and levels of contaminants in relevant media (e.g., groundwater, surface water, soil, sediment, air, and biota).

- Characterizing the environmental fate and transport mechanisms within specific environmental media.

- Identifying potential current and future human and/or environmental receptors.

- Identifying potential exposure routes and the extent of the actual or expected exposure.

- Characterizing current and future potential human health risks.

- Identifying the levels of uncertainty associated with the above items.

As outlined in the Scope of Work, the quantitative BRA to be performed at MCB Camp Lejeune for Site 35 is to utilize all available data to date that has been properly validated in accordance with EPA guidelines plus all data to be collected from additional sampling during this RI.

5.6.1 Human Health Evaluation Process

5.6.1.1 Site Location and Characterization

A background section will be presented at the beginning of each risk assessment to provide an overview of the characteristics of each site. This section will provide a site location, a general site description, and the site-specific chemicals as discussed in past reports. The physical characteristics of the site and the geographical areas of concern will be discussed. This site description will help to characterize the exposure setting.

5.6.1.2 Data Summary

Because decisions regarding data use may influence the resultant risk assessment, careful consideration must be given to the treatment of those data. For purposes of risk evaluation, the sites at MCB Camp Lejeune may be partitioned into zones or operable units for which chemical concentrations will be characterized and risks will be evaluated. Sites will be grouped into operable units if they are close to one another, have similar contamination, and/or may impact the same potential receptors. In selecting data to include in the risk assessment, the objective is to characterize, as accurately as possible, the distribution and concentration of chemicals in each operable unit.

Data summary tables will be developed for each medium sampled (e.g., surface water, sediment, groundwater, soil). Each data summary table will indicate the frequency of detection, observed range of concentrations (i.e., minimum and maximum concentration level), and the means and upper 95 percent confidence limit value for each contaminant detected in each medium. The arithmetic or geometric mean and the upper 95 percent confidence limit of that mean will be used in the summary of potential chemical data. The selection of arithmetic or geometric means will depend on whether the sample data are normally or lognormally distributed. In the calculation of the mean, concentrations presented as "ND" (nondetect) will be incorporated at one-half the sample quantitation limit (SQL). If SQLs cannot be obtained, then use one-half the Contract Required Detection Limits (CRQL), Method Detection Limit (MDL), or Instrument Detection Limit (IDL), in that order, with caution provided the number of nondetects is not greater than 10 to 15 percent of the data. The substituted values on the data summary tables will be clearly defined. Due to the size of the analytical database data frequency and statistical summaries may need to be presented in an appendix.

5.6.1.3 Identifying Chemicals of Potential Concern

The criteria to be used in selecting the Contaminants of Potential Concern (COPCs) from the constituents detected during the sampling and analytical phase of the investigation are: historical information, prevalence, mobility, persistence, toxicity, comparison of the ARARs, comparison to blank data or base-specific naturally occurring levels (i.e., background), and comparison to anthropogenic levels. These criterion chosen to establish the COPCs are derived from the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989).

The two times background soil concentration "rule of thumb" will be used in the selection of inorganic COPCs. In this evaluation base-specific and literature values will be used to warrant the elimination or retention of inorganics.

All of the available sample data will undergo review upon initiation of the risk assessment. Common laboratory contaminants such as acetone, methylene chloride, phthalate esters, toluene, and methyl ethyl ketone will be addressed only if concentrations are 10 times greater than the corresponding blanks. In addition, chemicals that are not common laboratory contaminants will be evaluated if they are greater than five times the laboratory blank. The number of chemicals analyzed in the risk assessment will be a subset of the total number of chemicals detected at a site based on the elimination criteria discussed previously.

Tables will be prepared that list chemical concentrations for all media by site. Data will be further grouped according to organic, inorganic, and chemical surety degradation compounds within each table.

5.6.1.4 Exposure Assessment

The objectives of the exposure assessment at MCB Camp Lejeune will be to characterize the exposure setting, identify exposure pathways, and quantify the exposure. When characterizing the exposure setting, the potentially exposed populations will be described. The exposure pathway will identify: the source and the mechanism of medium for the released chemical (e.g., groundwater), the point of potential human contact with the contaminated medium, and the exposure route(s) (e.g., ingestion). The magnitude, frequency, and duration for each exposure pathway identified will be quantified during this process.

The identification of potential exposure pathways at the two sites will include the activities described in the subsections that follow.

Analysis of the Probable Fate and Transport of Site- Specific Chemicals

To determine the environmental fate and transport of the chemicals of concern at the site, the physical/chemical and environmental fate properties of the chemicals will be reviewed. Some of these properties include volatility, photolysis, hydrolysis, oxidation, reduction, biodegradation, accumulation, persistence, and migration potential. This information will assist in predicting potential current and future exposures. It will help in determining those media that are currently receiving site-related chemicals or may receive site-related chemicals in the future. Sources that may be consulted in obtaining this information include computer databases (e.g., AQUIRE, ENVIROFATE), as well as available literature.

The evaluation of fate and transport may be necessary where the potential for changes in future chemical characteristics is likely and for those media where site-specific data on the chemical distribution is lacking.

Identification of Potentially Exposed Human Populations

Human populations, that may be potentially exposed to chemicals at the MCB Camp Lejeune, include base personnel and their families, base visitors, and on site workers and recreational fishermen/women. Camp Geiger has no family housing facilities and hunting is not permitted. The Base Master Plan will be consulted to confirm or modify these potential exposures. Nonworking residents who might be exposed to site-specific chemicals could include spouses and/or children of base personnel and resident workers. Resident and nonresident workers could be exposed to chemicals as they carry out activities at any of the sites located at MCB Camp Lejeune. The list of potential receptors and pathways to be evaluated will be refined during discussions with regulators prior to performing the BRA.

Identification of Potential Exposure Scenarios Under Current and Future Land Uses

The exposure scenarios will be finalized after consulting with the Base Master Plan, EPA and the State of North Carolina. Generally, exposure pathways will be considered preliminarily as follows:

- Soil Pathway
  - Incidental ingestion (current military personnel, future resident, current and future recreational users)
  - Inhalation of dust (current military personnel, future resident, current and future recreational users)
  - Dermal contact (current military personnel, future resident, current and future recreational users)

- Sediment Pathway
  - Dermal contact and incidental (current military personnel, future resident, current and future recreational users)

- Surface Water
  - Dermal contact (current military personnel, future resident, current and future recreational users)
  - Ingestion of contaminated fish (current military personnel, future resident, current and future recreational users)

- Groundwater (future potential only)
  - Direct ingestion (base personnel, on site residents, on site workers, visitors)
  - Inhalation (base personnel, on site residents, on site workers, visitors)
  - Dermal contact (base personnel, on-site residents, on-site workers, visitors)

- Biota
  - Ingestion of fish or shellfish (current military personnel, future resident, current and future recreational users)

Exposure Point Concentrations

After the potential exposure points and potential receptors have been defined, exposure point concentrations must be calculated. The chemical concentrations at these contact points are critical in determining intake and, consequently, risk to the receptor. The data from site investigations will be used to estimate exposure point concentrations.

The means and the upper 95 percent upper confidence limits (95% UCL) of the means will be used throughout the risk assessment. If the data are lognormally distributed, the means will be based on the geometric mean rather than the arithmetic mean. If there is great variability in measured or modeled concentration values (i.e., too few samples are collected to estimate a statistically relevant mean concentration) the 95% UCL on the average concentration or geometric mean will be high, and conceivably could be above the maximum detected or modeled concentration. In cases like these, although thought to be too conservative, the maximum value will be used to estimate potential exposure.

Exposure doses will be estimated for each exposure scenario from chemical concentrations at the point of contact by applying factors that account for contact frequency, contact duration, average body weight, and other route-specific factors such as breathing rate (e.g., inhalation). These factors will be incorporated into exposure algorithms that convert the environmental concentrations into chronic daily intakes. Intakes will be reported in milligrams of chemical taken in by the receptor (i.e., ingested, inhaled, etc.) per kilogram body weight per day (mg/kg/day). Intakes for potentially exposed populations will be calculated separately for the appropriate exposure routes and chemicals.

5.6.1.5 Toxicity Assessment

Toxicity values (i.e., numerical values derived from dose-response toxicity data for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity values will be obtained from the most recent versions of the following sources:

- Integrated Risk Information System (IRIS) - The principal toxicology database, which provides updated information from USEPA on cancer slope factors, reference doses, and other standards and criteria for numerous chemicals.

- Health Effects Assessment Summary Tables (HEAST) - A comprehensive listing of provisional risk assessment information relative to oral and inhalation routes.

For some chemicals, toxicity values (i.e., reference doses) may have to be derived if the principal references previously mentioned do not contain the required information. These derivations will be provided in the risk assessment for review by USEPA Region IV. The toxicity assessment will include a brief description of the studies on which selected toxicity values were based, the uncertainty factors used to calculate noncarcinogenic reference doses (RfDs), the USEPA weight-of-evidence classification for carcinogens, and their respective slope factors.

5.6.1.6 Risk Characterization

Risk characterization involves the integration of exposure doses and toxicity information to quantitatively estimate the risk of adverse health effects. Quantitative risk estimates based on the reasonable maximum exposures to the site contaminants will be calculated based on available information. For each exposure scenario, the potential risk for each chemical will be based on intakes from all appropriate exposure routes. Carcinogenic risk and noncarcinogenic hazard indices are assumed to be additive across all exposure pathways and across all of the chemicals of concern for each exposure scenario. Potential carcinogenic risks will be evaluated separately from potential noncarcinogenic effects, as discussed in the following subsections.

Carcinogenic Risk

For the potential carcinogens that are present at the site, the carcinogenic slope factor (q_1*) will be used to estimate cancer risks at low dose levels. Risk will be directly related to intake at low levels of exposure. Expressed as an equation, the model for a particular exposure route is:

$$\text{Excess lifetime cancer risk} = \text{Estimated dose x carcinogenic slope factor; or CDI x } q_1^*$$

Where: CDI = Chronic daily intake

This equation is valid only for risk less than 10^{-2} (1 in 100) because of the assumption of low dose linearity. For sites where this model estimates carcinogenic risks of 10^{-2} or higher, an alternative model will be used to estimate cancer risks as shown in the following equation:

$$\text{Excess lifetime cancer risk} = 1 - \exp(-\text{CDI x } q_1^*)$$

Where: exp = the exponential

For quantitative estimation of risk, it will be assumed that cancer risks from various exposure routes are additive. Since there are no mathematical models that adequately describe antagonism or synergism, these issues will be discussed in narrative fashion in the uncertainty analysis.

Noncarcinogenic Risk

To assess noncarcinogenic risk, estimated daily intakes will be compared with reference doses RfD for each chemical of concern. The potential hazard for individual chemicals will be presented as a hazard quotient (HQ). A hazard quotient for a particular chemical through a given exposure route is the ratio of the estimated daily intake and the applicable RfD, as shown in the following equation:

$$HQ = EDI/RfD$$

Where: HQ = Hazard quotient

EDI = Estimated daily intake or exposure (mg/kg/day)
RfD = Reference dose (mg/kg/day)

To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals through a variety of exposure routes, a hazard index (HI), which is the sum of all the hazard quotients, will be calculated. Ratios greater than one, or unity, indicate the potential for adverse effects to occur. Ratios less than one indicate that adverse effects are unlikely. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect. In some cases when the HI exceeds unity it may be appropriate to segregate effects, as expressed by the HI, by target organ since those effects would not be additive. As previously mentioned, where information is available about the antagonism or synergism of chemical mixtures, it will be appropriately discussed in the uncertainty analysis.

5.6.1.7 Uncertainty Analysis

There is uncertainty associated with any risk assessment. The exposure modeling can produce very divergent results unless standardized assumptions are used and the possible variation in others are clearly understood. Similarly, toxicological assumptions, such as extrapolating from chronic animal studies to human populations, also introduce a great deal of uncertainty into the risk assessment. Uncertainty in a risk assessment may arise from many sources including:

- Environmental chemistry sampling and analysis.
- Misidentification or failure to be all-inclusive in chemical identification.
- Choice of models and input parameters in exposure assessment and fate and transport modeling.
- Choice of models or evaluation of toxicological data in dose-response quantification.
- Assumptions concerning exposure scenarios and population distributions.

The variation of any factor used in the calculation of the exposure concentration will have an impact on the total carcinogenic and noncarcinogenic risk. The uncertainty analysis will qualitatively discuss non-site and site-specific factors that may product uncertainty in the risk assessment. These factors may include key modeling assumptions, exposure factors, assumptions inherent in the development of toxicological end points, and spatio-temporal variance in sampling.

5.6.2 Ecological Risk Assessment

5.6.2.1 Purpose and Approach

The overall purpose of an ecological risk assessment is to evaluate the likelihood that adverse ecological effects would occur or are occurring as a result of exposure to one or more physical or chemical stressors. The proposed evaluation will focus on identifying potential adverse effects of area-specific contamination on the ecological integrity of the terrestrial and aquatic receptors (e.g., flora and fauna) on, or adjacent to, each site, or group of sites (e.g, operable unit), at MCB Camp Lejeune. In addition, this assessment will evaluate the potential effects of contaminants on sensitive environments including wetlands, protected species, critical habitats, and breeding/nursery areas. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

The technical approach used in this ecological risk assessment parallels that used in the human health risk assessment; however, since the protocols for evaluating the ecological risks have not been sufficiently developed, the ecological risk assessment may be more qualitative than its human health counterpart. The results of the ecological risk assessment will be used in conjunction with the human health risk assessment in order to determine the appropriate remedial action at this site for the overall protection of public health and the environment.

The risk assessment methodologies to be used in this evaluation are consistent with those outlined in the Framework for Ecological Risk Assessment, which was developed by the USEPA in 1992. In addition, information found in the following documents will be used to supplement the USEPA guidance document:

USEPA Risk Assessment Guidance for Superfund - Volume II, Environmental Evaluation Manual (USEPA, 1989)

Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989)

Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates and Fish (USEPA, 1989)

The subsections that follow describe the general technical approach proposed to evaluate the likelihood that adverse ecological effects would occur or are occurring as a result of exposure to one or more physical or chemical stressors found at MCB Camp Lejeune. The ecological risk assessment will consist of three main components: (1) Problem Formulation, (2) Analysis, and (3) Risk Characterization. The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data is evaluated to determine the exposure and potential effects of the ecological receptors from the stressors. Finally, in the risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This component or step evaluates the potential impact on the ecological integrity at the site from the contaminants detected in the various environmental media.

5.6.2.1 Problem Formulation

Problem formulation is the first step of an ecological risk assessment and includes a preliminary characterization of exposure and effects, as well as scientific data needs, policy and regulatory issues, and site-specific factors to define feasibility, scope, and objectives. The components of the problem formulation phase consist of: stressor characteristics, ecosystems potentially at risk; ecological effects; endpoint selection; and, a conceptual model.

Stressor Characteristics

One of the initial steps in the problem formulation stage is to identify the physical and chemical stressor characteristics. Physical stressors include extremes of natural conditions (e.g., temperature and hydrologic changes) and habitat alteration or destruction. For the chemical stressors, the selection of contaminants of concern will be based on frequency of detection, background comparison, persistence of the contaminant, bioaccumulation potential, and the toxicity of the contaminant. Because of the differential toxicity of some contaminants to ecological versus human receptors, the contaminants of concern for ecological receptors may differ from those selected for the human health risk assessment.

Ecosystem Potentially at Risk

Based on available regional and site-specific ecology, the ecosystem within which effects from stressors would occur or are occurring is evaluated and ecological receptors that potentially are at risk are identified. This stressor-ecosystem-receptor relationship will be used to develop exposure scenarios in the analysis phase. Properties of the ecosystem used in this evaluation include a biotic environment (e.g., climatic conditions and soil or sediment properties), ecosystem structure (e.g., abundance and trophic level relationships), and ecosystem function (e.g., energy source, energy utilization, and nutrient processing). In addition, the types and patterns of historical disturbances are used to predict ecological receptor-stressor responses. Finally, spatial and temporal distribution is used to define the natural variability in the ecosystem.

Selection of the ecological components for evaluation in the ecological risk assessment will be based on the following factors:

- The nature of the stressor and the potential for the stressor to interact with the ecological component
- The value of the ecological component from an ecological or ecosystem perspective
- The value of the ecological component from a human perspective
- Rare, threatened, or endangered species
- Species of commercial or recreational importance

The potential for indirect effects will be considered in the selection of ecosystem components for evaluation. Indirect or secondary effects can include reduction in prey availability or habitat utilization.

Ecological Effects

Ecological effects data will be compiled for the physical and chemical stressors identified. Ecological effects data may come from a variety of sources including field observations (e.g., fish or bird kills, changes in community structure), field tests (e.g., micro/meso-cosm tests), laboratory tests (e.g., bioassays), and chemical structure-activity relationships. Considerations will be given to the extrapolation required for application of laboratory-based test to field situations and to the interpretation of field observations that may be influenced by natural variability or non-site stressor that are not the focus of the ecological risk assessment.

Endpoint Selection

The information compiled during the first stage of problem formulation (i.e., stressor characteristics, ecosystems potentially at risk, and ecological effects) will be used to select ecological endpoints, defined as assessment endpoints and measurement endpoints, that will be used in the ecological risk assessment. An endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor. The assessment endpoints are expressions of the actual environmental value that is to be protected. Measurement endpoints are measurable responses to a stressor that are related to the valued characteristic chosen as the assessment endpoint. The endpoints can be further divided into four primary ecological groups: individual; population; community; and, ecosystem ecological endpoints.

Conceptual Model

The conceptual model consist of a series of working hypotheses regarding how the stressor might affect ecological components of the ecosystem potentially at risk. The conceptual model is the summation of the preliminary analysis conducted pursuant to the problem formulation phase of the ecological risk assessment.

5.6.2.2 Analysis - Characterization of Exposure

The interaction of the stressor with the ecological component will be evaluated in the characterization of exposure. An exposure pathway is developed that quantifies the magnitude and spatial and temporal distributions of exposure for the various ecological components selected during the problem formulation and serves as input to the risk characterization. The components of the characterization of exposure phase consist of: stressor characterization, ecosystem characterization; exposure analysis; and exposure profile.

Stressor Characterization

The distribution or pattern of change of the stressor will be determined. For chemical stressors, a combination of modeling and monitoring data will be used to estimate or measure, respectively, releases into the environment and media concentrations over space and time. For physical stressors, the pattern of change will be dependent on historical information such as resource management, land-use practices, or climatic conditions. The timing of the stressor's interaction with the affected component of the ecosystem will be considered. If the stressor is episodic in nature, different species and life stages may be affected. In addition, heterogeneity of stressor distribution will be quantified, where possible.

Ecosystem Characterization

The spatial and temporal distribution of the ecological components will be characterized including a discussion of the regional ecology, site-specific ecology, and sensitive environments on and adjacent to the site. This evaluation will include a literature search to compile the available information on the populations, communities, and habitats in the potentially affected area.

Exposure Analysis/Profile

The spatial and temporal distributions of both the ecological component and the stressor will be combined to evaluate the exposure. Potential exposure scenarios will be developed for each of the environmental media including surface soils, surface water, sediments, and biota. For chemical stressors, the exposure analysis will focus on the amount of the chemical that is bioavailable through uptake as well as actual contact with the stressor. For physical stressors, the focus will be on co-occurrence with the alteration to the community or ecosystem. The information developed in the exposure analysis will be quantified in the exposure profile. For chemical stressors, the exposure profile will be expressed as dose units (i.e., estimated daily intakes) and exposure point concentrations. For physical stressor, the exposure profile will be expressed as magnitude of events per time.

5.6.2.3 Analysis - Characterization of Ecological Effects

The relationship between the stressors and the assessment and measurement endpoints identified during problem formulation will be quantified and summarized in a stressor-response profile. The stressor-response profile will be used as input to the risk characterization. Scientific literature and regulatory guidelines will be reviewed for media-specific and/or species specific toxicity data. On-line databases will be accessed, such as AQUIRE and PHYTOTOX, to obtain current stressor-response data. Toxicity values will be from the most closely related species, where possible. Reference areas will be compared to the potentially affected areas as a basis for characterizing effects.

5.6.2.4 Risk Characterization

Risk characterization is the final phase of the ecological risk assessment and uses the results of the exposure and ecological effects analyses. The likelihood of adverse effects occurring as a result of exposure to a stressor will be evaluated. To integrate the results of the exposure and ecological effects analyses, single effects and exposure values will be compared using the quotient method for both media exposure and uptake exposure. If the ratio exceeds one, some potential for risk is presumed. In addition, risks to communities will be assessed by considering species representation by trophic group, taxa, or habitat.

The ecological significance of the risks with consideration of the types and magnitudes of the effects and their spatial and temporal patterns will be discussed. Ecologically significant risks can be defined as those potential adverse risks or impacts to ecological integrity that affect populations, communities, and ecosystems, rather than individuals (i.e. measured impacts to individuals does not necessarily indicate impacts to the ecosystem). However, ecological risk assessments are seldom probabilistic in nature (i.e., the probability of an adverse effect is difficult to quantify as a numeric risk estimate). Therefore, unless the risk assessment can be strictly limited to comparisons with existing ecological quality criteria, the characterization of ecological risk will consist of a weight-of-evidence evaluation. The risk characterization component is therefore defined by either the presence of an adverse impact based on actual measurements, or the likelihood of an impact based on extrapolation from field or laboratory measurements or the scientific literature. The weight-of-evidence approach is used to approximate the risk based on the combination of empirical observations and inferences founded in reasonable scientific judgment.

5.6.2.5 Uncertainty Analysis

An ecological risk assessment, like a human health risk assessment, is subject to a wide variety of uncertainties. Virtually every step in the risk assessment process involves numerous assumptions that contribute to the total uncertainty in the final evaluation of risk. Assumptions are made in the exposure assessment regarding potential for exposure and exposure point locations. An effort is made to use assumptions that are conservative, yet realistic. The interpretation and application of ecological effects data is probably the greatest source of uncertainty in the ecological risk assessment. The uncertainty analysis will attempt to address the factors that affect the results of the ecological risk assessment.

5.7 Task 7 - Treatability Study/Pilot Testing

This task includes the efforts to prepare and conduct bench- or pilot-scale treatability studies should they be necessary. This task begins with the development of a Treatability Study Work Plan for conducting the tests and is completed upon submittal of the Final Report. The following are typical activities.

- Work plan preparation
- Test facility and equipment procurement
- Vendor and analytical service procurement
- Testing
- Sample analysis and validation
- Evaluation of results
- Report preparation
- Project management

Bench- or pilot-scale treatability studies for oil and fuel impacted soils are considered under the Interim RI/FS for Site 35. If soil contamination is encountered as a result of the soil investigation conducted under this RI, appropriate bench- or pilot-scale treatability studies will be considered under this task.

Bench- or pilot-scale treatability studies for groundwater may be required to assess pretreatment options (e.g., metal reduction). However the RI has been designed to acquire engineering data that may be sufficient to afford an adequate evaluation of pretreatment options without the performance of bench- or pilot-scale treatability studies.

5.8 Task 8 - Remedial Investigation Report

This task is intended to cover all work efforts related to the preparation of the document providing the findings once the data have been evaluated under Tasks 5 and 6. The task covers the preparation of a Preliminary Draft, Draft, Draft Final, and Final RI Report. This task ends when the Final RI Report is submitted.

5.9 Task 9 - Remedial Alternatives Screening

This task initiates the Feasibility Study (FS) and includes the efforts necessary to select the alternatives that appear feasible and require full evaluation. The task begins during data evaluation when sufficient data are available to initiate the screening of potential technologies. For reporting and tracking purposes, the task is defined as complete when a final set of alternatives is chosen for detailed evaluation.

5.10 Task 10 - Remedial Alternatives Evaluation

This task involves the detailed analysis and comparison of alternatives using the following criteria:

- Threshold Criteria:
    - Overall Protection of Human Health and the Environment
    - Compliance With ARARs
- Primary Balancing Criteria:
    - Long-Term Effectiveness and Permanence
    - Reduction of Toxicity, Mobility, and Volume Through Treatment
    - Short-Term Effectiveness
    - Implementability
    - Cost

- Modifying Criteria: State and EPA Acceptance

  Community Acceptance

5.11 Task 11 - Feasibility Study Report

This task is comprised of reporting the findings of the FS. The task covers the preparation of a Preliminary Draft, Draft, Draft Final, and Final FS report. This task ends when the Final FS report is submitted.

5.12 Task 12 - Post RI/FS Support

This task involves the technical and administrative support to LANTDIV to prepare a Draft, Draft Final, and Final Responsiveness Summary, Proposed Remedial Action Plan, and Record of Decision. These reports will be prepared using applicable EPA guidance documents.

5.13 Task 13 - Meetings

This task involves providing technical support to LANTDIV during the RI/FS. It is anticipated that the following meetings will be required:

- A meeting between Baker and LANTDIV in Coraopolis, Pennsylvania.

- Public meeting in Jacksonville, North Carolina, to present the proposed remedial alternatives.

- A TRC meeting in Jacksonville, North Carolina, to present the findings of the RI/FS.

- Back-to-back meetings over two days in Atlanta, Georgia. The first meeting will be with LANTDIV and MCB Camp Lejeune staff. The second meeting will be with regulators.

5.14 Task 14 - Community Relations

This task includes providing support to LANTDIV during the various public meetings identified under Task 13. This support includes the preparation of fact sheets, meeting minutes, coordination with Camp Lejeune EMD in contacting local officials and media, and the procurement of a stenographer.

This task also includes updating the existing Community Relations Plan (CRP) with respect to changes in personnel, contacts, phone numbers, or the addition of information relevant to this RI/FS. An addendum to the CRP will be prepared which summarizes these changes. Replacement pages to the existing CRP will be issued.

6.0 PROJECT MANAGEMENT AND STAFFING

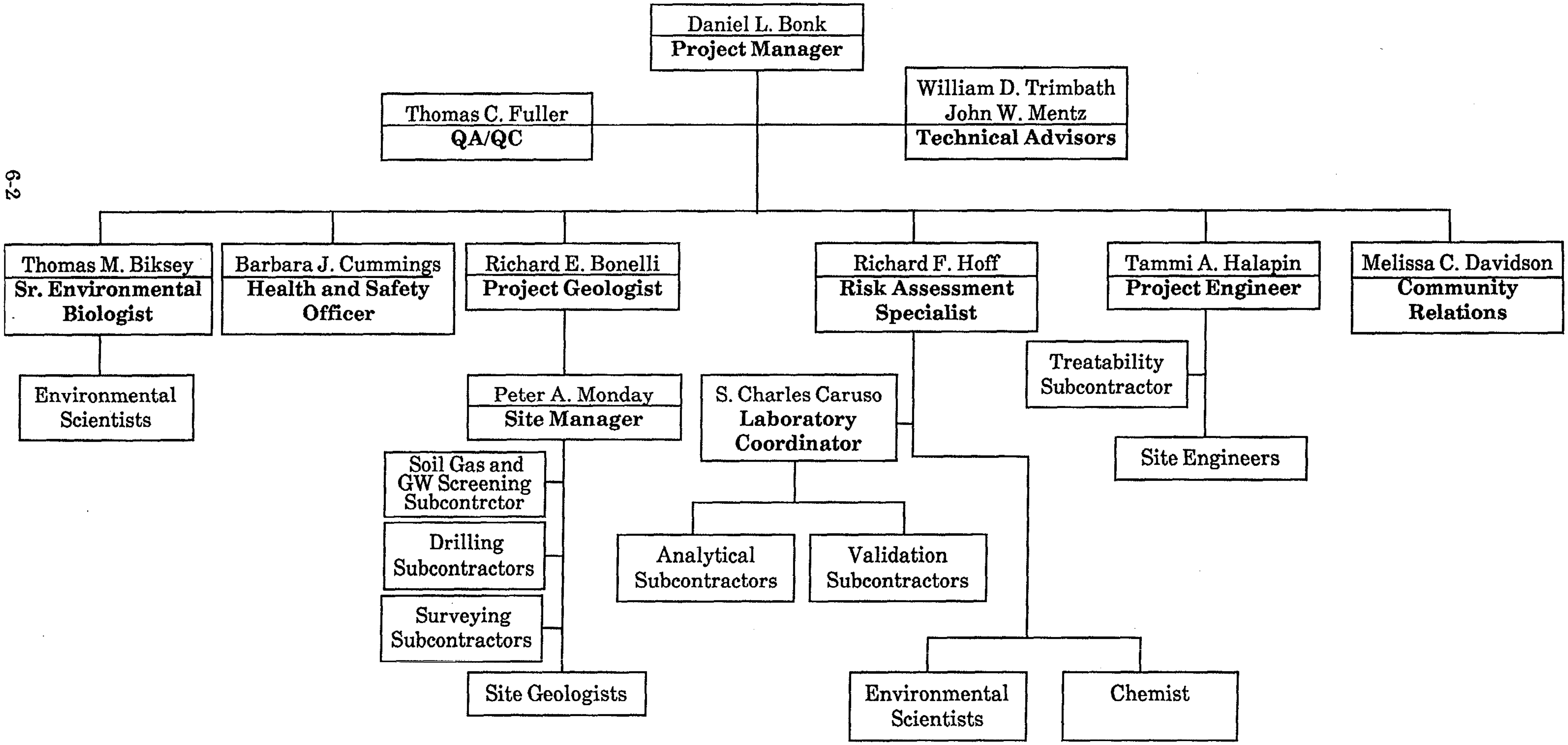
The proposed management and staffing of this RI/FS is depicted in Figure 6-1. The primary participants for this project include:

- Mr. Daniel L. Bonk, Project Manager
- Mr. Thomas C. Fuller, QA/QC
- Mr. Richard E. Bonelli, Project Geologist
- Ms. Tammi A. Halapin, Project Engineer
- Mr. Richard F. Hoff, Risk Assessment
- Mr. S. Charles Caruso, Laboratory Coordinator
- Mr. Thomas M. Biksey, Environmental Assessment
- Mr. Ronald Krivan, Health and Safety Officer
- Ms. Melissa C. Davidson, Community Relations Specialist

From a responsibility and coordination standpoint, Messers. Richard Bonelli, Richard Hoff, and Thomas Biksey will have the overall responsibility of completing the RI Report. Ms. Tammi Halapin will be responsible for overseeing the preparation of the FS report. These personnel will report directly to the Project Manager and the Activity Coordinator. They will be supported by geologists, engineers, biologists, chemists, data technicians, and clerical personnel.

Overall field and reporting QA/QC will be the responsibility of Mr. Thomas C. Fuller. Mr. William D. Trimbath, P.E. and Mr. John W. Mentz will provide Program-level technical and administrative support.

FIGURE 6-1
PROJECT ORGANIZATION
RI/FS AT OPERABLE UNIT NO. 10
(SITE 35)
MCB, CAMP LEJEUNE, NORTH CAROLINA



7.0 SCHEDULE

Two schedules are provided in this section. Figure 7-1 depicts the schedule prepared in accordance with the requirements of the Federal Facilities Agreement (FAA). Figure 7-2 depicts the Expedited Schedule.

Figure 7 - 1: Site Management Schedule

Site 35 (Operable Unit no. 10), MCB Camp Lejeune, NC

Task	Days	Start	Finish
RI/FS Project Plans	214d	5/1/93	2/25/94
Prepare Prelim Draft RI/FS Project Plans	60ed	5/1/93	6/30/93
Submit Prelim Draft RI/FS Project Plans	0ed	6/30/93	6/30/93
LANTDIV Review	30ed	6/30/93	7/30/93
Prepare Draft RI/FS Project Plans	30ed	7/30/93	8/29/93
Submit Draft RI/FS Project Plans	0ed	8/29/93	8/29/93
Agency Review	60ed	8/29/93	10/28/93
Prepare Draft Final RI/FS Project Plans	60ed	10/28/93	12/27/93
Submit Draft Final RI/FS Project Plans	0ed	12/27/93	12/27/93
Agency Review	30ed	12/27/93	1/26/94
Prepare Final RI/FS Project Plans	30ed	1/26/94	2/25/94
Submit Final RI/FS Project Plans	0ed	2/25/94	2/25/94
Field Investigation	42ed	3/1/94	4/12/94
Sample Analysis/Validation	84ed	3/1/94	5/24/94
Data Evaluation	21ed	5/24/94	6/14/94
Risk Assessment	28ed	6/14/94	7/12/94
RI Report	199d	6/14/94	3/19/95
Preliminary Draft RI Report	42ed	6/14/94	7/26/94
Comment Period	28ed	7/26/94	8/23/94
Draft RI Report	28ed	8/23/94	9/20/94
Comment Period	60ed	9/20/94	11/19/94
Draft Final RI Report	60ed	11/19/94	1/18/95
Comment Period	30ed	1/18/95	2/17/95
Final RI	30ed	2/17/95	3/19/95

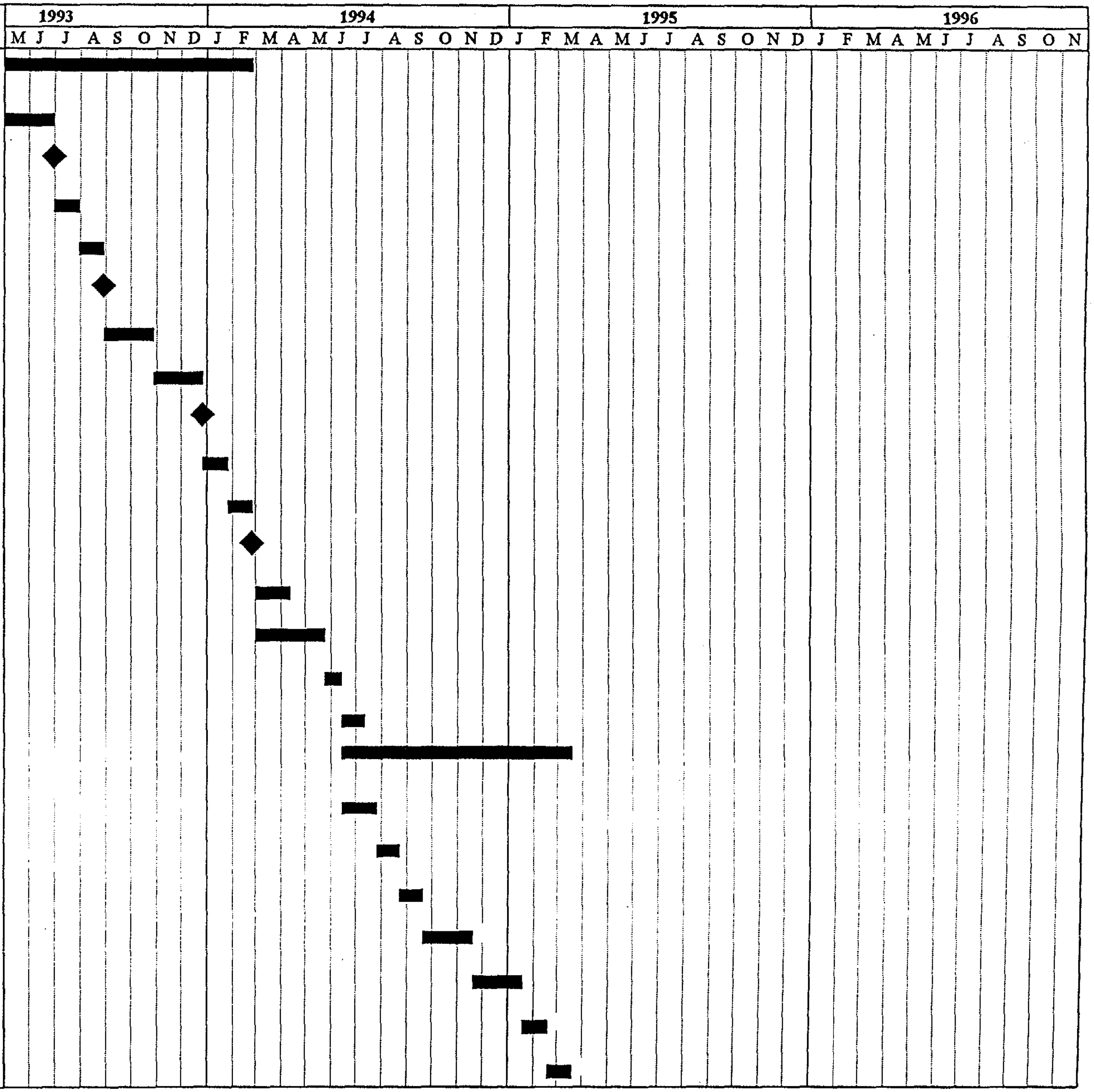


Figure 7 - 1: Site Management Schedule

Site 35 (Operable Unit no. 10), MCB Camp Lejeune, NC

Task	Days	Start	Finish
FS Report/PRAP	210d	7/26/94	5/16/95
Preliminary Draft FS/PRAP	28ed	7/26/94	8/23/94
Comment Period	28ed	8/23/94	9/20/94
Draft FS/PRAP	28ed	9/20/94	10/18/94
Comment Period	60ed	10/18/94	12/17/94
Draft Final FS/PRAP	60ed	12/17/94	2/15/95
Comment Period	30ed	2/15/95	3/17/95
Final FS/PRAP	30ed	3/17/95	4/16/95
Public Comment Period	30ed	4/16/95	5/16/95
ROD	171d	10/1/94	5/30/95
Preliminary Draft ROD	28ed	10/1/94	10/29/94
Comment Period	28ed	10/29/94	11/26/94
Draft ROD	21ed	11/26/94	12/17/94
Comment Period	60ed	12/17/94	2/15/95
Draft Final ROD	60ed	2/15/95	4/16/95
Comment Period	30ed	4/16/95	5/16/95
Final ROD	14ed	5/16/95	5/30/95
Remedial Design (1,2)	398ed	5/30/95	7/1/96
Procure RA Contractor	70ed	7/1/96	9/9/96
Begin RA (1,2)	0ed	9/9/96	9/9/96

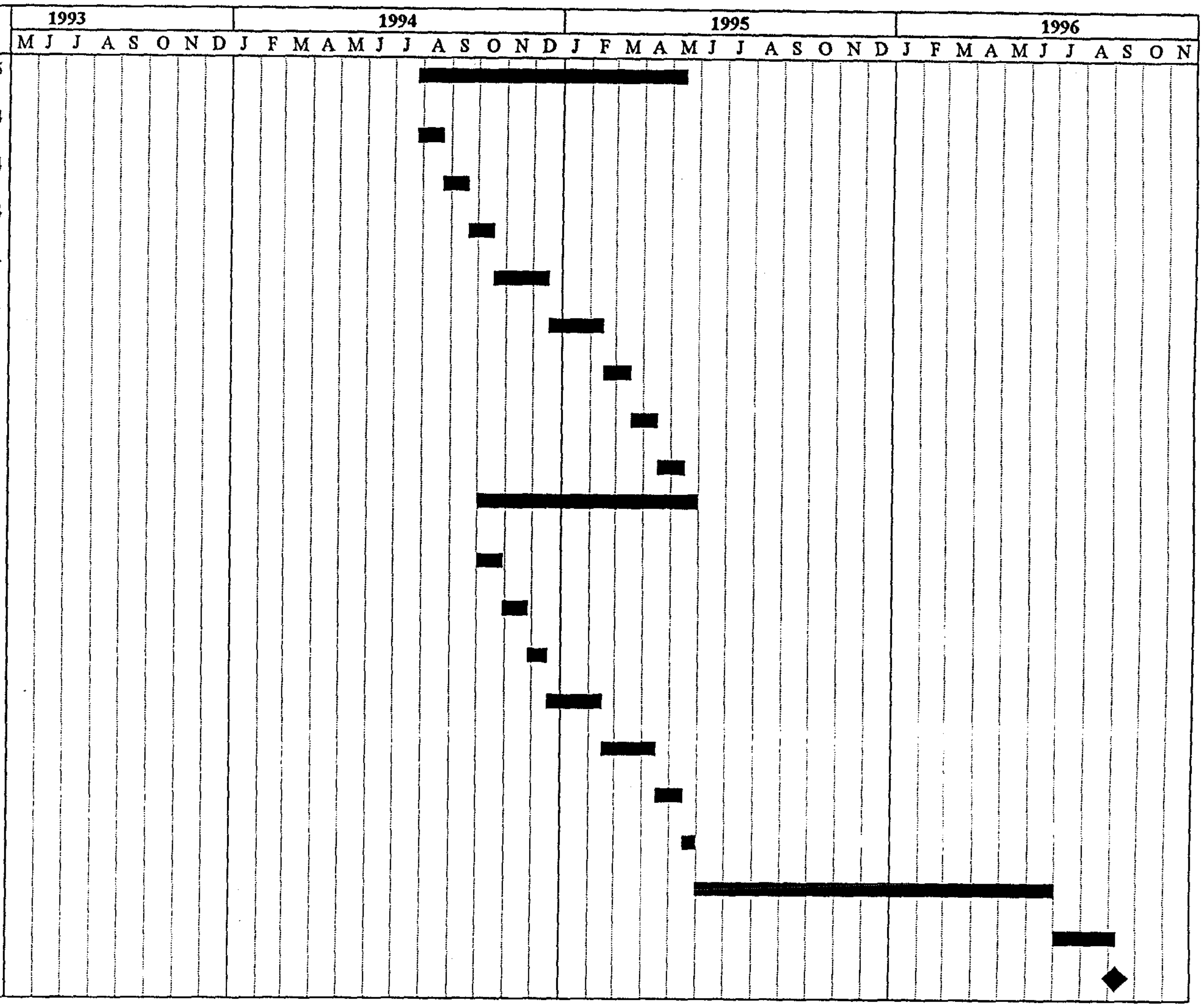


Figure 7 - 2: Expedited Site Management Schedule

Site 35 (Operable Unit no. 10), MCB Camp Lejeune, NC

Task	Days	Start	Finish
FS Report/PRAP	139d	7/26/94	2/6/95
Preliminary Draft FS/PRAP	28ed	7/26/94	8/23/94
Comment Period	21ed	8/23/94	9/13/94
Draft FS/PRAP	21ed	9/13/94	10/4/94
Comment Period	30ed	10/4/94	11/3/94
Draft Final FS/PRAP	30ed	11/3/94	12/3/94
Comment Period	21ed	12/3/94	12/24/94
Final FS/PRAP	14ed	12/24/94	1/7/95
Public Comment Period	30ed	1/7/95	2/6/95
ROD	122d	10/1/94	3/22/95
Preliminary Draft ROD	28ed	10/1/94	10/29/94
Comment Period	28ed	10/29/94	11/26/94
Draft ROD	21ed	11/26/94	12/17/94
Comment Period	30ed	12/17/94	1/16/95
Draft Final ROD	30ed	1/16/95	2/15/95
Comment Period	21ed	2/15/95	3/8/95
Final ROD	14ed	3/8/95	3/22/95
Remedial Design	305ed	3/22/95	1/21/96
Procure RA Contractor	60ed	1/21/96	3/21/96
Begin RA	0ed	3/21/96	3/21/96

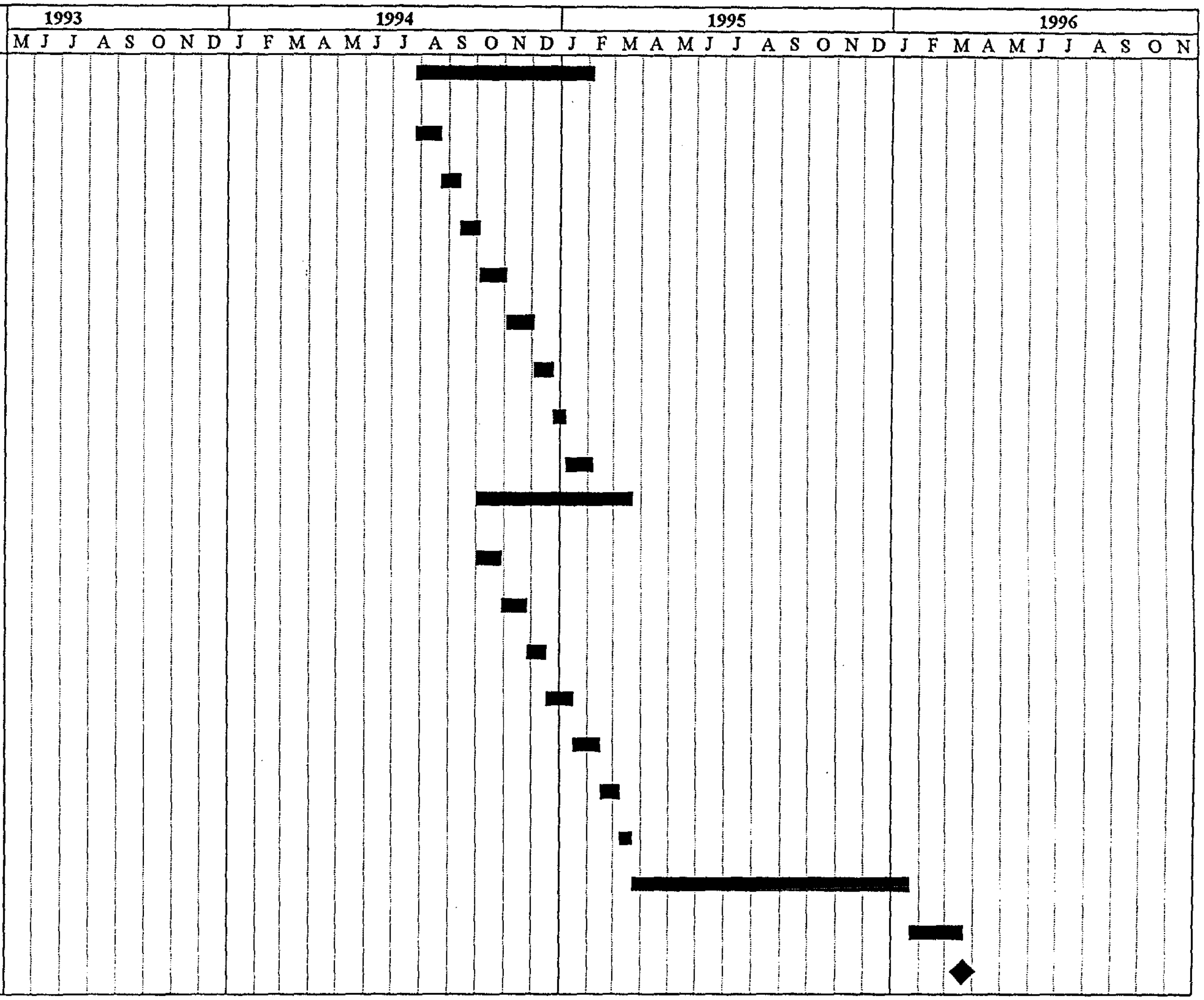
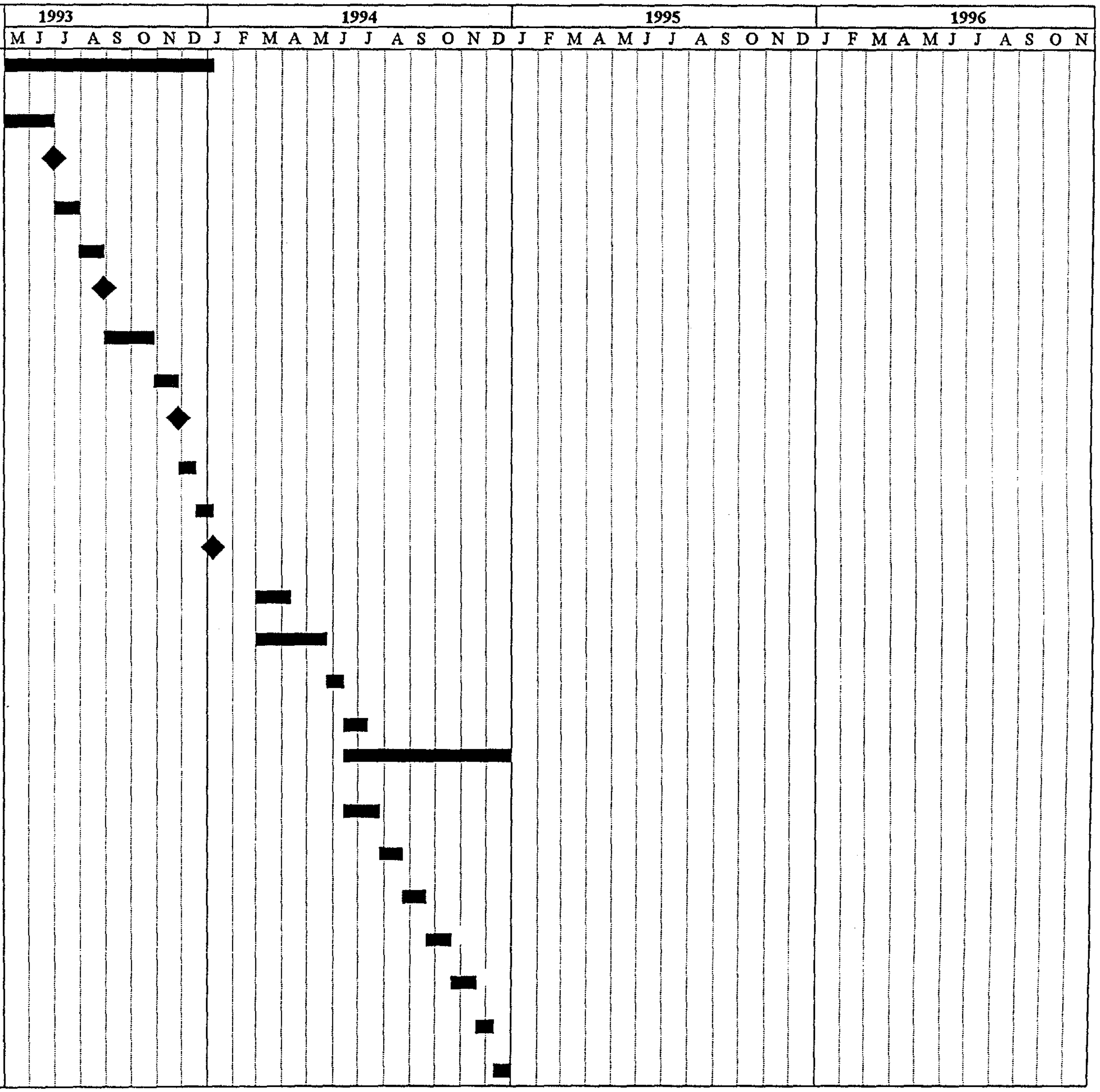


Figure 7 - 2: Expedited Site Management Schedule

Site 35 (Operable Unit no. 10), MCB Camp Lejeune, NC

Task	Days	Start	Finish
RI/FS Project Plans	180d	5/1/93	1/8/94
Prepare Prelim Draft RI/FS Project Plans	60ed	5/1/93	6/30/93
Submit Prelim Draft RI/FS Project Plans	0ed	6/30/93	6/30/93
LANTDIV Review	30ed	6/30/93	7/30/93
Prepare Draft RI/FS Project Plans	30ed	7/30/93	8/29/93
Submit Draft RI/FS Project Plans	0ed	8/29/93	8/29/93
Agency Review	60ed	8/29/93	10/28/93
Prepare Draft Final RI/FS Project Plans	30ed	10/28/93	11/27/93
Submit Draft Final RI/FS Project Plans	0ed	11/27/93	11/27/93
Agency Review	21ed	11/27/93	12/18/93
Prepare Final RI/FS Project Plans	21ed	12/18/93	1/8/94
Submit Final RI/FS Project Plans	0ed	1/8/94	1/8/94
Field Investigation	42ed	3/1/94	4/12/94
Sample Analysis/Validation	84ed	3/1/94	5/24/94
Data Evaluation	21ed	5/24/94	6/14/94
Risk Assessment	28ed	6/14/94	7/12/94
RI Report	144d	6/14/94	12/31/94
Preliminary Draft RI Report	42ed	6/14/94	7/26/94
Comment Period	28ed	7/26/94	8/23/94
Draft RI Report	28ed	8/23/94	9/20/94
Comment Period	30ed	9/20/94	10/20/94
Draft Final RI Report	30ed	10/20/94	11/19/94
Comment Period	21ed	11/19/94	12/10/94
Final RI	21ed	12/10/94	12/31/94



APPENDIX A
SELECTED PORTIONS FROM COMPREHENSIVE SITE ASSESSMENT REPORT (LAW 1992)

FINAL REPORT
UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

VOLUME I

CAMP GEIGER FUEL FARM
MARINE CORPS BASE

CAMP LEJEUNE, NORTH CAROLINA

February 8, 1992

Law Engineering Job No. J47590-6014

Law Engineering, Inc.
Raleigh, North Carolina

FINAL REPORT
UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

VOLUME I

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LAW ENGINEERING

1.0 INTRODUCTION

1.1 Purpose of Investigation

On September 29, 1990, the Commander of the Atlantic Division Naval Facilities Engineering Command (LANTDIV) in Norfolk, Virginia, contracted with Law Companies Group, Inc. to perform a Comprehensive Site Assessment (CSA) at the Camp Geiger Fuel Farm, Marine Corps Base (MCB), Camp Lejeune, North Carolina (Drawing 1.1). The purpose of the investigation was 1) to identify the presence, magnitude and extent of possible free-product accumulation and ground-water contamination and 2) to assess potential exposure to subsurface contaminants resulting from the release(s) of petroleum fuels. As stated in the CSA Workplan contained in Appendix A, the objective of the investigation was to provide sufficient data to meet the requirements of Sections 280.63 and 280.65 of 40 CFR Part 280, Federal Technical Standards for Underground Storage Tanks. This data should also be sufficient to meet the requirements of Sections .0704 and .0706 of Title 15A, Chapter 2, Subchapter 2N, North Carolina Criteria and Standards Applicable to Underground Storage Tanks.

1.2 Scope of Work

Authorization to proceed with the investigation was granted by the Commander of LANTDIV of Norfolk, Virginia, via Contract/Purchase Order No. N62470-90-D-7625/0002 dated September 29, 1990.

As outlined in the contract and the CSA Workplan, the Scope of Work included preparation of a health and safety plan, collection of ground-water samples using the Hydropunch ground-water sampling system, performance of a soil-gas survey and tracer testing of the underground fuel lines, excavation of soil borings, installation of monitoring wells, collection and analysis of soil and ground-water samples, performance of a preliminary exposure assessment, performance of a preliminary evaluation of remedial alternatives, preparation of a final report of investigation and presentation of data and conclusions. Specific methods employed during performance of the project activities are described within the appropriate sections of this report.

1.3 Previous Investigations

A leaking underground line was reportedly discovered at the Camp Geiger Fuel Farm (Fuel Farm) in 1957-58. Law Engineering could not locate written documentation of this incident, but found reference to it in a report by Environmental Science & Engineering (ESE) of Plymouth Meeting, Pennsylvania (1990). This report stated that the Camp Lejeune Fire Department estimated that thousands of gallons of fuel was released; the records documenting the exact quantities of the spill have been destroyed. The spill migrated to the east and northeast into Brinson Creek. Gasoline at the top of the surficial aquifer was exposed by digging trenches; the fuel was then ignited and burned. Fuel which reached Brinson Creek was also ignited and burned. Mr. Ron Waters of Direct Support Stock Control of the Logistics Department at Camp Geiger, who has been employed at Camp Geiger for 35 years, stated that a fireman from the Camp Geiger Fire Department had told him that the leak occurred when a dispensing pump was damaged. He was also told that the Fire Chief had to wade through the spilled product to turn off the valve to the pump.

MCB Camp Lejeune is listed on the National Priority List (NPL) and Wastelan Preremedial Report, both of which are compiled by the Environmental Protection Agency (EPA) and monitored by the Division of Solid Waste Management of the North Carolina Department of Environment, Health and Natural Resources. MCB Camp Lejeune was placed on the NPL in 1983, after Water and Air Research, Inc. of Gainesville, Florida performed an Initial Assessment Study of 76 potentially-contaminated sites at the base. Water and Air Research identified 21 of these sites as warranting further investigation. Camp Geiger Fuel Farm is one of the 21 sites recommended for further investigation. A twenty-second site at Camp Lejeune was later added to this list.

ESE performed Confirmation Studies of the 22 sites requiring further investigation and performed the Fuel Farm study between 1984 and 1987 (ESE, 1990). During this study, ESE advanced three hand-auger borings, collected ground-water and soil samples from each and documented ground water contaminated with lead and soil contaminated with lead, oil and grease. In 1986, ESE collected sediment and surface-water samples from Brinson Creek and installed three monitoring wells, two east of and one west of the Fuel Farm. These wells were sampled after installation and again in 1987. Laboratory analysis did not reveal surface-water contamination, but did document lead, oil and grease in the sediment and soil samples. Ground water from both the upgradient and downgradient wells was found to be contaminated with volatile organic compounds. ESE could not identify a source for the contamination documented in the upgradient well. ESE identified two possible sources for the contamination in the downgradient wells. The first was the fuel spill which occurred at the fuel farm in the 1950's and the second was an automotive maintenance shop located southeast to the Fuel Farm, in Building No. TC-474.

NUS Corporation performed an investigation in the area north of the Fuel Farm in 1990. According to the NUS report (NUS, 1990), fuel was observed in a stormwater drainage ditch. Base personnel constructed an earthen dam in the drainage ditch to contain the fuel and rerouted storm drainage to the south. NUS installed four monitoring wells, three in the vicinity of the ponded stormwater and one in an apparent upgradient position. Results of laboratory tests performed by NUS revealed that ground water in one well and soil from the cuttings of two soil borings in the vicinity of this drainage ditch were contaminated with petroleum-fuel constituents. No free-phase petroleum hydrocarbons (free product) were reportedly observed in the wells. Ms. Amy Hubbard, project manager of the investigation for NUS, stated that NUS personnel did not observe any free product over the 8-week period of their investigation. Ms. Hubbard stated that she believes that the contamination resulted from a one-time surface release of product. Ms. Stephanie del Re-Johnson of the Installation/Restoration Division of the Environmental Management Department (EMD) at Camp Lejeune stated that she had observed a 5-foot thickness of free product on the surface of the ponded water. NUS determined from the four monitoring wells that the local direction of ground-water flow was to the northeast.

During their investigation, NUS also conducted a geophysical survey in an attempt to determine if underground storage tanks (USTs) remained at the site of the former gasoline station. This gasoline station was located west of the Fuel Farm and south of the headwaters of the drainage ditch in which the fuel was discovered. From the data acquired during this geophysical survey, NUS identified an anomaly to the north of the foundation of the gasoline station.

In addition to the ESE and NUS assessments, the United States Geological Survey (USGS) performed an investigation at MCB Camp Lejeune (Harned et al, 1989). This study is referenced fully in Section 8.0 of this report and includes discussions of the hydrology and hydrogeology of Camp Lejeune.

2.0 DESCRIPTION OF SITE

2.1 Area of Investigation

The Camp Geiger Fuel Farm is located on the north side of Fourth Street at its intersection with G Street at Camp Geiger, Camp Lejeune MCB, Onslow County, North Carolina (Drawing 1.1). The site is situated entirely within the confines of Camp Geiger. The study area is bounded on the west by D Street, on the north by Second Street, on the east by Brinson Creek, and on the south by Building No. TC-474

(Drawing 2.1). Mr. Tom Morris of the Installation/Restoration Division of the EMD and Mr. John Starcalla of the Public Works Department at Camp Lejeune provided numerous site drawings showing the locations of underground utilities and aboveground structures. We have included a list of these drawings in Table 2.1.

2.2 History and Operations of the Site

2.2.1 History of the Site

Construction of Camp Lejeune began in 1941. Construction of Camp Geiger was completed in 1945. We have not been able to identify when Camp Geiger Fuel Farm was constructed, although we have reviewed a site plan for the Fuel Farm which is dated July 17, 1941 (Y. and D. Drawing No. 161783). When constructed, the tanks at the Fuel Farm were used for the storage of No. 6 fuel oil. The tanks were converted for storage of other petroleum products when No. 6 fuel was no longer needed. Law Engineering could not determine when this conversion occurred.

Law Engineering has identified three sites in the study area which once were the sites of structures which have since been demolished. The first site is an ice house, which was located adjacent to the railroad spur on the west side of the Fuel Farm. The ice house was supplied with ice brought to the site by train. Mr. Morris provided drawings of the ice house (Building No. TC-360, Y. & D. Drawing Nos. 161813 and 161814, dated June 26, 1941). The site drawing does not show underground utilities other than water and water drains. We cannot determine when the ice house was demolished. The foundation and pilings which supported the ice house remain at the site.

The second site is a "filling" (gasoline) station, which was located on the northeast corner of the intersection of F and Fourth Streets, adjacent to the ice-house site. Mr. Morris provided a site drawing of the building which had occupied the site (Building No. 341, P.W. Drawing No. 2816, dated November 12, 1947) but could not locate a site plan showing the location of the storage tanks, distribution lines and dispensing pumps. We cannot determine when the filling station was demolished. The foundation to the filling station remains at the site.

The third site is a mess hall, with an associated boiler and underground storage tank (UST), which was located adjacent to D Street, between Third and Fourth Streets. Mr. Morris provided a drawing (Y. and D. Drawing No. 161873) showing the location of an underground fuel distribution line, which extended from the Fuel Farm to the UST, and the approximate location of the UST. Mr. Morris stated that this UST stored

No. 6 fuel oil when the boiler was in operation. We cannot determine when the mess hall was demolished, although Mr. Morris stated that he believed this occurred in the 1960's.

In Building No. TC-474, south of the Fuel Farm, Law Engineering understands that automotive maintenance was performed until approximately 4 years ago. Although this building is outside of the study area, activities undertaken there may have had an environmental impact on the area around the Fuel Farm.

Mr. Anthony Koonce, civilian-in-charge of fuel dispensing at the fuel farm, discussed with Law Engineering an incident which occurred approximately 4 years ago. Mr. Koonce stated that daily inventory-control records at the Fuel Farm were out of balance by approximately 30 gallons per day. After review, this imbalance was attributed to a leak in the gasoline line which carried gasoline from the pump house to the dispensing island. This line was sealed off at both ends and replaced by a line which runs along the eastern side of the Fuel Farm. A subsurface investigation was not undertaken at the time of the possible release to document soil or ground-water contamination which may have resulted from this leak.

Law Engineering identified a UST located behind and adjacent to Building TC-480 which was installed in 1976. This UST has a capacity of 550 gallons and contains #2 fuel oil, which is used to heat Building TC-480.

2.2.2 Operations of the Site

The Fuel Farm contains aboveground storage tanks (ASTs) which are used to dispense gasoline, diesel and kerosene to government vehicles and to supply USTs in use at Camp Geiger and the Air Station. These ASTs are refilled by trucks which are operated by commercial carrier and which deliver product to fill ports at the southern end of the storage facility. The operation of the Fuel Farm is supervised by two attendants who operate the facility from a small building (Building No. TC-364, Drawing 2.2) at the southern end of the Fuel Farm. There are five ASTs at the Fuel Farm:

- two diesel fuel ASTs, each with a capacity of 15,000 gallons,
- two unleaded gasoline ASTs, each with a capacity of 15,000 gallons, and

- one kerosene AST with a capacity of 15,000 gallons.

According to the site drawing referenced in Section 2.2.1, the initial tanks were placed in service in the early 1940's. Mr. Waters stated that the original tanks have never been replaced.

There are six underground lines used to distribute fuel within the fuel farm (Drawing 2.3). These are:

- an unleaded gasoline line approximately 70 feet long which connects the fill port and pump house;
- an unleaded gasoline line approximately 140 feet long which connects the pump house and vehicle dispensing pump;
- a diesel line approximately 70 feet long which connects the fill port and pump house;

- a diesel line approximately 120 feet long which connects the pump house and both the overhead dispensing pump and the vehicle-dispensing pump on the pump island;
- a kerosene line approximately 80 feet long which connects the fill port and pump house; and
- a kerosene line approximately 110 feet long which connects the pump house and the overhead dispensing pump.

The underground lines now in place are those originally installed, with the exception of the recently-installed gasoline line referenced in Section 2.2.1. Mr. Koonce stated that their standard operating procedures include performing daily inventory-control procedures.

There are also three underground lines at the Fuel Farm which are no longer used and which have been sealed off. These three abandoned lines are:

- a gasoline line approximately 60 feet long which connected an abandoned fill port and the pump house;

- a diesel line approximately 20 feet long which connected an abandoned fill port and the pump house; and
- a gasoline line approximately 120 feet long which connected the pump house and pump island.

Law Engineering has found evidence that there also may be one additional line connecting the Fuel Farm and an underground storage tank (UST). The path of this line is shown on Drawing No. 2.4. As indicated in Section 2.2.1, this line carried No. 6 fuel oil from the Fuel Farm to a UST which may still be located at the site of a former mess hall. Law Engineering could not determine if this line was removed when the UST was abandoned.

2.3 Inventory of Contaminant Sources

USTs identified in and around the Fuel Farm are listed in Table 2.2. The location of USTs with respect to the site are presented in Drawing 2.5. Please note that Table 2.2 includes only those tanks that have been identified during the course of this investigation. The possibility remains, however, that other unidentified USTs are present near or were in the past located near the Camp Geiger Fuel Farm.

In addition to the USTs listed in Table 2.2, nine active and inactive product transmission lines are or have been located in the study area, as identified in Section 2.2.2. These product lines are also presented in Drawing 2.5.

2.4 Inventory of Water Wells

As part of our survey to identify potential receptors of ground-water contaminants, Law Engineering performed a survey of drinking-water wells in the vicinity of Camp Geiger Fuel Farm by reviewing USGS Report 89-4096 and through discussions with Mr. Morris. This report shows the locations of drinking-water wells in Camp Geiger, all of which are located adjacent to A Street and over 2000 feet west of the Fuel Farm (Drawing 2.6). Our survey of wells targeted those located within one-half mile of the project site in order to provide an adequate area of coverage. A discussion of the results of the survey of potential receptors is provided in Section 6.0 of this report.

We have presented a summary of the well inventory in Table 2.3, which provides information on the well depth, casing diameter, well usage and the well's approximate distance from the Fuel Farm. Each of the wells identified was constructed as an open-hole wells in the Castle Hayne Aquifer. The Castle Hayne aquifer and the hydrogeology of the area are introduced and referenced in Section 3.0 of this report.

2.5 Survey of Underground Utilities

Subsurface utility trenches can often provide preferential pathways for migration of contaminants. Therefore, Law Engineering attempted to identify and locate subsurface utilities in the vicinity of Camp Geiger Fuel Farm. Mr. Morris provided plans and drawings showing the locations of subsurface utilities, the locations of which are shown in Drawings 2.7, 2.8 and 2.9. Typically, underground utility lines are buried 2 to 6 feet below land surface (bls). As previously indicated, underground fuel transmission lines are exhibited in Drawing 2.5.

3.0 SITE HYDROGEOLOGIC CHARACTERIZATION

3.1 Site Topography

As indicated by the Jacksonville South, N.C. topographic quadrangle, published by the United States Geological Survey in 1952 and photorevised in 1971 (Drawing 1.1), the elevation of land surface in the vicinity of Camp Geiger Fuel Farm generally ranges from 3 to 17 feet above mean sea level (msl) and the land surface slopes toward the northeast. Most of the study area is not serviced by storm sewers, and runoff generally travels by sheet flow before entering natural drainage ditches which discharge into Brinson Creek, to the east and northeast of the study area.

3.2 Regional Geology/Hydrogeology

The study area is located within the Lower Coastal Plain Soil System (Wiscomico and Talbot System) and the Coastal Plain/Castle Hayne Limestone hydrologic area. A brief summary of the geologic/hydrogeologic setting at the Camp Geiger Fuel Farm is provided in Section 2.2 of the CSA Workplan (Appendix A). In general, downward movement of ground water is obstructed by the presence of clay layers in Coastal Plain formations and consequently most of the ground-water recharge migrates laterally toward discharge areas through the surficial aquifer (Heath, 1980). Further details of regional geologic/hydrogeologic characteristics are provided in the USGS Water-Resources Investigation previously cited (Harned 1989).

3.3 Site Soils and Geology

Law Engineering performed field activities on August 15-30, 1991, which consisted of the following:

- Advancing 18 soil borings, which were subsequently used for the installation of monitoring wells;
- Advancing 5 soil borings to check for the presence of soil contamination;
- Advancing 3 stratigraphic borings to determine the geology of the subsurface in the study area; and
- Advancing 9 shallow hand-auger borings to check for the presence of soil contamination in suspect areas.

The locations of these borings are shown on Drawing 3.1. We were unable to complete boring B-3 as planned. We attempted this boring six times and each time encountered auger refusal due to steel reinforcing wire in the concrete pad or unidentified obstructions just below the pad.

Law Engineering accomplished all drilling using hollow-stem augers and techniques described in ASTM D-1452. We steam-cleaned our down-hole drilling equipment prior to work at each drilling location. We used augers with an inside diameter of either

3.25 or 3.75 inches for the drilling of a "pilot" hole and for the collection of soil samples. After completing the "pilot" hole, we reentered each monitoring-well borehole using augers with an inside diameter of 8.25 inches to allow the placement of two sets of PVC pipe in the well. We grouted to land surface those soil borings not used for the installation of monitoring wells.

Site geologists collected soil samples from each of the soil borings for field classification, headspace testing and chemical testing. We generally obtained soil samples for field classification at depths of 0 to 1.5 feet, 1.5 to 3 feet, 3 to 4.5 feet and on 5-foot centers thereafter to boring termination. We collected these soil samples with a split-spoon sampler 24 inches long and with an inside diameter of 1.375 inches (outside diameter of 2 inches). We obtained each soil sample by repeatedly allowing a 140-pound hammer to fall free for 30 inches, until the sampler was driven 18 inches into the substrate. We performed split-spoon sampling in general accordance with ASTM D-1586 and recorded on the field boring log the number of blows required to drive the sampler each 6-inch increment. After donning laboratory-grade gloves, we placed representative portions of each sample in two, pre-labeled plastic bags and sealed each bag for subsequent headspace testing.

Site geologists examined in the field the soil collected at each interval using visual/manual techniques described in ASTM D-2487 and ASTM D-2488 and classified the soil in general accordance with the United Soil Classification System. We have included a record of each test boring in Appendix B.

The soil and stratigraphic borings penetrated three distinctive units. The first unit is a fine- to medium-grained, unconsolidated sand. The thickness of this unit ranges from 15 to 30 feet. Law Engineering selected two samples of this unit to be analyzed for grain-size distribution, the results of which are presented in Appendix C. We performed these analyses on samples from MW-23, collected from a depth of 8.5 to 10.5 feet, and from MW-24, collected from a depth of 13.5 to 15.5 feet. These analyses revealed that the samples generally contain 96% sand and 4% silt and clay.

The second unit is a oolitic, fossiliferous limestone which ranges in thickness from 6.5 to 20 feet. The fossils consist of fragments of mollusks; the matrix consists of fine-grained sand, fine-grained phosphate grains and lime mud. Under the Folk classification (Blatt et al, 1972), this unit is a biosparite. Mr. Rick Shiver of the Wilmington Regional Office of the DEM stated that this unit is common in the Jacksonville area and is considered part of the unconfined, surficial aquifer. Law Engineering believes this unit is the River Bend Formation.

The third unit is an unconsolidated, dark gray to black silty, clayey sand. Because this unit may be a confining unit separating the surficial and Castle Hayne aquifers, Law Engineering did not attempt to completely penetrate this clayey sand, and therefore, the thickness is not known. We sampled this unit in SB-1, SB-2, SB-3 and MW-19 and observed this unit up to 4 feet thick in SB-2. Law Engineering selected the sample of this unit from SB-1 to be analyzed for grain-size distribution, the results of which are presented in Appendix C. This analysis revealed that the sample contained 79% fine sand, 9% silt and 12% clay.

This clayey sand is probably the same described by Harned et al (1989) as one of many occurring in the surficial aquifer and the Castle Hayne. These units are reportedly not confining units in the Camp Lejeune area because the units are thin and discontinuous. This report noted, however, that the units appears to be thicker and more continuous in the northwestern part of Camp Lejeune, where the Fuel Farm is located. Law Engineering believes that this clayey sand acts as a confining unit in the study area due to its relatively high percentage of silt and clay. We believe that this unit separates the surficial aquifer from the underlying Castle Hayne aquifer.

Law Engineering developed two cross sections from soil-boring records in order to facilitate lithologic interpretation. The locations of these cross sections are exhibited in Drawing 3.2; the cross sections are illustrated in Drawings 3.3 and 3.4. As shown in the cross sections, the stratigraphic units encountered within the surficial aquifer consist of the unconsolidated sand, lithified limestone (River Bend Formation) and clayey sand. Law Engineering believes that the upper contact of the River Bend Formation is not a planar surface and we expect its thickness to be highly variable. We observed this variability in SB-3 and MW-19. While only 240 feet apart, the thickness of the River Bend in SB-3 is 20 feet and the thickness in MW-19 is 6.5 feet.

3.4 Site Hydrogeology

Law Engineering installed a total of 18 ground-water monitoring wells, utilizing the materials and installation procedures described in the CSA Workplan. In order to monitor ground water at multiple depths and delineate the vertical extent of ground-water contamination at the Fuel Farm, we installed "paired" monitoring wells in 17 of 18 boreholes, each with a "shallow" screened interval and a "deep" screened interval. There is one well (MW-20) that is not paired; we encountered auger refusal with the large-diameter augers at the top of the River Bend Formation and therefore were not able to set a deep screen. Installing paired wells allowed us to sample the ground water at the water table and at depths of 10 to 20 feet below the water table, thus enabling us to investigate the vertical extent of contamination.

The specifications for each soil boring included decontaminating the drilling equipment and well construction materials with a pressurized steam-cleaning unit, emplacing a silica-sand filter pack and a bentonite seal above the filter pack, grouting the well above the bentonite seal with a cement/bentonite slurry, and developing the well through low-yield pumping. In Tables 3.1 and 3.2, we have listed the approximate volumes of water removed during well development and our observations of turbidity of the development water.

The wells constructed by Law Engineering are protected by a lockable, stick-up cover constructed of steel. This stick-up cover is embedded in a concrete pad and is protected by three steel bollards filled with concrete. Details for the installation of the monitoring wells are included in Appendix D.

During the period September 3-5, 1991, Law Engineering measured depths to ground water in all monitoring wells, the results of which are listed on the Monitoring-well Casing and Water-elevation Worksheets in Appendix E. Elevations of all measuring points were reviewed and certified by a Registered Land Surveyor; these points are also listed in these worksheets.

Based on ground-water elevations measured in the "shallow" monitoring well of each well pair and several of the pre-existing wells, we prepared a water-table contour map, from which we determined the direction of ground-water flow (Drawing 3.5). Ground water in the surficial aquifer generally flows across the project site to the east, towards Brinson Creek. As indicated by comparing water level elevations recorded on September 3, 1991 between "shallow" and "deep" screened intervals, ground water in the surficial aquifer generally moves laterally across the project site with no significant vertical gradient. However, we observed a slight vertical component of upward movement in MW-23 and MW-25, both of which are located near natural discharge points -- Brinson Creek and the intermittent streams which discharge into Brinson Creek. At these locations we would normally expect some upward component of ground-water flow as ground water seeks to discharge into surface drainage features. We did not use the ground-water elevations measured in EMW-6 and EMW-7 because these wells are screened below the water table and the elevations were inconsistent with measurements obtained from nearby wells. Likewise, we did not use the ground-water elevation measured in MW-24 because the measurement was so dissimilar from nearby wells. Law Engineering cannot determine the reason for this dissimilarity.

The rate or average linear velocity of ground-water movement across the project site is a function of the hydraulic conductivity (K) of the aquifer medium, the effective porosity (n) of the aquifer medium and the hydraulic gradient (dh/dl) that exists in the surficial aquifer. We calculated the hydraulic conductivity of the unconsolidated sands in the surficial aquifer at the study area based on results of previous studies performed on unconsolidated sands by F.D. Masch and K.J. Denny (in Freeze and Cherry, 1979). We used the data in the grain-size gradation curves (Appendix C) in these calculations for the samples from MW-23 and MW-24. Based on the results of the calculations, we expect the hydraulic conductivity of the unconsolidated sands within the surficial aquifer to be approximately 28 feet/day (Appendix C). Based on the recharge rate of the wells screened over this unit and a review of hydraulic conductivity estimates published by Freeze and Cherry (1979), we expect that the hydraulic conductivity of the River Bend is at least as great as that of the unconsolidated sand.

We calculated the average, linear velocity of ground-water flow in the unconsolidated sands within the surficial aquifer, using the computer program Water-Vel (1989). This program allows us to predict the general direction and average, linear velocity of ground-water flow based on three values: piezometric (water-table elevation) measurements, calculated value of hydraulic conductivity, and estimated values for effective porosity. Water-Vel calculations are based on Darcy's Law ($q = K\ [dh/dl]$)

and the relationship between Darcy velocity (q) and average, linear, velocity of ground water (v = q/n).

Using Water-Vel, we calculated a range of average, linear velocities of between 0.99 feet/day (n = 25%) and 1.66 feet/day (n = 15%) using values for effective porosity of 15% to 25% for fine sand, as estimated by Walton (1984). These calculations are included in Appendix F. The values for effective porosity are an estimate and are based on the predominant soil types encountered during construction of borings at the project site. Please note that this calculated velocity is an average velocity across the entire project site; the actual rate at a specific location at the site may be more or less than the rate calculated herein.

4.0 ASSESSMENT OF SUBSURFACE CONTAMINATION

4.1 Tracer Tight Leak Testing

Law Engineering subcontracted with Tracer Research Corporation of Tucson, Arizona to perform a tracer test of the underground fuel lines within the Fuel Farm, the report of which is included as Appendix G. This test was accomplished by adding a highly-volatile liquid tracer to the fuel in the fuel system and allowing approximately two weeks for the tracer to become distributed throughout the system. On August 19, 1991, personnel from Tracer Research and Law Engineering installed 29 soil-gas probes along the underground fuel transmission lines at the fuel Farm (Drawing 4.1) to detect tracer gas that may have been released to the surrounding soil.

Tracer gas was not detected in samples collected by the probes. Based on this result, Tracer determined that the tank and pipe systems that were tested at the Fuel Farm passed the precision leak test, which is capable of detecting leaks of 0.05 gallons per hour with a probability of detection of 0.97 and a probability of false alarm of 0.029. However, samples collected by the probes did contain volatile hydrocarbons in three locations, as shown in Figure 2 of the Tracer study. The largest vapor "plume" occurs below the fuel-loading pad and may have resulted from the contamination from the leaking gasoline line referenced in Section 2.2.1. There are two smaller plumes under the fuel tanks which may have resulted from surface spills. We used the results of this study to determine locations of soil borings B-2 and B-3 and hand-auger borings HA-3 and HA-4, which are located in two of the three plumes identified in the Tracer study.

4.2 Soil Contamination

4.2.1 Scanning Procedures

Law Engineering monitored all soil-investigation activities with a photoionization detector (PID) manufactured by HNu Systems (Model PI 101) which had been calibrated to isobutylene. We used the PID to qualitatively measure total volatile organics in the borehole, in ambient air, and in the individual soil samples. Values recorded with the PID are qualitative only and are not directly comparable to actual laboratory analytical results. However, the PID is useful in providing a relative indication of the presence of volatile organics in soil samples.

4.2.2 Hand-auger Borings

Law Engineering advanced hand-auger borings, each to a depth of 5 feet, to accomplish two objectives. The first objective was to check for the presence of USTs in the vicinity of the geophysical anomaly identified during the ESE investigation (Drawing 3.1) at the site of the former gasoline station. We advanced 16 hand-auger borings in this area but did not detect evidence of USTs or soil contamination by volatile organics.

The second objective of the hand-auger borings was to check for the presence of soil contamination and USTs in suspect areas. We performed these borings in four areas (Drawing 3.1). In the first area, we advanced hand-auger borings HA-1 and HA-2 where we suspected the presence of the UST associated with the former mess-hall operations. HA-1 encountered auger refusal at a depth of approximately 2 feet, which may have been due to the presence of this UST. HA-2 was advanced approximately 10 feet east of HA-1 and encountered soils with anomalous PID readings. Based on these readings, we drilled boring B-4 to check for soil contamination.

In the second area of hand-auger borings, we advanced HA-3 and HA-4 near the pump house where we identified data anomalies in the soil-gas survey. We collected soil samples for laboratory analysis from each of these borings.

In the third area of hand-auger borings, we advanced HA-5 and HA-6 behind the gasoline station and to the west of the 16 hand-auger borings, in a location where Mr. Morris had suggested that a UST may remain. We observed no indication of USTs or soil contamination in either of these borings.

In the fourth area of hand-auger borings, we advanced HA-7, HA-8 and HA-9 near where the fuel line extending from the Fuel Farm to the mess-hall UST makes a 90°

turn to the west (Drawing 4.2). We chose this location because it was in the vicinity of the contaminant plume identified by the Hydropunch sampling and because pipe joints are particularly susceptible to leakage. We collected one soil sample from HA-7 based on PID readings.

4.2.3 Soil Borings

Locations of the soil borings (B-1 through B-6, SB-1 through SB-3) and wells constructed from soil borings (MW-8 through MW-25) are shown in Drawing 3.1. Depths of the soil-test borings ranged from 15 to 44.5 feet. Moist soil conditions were generally encountered at a depth of 8 to 10 feet bls. None of the soil borings penetrated the Castle Hayne Formation, which supplies drinking water for Camp Lejeune.

We collected soil samples from each boring for headspace testing and laboratory chemical analysis according to the following procedure:

- The decontaminated split-spoon sampler was driven to the desired depth interval.

- The split-spoon sampler was retrieved and immediately opened. Portions of sample aliquots were quickly removed from the split-spoon sampler and placed into two, pre-labeled, airtight plastic bags. Sample handling was executed carefully in an effort to reduce the loss of the volatile organics. The bags were sealed and placed in a warm location.

- After approximately 10 minutes, the headspace gas in one of the two bags was tested with the PID and the peak value was recorded. This procedure was conducted for the soil sample collected at each sample-depth interval.

- From the soil samples collected from the borings, the two samples that exhibited the highest PID reading were targeted for chemical analysis. For those samples, the paired sample was transferred to a laboratory-supplied glass container, placed into a cooler, packed on ice and shipped to the laboratory for chemical analysis. Law Engineering maintained custody of the samples until shipment at the end of each day.

4.2.4 Results of the Soil Sampling

A summary of headspace analyses are presented in Table 4.1. Results show that volatile organics were detected in samples collected from 19 of the 24 boreholes. In general, concentrations of contamination were greatest in the samples collected at depths of 8.5 to 10 feet, near or just below the water table. Therefore, we suspect that lateral movement of the dissolved-phase plume and seasonal fluctuations of the water table has resulted in adsorbed-hydrocarbon contamination in the capillary-fringe area.

A summary of the results of laboratory analyses of the soil samples are presented in Table 4.2. The laboratory analyses are included in Appendix H. The soil samples were tested for total petroleum hydrocarbons (TPH) using EPA Methods 3550 (semi-volatile) and 5030 (volatile) and for lead using EPA Method 6010. We also analyzed 10 soil samples for ignitability using EPA Method 1010. Although the headspace testing indicated the presence of volatile organics in a majority of the boreholes, laboratory testing for total petroleum hydrocarbons (TPH) indicated the presence of primarily high-boiling-point hydrocarbons in samples from 13 of the boreholes. We have combined the measured values of both high- and low-boiling-point hydrocarbons from samples collected above the water table and presented these data in an isopleth map of total petroleum hydrocarbons (Drawing 4.3). This map illustrates three areas of soil contamination, all of which correlate to areas of known or suspected USTs or transmission lines. These areas are:

- the vicinity of boring no. B-4, which was installed near the location of the UST adjacent to the site of the former mess hall;
- the vicinity of the UST behind Building No. 480 and extending to the northeast towards the ponded stormwater (the area of contamination documented in the NUS report); and
- the AST and fuel-dispensing area of the Fuel Farm, in support of the results of the tracer testing discussed in Section 4.1 and in concurrence with the verbal report of the 4-year-old release of gasoline. However, soil contamination in this area appears to be concentrated at depths below the water table.

Based on this data, it appears that there have been releases of fuel in at least three separate locations within the study area. The plume of contamination originating behind Building No. 480 may have resulted from two releases, one from the UST system at Building No. 480 and one from a possible surface release, northeast of that site, which was investigated by NUS (Section 1.3). The pattern of soil contamination corresponds with the direction of ground-water flow. Therefore, it appears that petroleum fuel was released at these source locations and subsequently migrated through the soil towards Brinson Creek partly as a free-phase liquid hydrocarbon prior to dispersion, adsorption and dissolution into the ground water.

Law Engineering also analyzed each soil sample for lead. There was one sample (HA-4) which exhibited concentrations of lead in excess of the laboratory detection limit. This sample was collected from a location adjacent to the pump house. Because this sample was not contaminated with petroleum hydrocarbons, it appears that this lead did not originate from a discharge of leaded fuel.

Law Engineering also analyzed 10 soil samples for ignitibility. Based on the laboratory results, we determined that the flashpoint of each of the ten samples is in excess of 200°F.

4.3 Occurrence of Free Product

The monitoring wells were constructed to allow for detection of free product in the capillary-fringe area. As indicated on the Monitoring-well Casing and Water-elevation Worksheets (Appendix E), we did not detect free product using probe measurement in the wells. Therefore, Law Engineering has no evidence to indicate that free product remains in the subsurface in the study area. However, our experience reveals that, given ample time, free product can accumulate in wells which initially showed no signs of free product.

4.4 Dissolved Ground-Water Contamination

4.4.1 Hydropunch Ground-water Sampling

From August 5-7, 1991, as the initial phase of our investigation, Law Engineering collected ground-water samples using the Hydropunch ground-water sampling system, utilizing the materials and installation procedures described in the CSA Workplan. We collected these ground-water samples at locations indicated on Drawing 4.4 to evaluate the lateral extent of ground-water contamination and to determine the optimal locations for the monitoring wells. This initial phase of investigation indicated two areas of ground-water contamination, one near the Fuel Farm and one northeast of Building No. 480.

4.4.2 Monitoring-well Sampling Procedures

As stated in Section 3.4, Law Engineering installed 18 wells during the investigation to complement the seven installed during previous investigations. Prior to sampling each well, Law Engineering measured and recorded the depth to ground water using an electronic, water-level probe. We recorded the data collected and observations made on the Monitoring Well and Sampling Field Data Worksheets (Appendix I).

We evacuated all monitoring wells prior to collecting ground-water samples in order to remove stagnant water from the well casing and sand pack. We performed this task in an effort to collect samples representative of the water quality in the surficial aquifer. To evacuate the wells, we used decontaminated, Teflon bailers attached to new nylon cord. We measured and recorded specific conductance, pH, and water temperature throughout the evacuation process. We evacuated the wells of at least three standing well volumes and until indicator parameters had stabilized (or until the well exhibited dryness).

We collected ground-water samples from the 18 monitoring wells installed by Law Engineering, 17 of which were "paired" wells, and from the seven "single-cased" wells that had been installed during previous investigations. Prior to sampling the wells, Law Engineering personnel donned laboratory-grade gloves. We collected the water samples and immediately decanted the samples from the bailer into pre-labeled sample containers.

We sealed the containers, stored the containers in chilled coolers, and maintained custody of the samples until shipment at the end of each day. Chain-of-custody forms are included in Appendix J.

4.4.3 Results of the Ground-water Sampling

We have presented a summary of laboratory analyses of the ground-water samples from the Hydropunch sampling in Table 4.3. Reports of laboratory analyses are included in Appendix H. The ground-water samples were tested for purgeable aromatics by EPA Method 602, modified to include methyl tertiary butyl ether (MTBE).

We have presented isopleth maps for the combined total concentrations of benzene, toluene, ethylbenzene and total xylenes (BTEX) (Drawing 4.5) and for MTBE concentrations (Drawing 4.6) documented in the Hydropunch ground-water samples. This map shows two plumes of contamination, one in the vicinity of the Fuel Farm and one extending from the area just north of Building No. 480 to the northeast. This preliminary identification of contaminant plumes allowed us to effectively place permanent monitoring wells.

We have presented a summary of laboratory analyses of the ground-water samples collected from the monitoring wells in Table 4.4 for the shallow screened intervals and in Table 4.5 for the deep screened intervals. The laboratory analyses are included in Appendix H. We tested these ground-water samples for purgeable halocarbons by EPA Method 601, for purgeable aromatics by EPA Method 602 modified to include MTBE, and for lead by EPA Method 7000. We also tested samples from four wells (MW-8S, MW-14S, MW-24S and MW-25S) for polynuclear aromatic hydrocarbons by EPA Method 610.

The laboratory results, when compared with the results of the soil analyses, show what appears to be at least two separate plumes of ground-water contamination. We have presented an isopleth map (Drawing 4.7) for the combined total concentrations of benzene, toluene, ethylbenzene and total xylenes (BTEX) in the shallow screened interval which shows these two plumes. We have presented a second isopleth map

(Drawing 4.8) for the combined total concentrations of BTEX in the deep screened interval. The isopleth map of the lower screened interval shows significantly lower levels of ground-water contamination, in the areas which generally correspond to the plumes observed in the shallow screened interval.

The first plume of the shallow screened interval is in the vicinity of the Fuel Farm. The ground water has been contaminated with hydrocarbons typically related to petroleum fuel including BTEX. The hydrocarbon contamination appears to be originating within the fuel storage and transmission area, in agreement with the results of the Tracer study, which indicated petroleum vapors beneath the Fuel Farm. Contaminants appear to be migrating to the northeast, the predominant direction of ground-water flow.

The second plume of the shallow screened interval is in the vicinity of the UST located behind Building No. 480 and extends to the northeast, towards the ponded stormwater. The ground water has been contaminated with BTEX and other petroleum-related constituents (heavier hydrocarbons) including fluorene, naphthalene, 1-methylnapthalene and 2-methylnapthalene.

Law Engineering has also identified three areas of ground water contaminated with chlorinated compounds from samples collected over the shallow screened interval. The first is in the vicinity of MW-10 and EMW-5, the second is in the vicinity of EMW-7 and MW-19 and the third is in the vicinity of MW-14 (Drawing 4.9). Laboratory analyses of the ground-water samples from these wells document contamination by trichloroethene and tetrachloroethane, constituents commonly found in solvents and degreasers.

The source of contamination in MW-10 is apparently outside the study area and is unknown at this time. The contamination found in and downgradient of MW-14 may be related to the gasoline station formerly located adjacent to the ice house. Solvents and degreasers are commonly used at gasoline stations and maintenance facilities, and it is possible that the waste solvents from these sites were disposed of onto the ground. Over an extended period of time, continual disposal of these solvents in this manner could result in ground-water contamination.

Law Engineering could not identify a source of the chlorinated compounds detected in samples collected from EMW-7 and MW-19, although these compounds may be related to activities of the former automotive maintenance shop in Building No. TC-474, south of the study area. Law Engineering recommends identifying the source of this contamination.

Law Engineering also identified ground water contaminated with chlorinated compounds in the deep screened interval (Drawing 4.10). The areas of contamination generally correspond to those observed in the shallow screened intervals of wells.

Law Engineering cannot identify a consistent pattern of lead concentrations in either the shallow or deep screened intervals at the study area (Drawings 4.11 and 4.12). The well with the highest concentration of lead, EMW-5, is upgradient of known or suspected contaminant sources, while wells within the two contaminant plumes (for example, MW-20, MW-21, MW-22, MW-25) often exhibit relatively low levels of lead contamination. We also observed wells near the boundaries of the BTEX plumes with low levels of contamination (for example, MW-17, MW-23, MW-14) and levels of lead contamination similar to those wells with high levels of contamination. In summary, we are not able to draw any conclusions regarding the probable relationship between lead concentrations detected at the Fuel Farm and migration patterns of water-borne lead resulting from petroleum-fuel releases.

Law Engineering has documented concentrations of MTBE, an unleaded gasoline additive, below the state interim standard in five wells, four in the shallow screened interval (Drawing 4.13) and one (MW-18) in the deep screened interval. MTBE is highly soluble in water, and often is the first contaminant observed at the leading edge of a plume. The levels of MTBE documented in EMW-6, MW-17 and MW-18, all of which are downgradient of the Fuel Farm, are likely the result of the leaking gasoline line referenced in Section 2.2.1. Law Engineering has not identified a likely source for the MTBE documented in MW-9.

Law Engineering documented ground water containing levels of chloroform in excess of the state ground-water quality standard in MW-14. Law Engineering collected a sample of the potable water at the base from the spigot adjacent to Building No. TC-364 and tested the sample for purgeable halocarbons and purgeable aromatic hydrocarbons. The laboratory analysis of this water sample (identified as "potable water" in Table 4.4) revealed concentrations of chloroform, bromoform, bromodichloromethane, and dibromochloromthane in excess of the laboratory detection limits and of state ground-water standards. These compounds may often be found in municipal water supplies as a result of the chlorination process.

In summary, Law Engineering has documented ground-water contamination both in the upper portion of the surficial aquifer and, to a lesser extent, at depths 10 to 15 feet below the water table. We have identified a confining layer within the surficial aquifer which may act as a barrier to the vertical migration of these contaminants.

The rate at which these contaminants migrate through the subsurface is affected by several geohydrochemical processes including molecular diffusion, mechanical mixing, sorption-desorption, ion-exchange, hydrolysis and biodegradation. Because the resources involved in attempting to model the effects of these processes at the project site are significant, we have chosen to apply a relatively simple analytical technique (USEPA, 1985b) with which to arrive at conservative (greater than anticipated) estimates of contaminant-migration rates at the study area. This analytical technique takes into account only sorption-desorption of the contaminant constituent (expressed in terms of the "retardation factor") and the average, linear velocity of ground-water flow at the site.

For purposes of these calculations, we selected an average linear velocity of ground-water flow of 1.33 feet/day (the mean value of those reported in Section 3.5). The resulting calculations, contained in Appendix K, show that the rate of benzene movement is estimated at 0.44 feet/day. By comparison, naphthalene (a relatively hydrophobic compound) is estimated to migrate at a rate of 0.029 feet/day. With the exception of MTBE, the migration rates of remaining organic constituents detected in the study area are likely to fall within the range bounded by benzene and naphthalene. Please note that these migration rates are only gross estimates which may vary considerably from actual field-migration rates.

5.0 PROCEDURES FOR QUALITY CONTROL

5.1 Decontamination of Equipment

The CSA Workplan details the quality-control procedures followed for handling and decontaminating equipment in the field. As outlined in the Workplan, we decontaminated our drilling equipment in an open area just south of Fourth Street, opposite the Fuel Farm.

5.2 Collection and Shipment of Samples

The CSA Workplan details the quality-control procedures followed for collecting, handling and shipping samples. We employed three quality-control measures to provide checks on the integrity and quality of our ground-water sampling program: rinse blanks, trip blanks and duplicate samples.

Law Engineering submitted equipment rinse blanks to the laboratory for evaluation of procedures which we used to decontaminate the Teflon bailers. Law Engineering also submitted trip blanks to the laboratory to check the integrity of the sample containers, to determine if contaminants may have entered the sample containers during shipment to and from the job site, and to check for laboratory-induced contamination. Each of the blanks was analyzed for purgeable aromatics. The two rinse blanks and four trip blanks submitted with the Hydropunch ground-water samples did not contain contaminant levels above the laboratory detection limit. Six of the ten blanks submitted with the monitoring-well ground-water samples exhibited contamination with xylenes and, in one instance, MTBE in excess of, but near, the laboratory detection limits (Table 5.1).

Law Engineering collected two duplicate ground-water samples as a check on our sampling technique and on the reproducibility of laboratory-testing procedures. For this test, we collected a sample from MW-14S, which we labelled as MW-26S, and a sample from MW-24S, which we labelled as MW-27S. Laboratory analyses of these duplicates are included in Table 4.4.

Analysis of our procedures revealed that bailer decontamination was successful in eliminating the introduction of contaminants through the sampling equipment. Based on the relatively low concentrations of xylenes (2.0 ug/l) detected in the blanks, Law Engineering believes that no significant petroleum-hydrocarbon contamination of ground-water samples occurred as a result of contaminated sampling equipment.

TABLES

TABLE 2.1
LIST OF DRAWINGS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

DRAWING NUMBER	DESCRIPTION	DATE
2816	Filling Station/Fire Station Plans	11/12/47
161813	Ice Storage House	6/26/41
161814	Ice Storage House	6/26/41
161821	Mess Hall UST Fuel Line	10/28/41
161870	Drinking Water Well Locations	8/25/41
161873	Fuel Farm/Mess Hall UST	7/17/41
162072	Fuel Farm	2/2/42
267402	Storm Sewer/Fire Hydrant/Sanitary Sewer Lines	Unknown
267403	Barracks Plan	10/29/43
4009116	Building No. 480	6/18/75
4714380	Piping Plan/Fuel Farm	Not Dated
4174381	Demolition Plan/Fuel Farm	Not Dated
4174383	Fuel Farm	Not Dated
417439?	Electrical Plan/Fuel Farm	Not Dated
Unnumbered	Steam Lines	7/31/84
Unnumbered	Wastewater Lines	7/31/84
Unnumbered	Electrical Lines	7/31/84

TABLE 2.2
INVENTORY OF POTENTIAL CONTAMINANT SOURCES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

TANK LOCATION	PRODUCT TYPE	TANK TYPE	INSTALL DATE	SIZE OF TANK	TANK STATUS
Building No. 480	No. 2 Fuel Oil	UST	1976	550 Gallons	Active
Former Mess Hall	No. 6 Fuel Oil	UST	1941?	Unknown	Abandoned
Building No. 474	Waste Oil	UST	1946	550 Gallons	Abandoned

Underground lines associated with these tanks, the aboveground tanks and the oil-water separator located southeast of the Fuel Farm are also potential contaminant sources.

TABLE 2.3
LIST OF WATER-SUPPLY WELLS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

LAW ENGINEERING JOB NO. J47590-6014

USGS WELL NO.	CAMP GEIGER WELL LETTER	TOTAL WELL DEPTH (Ft.)	CASING LENGTH (Ft.)	CASING DIAMETER (INCHES)	APPROX. DISTANCE FROM FUEL FARM (FEET)	STATUS
TC104	A	Unknown	Unknown	Unknown	2600	Abandoned
TC100	B	Unknown	Unknown	Unknown	2600	Abandoned
TC202	I	Unknown	Unknown	Unknown	2600	Abandoned
TC325	C	70’	20’	18"	2600	Abandoned
TC502	D	184’	110’	10"	2600	Drinking
TC600	E	170’	21’	20"	2600	Drinking
TC700	F	76’	27.5’	18"	3300	Drinking
TC901	G	76’	25’	18"	3900	Abandoned

TABLE 3.1
SUMMARY OF DEVELOPMENT OF "SHALLOW" MONITORING WELLS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

MONITORING WELL IDENTIFICATION NUMBER	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL)
MW-8S	1	50
MW-9S	1	50
MW-10S	1	45
MW-11S	1	40
MW-12S	1	50
MW-13S	1	60
MW-14S	1	45
MW-15S	1	30
MW-16S	1	40
MW-17S	1	40
MW-18S	1	45
MW-19S	1	45
MW-20S	1	30
MW-21S	1	60
MW-22S	1	30
MW-23S	1	35
MW-24S	1	30
MW-25S	1	25

Note:

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

TABLE 3.2
SUMMARY OF DEVELOPMENT OF "DEEP" MONITORING WELLS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

MONITORING WELL IDENTIFICATION NUMBER	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL)
MW-8D	1	70
MW-9D	1	60
MW-10D	1	60
MW-11D	1	50
MW-12D	1	50
MW-13D	1	55
MW-14D	1	50
MW-15D	1	60
MW-16D	1	50
MW-17D	1	55
MW-18D	1	50
MW-19D	1	60
MW-21D	1	55
MW-22D	1	60
MW-23D	1	60
MW-24D	1	50
MW-25D	1	50

Note:

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

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MONITORING WELL SOIL BORINGS			
MW-8	1.5 - 2	8	
	3.5 - 4	3	
	5.5 - 6	55	
	7.5 - 8	85	*
	9.5 - 10	42	
	11.5 - 12	4	
	13.5 - 14	32	
	15.5 - 16	65	*
	17.5 - 18	5	
	19.5 - 20	2.5	
MW-9	1.5 - 2	0	
	3.5 - 4	0	
	5.5 - 6	0	
	7.5 - 8	0	*
	9.5 - 10	0	
	11.5 - 12	0	
	13.5 - 14	0	
	15.5 - 16	0	
	17.5 - 18	0	*
	19.5 - 20	0	
	25 - 25.5	0	

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-10	1.5 - 2	>2000	*
	3.5 - 4	220	*
	5.5 - 6	105	
	10 - 10.5	40	
	15 - 15.5	6	
	20 - 20.5	<1	
MW-11	1.5 - 2	0	
	3.5 - 4	1.5	
	5.5 - 6	30	*
	10 - 10.5	31	*
	15 - 15.5	7.3	
	20 - 20.5	<1	
MW-12	0 - 1.5	>2000	*
	1.5 - 3	75	
	3 - 4.5	200	*
	8.5 - 10	45	
	13.5 - 15	<1	
	18.5 - 20	0	
MW-13	1.5 - 2	<1	
	3.5 - 4	<1	
	5.5 - 6	<1	
	10 - 10.5	<1	*
	15 - 15.5	<1	
	20 - 20.5	<1	*

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-14	0 - 1.5	<1	
	1.5 - 3	3	
	3 - 4.5	60	•
	8.5 - 10	16	
	13.5 - 15	3	
	18.5 - 20	145	•
MW-15	1.5 - 2	<1	
	3.5 - 4	<1	
	5.5 - 6	<1	•
	10 - 10.5	65	•
	15 - 15.5	<1	
	20 - 20.5	<1	
MW-16	0 - 1.5	30	
	1.5 - 3	110	
	3 - 4.5	200	•
	8.5 - 10	155	
	13.5 - 15	200	
	18.5 - 20	250	•
MW-17	1.5 - 2	<1	
	3.5 - 4	<1	
	5.5 - 6	<1	•
	10 - 10.5	<1	
	15 - 15.5	<1	
	20 - 20.5	<1	•

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-19	1.5 - 2	<1	
	3.5 - 4	<1	*
	5.5 - 6	<1	
	10 - 10.5	<1	*
	15 - 15.5	<1	
	20 - 20.5	<1	
	25 - 25.5	<1	
MW-20	0 - 1.5	40	
	1.5 - 3	65	
	3 - 4.5	300	*
	8.5 - 10	220	*
	13.5 - 15	75	
	18.5 - 20	55	
	23.5 - 25	110	
MW-21	1.5 - 2	<1	
	3.5 - 4	60	*
	5.5 - 6	75	*
	10 - 10.5	35	
	15 - 15.5	17	
	20 - 20.5	<1	
	25 - 25.5	<1	

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
MW-22	0 - 1.5	10	
	1.5 - 3	2	
	3 - 4.5	150	•
	9.5 - 11	90	•
	14.5 - 16	5	
	19.5 - 21	4	
	24.5 - 26	0	
	29.5 - 31	0	
MW-23	1.5 - 2	<1	•
	3.5 - 4	<1	
	5.5 - 6	<1	
	10 - 10.5	<1	
	15 - 15.5	<1	•
	20 - 20.5	<1	
MW-24	1.5 - 2	<1	
	3.5 - 4	<1	•
	5.5 - 6	0	
	10 - 10.5	3	•
	15 - 15.5	0	
	20 - 20.5	<1	
MW-25	1.5 - 2	22	
	3.5 - 4	45	•
	5.5 - 6	45	•
	10 - 10.5	2.5	
	15 - 15.5	25	

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
SOIL BORINGS			
B-1	0 - 1.5	200	
	1.5 - 3	160	•
	3 - 4.5	40	
	8.5 - 10	140	•
	13.5 - 15	4	
B-2	2 - 2.5	3	
	3 - 3.5	2	
	4 - 4.5	8	
	5 - 5.5	7.5	
	5.5 - 6	12	•
	8.5 - 10	51	•
	13.5 - 15	6.2	
B-3	ATTEMPTED 6 TIMES, ABANDONED		
B-4	0 - 1.5	0	
	1.5 - 3	11	
	3 - 4.5	22	•
	8.5 - 10	50	•
	13.5 - 15	18	
B-5	2" - 1.5'	<1	
	1.5 - 3	0	
	3 - 4.5	20	•
	8.5 - 10	2	•
	13.5 - 15	0	

TABLE 4.1
SUMMARY OF HEADSPACE ANALYSES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft.)	PID READING (ppm)	SAMPLE SELECTED FOR LABORATORY ANALYSIS
SB-3 (formerly MW-18)	27.5 - 29	<1	
	29 - 30.5	<1	
	30.5 - 32	<1	
	32 - 33.5	<1	
	33.5 - 35	<1	
	35 - 36.5	<1	
	36.5 - 38	200	
	38 - 39	155	
HAND-AUGER BORINGS			
HA-3	2'	2	*
	4'	5	
HA-4	2'	4	*
	5'	3	
HA-7	3'	10	
	5'	60	*
HA-8	5'	8	
HA-9	3'	<1	
	5'	8	

KEY TO SYMBOLS

SUMMARY OF LABORATORY ANALYSES

* Numerical standard has not been established; substances not allowed in detectable concentrations.

** Interim standard

N.D. = Not detected: see laboratory reports for applicable detection limits.

\- = Sample not analyzed for this parameter.

TABLE 4.2 (Page 1 of 3)
SUMMARY OF LABORATORY ANALYSES OF SOIL SAMPLES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft)	TOTAL PETROLEUM HYDROCARBONS		IGNITABILITY (Degrees F)	LEAD (ug/L)
		VOLATILES (mg/kg)	SEMI-VOLATILES (mg/kg)		
HA-3	4	N.D.	17	--	N.D.
HA-4	2	N.D.	N.D.	--	42
HA-7	5	N.D.	5700	--	N.D.
B-1A	1.5 - 3.0	N.D.	N.D.	--	N.D.
B-1B	8.5 - 10.0	N.D.	N.D.	--	N.D.
B-2	5.5 - 6.0	N.D.	N.D.	--	N.D.
B-2	8.5 - 10.5	630	7600	--	N.D.
B-4A	3 - 4.5	N.D.	8400	--	N.D.
B-4B	8.5 - 10	N.D.	5100	--	N.D.
B-5A	3 - 4.5	N.D.	980	--	N.D.
B-5B	8.5 - 10	N.D.	280	--	N.D.
B-6A	3 - 4.5	N.D.	7	--	N.D.
B-6B	8.5 - 10	N.D.	6200	--	N.D.
MW-8	6.0 - 8.0	N.D.	9100	>200	N.D.
MW-8	14.0 - 16.0	N.D.	14,600	>200	N.D.
MW-9	6.0 - 8.0	N.D.	N.D.	>200	N.D.
MW-9	16.0 - 18.0	N.D.	N.D.	>200	N.D.
MW-10	0 - 1.5	N.D.	N.D.	--	N.D.

TABLE 4.2 (Page 2 of 3)
SUMMARY OF LABORATORY ANALYSES OF SOIL SAMPLES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft)	TOTAL PETROLEUM HYDROCARBONS		IGNITABILITY (Degrees F)	LEAD (ug/L)
		VOLATILES (mg/kg)	SEMI-VOLATILES (mg/kg)		
MW-10	1.5 - 3.0	N.D.	N.D.	--	N.D.
MW-11	4.0 - 6.0	N.D.	2100	>200	N.D.
MW-11	8.5 - 10.5	N.D.	4	>200	N.D.
MW-12	0 - 1.5	N.D.	N.D.	--	N.D.
MW-12	3.0 - 4.5	N.D.	N.D.	--	N.D.
MW-13	8.5 - 10.0	N.D.	N.D.	--	N.D.
MW-13	18.5 - 20.5	N.D.	N.D.	--	N.D.
MW-14	3.0 - 4.5	0.3	N.D.	--	N.D.
MW-14	18.5 - 20.0	N.D.	N.D.	--	N.D.
MW-15	4.0 - 6.0	N.D.	N.D.	--	N.D.
MW-15	8.5 - 10.5	N.D.	3500	--	N.D.
MW-16	3.0 - 4.5	N.D.	N.D.	--	N.D.
MW-16	18.5 - 20.0	1	8	--	N.D.
MW-17	4.0 - 6.0	N.D.	N.D.	--	N.D.
MW-17	18.5 - 20.5	N.D.	N.D.	--	N.D.
MW-18	3.0 - 4.5	N.D.	N.D.	--	N.D.
MW-18	8.5 - 10.0	N.D.	N.D.	--	N.D.
MW-19	2.0 - 4.0	N.D.	N.D.	--	N.D.

TABLE 4.2 (Page 3 of 3)
SUMMARY OF LABORATORY ANALYSES OF SOIL SAMPLES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER AREA FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	SAMPLE DEPTH (ft)	TOTAL PETROLEUM HYDROCARBONS		IGNITABILITY (Degrees F)	LEAD (ug/L)
		VOLATILES (mg/kg)	SEMI-VOLATILES (mg/kg)		
MW-19	8.5 - 10.5	N.D.	N.D.	--	N.D.
MW-20	3.0 - 4.5	N.D.	14	--	N.D.
MW-20	8.5 - 10.0	N.D.	22,000	>200	N.D.
MW-21	2.0 - 4.0	N.D.	5,200	>200	N.D.
MW-21	4.0 - 6.0	N.D.	21,000	>200	N.D.
MW-22	3.0 - 4.5	N.D.	5	--	N.D.
MW-22	9.5 - 11.0	540	8900	>200	N.D.
MW-23	0 - 2.0	N.D.	N.D.	--	N.D.
MW-23	13.5 - 15.5	N.D.	N.D.	--	N.D.
MW-24	2.0 - 4.0	N.D.	N.D.	--	N.D.
MW-24	8.5 - 10.5	N.D.	21	--	N.D.
MW-25	2.0 - 4.0	N.D.	8700	--	N.D.
MW-25	4.0 - 6.0	N.D.	5700	--	N.D.

TABLE 4.3 (Page 1 of 2)
SUMMARY OF LABORATORY ANALYSES
HYDROPUNCH GROUND-WATER SAMPLES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER FUEL FORM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	DATE SAMPLED	LABORATORY RESULTS (ug/l)				
		BENZENE	ETHYLBENZENE	TOLUENE	XYLENES (TOTAL)	METHYL TERT BUTYL ETHER
HP-1	8/5/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-2	8/7/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-3	8/7/91	0.7	N.D.	N.D.	N.D.	0.6
HP-4	8/6/91	0.2	1	N.D.	13	N.D.
HP-5	8/6/91	610	520	130	1900	N.D
HP-6	8/7/91	240	14	N.D.	N.D.	410
HP-7	8/6/91	8	1	N.D.	1	83
HP-8	8/7/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-9	8/7/91	N.D.	N.D.	N.D.	N.D.	3
HP-10	8/7/91	11	0.6	N.D.	2	N.D.
HP-11	8/6/91	350	350	N.D.	540	N.D.
HP-12	8/6/91	100	350	170	820	N.D.
HP-13	8/6/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-14	8/6/91	0.4	32	N.D.	24	N.D.
HP-15	8/6/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-16	8/6/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-17	8/6/91	N.D.	N.D.	2	N.D.	N.D.
HP-18	8/6/91	260	310	N.D.	740	N.D.

TABLE 4.3 (Page 2 of 2)
SUMMARY OF LABORATORY ANALYSES
HYDROPUNCH GROUND-WATER SAMPLES

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT
CAMP GEIGER FUEL FORM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE LOCATION	DATE SAMPLED	LABORATORY RESULTS (ug/l)				
		BENZENE	ETHYLBENZENE	TOLUENE	XYLENES (TOTAL)	METHYL TERT BUTYL ETHER
HP-19	8/6/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-20	8/6/91	N.D.	N.D.	N.D.	N.D.	N.D.
HP-21	8/7/91	N.D.	N.D.	N.D.	N.D.	N.D.

TABLE 4.4 (Page 1 of 3)
SUMMARY OF LABORATORY ANALYSES
MONITORING WELL GROUND-WATER SAMPLES
SHALLOW SCREENED INTERVAL

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

	WELL NUMBER	NC GROUND WATER STANDARD	EMW-1 (CGMW-1)	EMW-2 (CGMW-2)	EMW-3 (CGMW-3)	EMW-4 (CGMW-4)	EMW-5 (35GW-4)	EMW-6 (35GW-5)	EMW-7 (35GW-6)	MW-8S	MW-9S	MW-10S
	DATE SAMPLED		9/3/91	9/5/91	9/5/91	9/5/91	9/4/91	9/5/91	9/5/91	9/4/91	9/3/91	9/3/91
PARAMETER (ug/l)	SCREENED INTERVAL (Feet)		8.5-17.5	1.87-10.87	3.06-12.06	2.61-11.61	10.5-24.5	10.5-24.5	10.5-24.5	4.5-13.5	3.5-12.5	4.5-13.5'
BENZENE		1	ND	40	ND	13	0.4	0.3	ND	52	45	3
TOLUENE		1000	ND	12	ND	ND	ND	ND	ND	ND	ND	5
ETHYLBENZENE		29	ND	41	ND	0.7	ND	ND	ND	73	ND	7
XYLENES TOTAL		400	ND	76	ND	2	ND	ND	ND	420	4	ND
METHYL TERTIARY BUTYL ETHER (MTBE)		50**	ND	ND	ND	ND	ND	3	ND	ND	46	ND
LEAD		50	14	ND	2	28	75	ND	12	5	ND	3
TRANS-1,2-DICHLOROETHENE		70	ND	ND	2	ND	0.7	ND	18	ND	ND	17
TRICHLOROETHENE		2.8	ND	ND	8	0.6	3	0.6	59	ND	ND	170
1-METHYLNAPTHALENE		•	-	-	-	-	-	-	-	450	-	-
2-METHYLNAPTHALENE		•	-	-	-	-	-	-	-	460	-	-

LAW ENGINEERING

TABLE 4.4 (Page 2 of 3)
SUMMARY OF LABORATORY ANALYSES
MONITORING WELL GROUND-WATER SAMPLES
SHALLOW SCREENED INTERVAL

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

	WELL NUMBER	NC GROUND WATER STANDARD	MW-11S	MW-12S	MW-13S	MW-14S	MW-15S	MW-16S	MW-17S	MW-18S	MW-19S	MW-20S
	DATE SAMPLED		9/4/91	9/4/91	9/4/91	9/4/91	9/4/91	9/5/91	9/5/91	9/5/91	9/4/91	9/4/91
PARAMETER (ug/l)	SCREENED INTERVAL (Feet)		4.5'-13.5'	5'-14'	5.5'-14.5'	3.5'-12.5'	4.5'-13.5'	5.0'-14.0'	7.5'-16.5'	3.0'12.0'	4.5'-13.5'	3.0'-12.0'
BENZENE		1	ND	ND	ND	0.6	4	40	0.5	52	ND	140
TOLUENE		1000	ND	ND	ND	ND	ND	230	ND	ND	ND	280
ETHYLBENZENE		29	80	ND	ND	ND	3	76	ND	ND	ND	320
XYLENES TOTAL		400	170	ND	ND	ND	29	800	ND	ND	ND	830
METHYL TERTIARY BUTYL ETHER (MTBE)		50**	ND	ND	ND	ND	ND	ND	1	32	ND	ND
LEAD		50	ND	16	7	2	5	6	6	9	36	ND
CHLOROFORM		0.19	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE		70	ND	ND	ND	44	ND	ND	ND	ND	5	ND
TRICHLOROETHENE		2.8	ND	ND	ND	110	ND	ND	0.6	ND	31	ND
1,2-DICHLOROETHANE		*	ND	ND	ND	ND	ND	ND	1	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE		*	ND	ND	ND	ND	ND	ND	ND	ND	12	ND
TETRACHLOROETHENE		*	ND	ND	ND	ND	ND	ND	ND	ND	1	ND

TABLE 4.4 (Page 3 of 3)
SUMMARY OF LABORATORY ANALYSES
MONITORING WELL GROUND-WATER SAMPLES
SHALLOW SCREENED INTERVAL

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

	WELL NUMBER	NC GROUND WATER STANDARD	MW-21S	MW-22S	MW-23S	MW-24S	MW-25S	MW-26S (MW-14S)	MW-27S (MW-24S)	POTABLE WATER
	DATE SAMPLED		9/4/91	9/4/91	9/5/91	9/5/91	9/4/91	9/4/91	9/5/91	5/29/91 8/5/91
PARAMETER (ug/l)	SCREENED INTERVAL (Feet)		4.5-13.5	5.5'-14.5'	2.5-9.5	8.5-17.5	4.5-13.5	3.5-12.5	8.5-17.5	-
BENZENE		1	220	2300	ND	11	26	0.6	12	ND
TOLUENE		1000	ND	ND	ND	ND	160	ND	ND	ND
ETHYLBENZENE		29	590	560	ND	10	190	ND	10	ND
XYLENES TOTAL		400	1100	740	ND	43	500	ND	43	ND
METHYL TERTIARY BUTYL ETHER (MTBE)		50**	ND	ND	ND	ND	ND	ND	ND	ND
LEAD		50	4	3	2	5	1	2	7	ND
CHLOROFORM		0.19	ND	ND	ND	ND	ND	3	ND	9
TRANS-1,2-DICHLOROETHENE		70	ND	ND	ND	ND	ND	51	ND	ND
TRICHLOROETHENE		2.8	ND	ND	0.6	ND	ND	120	ND	ND
TRICHLOROFLUOROMETHANE		*	ND	ND	0.9	ND	ND	ND	ND	ND
BROMODICHLOROMETHANE		*	ND	ND	ND	ND	ND	ND	ND	14
BROMOFORM		0.19	ND	ND	ND	ND	ND	ND	ND	16
DIBROMOCHLOROMETHANE		*	ND	ND	ND	ND	ND	ND	ND	27
ACENAPTHENE		*	-	-	-	ND	ND	ND	0.7	-
FLUORENE		*	-	-	-	1	ND	ND	ND	-
1-METHYLNAPTHALENE		*	-	-	-	64	190	ND	42	-
2-METHYLNAPTHALENE		*	-	-	-	63	270	ND	42	-
NAPTHALENE		*	-	-	-	41	220	ND	31	-

TABLE 4.5 (Page 1 of 2)

SUMMARY OF LABORATORY ANALYSES
MONITORING WELL GROUND-WATER SAMPLES
DEEP SCREENED INTERVAL

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

	WELL NUMBER	NC GROUND WATER STANDARD	MW-8D	MW-9D	MW-10D	MW-11D	MW-12D	MW-13D	MW-14D	MW-15D
	DATE SAMPLED		9/4/91	9/3/91	9/3/91	9/4/91	9/4/91	9/4/91	9/4/91	9/4/91
PARAMETER (ug/l)	SCREENED INTERVAL (Feet)		20.5-29.5	25.5-29.5	25.5-29.5	25.5-29.5	24-28	25.5-29.5	24.5-28.5	25.5-29.5
BENZENE		1	1	0.3	3	ND	ND	ND	0.8	ND
TOLUENE		1000	3	ND	2	ND	ND	ND	ND	ND
ETHYLBENZENE		29	26	ND	1	ND	ND	ND	ND	ND
XYLENES (TOTAL)		400	52	ND	ND	9	ND	ND	ND	ND
METHYL TERTIARY BUTYL ETHER (MTBE)		50**	ND	ND	ND	ND	ND	ND	ND	ND
LEAD		50	8	14	11	10	9	3	14	5
TRANS-1,2-DICHLOROETHENE		70	ND	0.9	110	ND	ND	ND	7	ND
TRICHLOROETHENE		2.8	0.7	14	810	ND	ND	ND	13	ND
VINYL CHLORIDE		*	ND	ND	6	ND	ND	ND	ND	ND

TABLE 4.5 (Page 2 of 2)

SUMMARY OF LABORATORY ANALYSES
MONITORING WELL GROUND-WATER SAMPLES
DEEP SCREENED INTERVAL

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

	WELL NUMBER	NC GROUND WATER STANDARD	MW-16D	MW-17D	MW-18D	MW-19D	MW-21D	MW-22D	MW-23D	MW-24D	MW-25D
	DATE SAMPLED		9/5/91	9/5/91	9/5/91	9/4/91	9/4/91	9/4/91	9/5/91	9/5/91	9/4/91
PARAMETER (ug/l)	SCREENED INTERVAL (Feet)		24.5'-28.5'	25-29	20.5-24.5	22.5-24.5	25.5-27	32'-35'	17.5-20	26.5-29	27.5-30
BENZENE		1	12	ND	ND	ND	0.4	50	ND	0.7	ND
TOLUENE		1000	23	ND	ND	ND	13	1	ND	ND	33
ETHYLBENZENE		29	21	ND	ND	ND	17	10	ND	1	110
XYLENES (TOTAL)		400	100	ND	ND	ND	93	8	ND	3	290
METHYL TERTIARY BUTYL ETHER (MTBE)		50**	ND	ND	1	ND	ND	ND	ND	ND	ND
LEAD		50	9	7	5	9	3	10	2	7	ND
TRANS-1,2-DICHLOROETHENE		70	ND	0.6	ND	92	2	ND	ND	ND	ND
TRICHLOROETHENE		2.8	ND	ND	0.9	630	6	ND	0.7	0.6	ND

TABLE 5.1
SUMMARY OF LABORATORY ANALYSES
RINSE AND TRIP BLANKS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

SAMPLE NUMBER	TYPE OF BLANK	DATE COLLECTED	DATE SUBMITTED	RESULTS (mg/l)
HYDROPUNCH SAMPLES				
AA11637	Trip		8/6	ND
AA11677	Trip		8/8	ND
AA11685	Rinse	8/6	8/8	ND
AA11686	Trip		8/8	ND
AA11740	Rinse	8/7	8/9	ND
AA11741	Trip		8/9	ND
MONITORING WELL SAMPLES				
AA12927	Trip		9/6	ND
AA12939	Rinse	9/4	9/6	Total Xylenes 2 MTBE 1
AA12940	Trip		9/6	Total Xylenes 2
AA12951	Rinse	9/4	9/6	Total Xylenes 2
AA12952	Trip		9/6	Total Xylenes 2
AA12985	Rinse	9/5	9/6	Total Xylenes 1
AA12986	Rinse	9/5	9/6	ND
AA12987	Trip		9/6	ND
AA12992	Rinse	9/5	9/6	Total Xylenes 1
AA12993	Trip		9/6	ND

TABLE 6.1
SUMMARY OF EXPOSURE PATHWAYS

REPORT OF UNDERGROUND FUEL INVESTIGATION
COMPREHENSIVE SITE ASSESSMENT

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA
LAW ENGINEERING JOB NO. J47590-6014

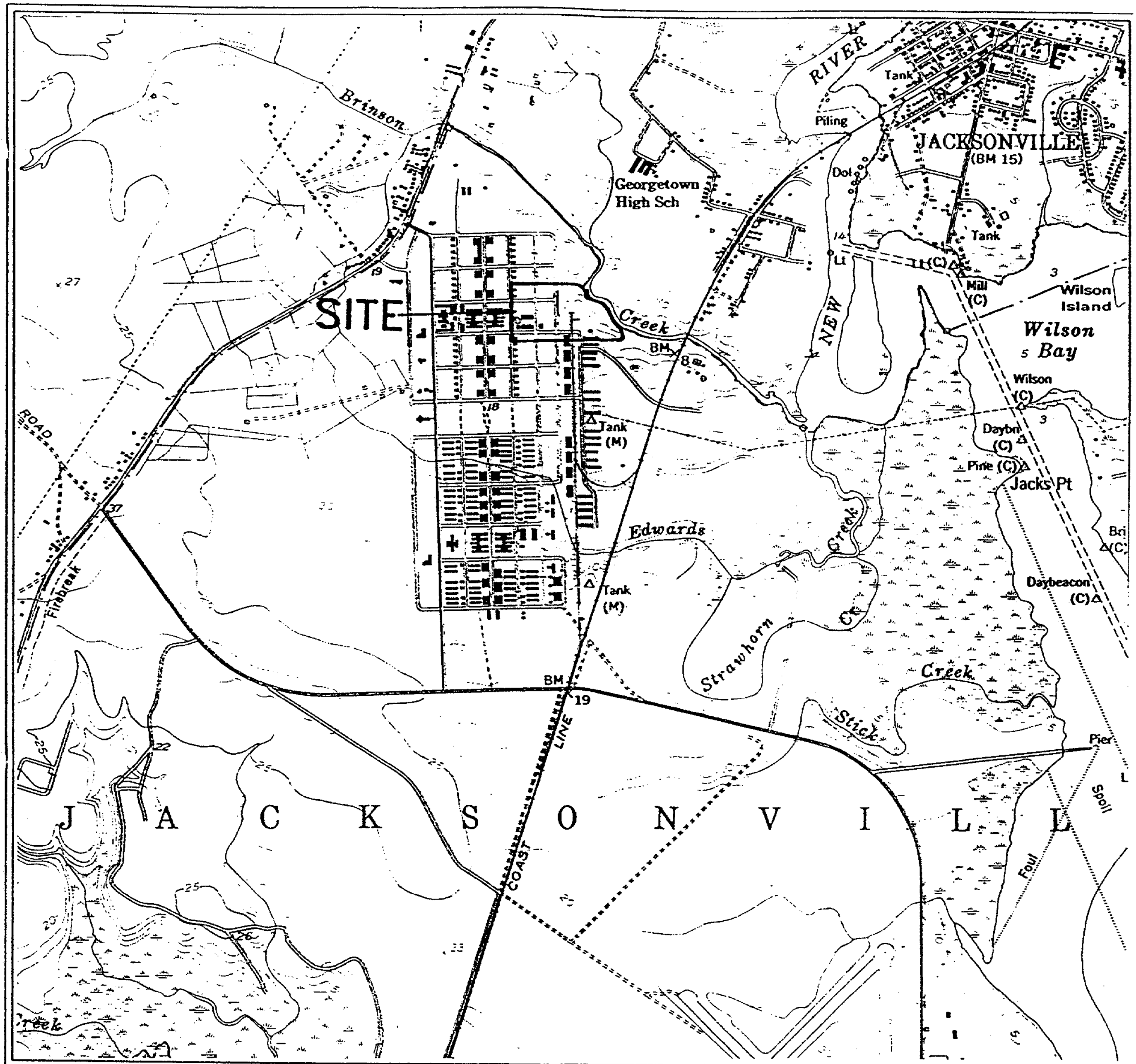
CONTAMINATED MEDIUM	INGESTION (EATING)	INGESTION (DRINKING)	INHALATION	ABSORPTION
Free Product	NA	No Exposure (1)	NA	No Exposure (1)
Soil	Contingent Exposure (2)	NA	NA	Contingent Exposure (2)
Ground Water	Exposure Unlikely (3)	Exposure Unlikely (3)	NA	Exposure Unlikely (3)
Surface Water	No Exposure (4)	No Exposure (4)	NA	No Exposure (4)
Vapor	NA	NA	Possible Exposure (5)	NA

Notes:

(1) No free product detected in surface waters; water supply wells draw from Castle Hayne aquifer.
(2) Potential for exposure only if subsurface below 8 feet BLS is disturbed.
(3) Through use of Camp Geiger water-supply wells for drinking, cooking, and bathing.
(4) Ground-water sampling results indicate that plume does not extend to surface waters.
(5) Potential for exposure during maintenance/repair work in subsurface utility confinements.

DRAWINGS

LAW ENGINEERING



NORTH

JACKSONVILLE SOUTH, N.C.
NW/4 NEW RIVER 15' QUADRANGLE
N3437.5—W7722.5/7.5
1952
PHOTOINSPECTED 1971
AMS 5553 III NW—SERIES V 842

CONTOUR INTERVAL 5 FEET

GRAPHIC SCALE FEET
2000 1000 0 2000 4000

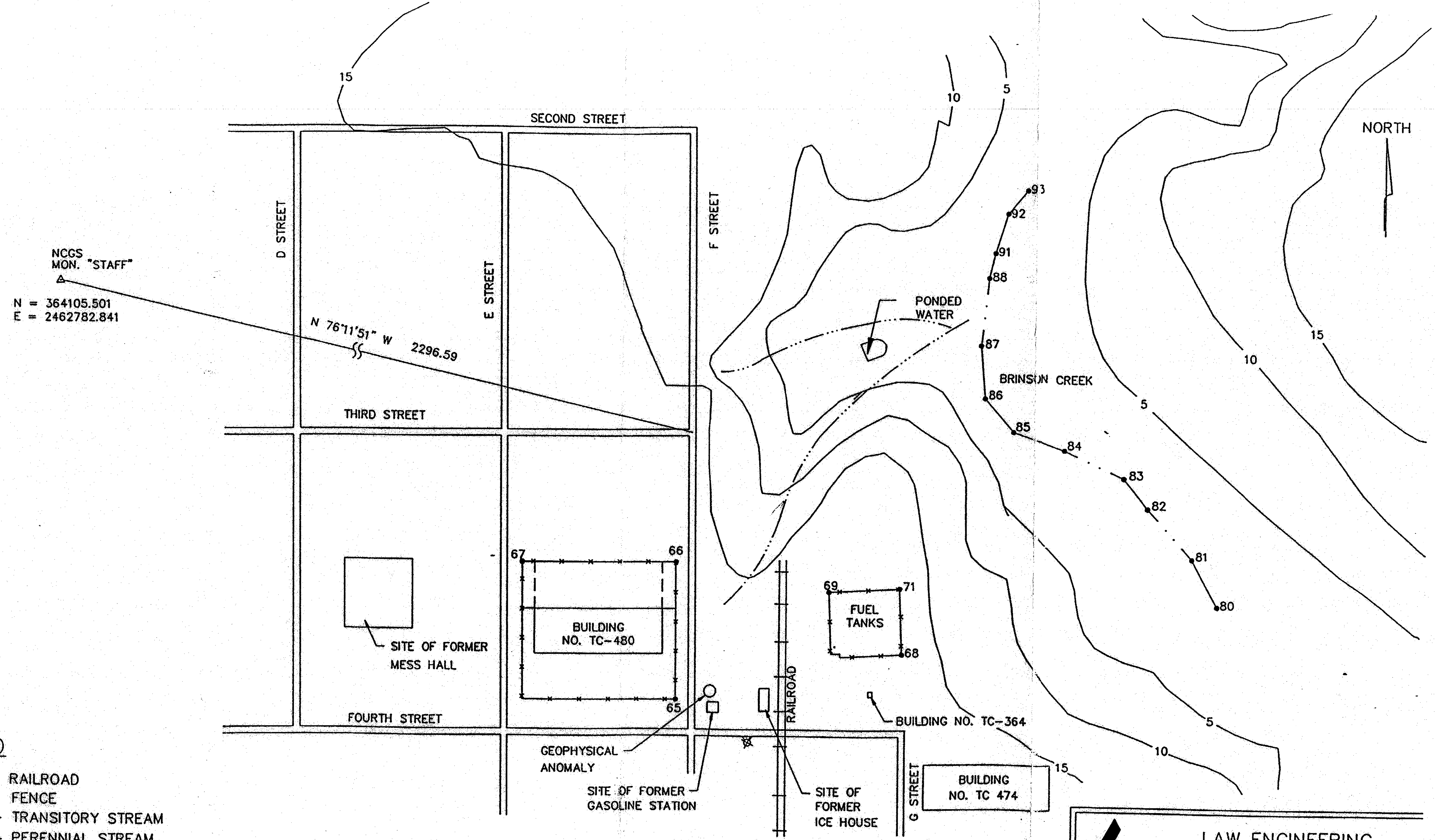
QUADRANGLE LOCATION

NOTE: SITE LOCATIONS ARE APPROXIMATE.

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOPOGRAPHIC SITE MAP
UNDERGROUND FUEL INVESTIGATION
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK:	SCALE: 1:24000
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: W.D.Dixon	DWG: 1.1



LEGEND

┼┼	RAILROAD
—×—	FENCE
—·· —	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
•67	POINTS OF REFERENCE
⊠	SITE B.M. – TOP OF FLANGE BOLT THAT HAS I.D. NUMBER ATTACHED. ELEV. = 18.08
—10—	TOPOGRAPHIC CONTOUR (FEET ABOVE MSL)

NOTE: CONTOUR INTERVAL 5 FEET

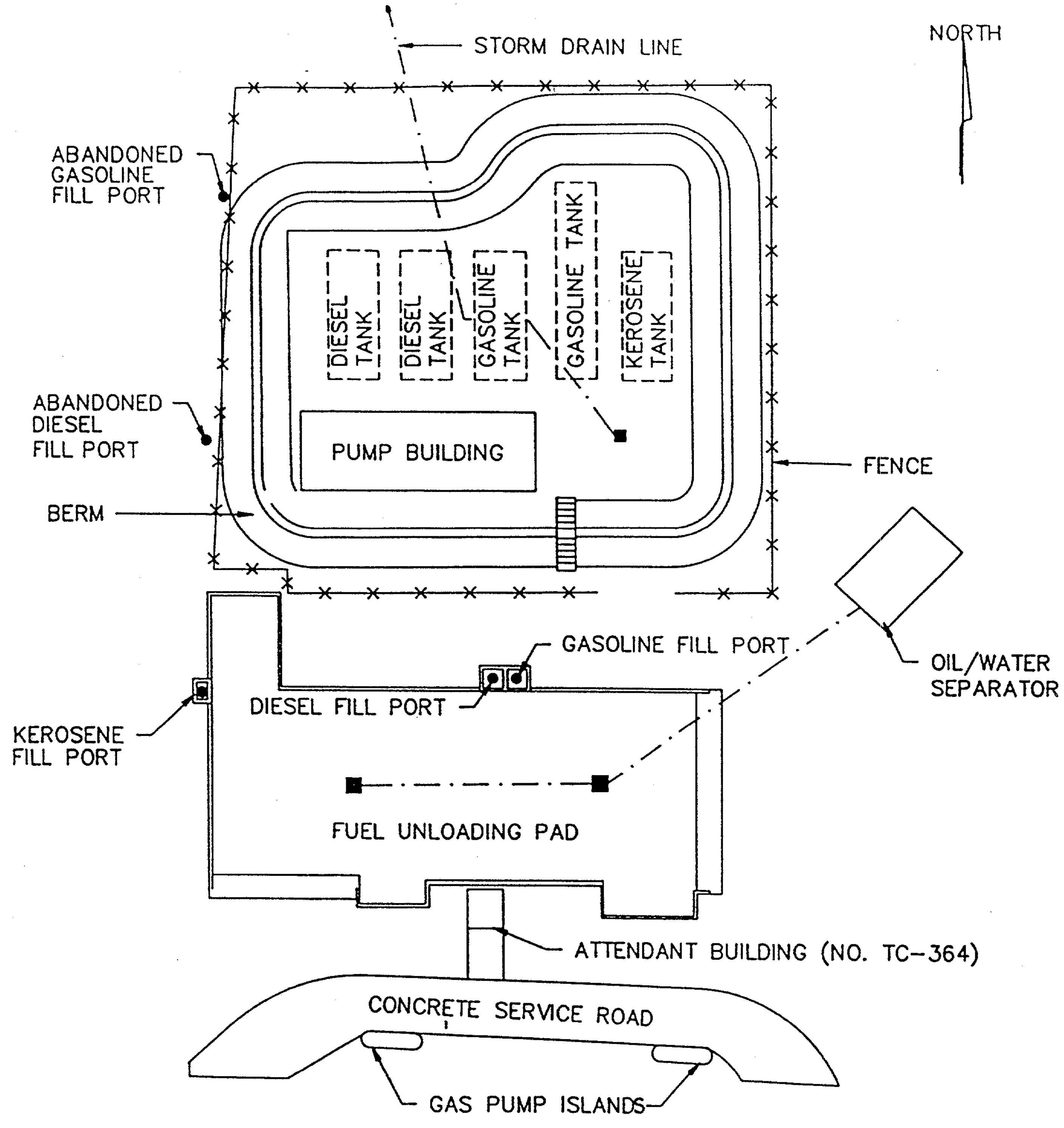
J6014BB1

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

BASE MAP
CAMP GEIGER FUEL FARM STUDY AREA
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WADixon	JOB: J47590-6014
APPROVAL: WADixon	DWG: 2.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

■ GRATES

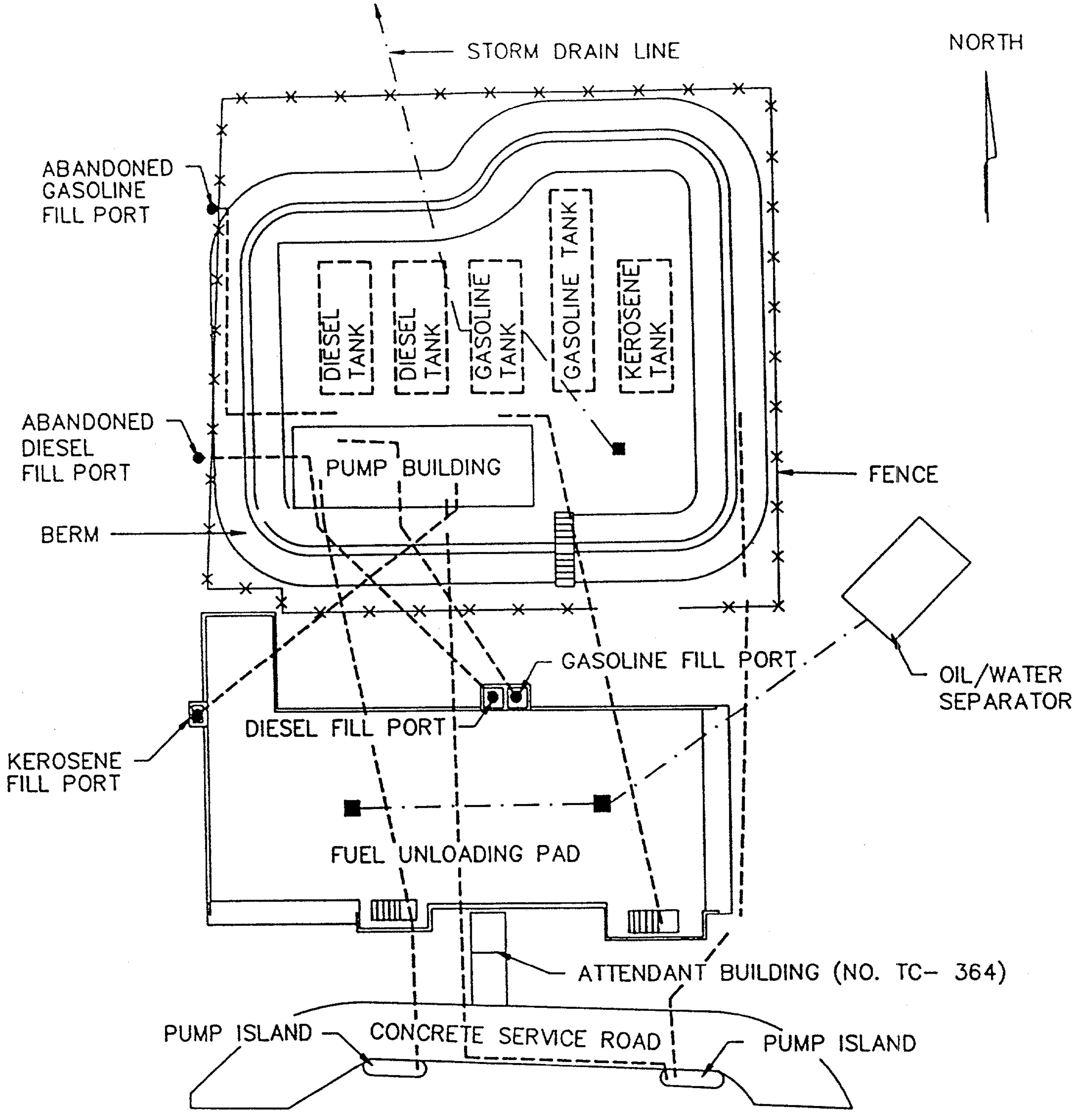
J6014BZ5 1:3

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

BASE MAP
FUEL FARM AREA
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK: DCC	SCALE: 1"=30'
ENG CHECK:	JOB: J47590-6014
APPROVAL:	DWG: 2.2

REFERENCE: NAVFAC DWG. NO. 4174383



LEGEND

■ GRATES

------- LOCATION OF UNDERGROUND FUEL LINES

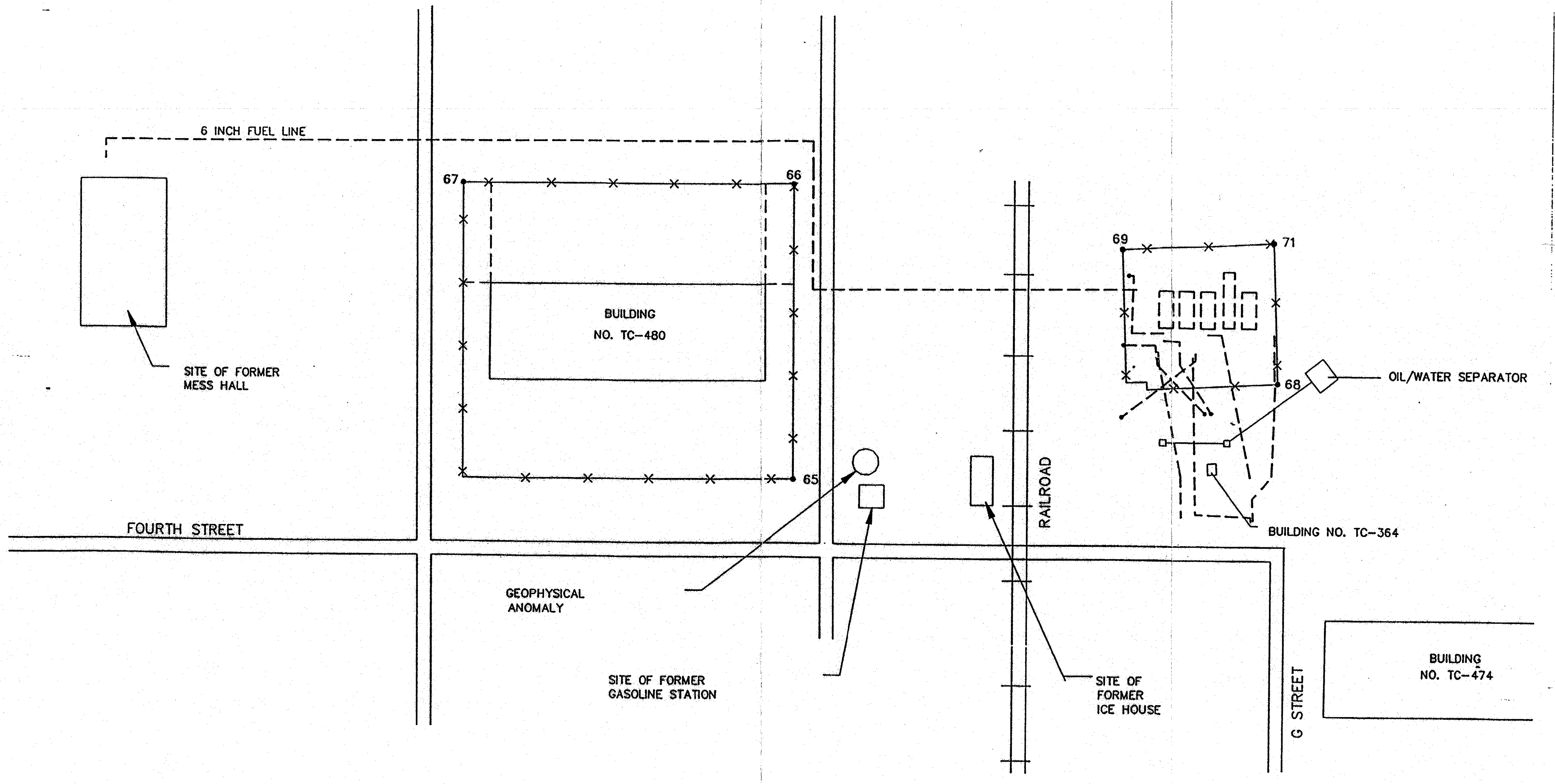
6014BZ6A 1:3

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

UNDERGROUND FUEL LINES
FUEL FARM AREA
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK: DCC	SCALE: 1"=30'
ENG CHECK:	JOB: J47590-6014
APPROVAL:	DWG: 2.3

REFERENCE: NAVFAC DWG. NO. 4174383; TRACER RES. CORP. REPORT NO. 2-91-425T.



LEGEND

– – – – – – LOCATION OF UNDERGROUND FUEL LINES

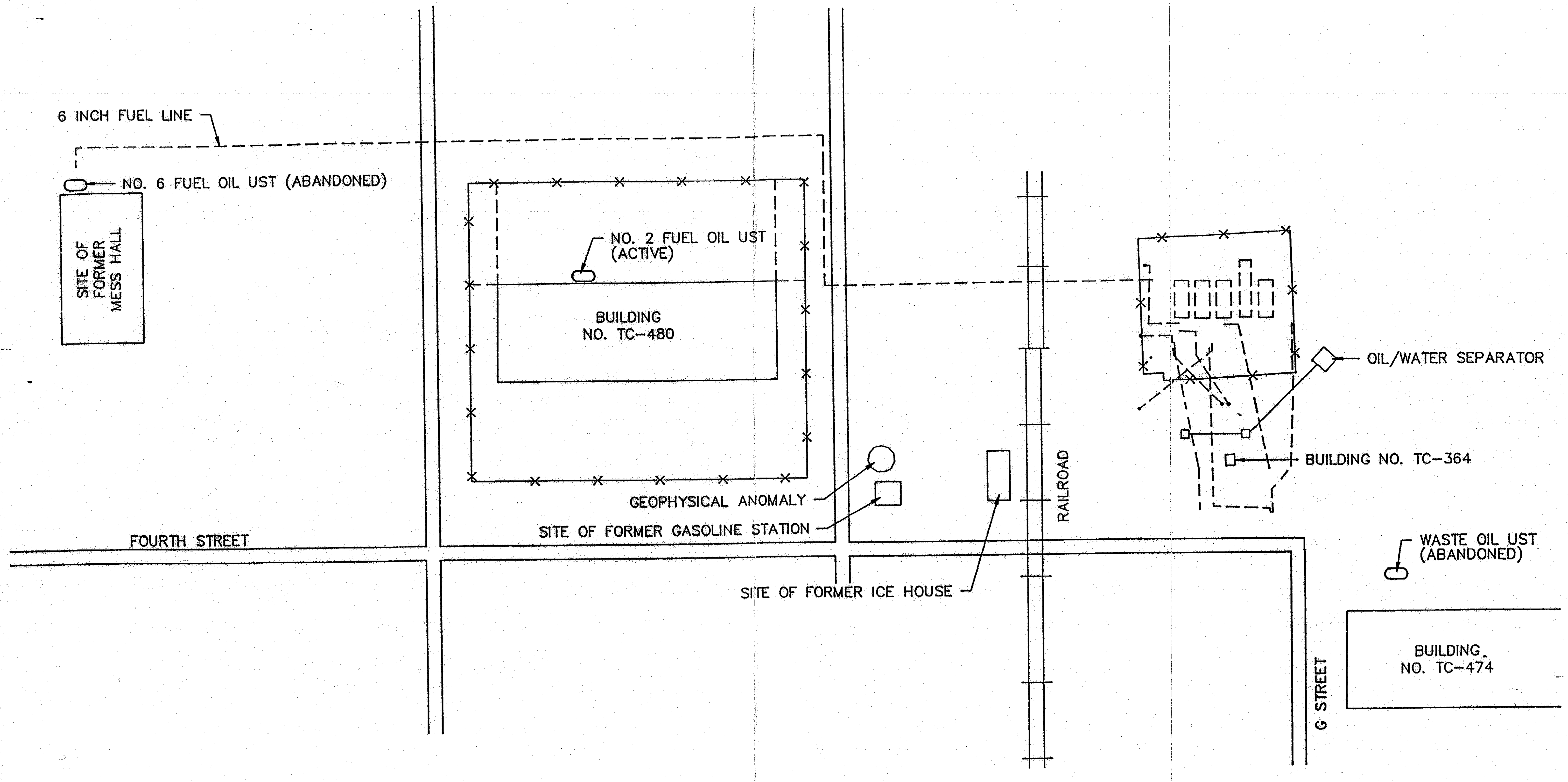
J6014Z23

UNDERGROUND FUEL LINES
CAMP GEIGER FUEL FARM STUDY AREA
CAMP LEJEUNE, NORTH CAROLINA

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=70'
ENG CHECK: WADixon	JOB: 47590-6014
APPROVAL: WDDixon	DWG: 2.4

REFERENCE: JAMES E. STEWART & ASSOC. SHT 1&2 OF 2; NAVFAC DWG.4174383; TRACER RES.#2-91-425T.



J6014Z24

LEGEND

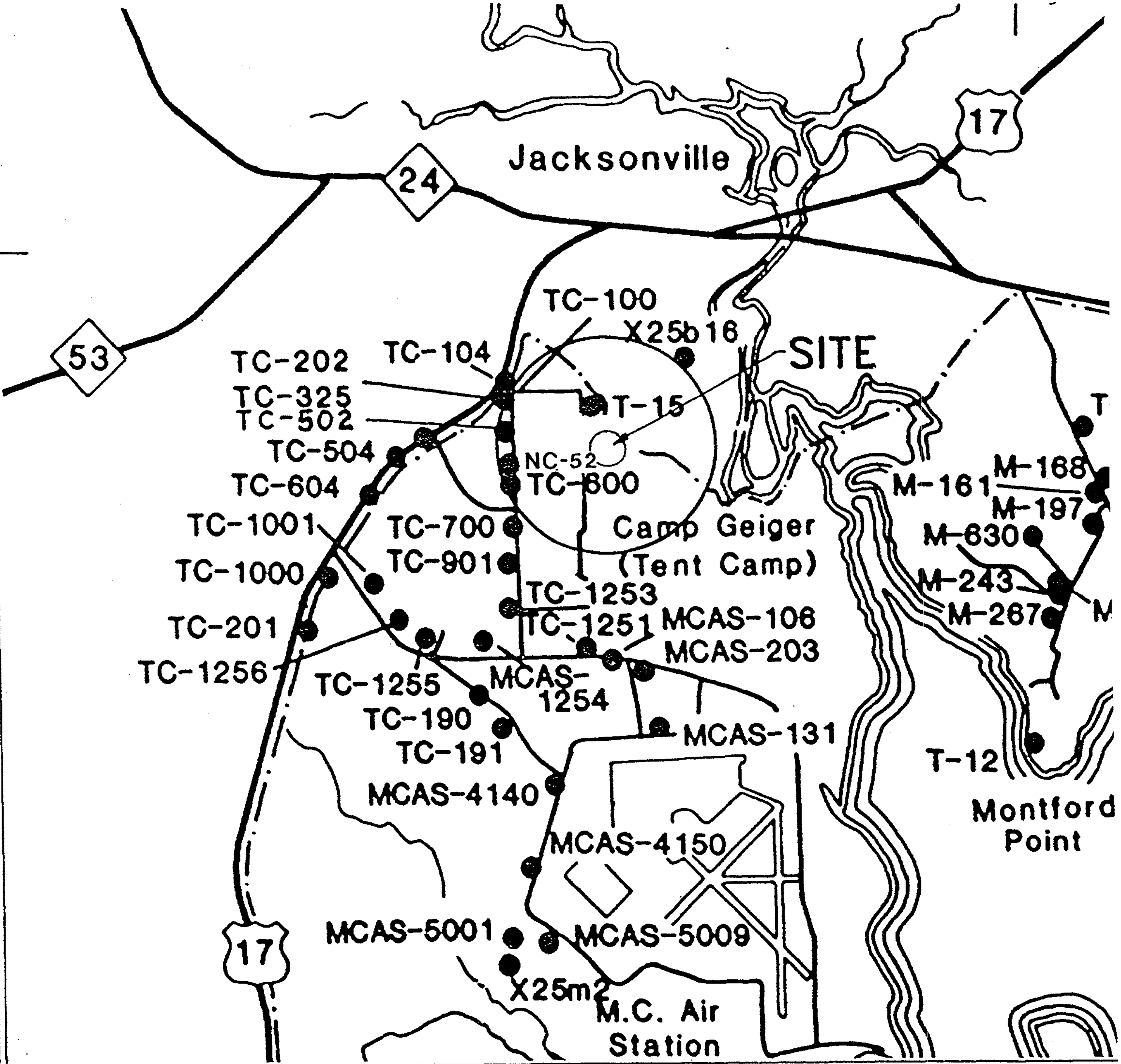
– – – – – –	LOCATION OF UNDERGROUND FUEL LINES
⬭	APPROXIMATE LOCATION OF UNDERGROUND STORAGE TANKS

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATION OF POTENTIAL CONTAMINANT SOURCES
CAMP GEIGER FUEL FARM STUDY AREA
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=70'
ENG CHECK:	JOB: 475-06014-01
APPROVAL:	DWG: 2.5

REFERENCE: JAMES E. STEWART & ASSOC. SHT 1&2 OF 2; NAVFAC DWG.4174383; TRACER RES.#2-91-425T.



NORTH

LEGEND

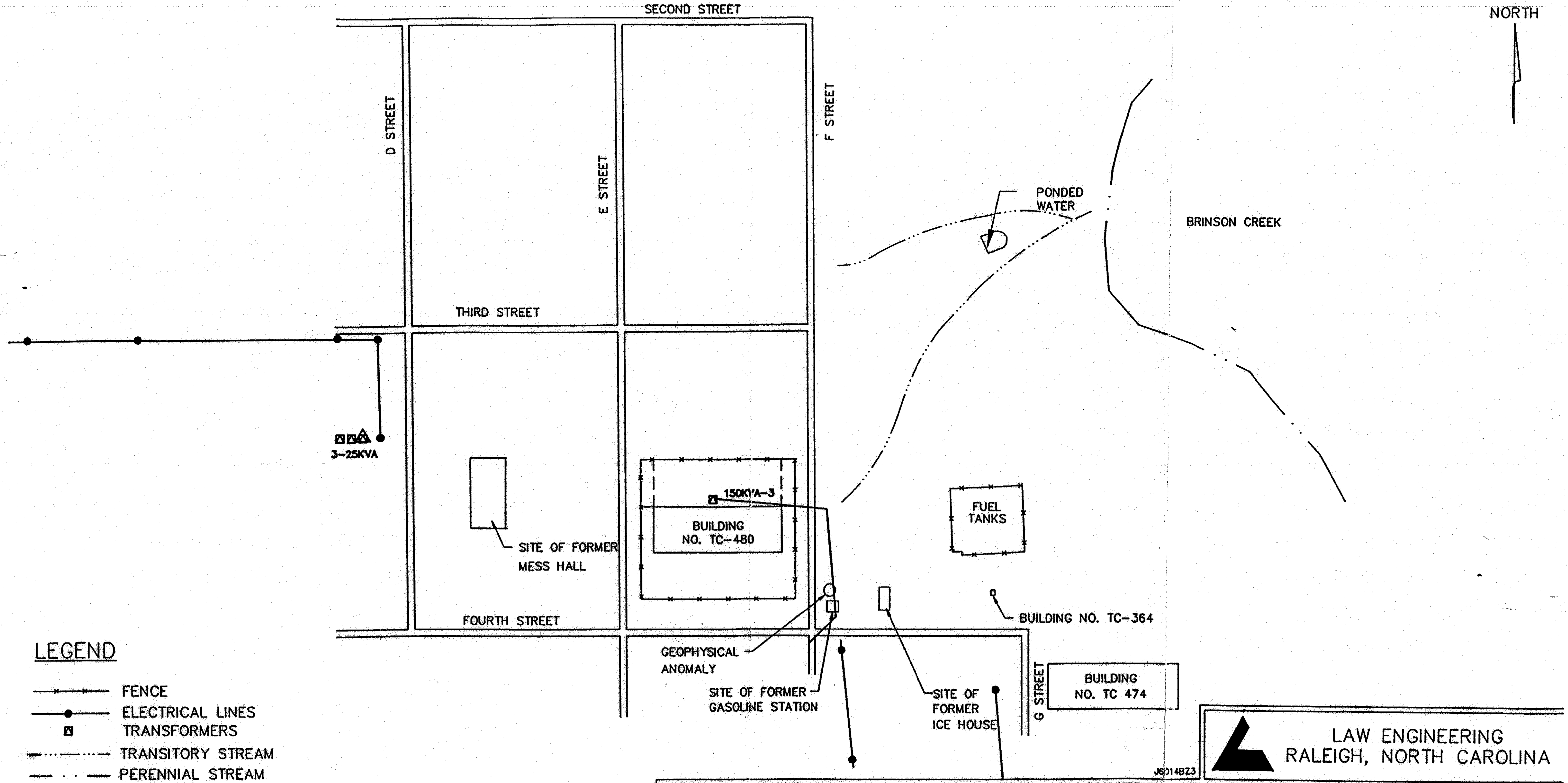
● TC-202 LOCATION OF WATER-SUPPLY WELL AND WELL NUMBER

1/2 MILE RADIUS AROUND SITE

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATIONS OF WATER-SUPPLY WELLS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK:	SCALE: 1"=3500'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WD Dixon	DWG: 2.6

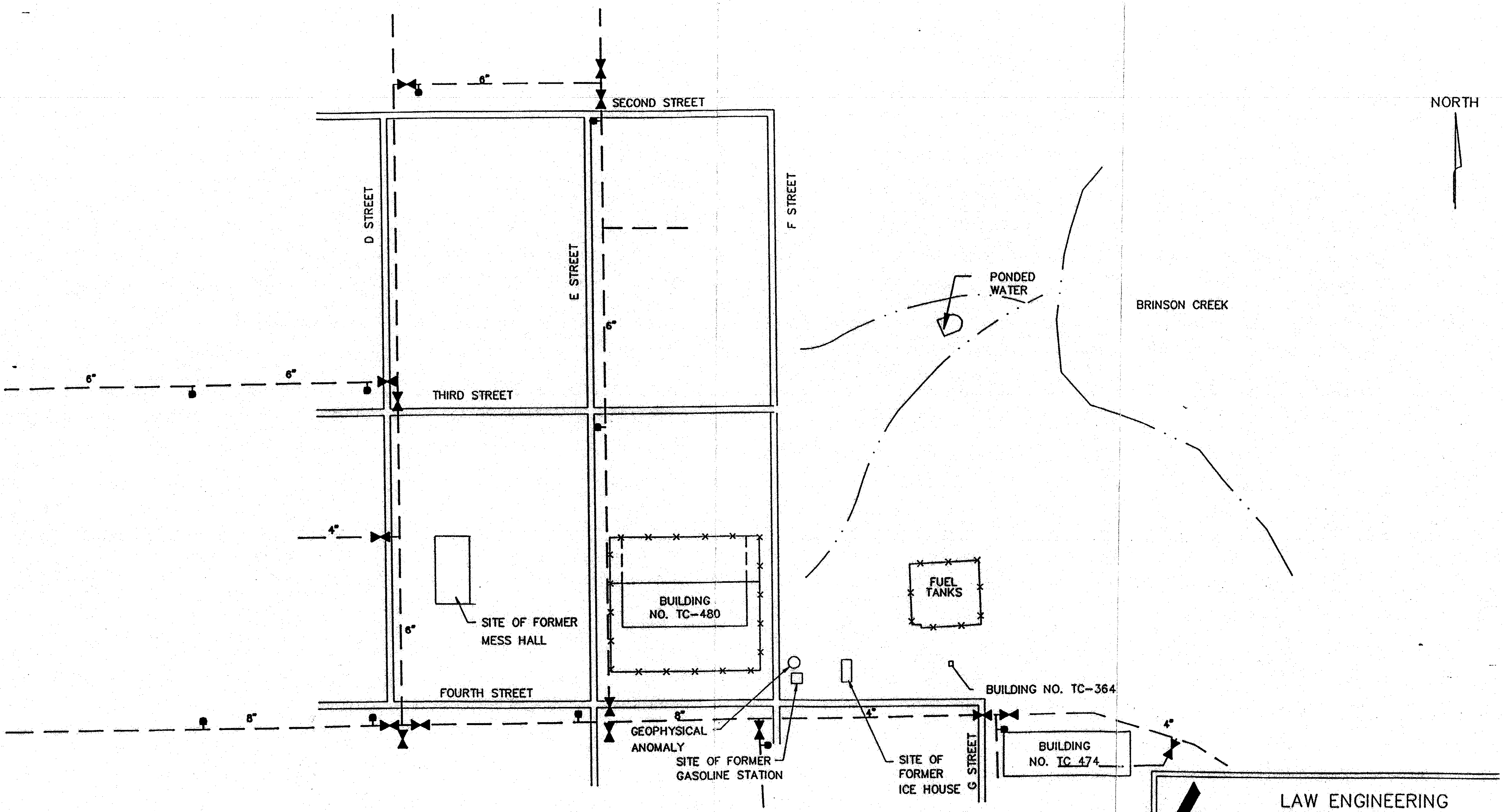


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATION OF UNDERGROUND ELECTRICAL LINES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 2.7

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1 AND 2 OF 2; 9-13-91; ELEC. SYS. SHT. A-2 OF 73.



LEGEND

—×—×— FENCE

— 6" — POTABLE WATER MAIN WITH CORRESPONDING SIZE

— ⋈ — GATE VALVE

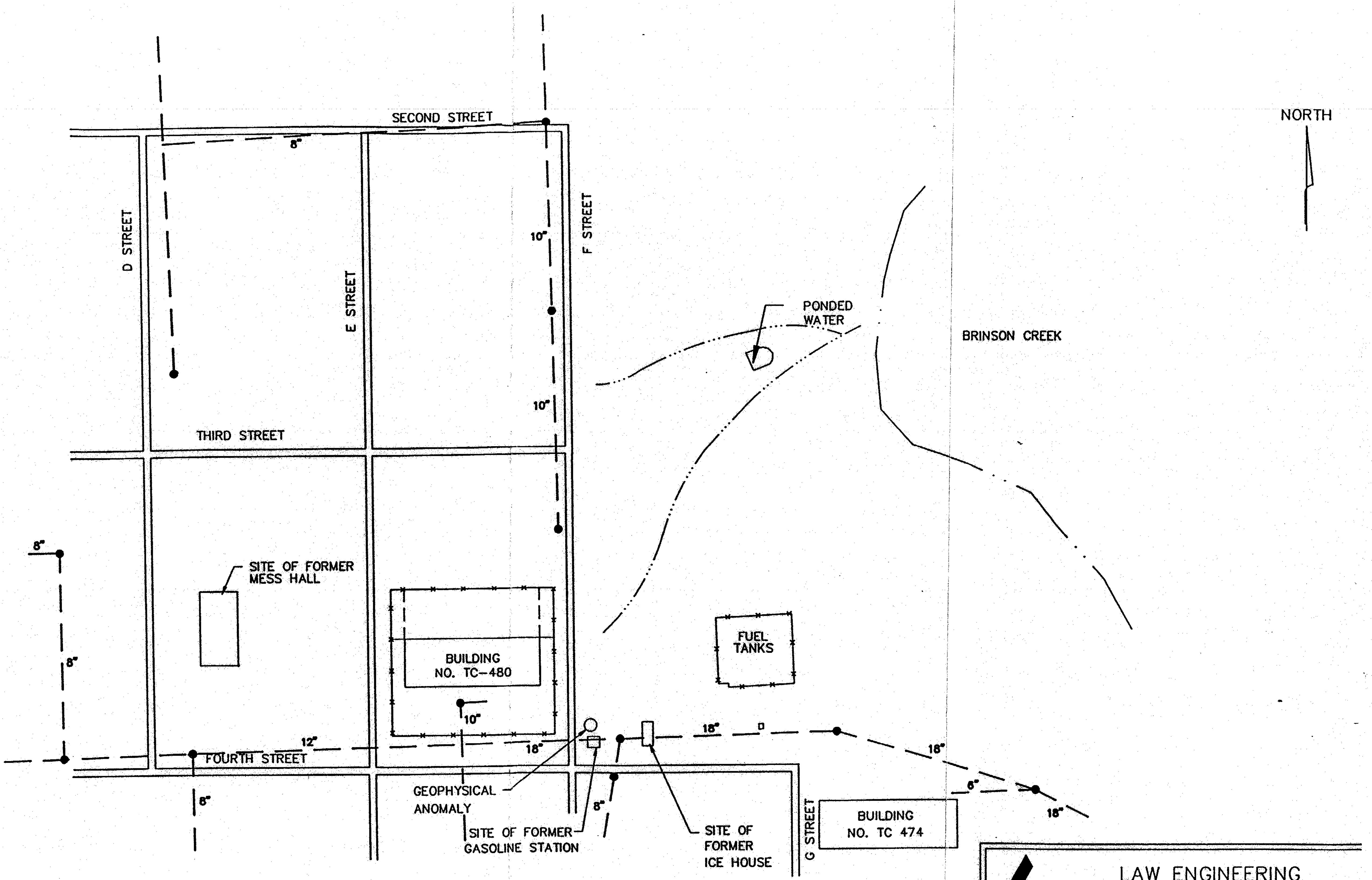
— ● — FIRE HYDRANT

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATIONS OF POTABLE WATER LINES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WRDixon	JOB: J47590-6014
APPROVAL: WRDixon	DWG: 2.8

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1 AND 2 OF 2; 9-13-91: EXIST. WATER DIST. SYS. A-2 OF 73.



J60148Z2

LEGEND

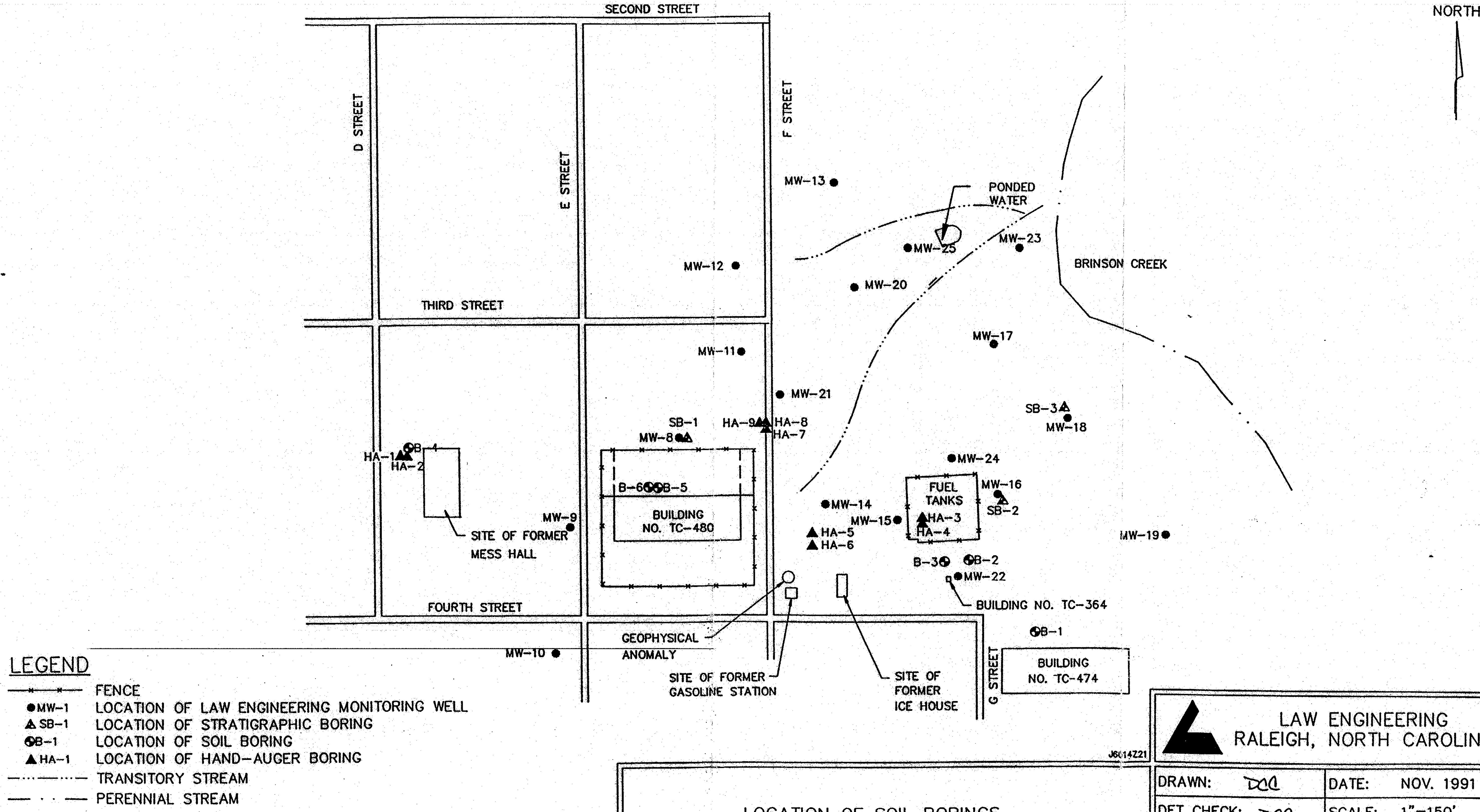
—×—×— FENCE
— 18" — WASTEWATER LINES WITH CORRESPONDING LINE SIZE
— ● — MANHOLE
—·····—····· TRANSITORY STREAM
— · · — PERENNIAL STREAM

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATION OF WASTEWATER LINES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: W D Dixon	DWG: 2.9

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1 AND 2 OF 2; 9-13-91; EXIST. WASTEWATER SYS. A-2 OF 7

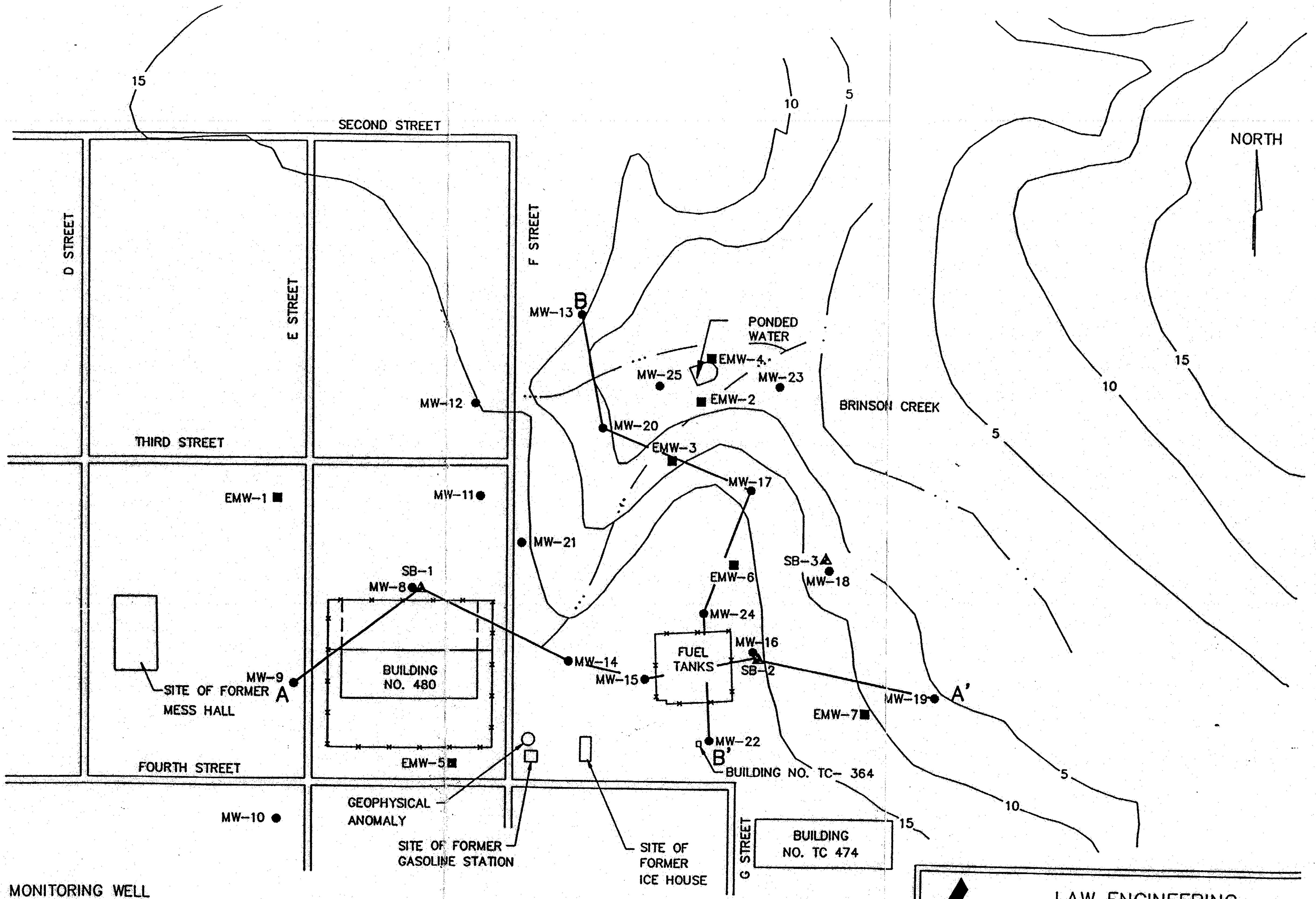


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 3.1

LOCATION OF SOIL BORINGS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

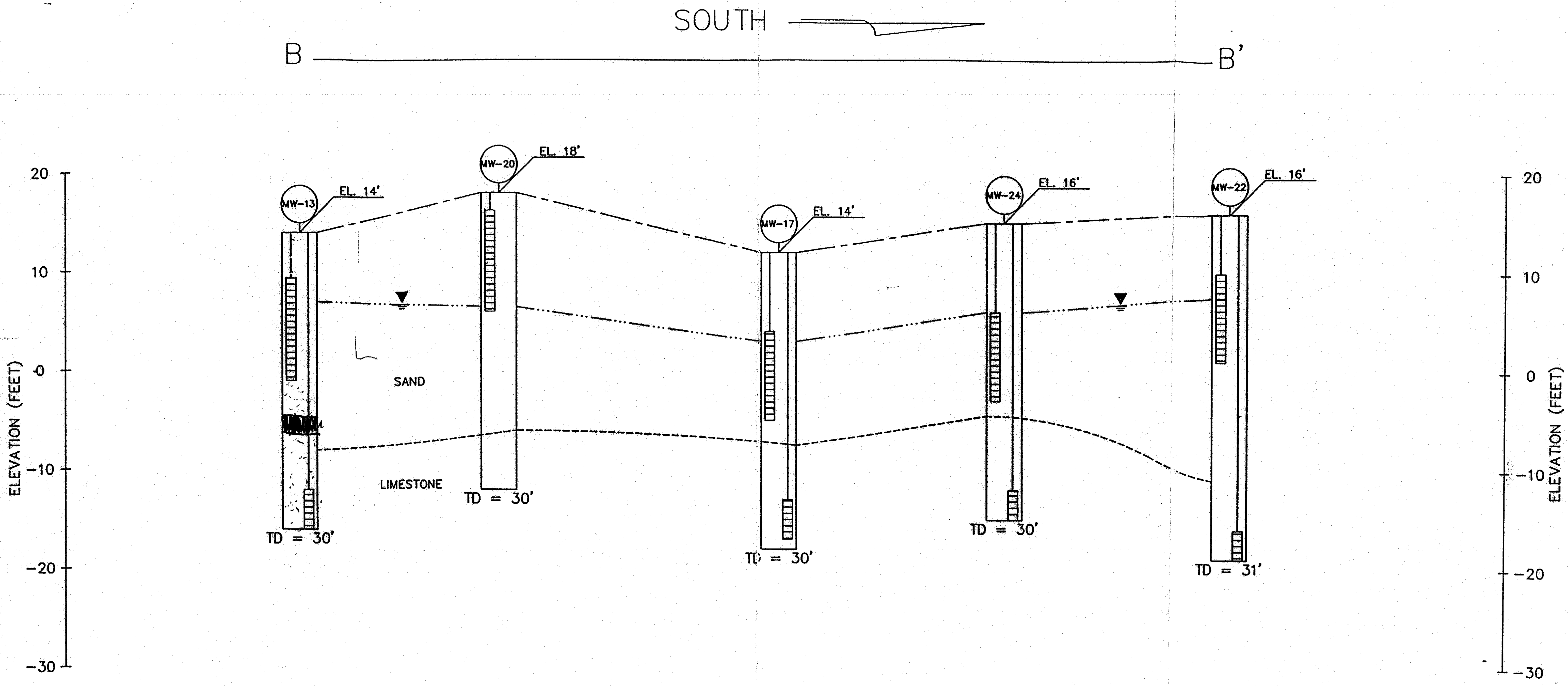
—×—×—	FENCE
■ EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
● MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
▲ SB-1	LOCATION OF STRATIGRAPHIC BORING
———	LINE OF CROSS SECTION
-·-·-·-	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
—10—	TOPOGRAPHIC CONTOUR (FEET ABOVE MSL)

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

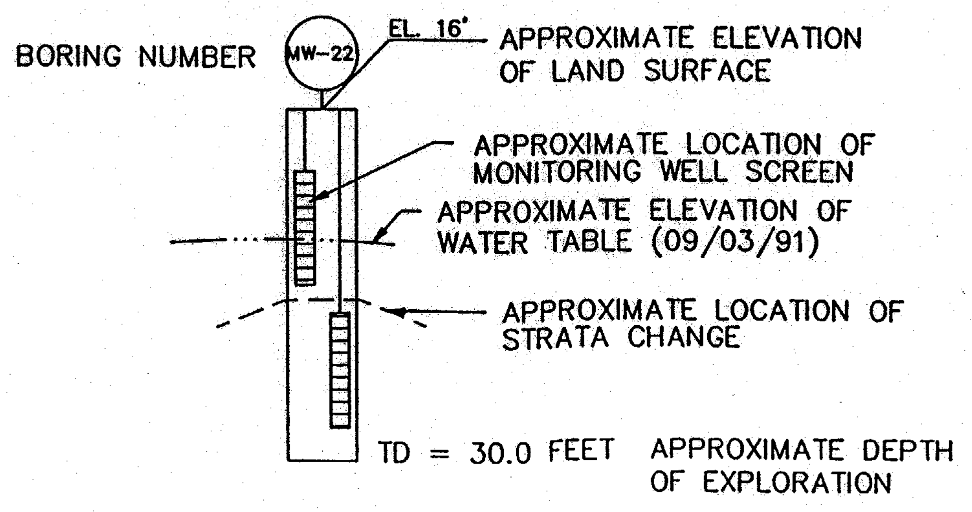
PLAN VIEW OF CROSS SECTIONS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: RAKolb	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 3.2

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND



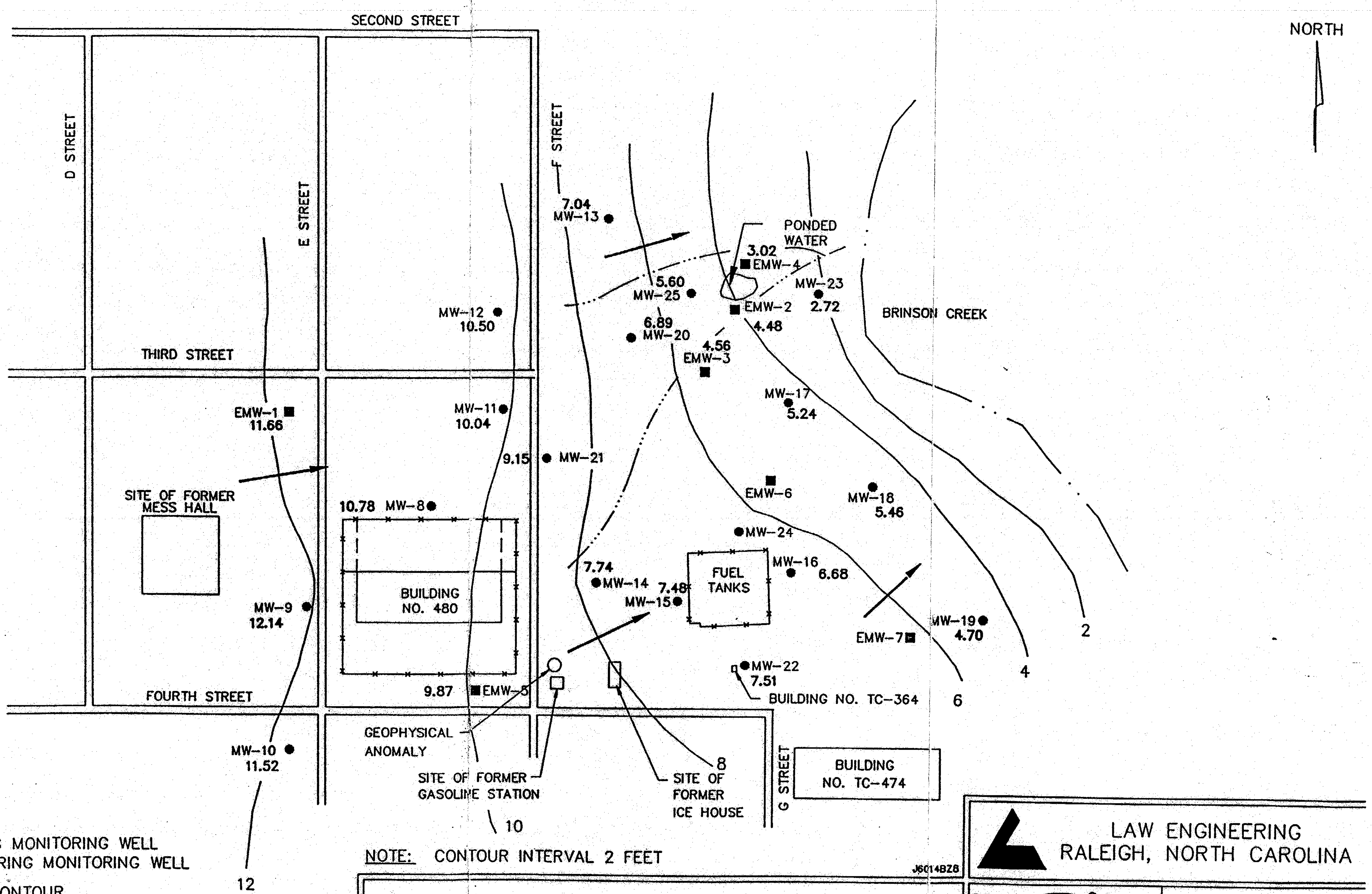
J6014802

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

CROSS SECTION B-B'
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: VERT. 1"=10' HORIZ. 1"=80'
ENG CHECK: WAD, YOA	JOB: J47590-6014
APPROVAL: WAD, YOA	DWG: 3.4

REFERENCE: FIELD NOTES



NOTE: CONTOUR INTERVAL 2 FEET

LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
10	ESTIMATED WATER TABLE CONTOUR
5.60	GROUND WATER ELEVATION IN FEET
——→	DIRECTION OF GROUND WATER FLOW
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

NOTE: ELEVATIONS OF EMW-6,7,AND 24 NOT USED.

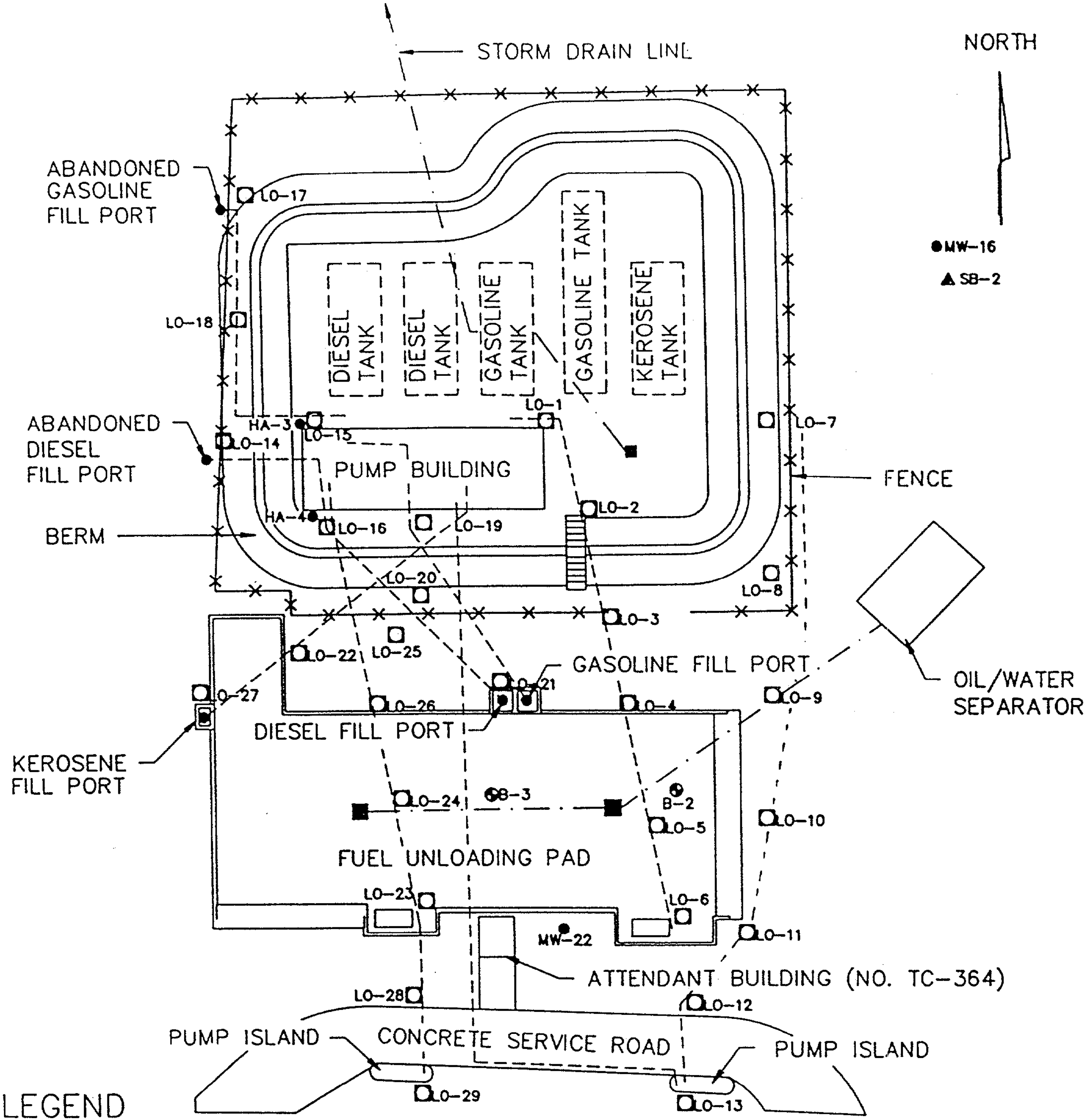
J6014BZ8

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

WATER-TABLE CONTOUR MAP
SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DAA	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 3.5

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91.



LEGEND

■	GRATES
▢LO-29	LOCATION OF SOIL-GAS PROBE
▲SB-2	LOCATION OF STRATIGRAPHIC BORING
●MW-16	LOCATION OF MONITORING WELL
⊕B-2	LOCATION OF SOIL BORING
●HA-3	LOCATION OF HAND AUGER BORING
--------	LOCATION OF UNDERGROUND FUEL LINES

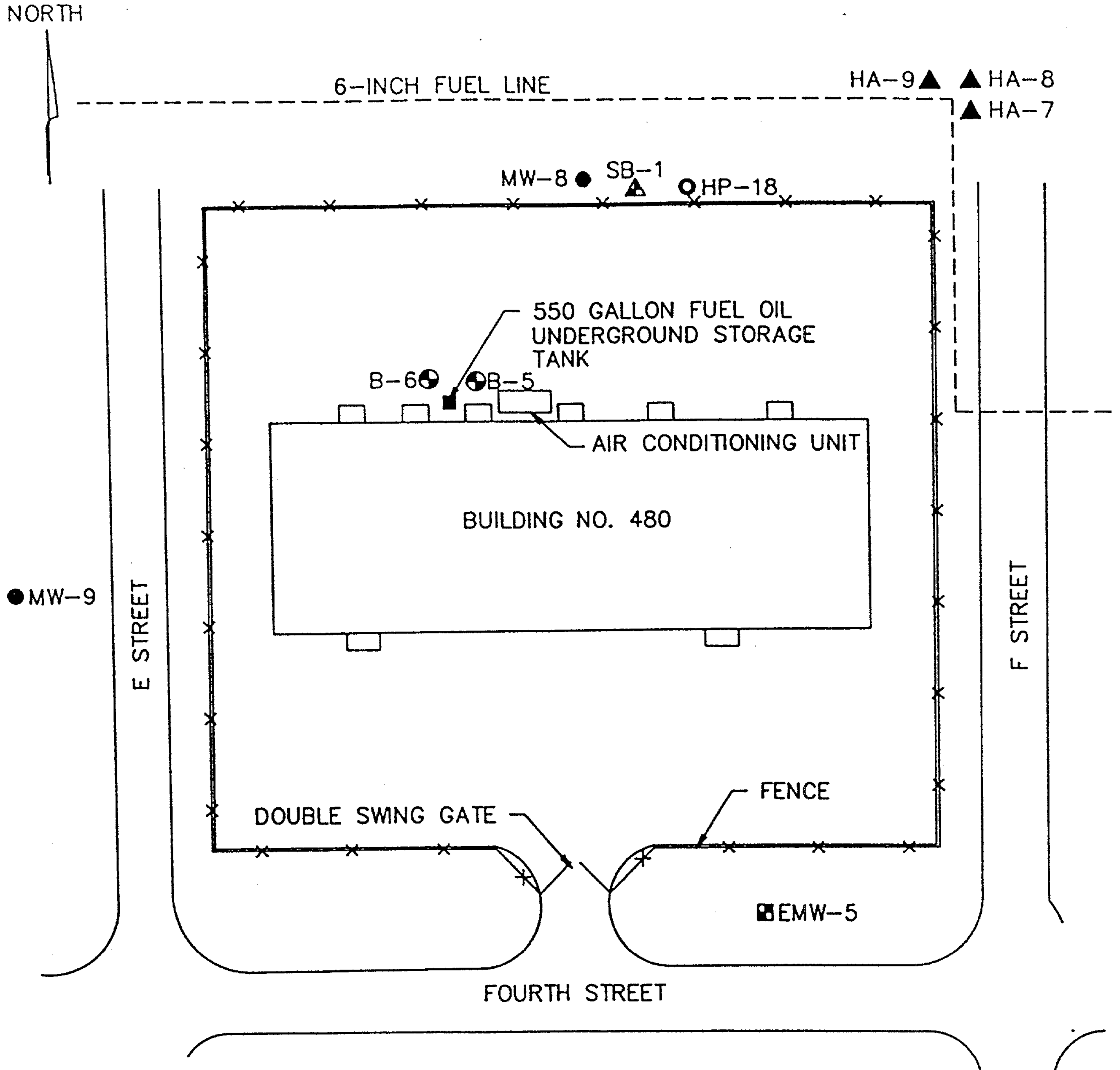
J6014BZ6 1:3

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATION OF SOIL-GAS PROBES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: [illegible]	SCALE: 1"=30'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.1

REFERENCE: NAVFAC DWG. NO. 4174383; TRACER RES. CORP. REPORT NO. 2-91-425T.



LEGEND

▣ EMW-5	LOCATION OF PRE-EXISTING MONITORING WELL
● MW-8	LOCATION OF MONITORING WELL
◬ SB-1	LOCATION OF STRATIGRAPHIC BORING
⊕ B-5	LOCATION OF SOIL BORING
▲ HA-8	LOCATION OF HAND-AUGER BORING
○ HP-18	LOCATION OF HYDROPUNCH BORING

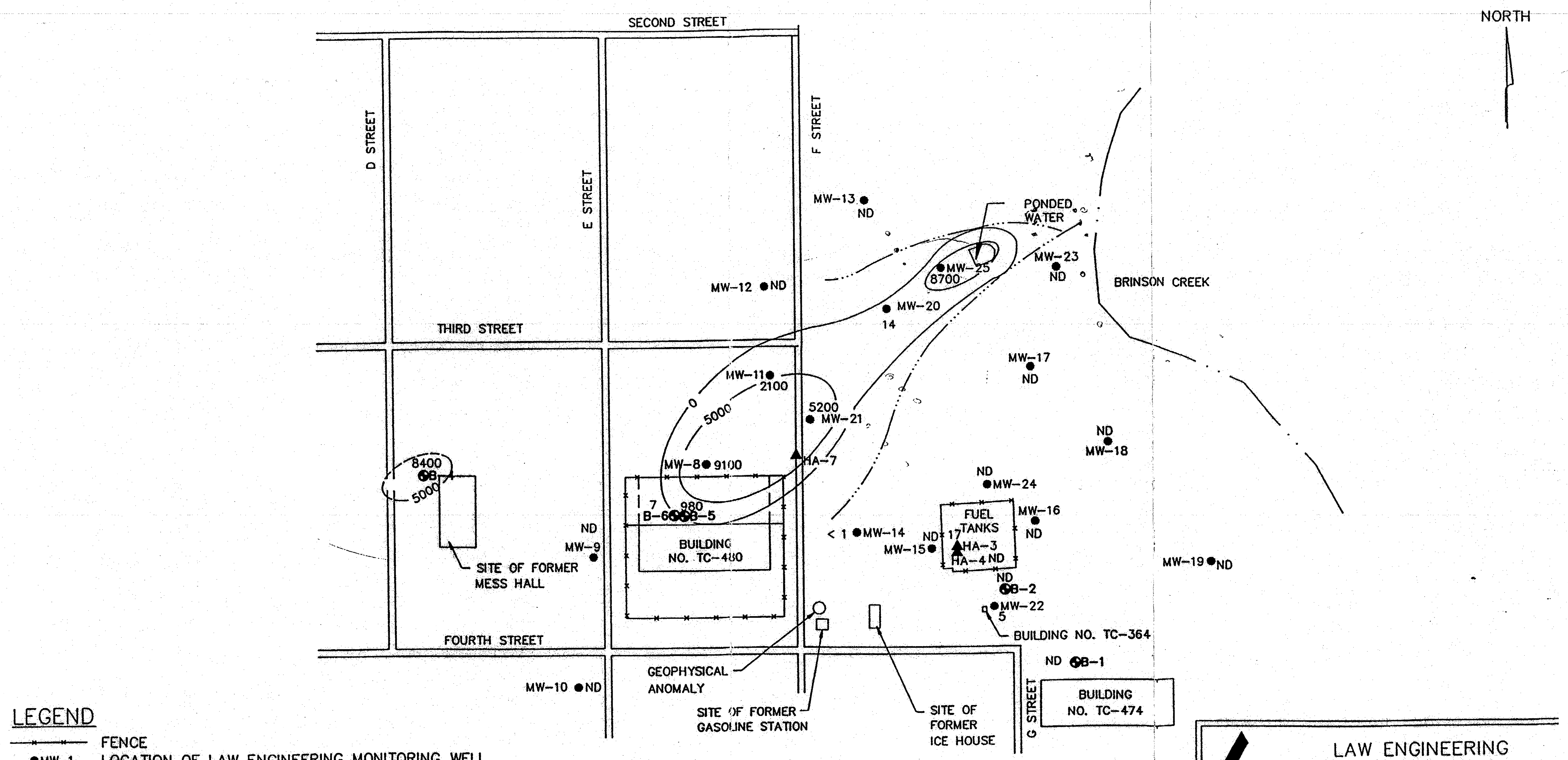
J60148Z7 1:5

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

BUILDING NO. 480 SITE PLAN
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK: DCC	SCALE: 1"=50'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.2

REFERENCE: NAVFAC DRAWING NO. 4009116



NOTE: CONTOUR INTERVAL 5000 ug/L

6014Z17

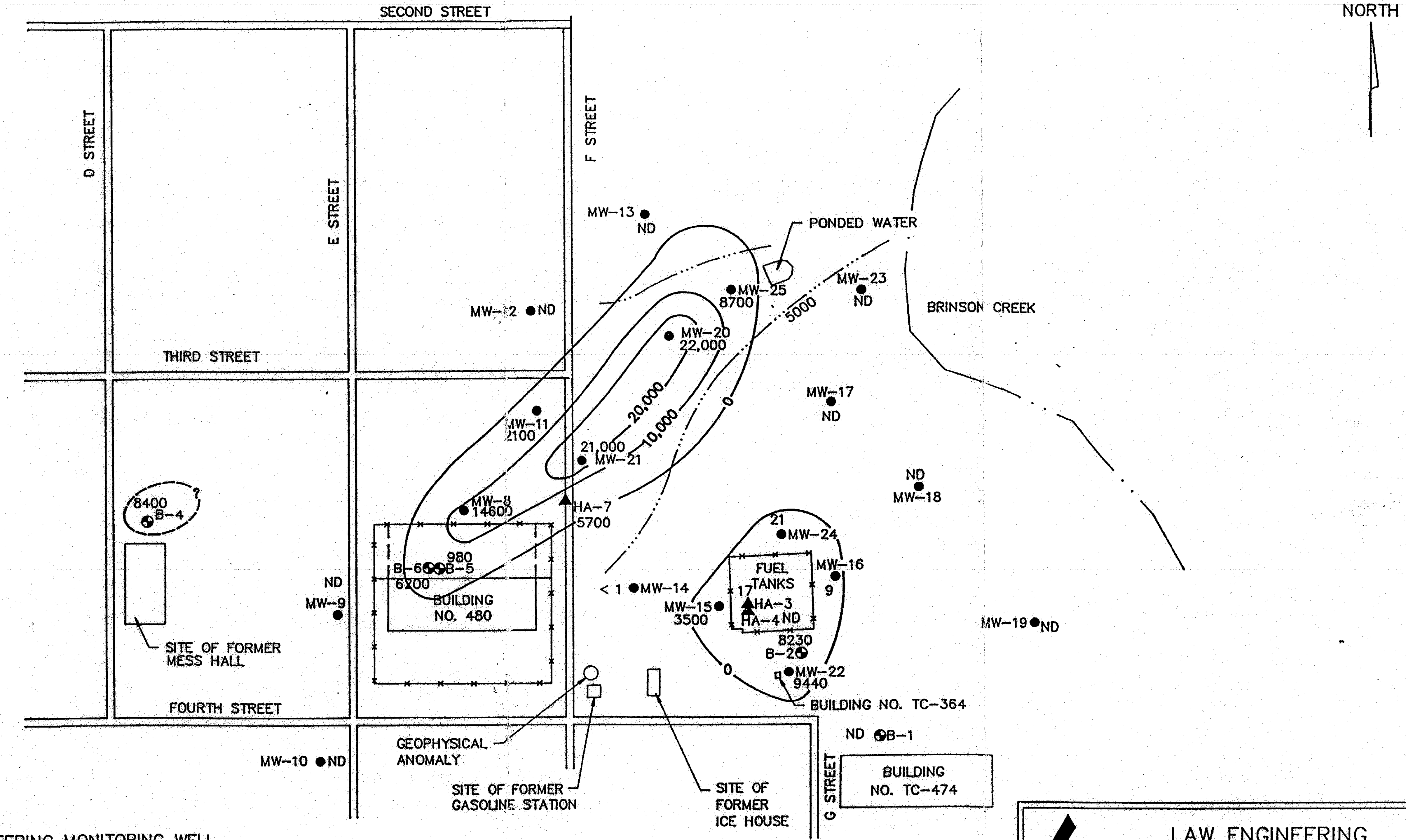
ISOPLETH MAP – TPH CONCENTRATIONS COMBINED VOLATILES AND SEMI-VOLATILES SOIL SAMPLES ABOVE THE WATER TABLE
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN: DCG	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: JPD	JOB: J47590-6014
APPROVAL: WD Dixon	DWG: 4.3

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.

01131FB82



LEGEND

—×—×—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
⊕B-1	LOCATION OF SOIL BORING
▲HA-1	LOCATION OF HAND-AUGER BORING
—···—···	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
8400	CONCENTRATION OF TPH IN mg/kg
ND	NONE DETECTED

CONTOUR INTERVAL 10,000 mg/kg

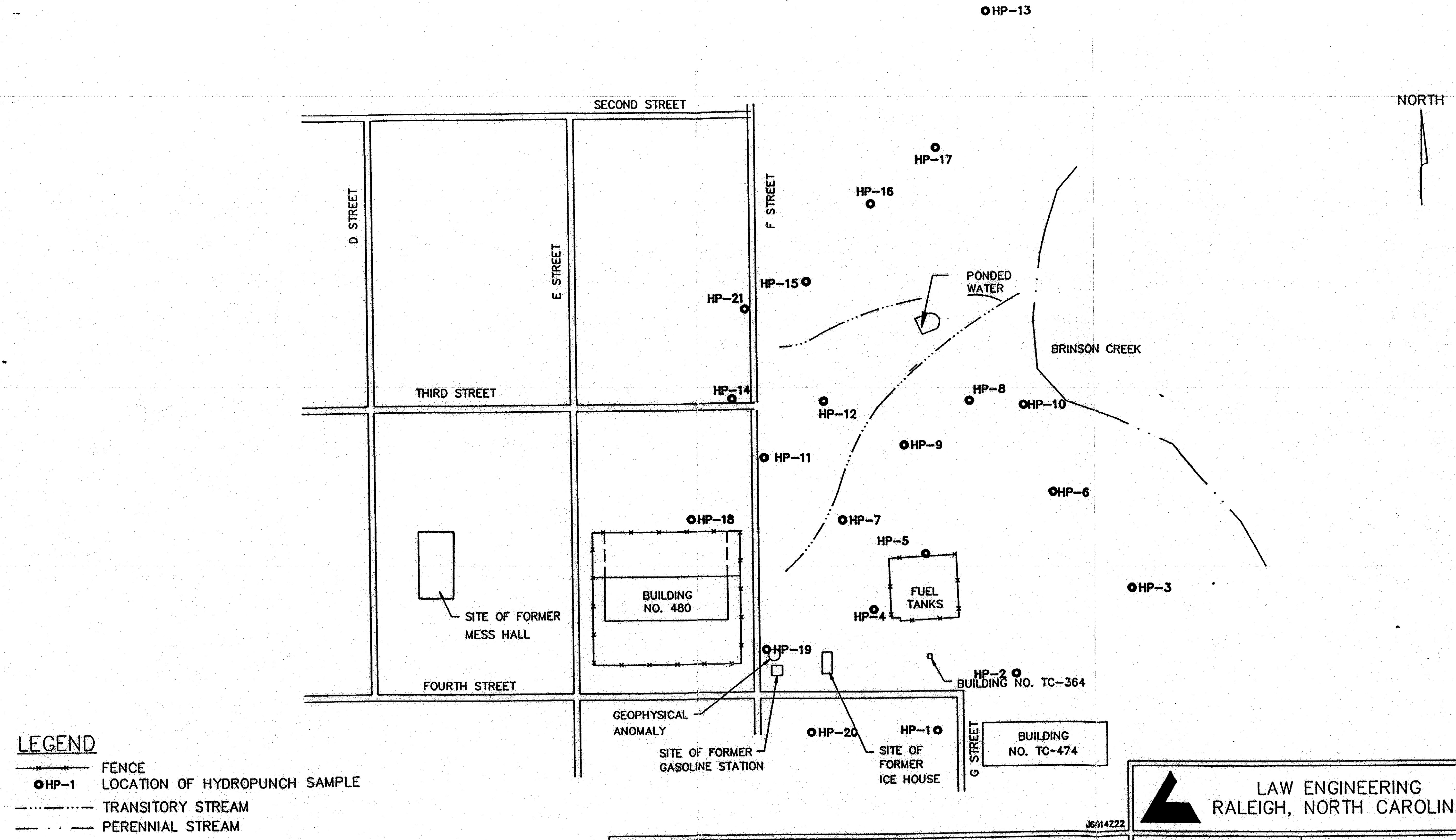
J6014809

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TPH CONCENTRATIONS
COMBINED VOLATILES AND SEMI-VOLATILES
SOIL SAMPLES WITH HIGHEST TPH CONCENTRATIONS
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.3.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.

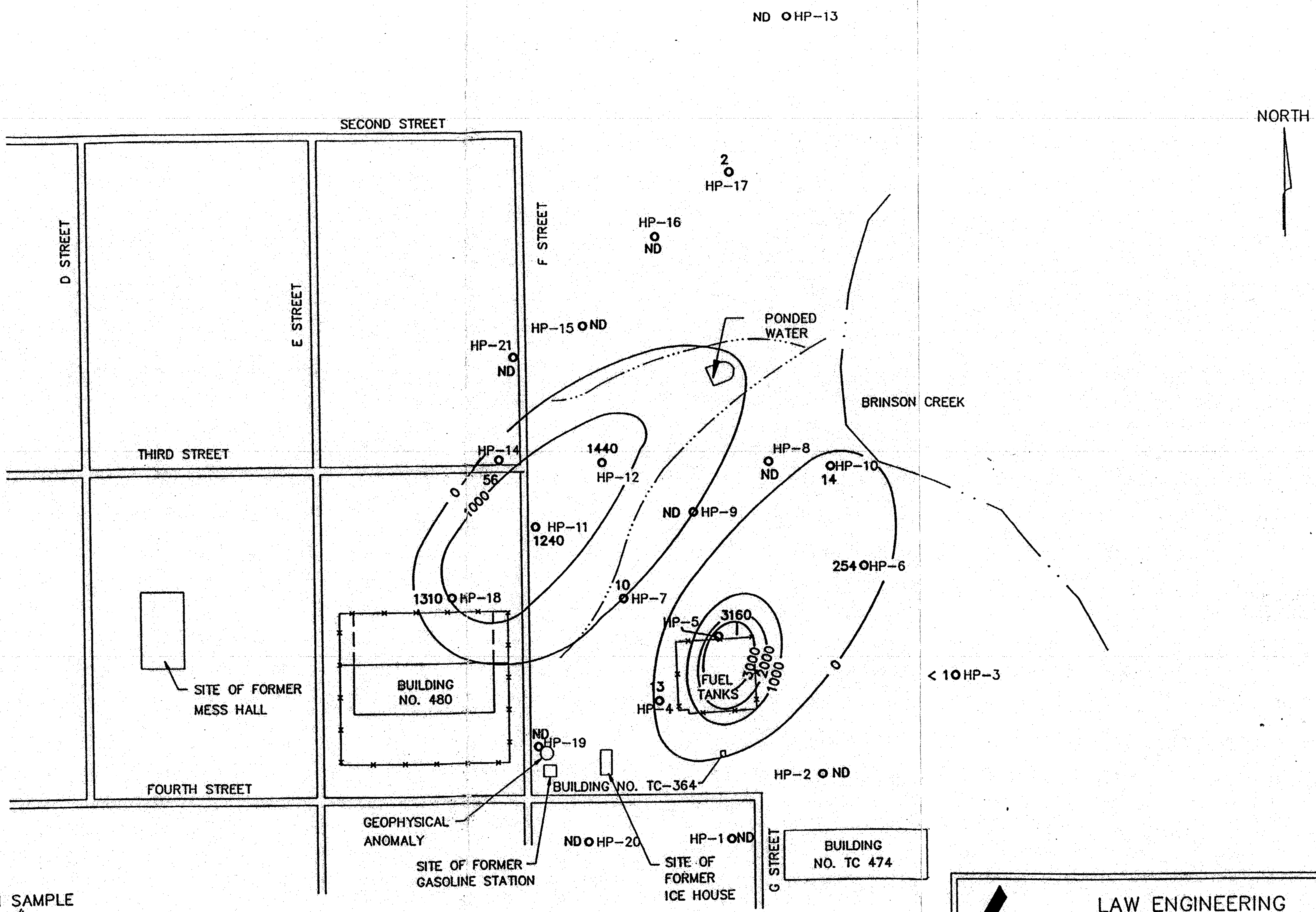


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

LOCATION OF HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.4

REFERENCE: JAMES E. STEWART AND ASSOC.;SHT 1&2 OF 2;9/13/91



LEGEND

—×—×—	FENCE
○HP-1	LOCATION OF HYDROPUNCH SAMPLE
3160	BTEX CONCENTRATION IN ug/L
ND	NONE DETECTED
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

NOTE: CONTOUR INTERVAL 1000 ug/L

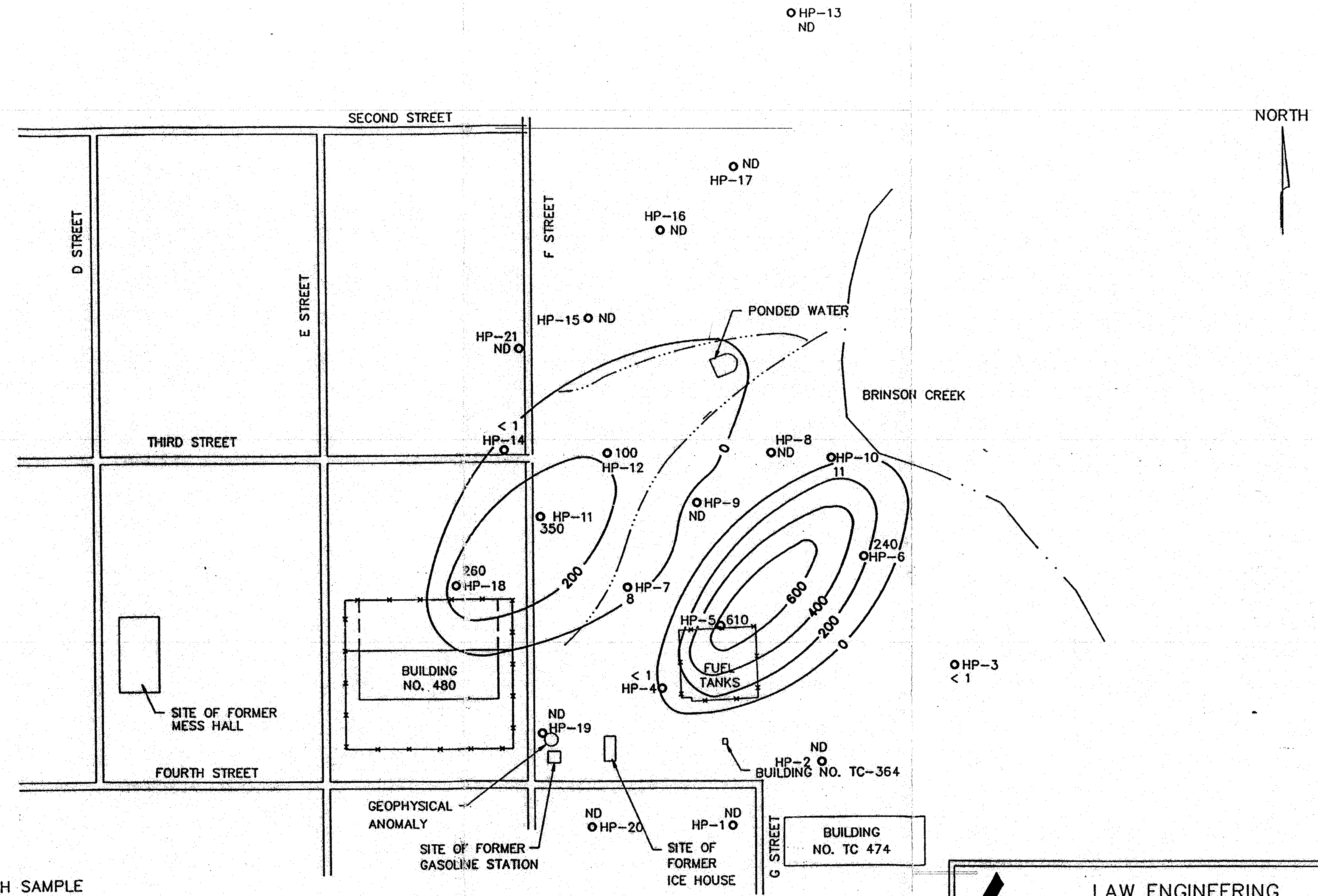
J60148Z0

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP
COMBINED BTEX CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: OCT. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.5

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

FENCE

O HP-1 LOCATION OF HYDROPUNCH SAMPLE

TRANSITORY STREAM

PERENNIAL STREAM

8905 BENZENE CONCENTRATION IN ug/L

ND NONE DETECTED

CONTOUR INTERVAL = 200 ug/L

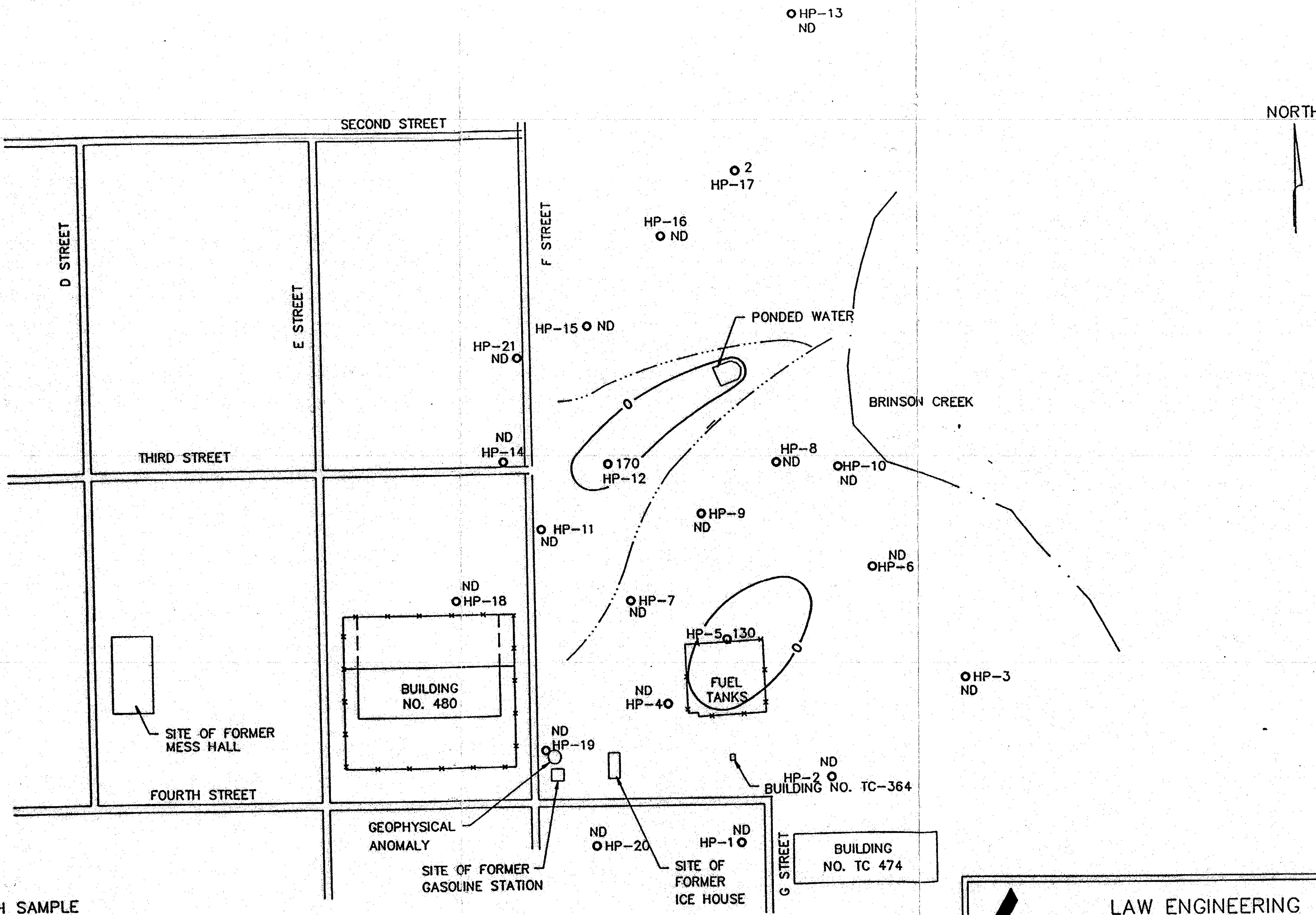
J6014B10

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP - BENZENE CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: RAK	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.5.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2; 9/13/91.



LEGEND

—×—×—	FENCE
○ HP-1	LOCATION OF HYDROPUNCH SAMPLE
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
8905	TOLUENE CONCENTRATION IN ug/L
ND	NONE DETECTED

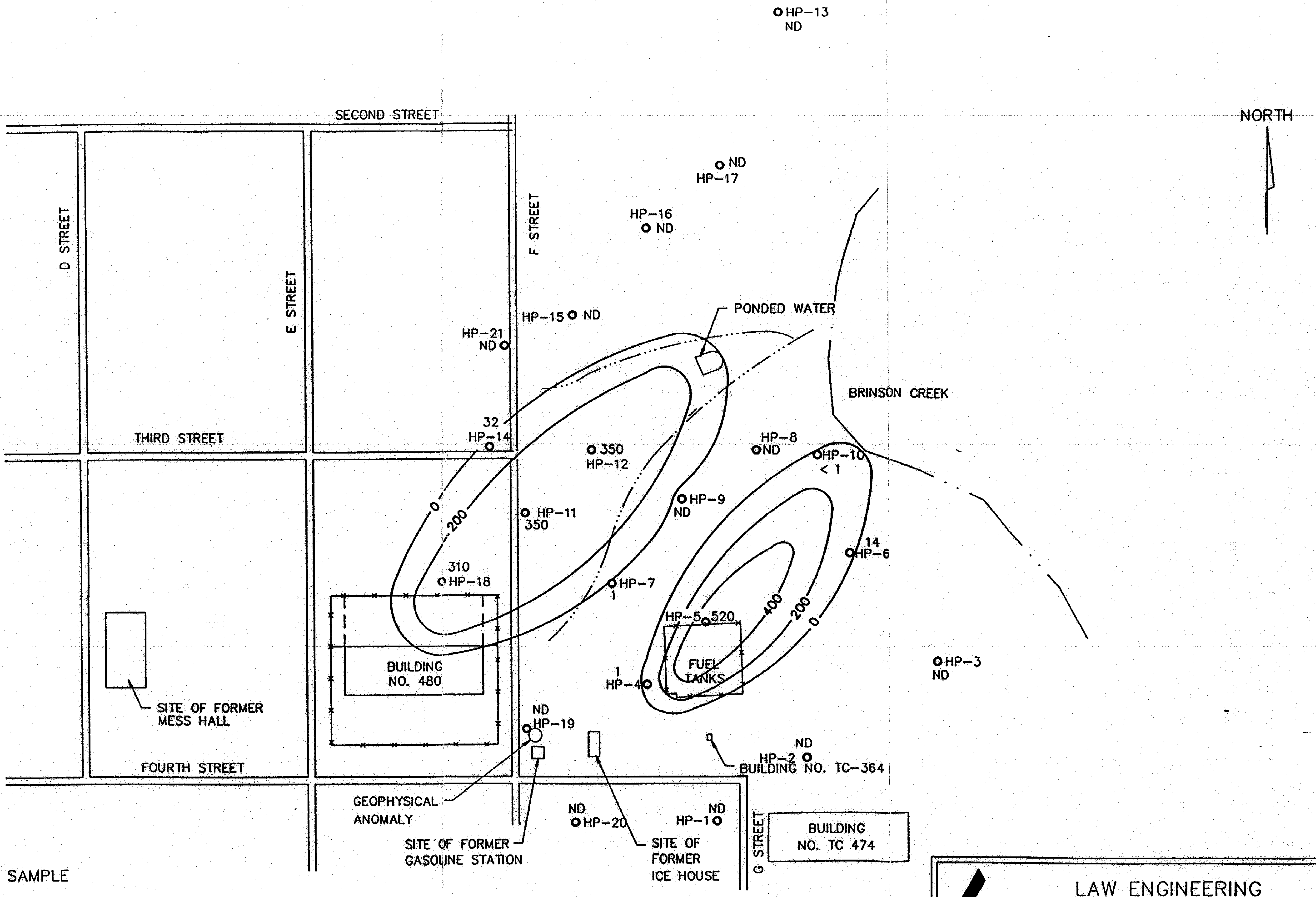
J6014B12

ISOPLETH MAP – TOLUENE CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2; 9/13/91.

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: RSE	JOB: J47590-6014
APPROVAL: WDD, taw	DWG: 4.5.2



LEGEND

—x—x—	FENCE
○ HP-1	LOCATION OF HYDROPUNCH SAMPLE
·····—·····	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
8905	ETHYLBENZENE CONCENTRATION IN ug/L
ND	NONE DETECTED

CONTOUR INTERVAL = 200 ug/L

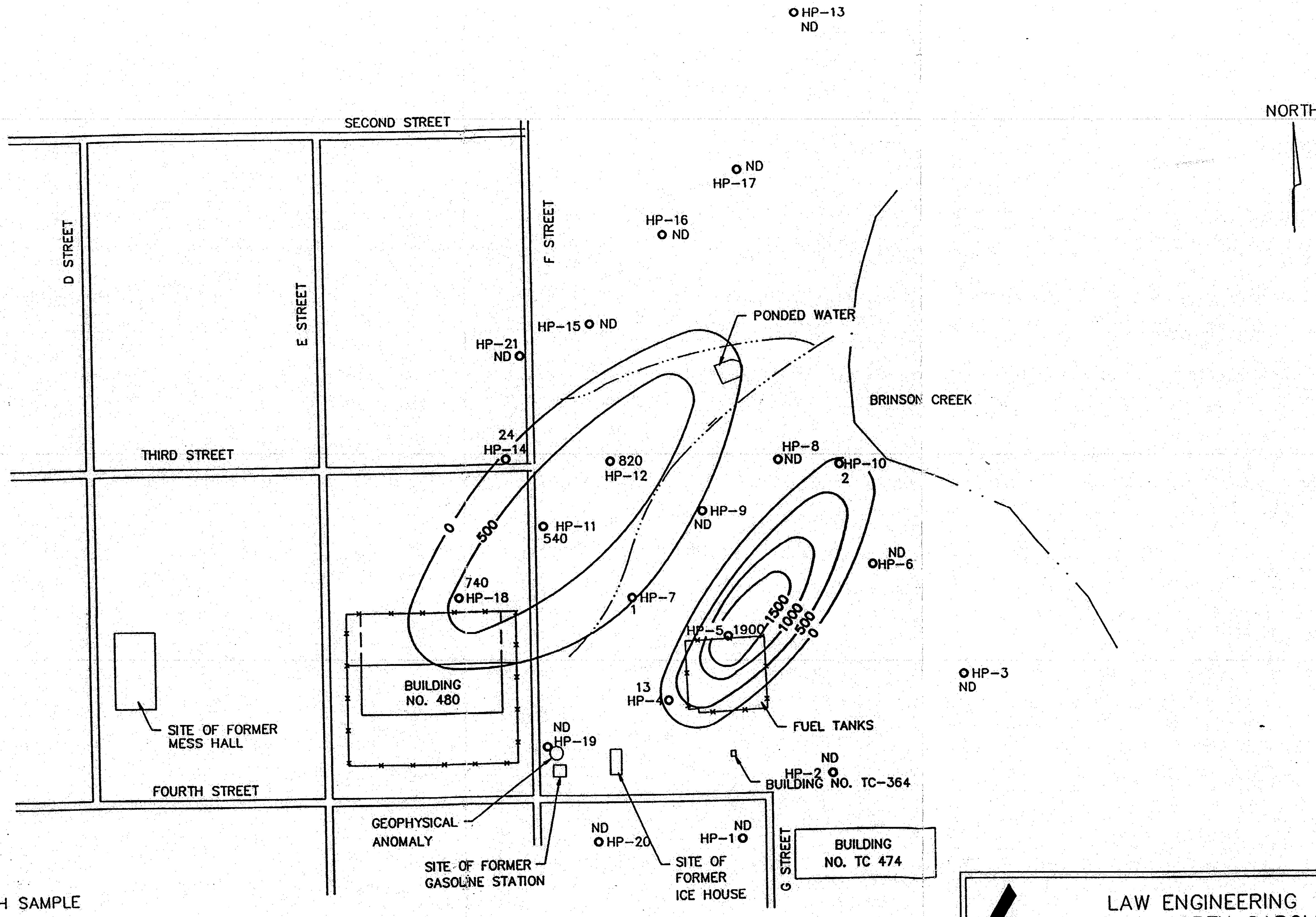
J6014B11

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – ETHYLBENZENE CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: DAL	JOB: J47590-6014
APPROVAL: WSDixon	DWG: 4.5.3

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2; 9/13/91.



LEGEND

—x—x—	FENCE
○ HP-1	LOCATION OF HYDROPUNCH SAMPLE
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM
8905	XYLENES CONCENTRATION IN ug/L
ND	NONE DETECTED

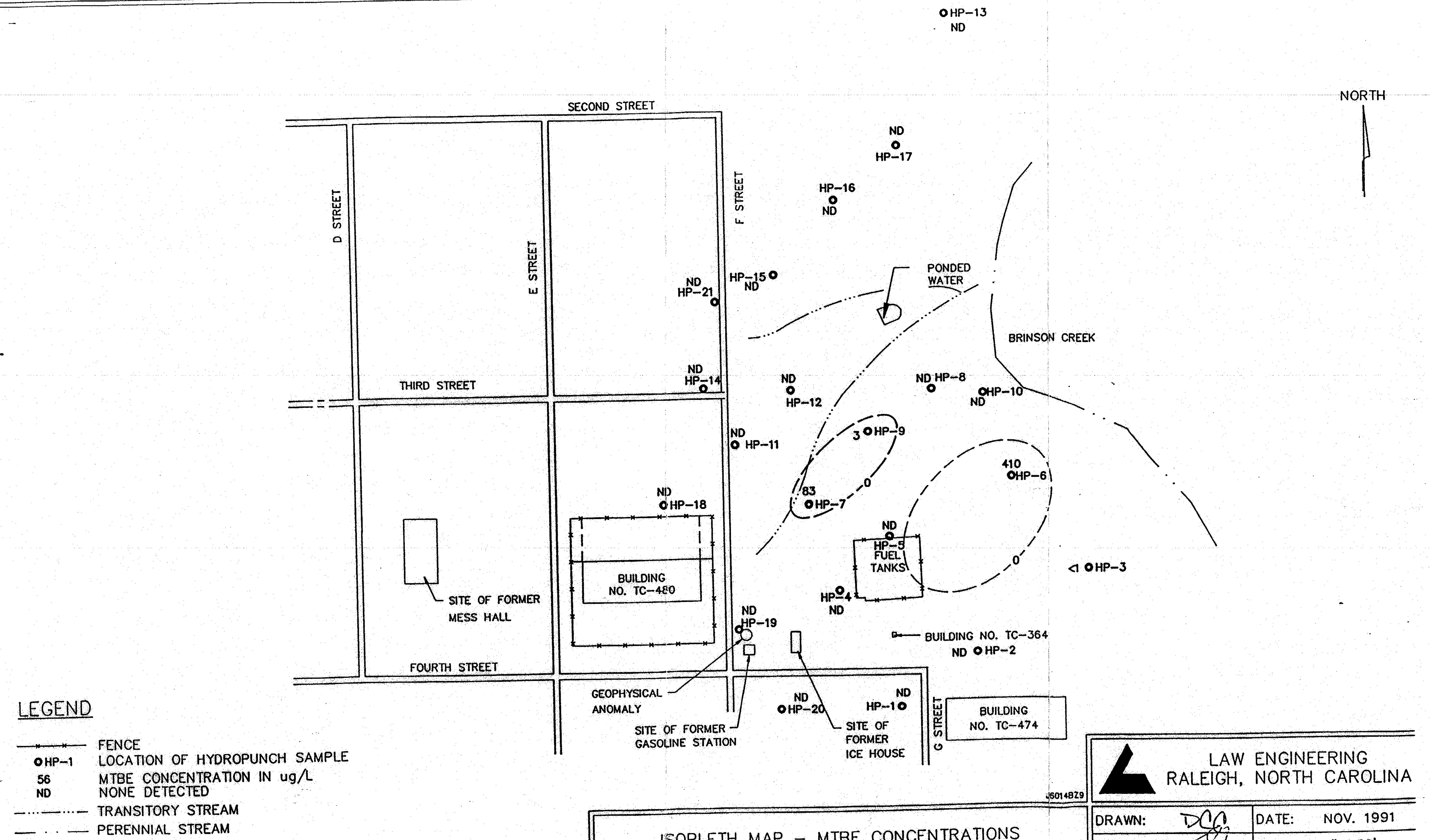
CONTOUR INTERVAL = 500 ug/L

ISOPLETH MAP – TOTAL XYLENES CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2; 9/13/91.

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WJDixon	DWG: 4.5.4

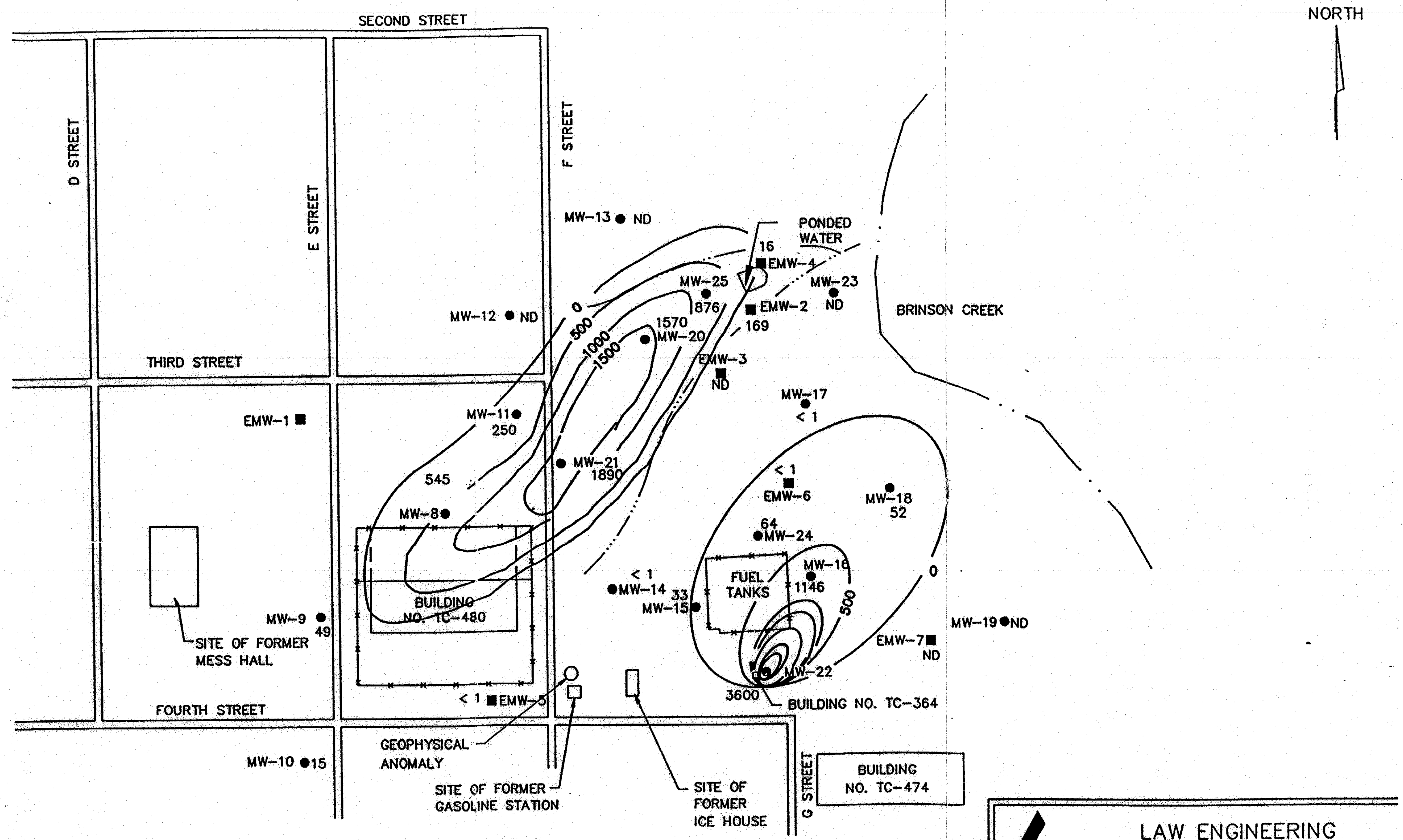


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP - MTBE CONCENTRATIONS
HYDROPUNCH GROUND-WATER SAMPLES
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCG	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WADixon	JOB: J47590-6014
APPROVAL: WADixon	DWG: 4.6

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

—×—×— FENCE

■EMW-1 LOCATION OF PRE-EXISTING MONITORING WELL

●MW-1 LOCATION OF LAW ENGINEERING MONITORING WELL

8905 BTEX CONCENTRATION IN ug/L

ND NONE DETECTED

—···—···— TRANSITORY STREAM

— · · — PERENNIAL STREAM

CONTOUR INTERVAL = 500 ug/L

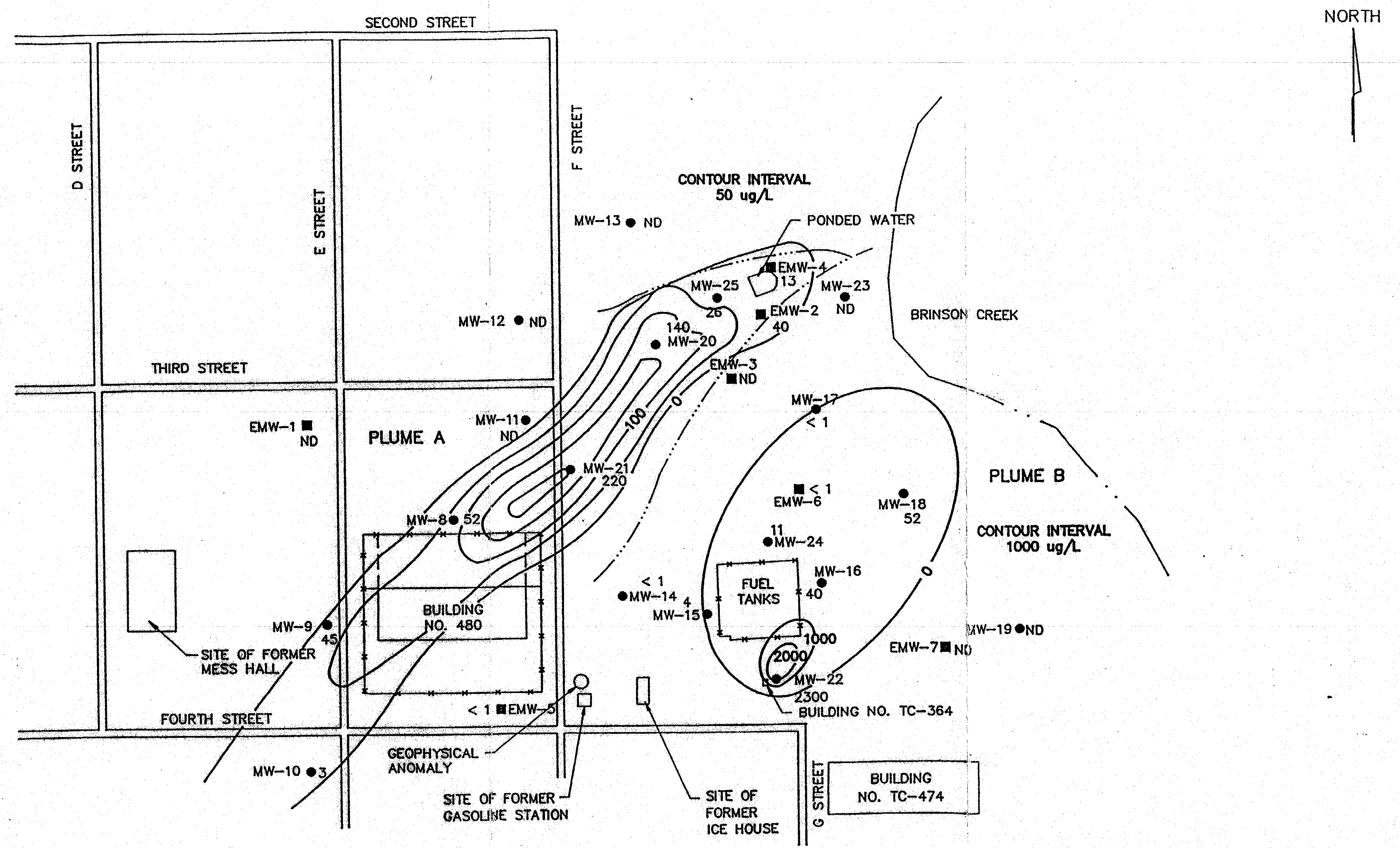
J6019Z19

ISOPLETH MAP – COMBINED BTEX CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN: DAC	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WADixon	JOB: J47590-6014
APPROVAL: WADixon	DWG: 4.7

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
8905	BENZENE CONCENTRATION IN ug/L
ND	NONE DETECTED
——·····——	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

PLUME A CONTOUR INTERVAL 50 ug/L
PLUME B CONTOUR INTERVAL 1000 ug/L

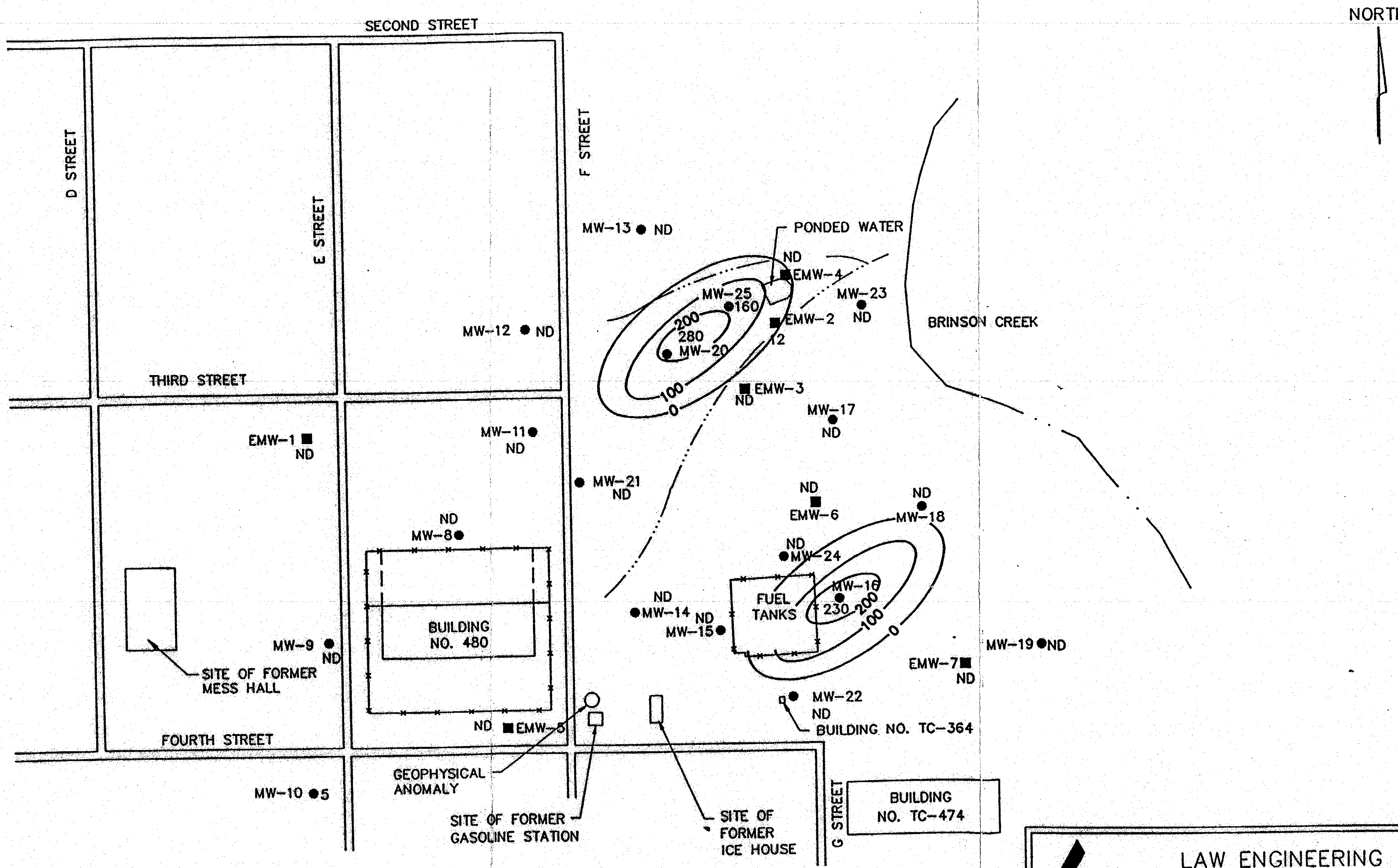
J6014805

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – BENZENE CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.7.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
8905	TOLUENE CONCENTRATION IN ug/L
ND	NONE DETECTED
—···—···—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

CONTOUR INTERVAL = 100 ug/L

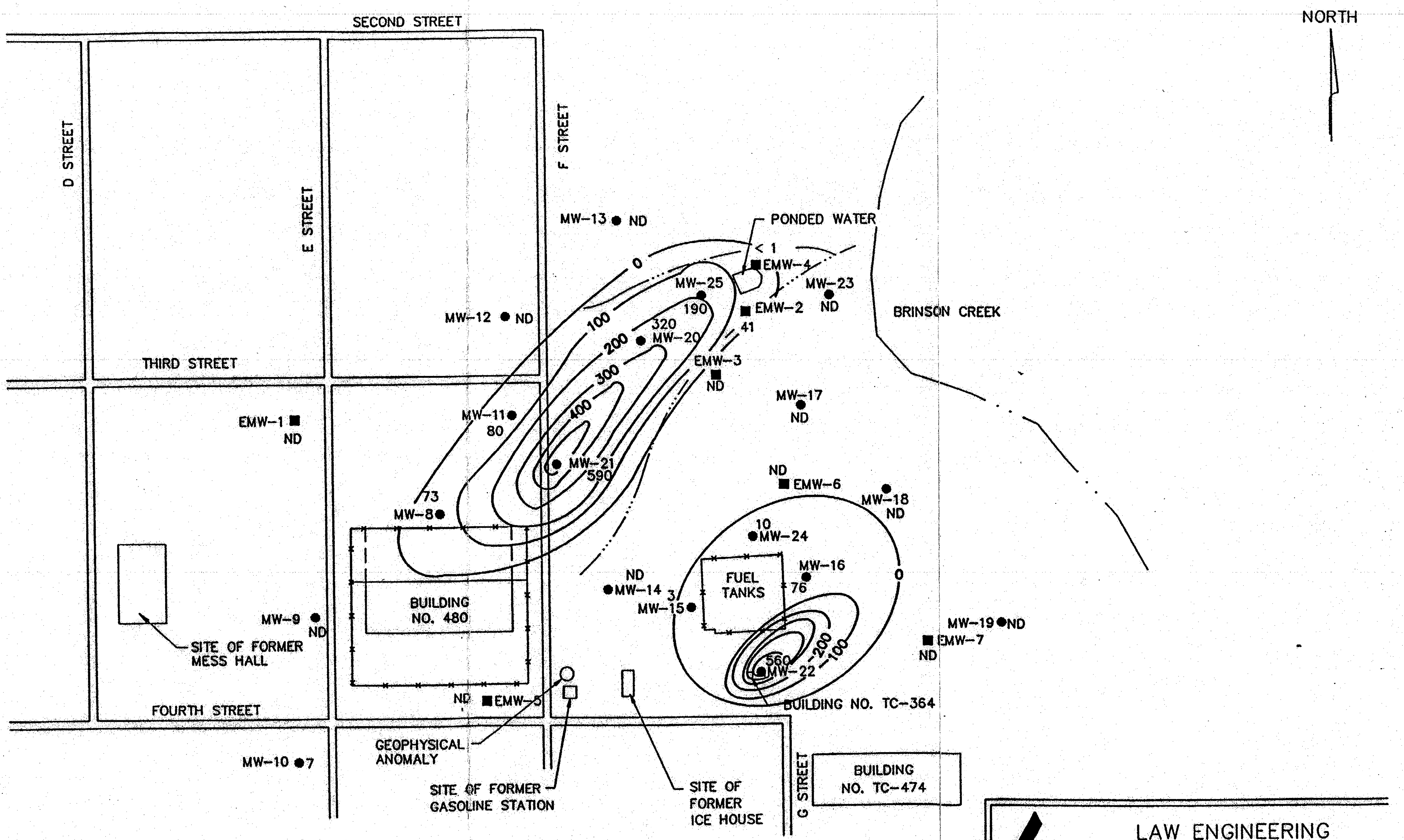
J6014B06

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TOLUENE CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: BAL	JOB: J47590-6014
APPROVAL: WAD	DWG: 4.7.2

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
8905	ETHYLBENZENE CONCENTRATION IN ug/L
ND	NONE DETECTED
—···—···—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

CONTOUR INTERVAL = 100 ug/L

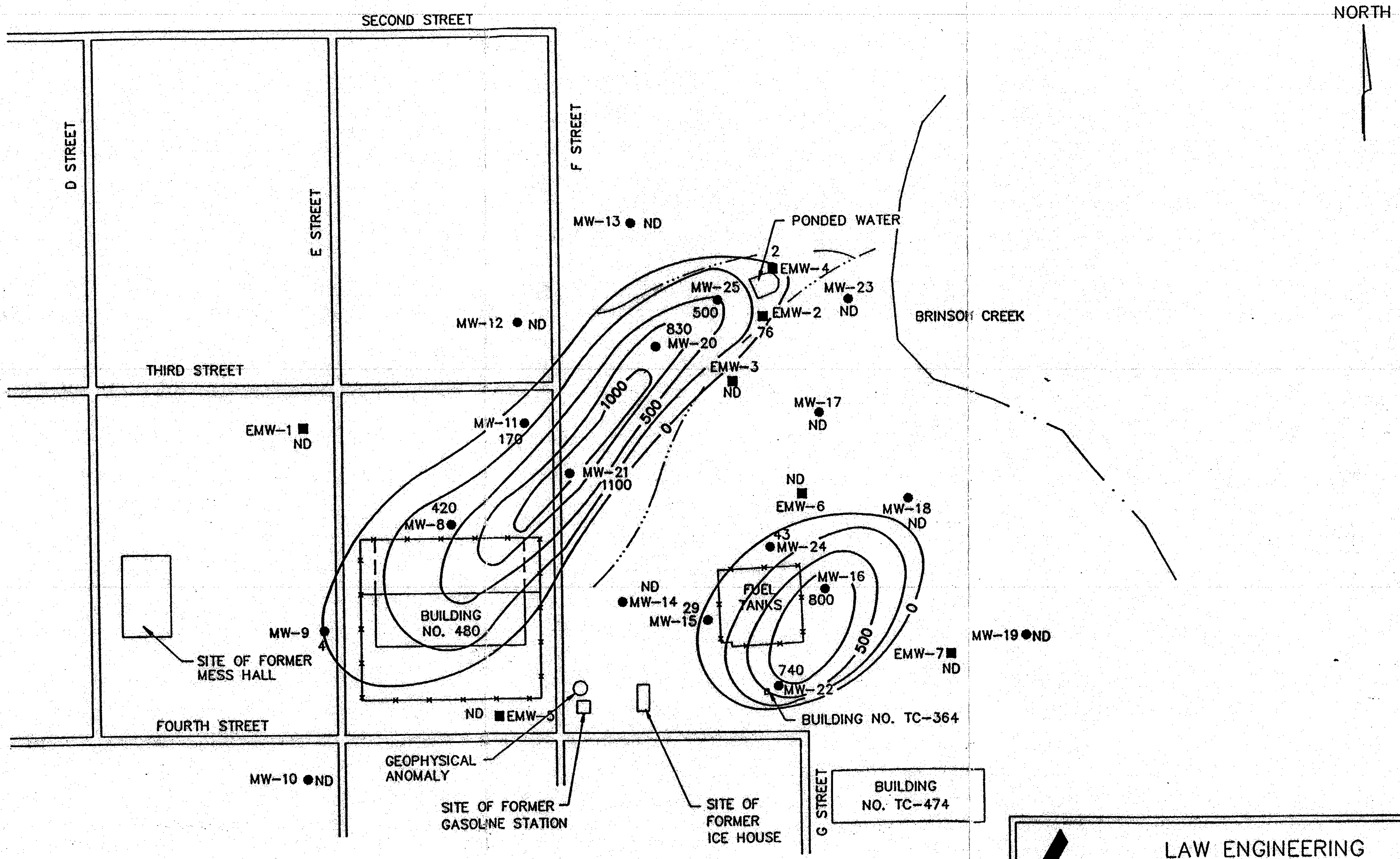
J6014B07

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – ETHYLBENZENE CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: EAC	JOB: J47590-6014
APPROVAL:	DWG: 4.7.3

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
8905	XYLENES CONCENTRATION IN ug/L
ND	NONE DETECTED
—·······—·····	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

CONTOUR INTERVAL = 250 ug/L

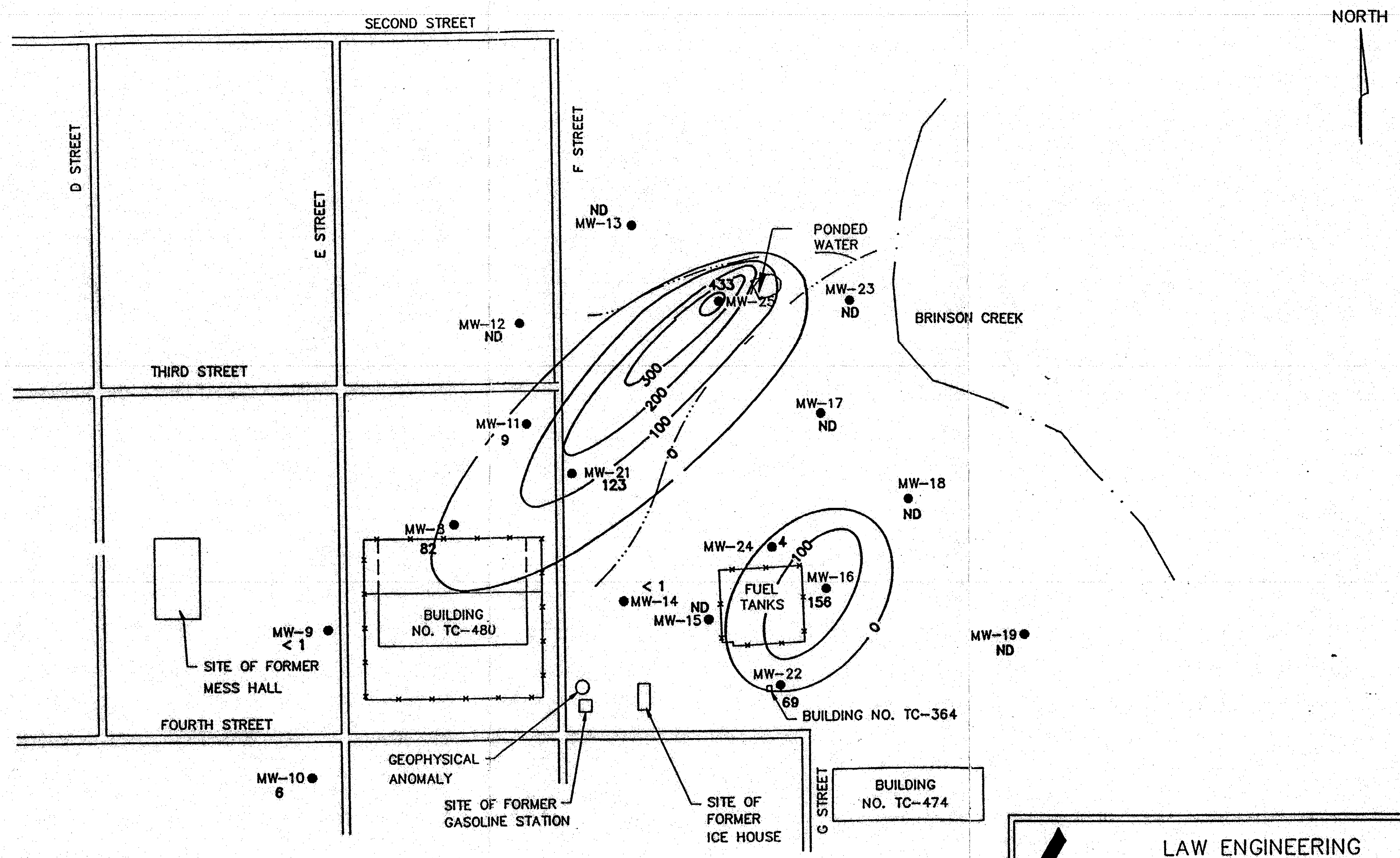
J6119B08

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP
TOTAL XYLENES CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: BAK	JOB: J47590-6014
APPROVAL: WADixon	DWG: 4.7.4

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×——×—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
123	CONCENTRATION OF BTEX IN ug/L
ND	NONE DETECTED
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

NOTE: CONTOUR INTERVAL 100 ug/L.

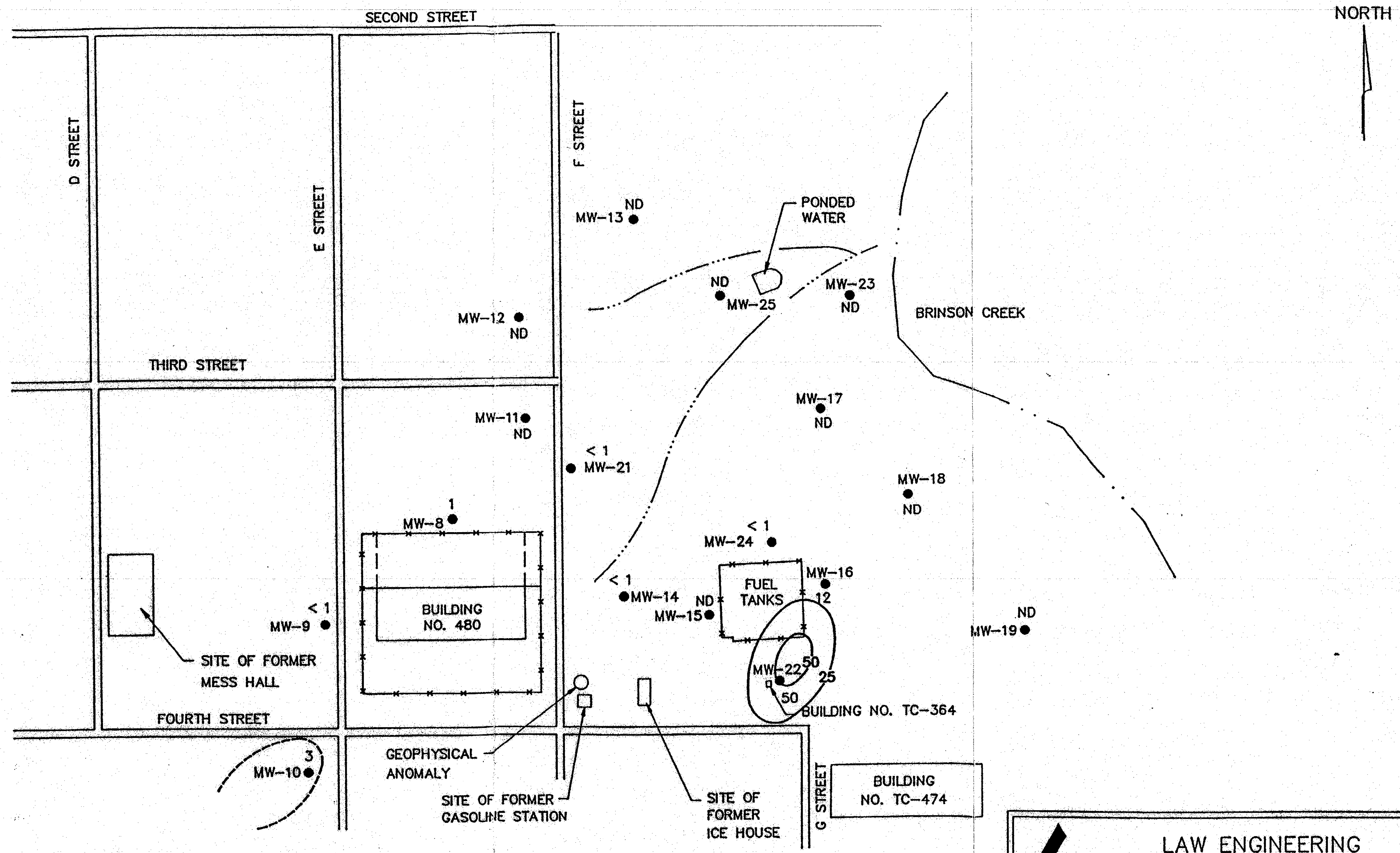
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – COMBINED BTEX CONCENTRATIONS WATER SAMPLES FROM DEEP SCREENED INTERVAL

CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DGC	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WDD	JOB: J47590-6014
APPROVAL: WDD	DWG: 4.8

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

—x—x—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
123	CONCENTRATION OF BENZENE IN ug/L
ND	NONE DETECTED
—·····—····—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

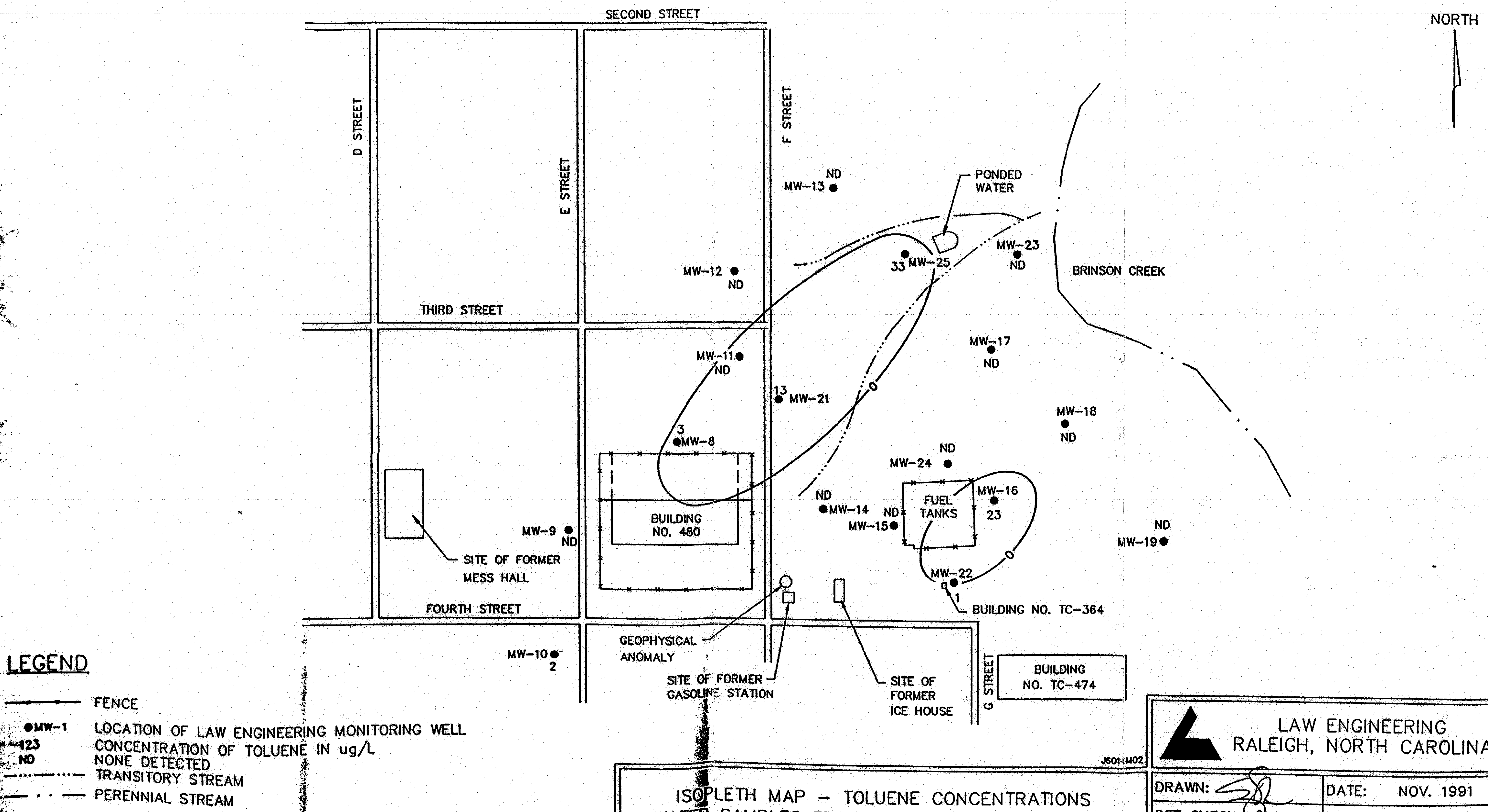
J6014M01

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – BENZENE CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: WAD	DWG: 4.8.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.

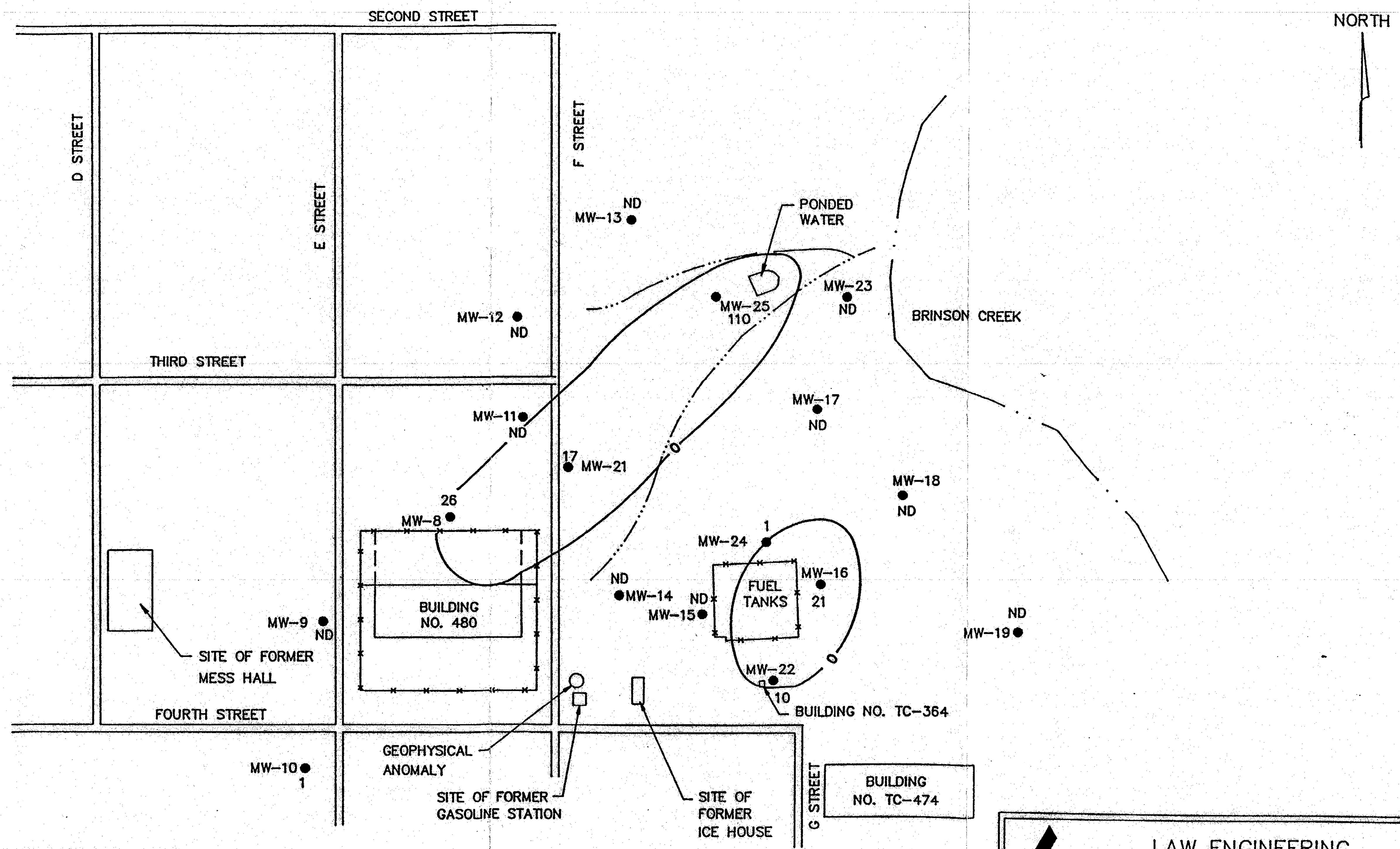


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TOLUENE CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: ECC	SCALE: 1"=150'
ENG CHECK: BAK	JOB: J47590-6014
APPROVAL: WBDixon	DWG: 4.8.2

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

—×—×—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
123	CONCENTRATION OF ETHYLBENZENE IN ug/L
ND	NONE DETECTED
—·····—····—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

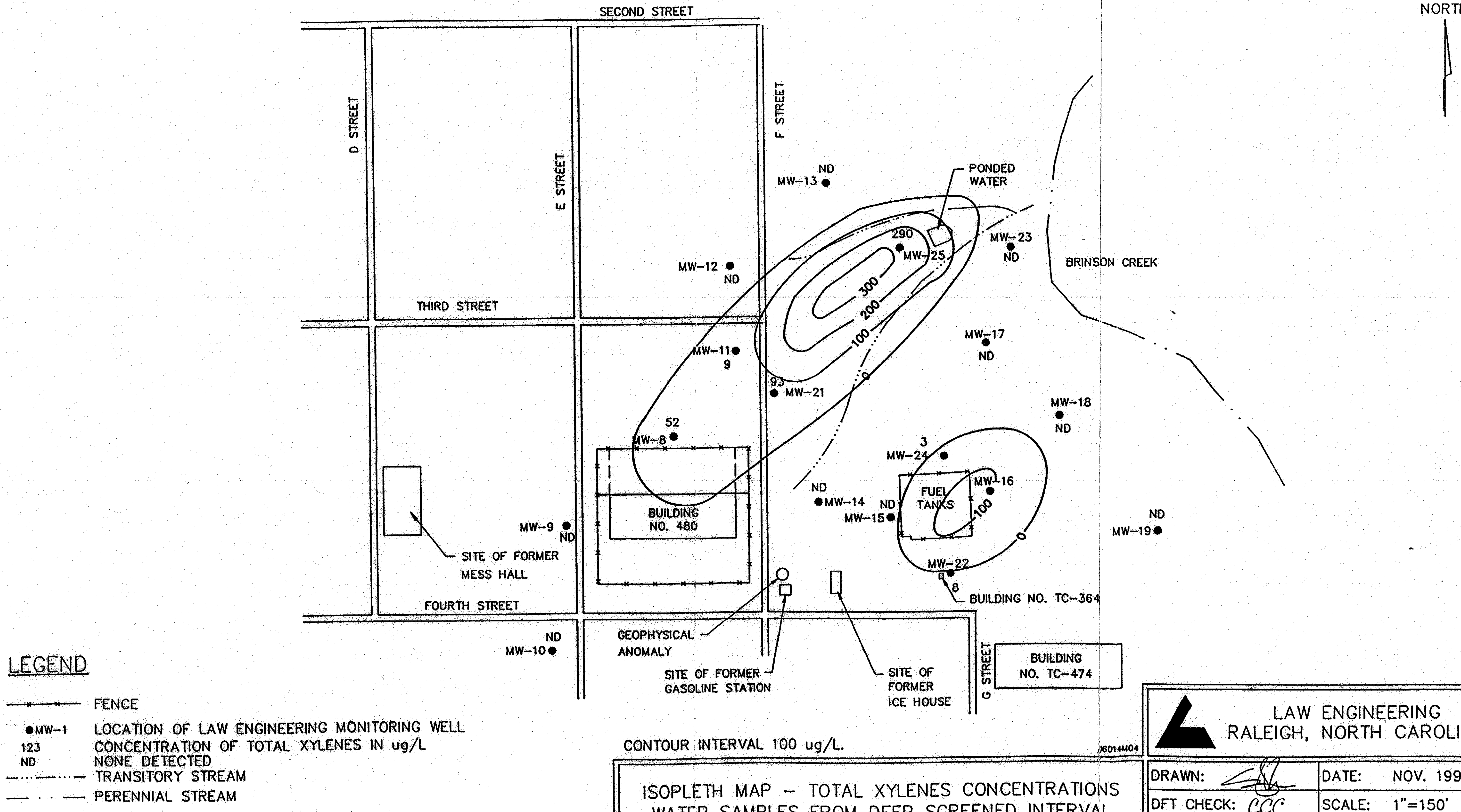
J6014M03

ISOPLETH MAP – ETHYLBENZENE CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL: W. A. Dixon	DWG: 4.8.3

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.

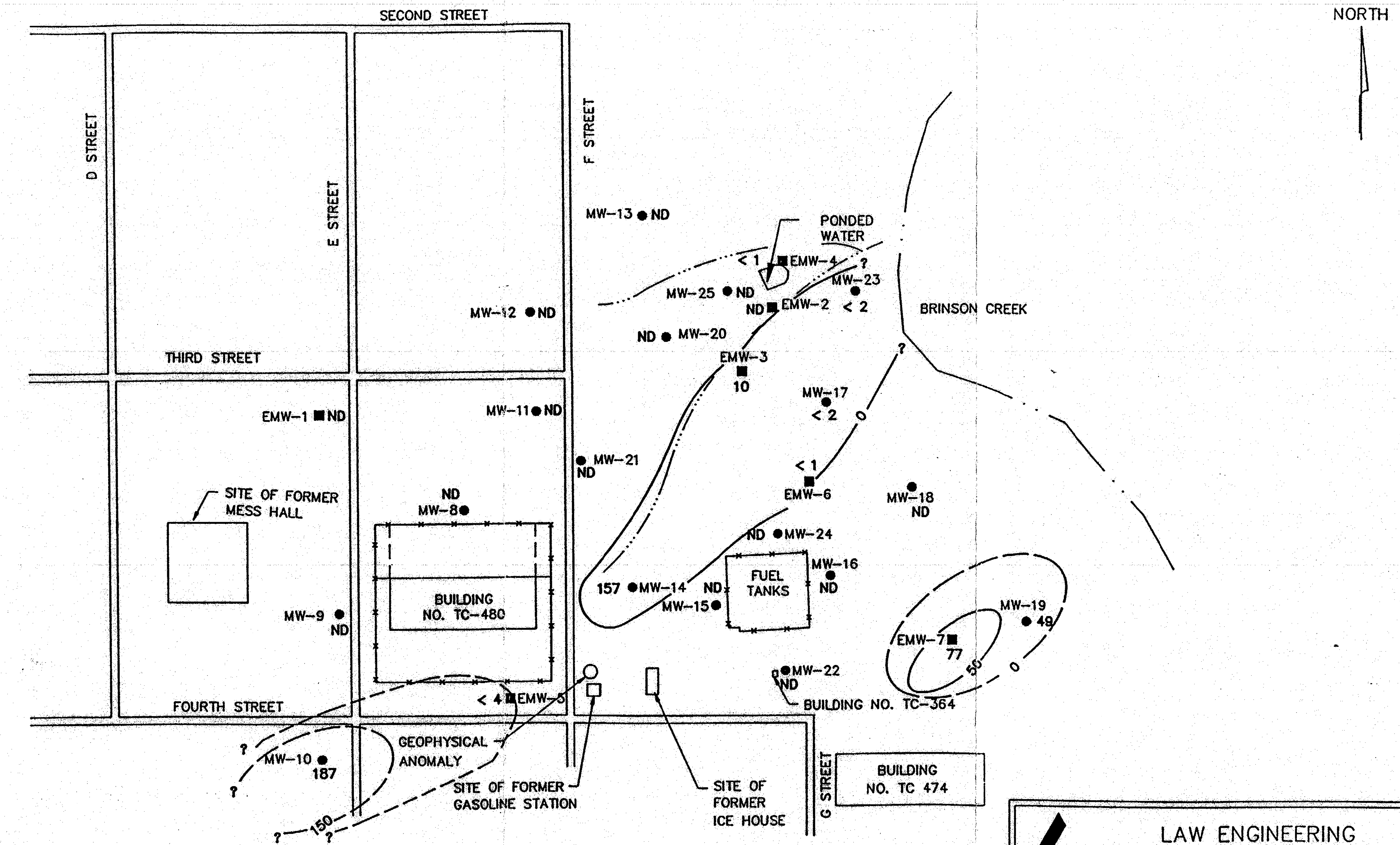


LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TOTAL XYLENES CONCENTRATIONS WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN:	DATE: NOV. 1991
DFT CHECK: CCC	SCALE: 1"=150'
ENG CHECK: BAK	JOB: J47590-6014
APPROVAL: WADixon	DWG: 4.8.4

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91: USGS JACKSONVILLE SOUTH, N.C.



LEGEND

—x—x—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
49	CONCENTRATION OF CHLORINATED COMPOUNDS IN ug/L
ND	NONE DETECTED
—···—·—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

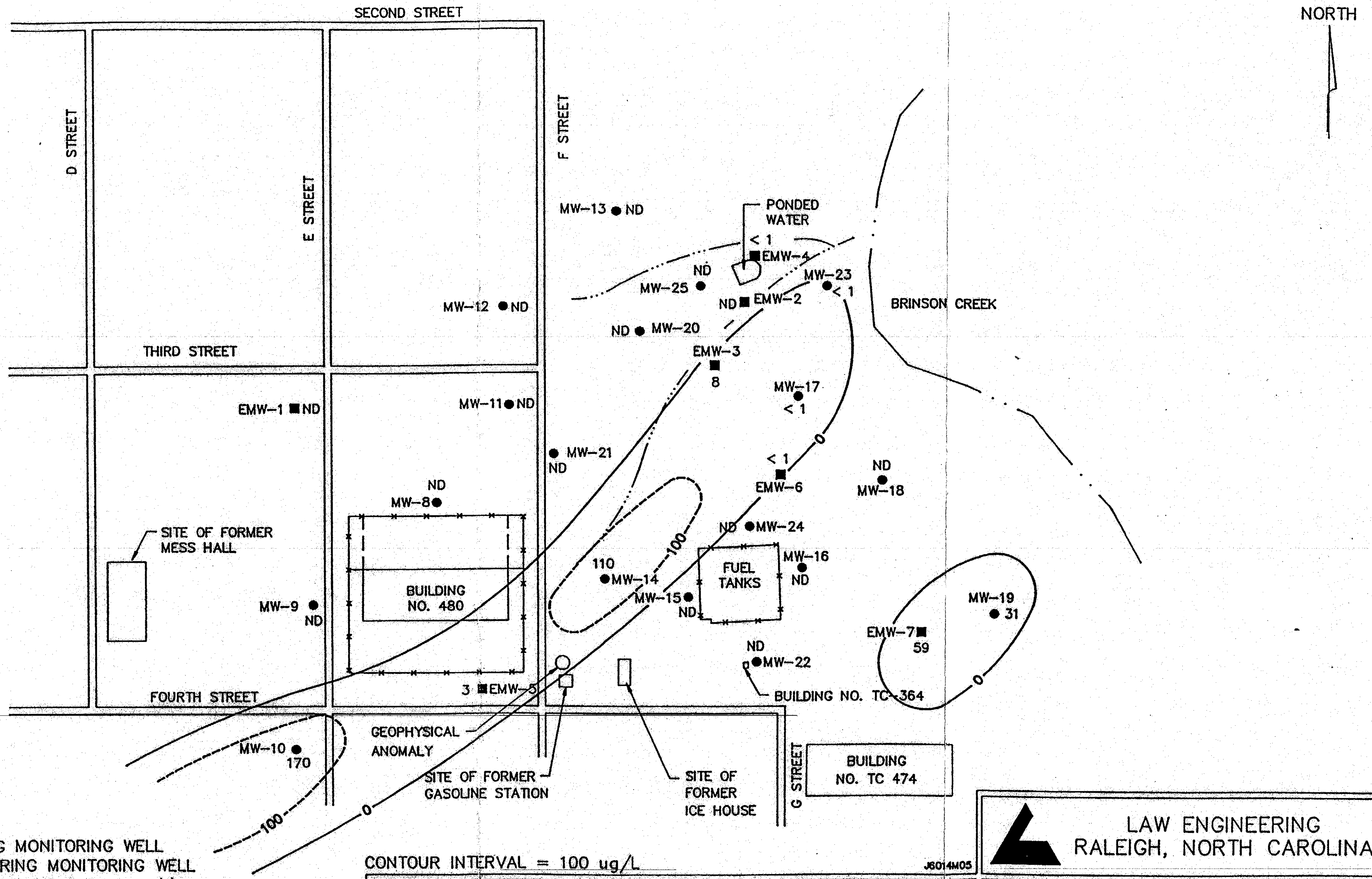
J6014Z20

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP
COMBINED CONCENTRATIONS OF CHLORINATED COMPOUNDS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WDD	JOB: J47590-6014
APPROVAL: WDD	DWG: 4.9

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
49	CONCENTRATION OF TRICHLOROETHENE IN ug/L\
ND	NONE DETECTED
----·-----·--	TRANSITORY STREAM
—— · · ——	PERENNIAL STREAM

CONTOUR INTERVAL = 100 ug/L

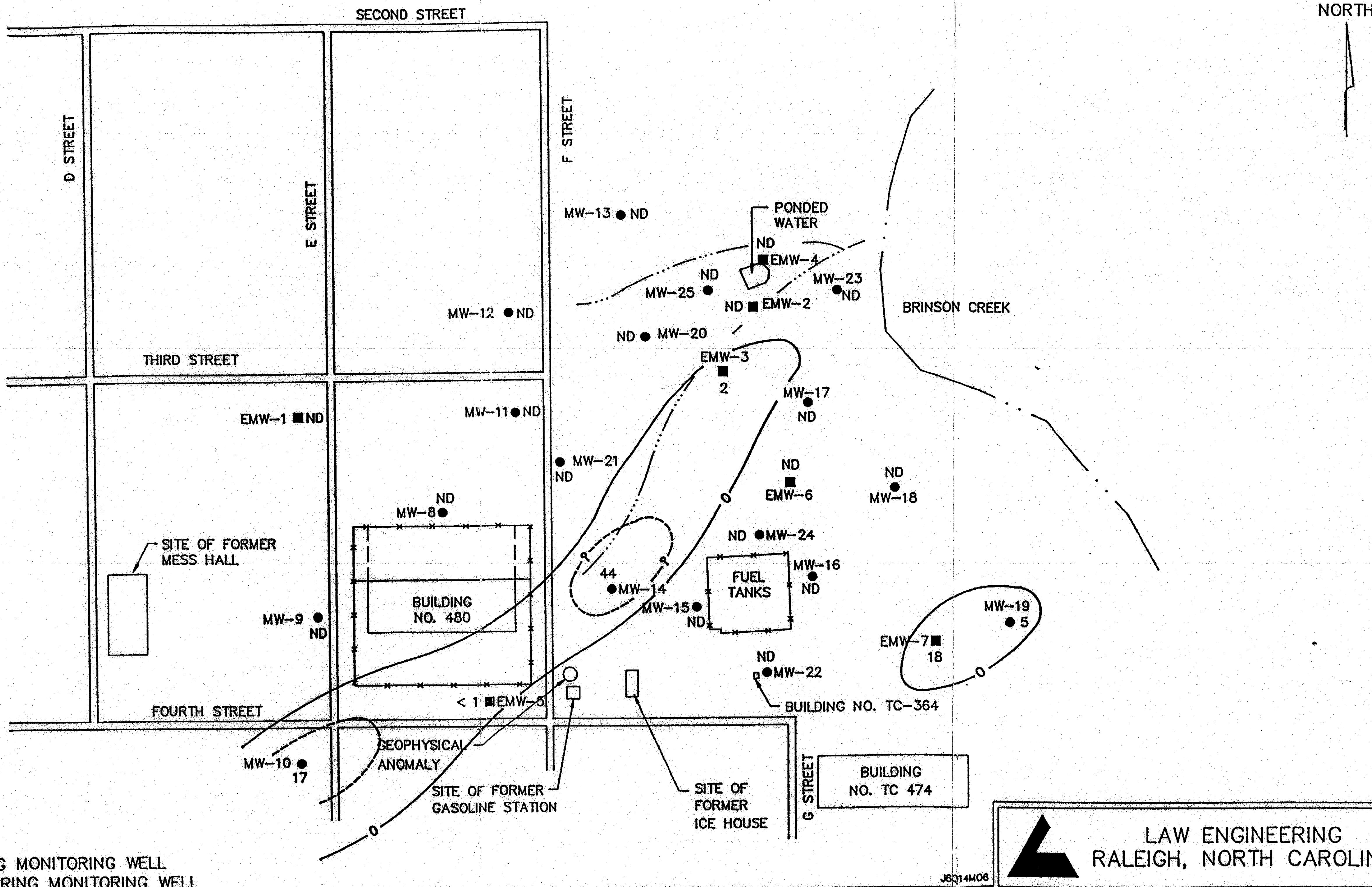
J6014M05

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TRICHLOROETHENE CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: RAkolli	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.9.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1 & 2 OF 2; 9/13/91.



LEGEND

———×———×——— FENCE

■EMW-1 LOCATION OF PRE-EXISTING MONITORING WELL

●MW-1 LOCATION OF LAW ENGINEERING MONITORING WELL

49 CONCENTRATION OF TRANS-1,2-DICHLOROETHENE IN ug/L

ND NONE DETECTED

——·——····· TRANSITORY STREAM

—— · · —— PERENNIAL STREAM

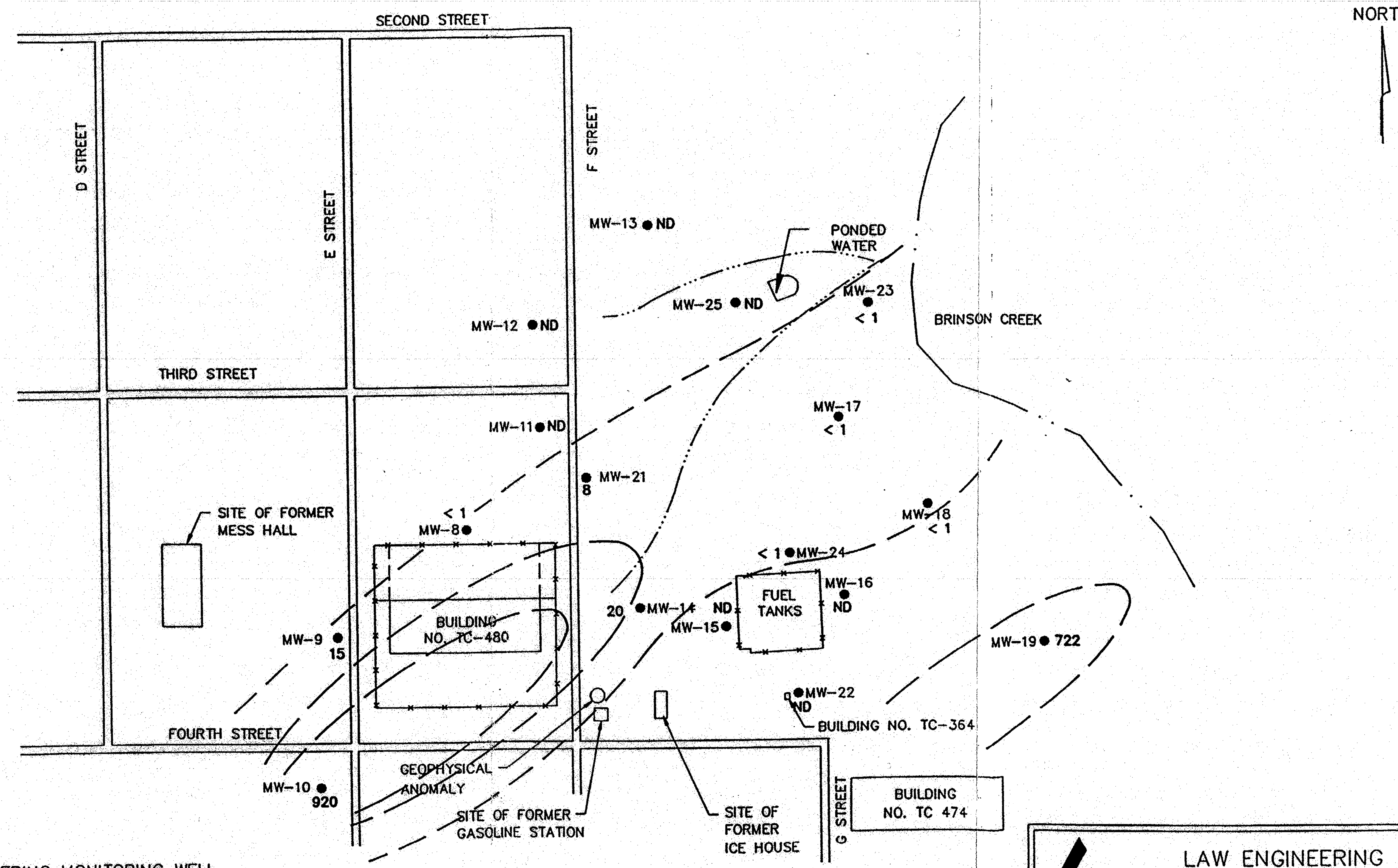
LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TRANS-1,2-DICHLOROETHENE CONCENTRATIONS

WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL:	DWG: 4.9.2

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

—×—×—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
920	CONCENTRATION OF CHLORINATED COMPOUNDS IN ug/L
ND	NONE DETECTED
—···—···	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

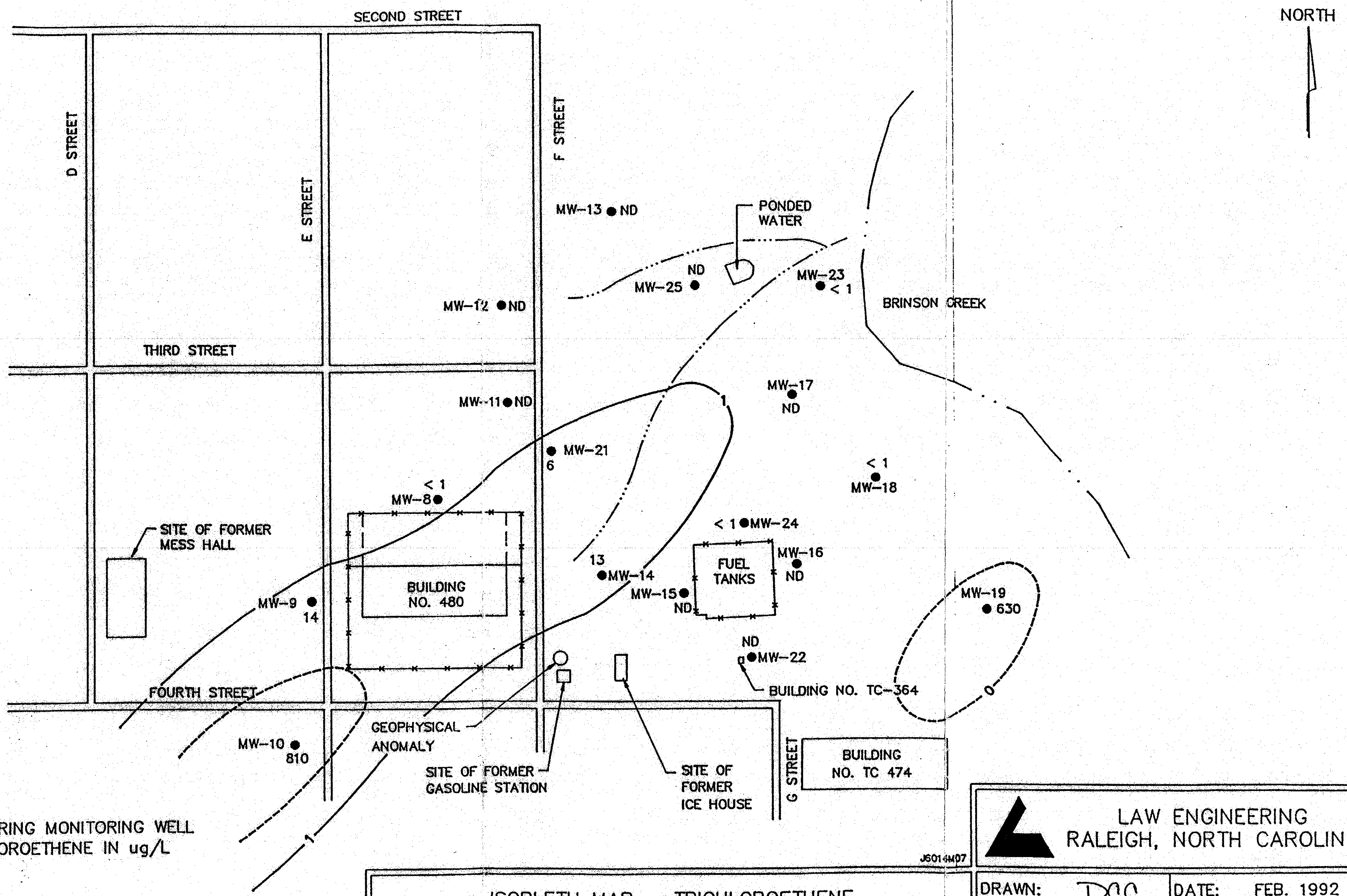
J6014Z18

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP
COMBINED CONCENTRATIONS OF CHLORINATED COMPOUNDS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: WDDixon	JOB: J47590-6014
APPROVAL: WDDixon	DWG: 4.10

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

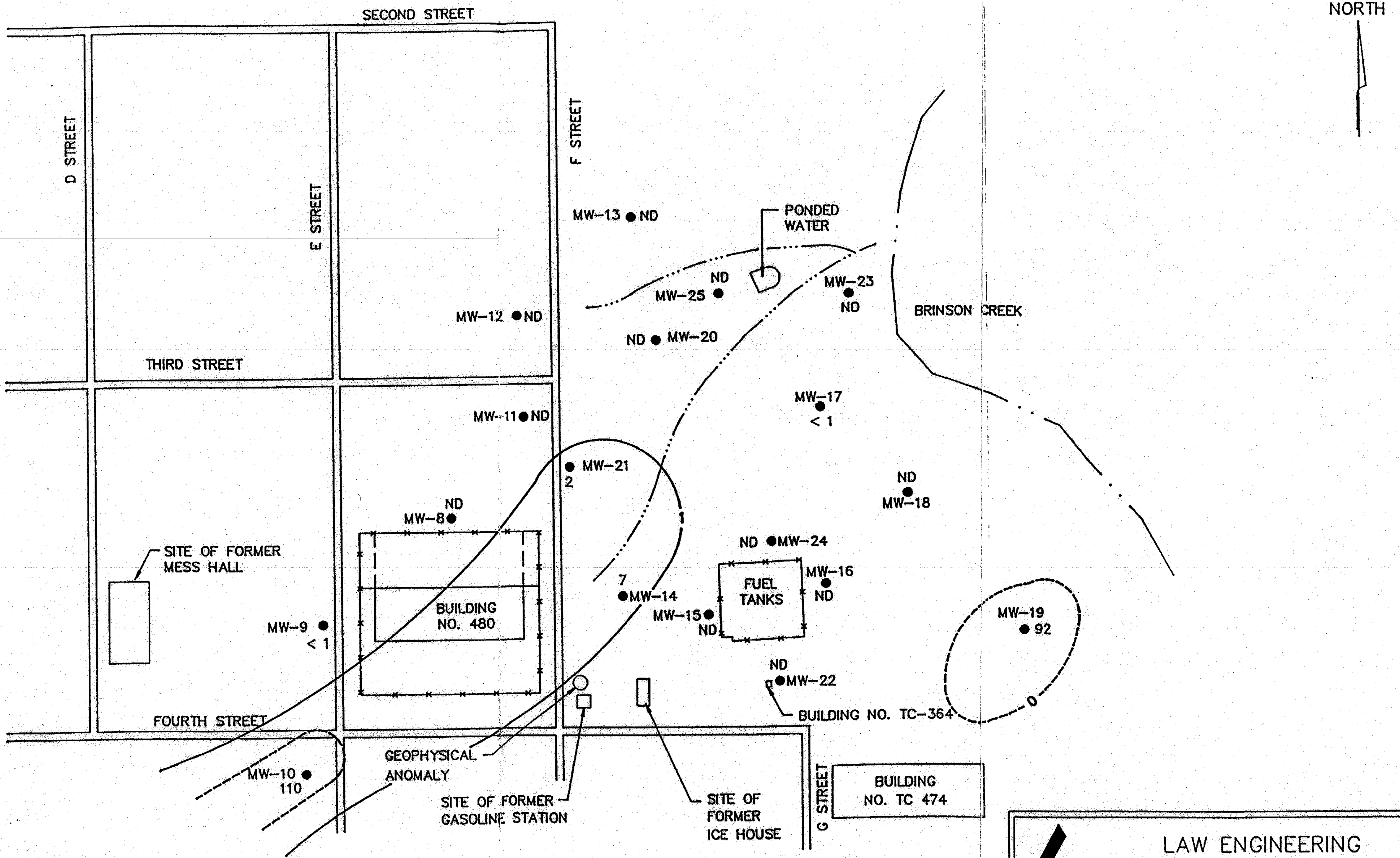
—×——×—	FENCE
●MW–1	LOCATION OF LAW ENGINEERING MONITORING WELL
49	CONCENTRATION OF TRICHLOROETHENE IN ug/L
ND	NONE DETECTED
—···——···	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TRICHLOROETHENE CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK:	SCALE: 1"=150'
ENG CHECK: RATcliff	JOB: J47590–6014
APPROVAL: WAD	DWG: 4.10.1

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

——x——x——	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
49	CONCENTRATION OF TRANS-1,2-DICHLOROETHENE IN ug/L
ND	NONE DETECTED
——·——··——	TRANSITORY STREAM
—— · · ——	PERENNIAL STREAM

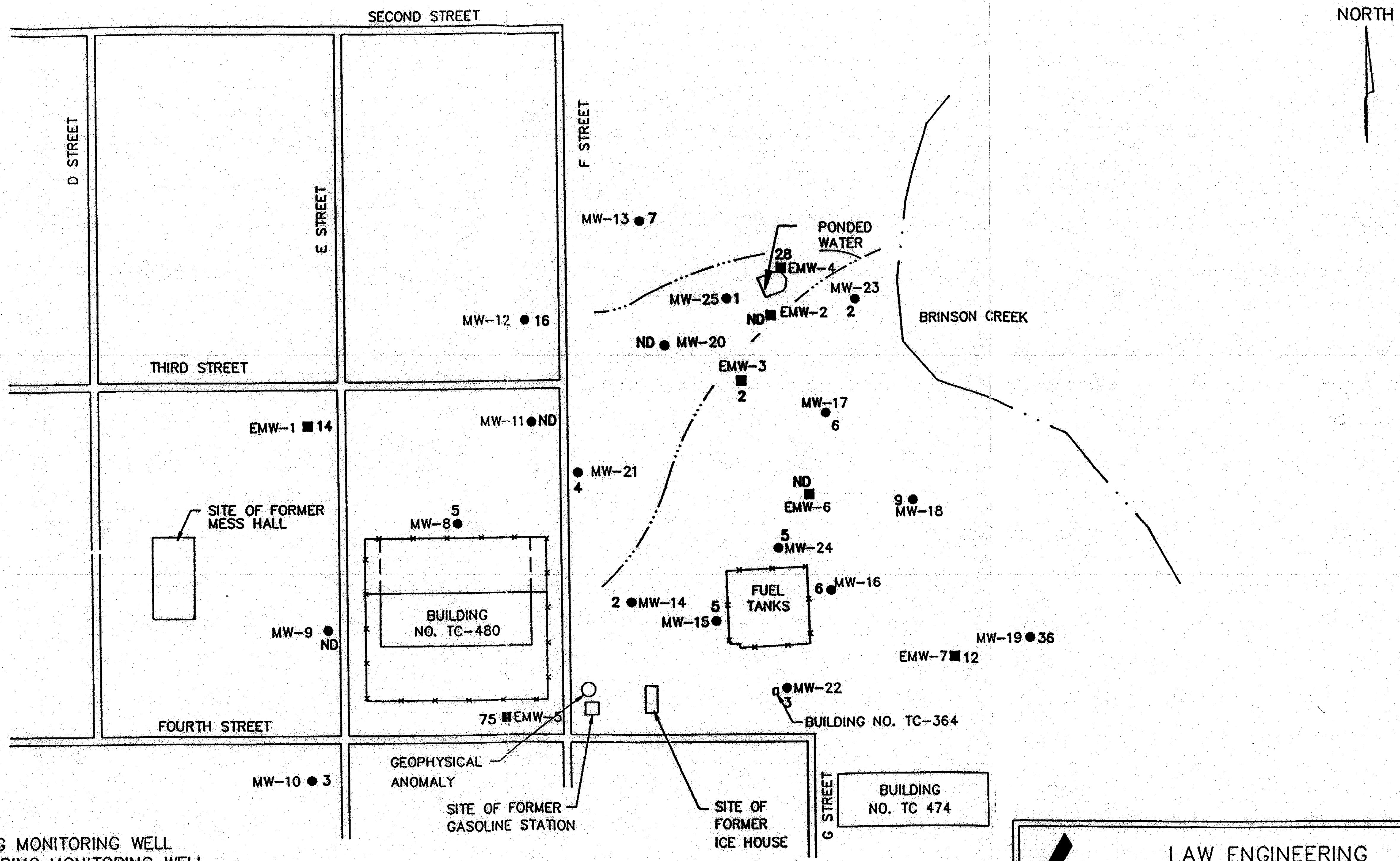
J6014M08

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

ISOPLETH MAP – TRANS-1,2-DICHLOROETHENE
CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: FEB. 1992
DFT CHECK: SJL	SCALE: 1"=150'
ENG CHECK: RAtcliff	JOB: J47590-6014
APPROVAL:	DWG: 4.10.2

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

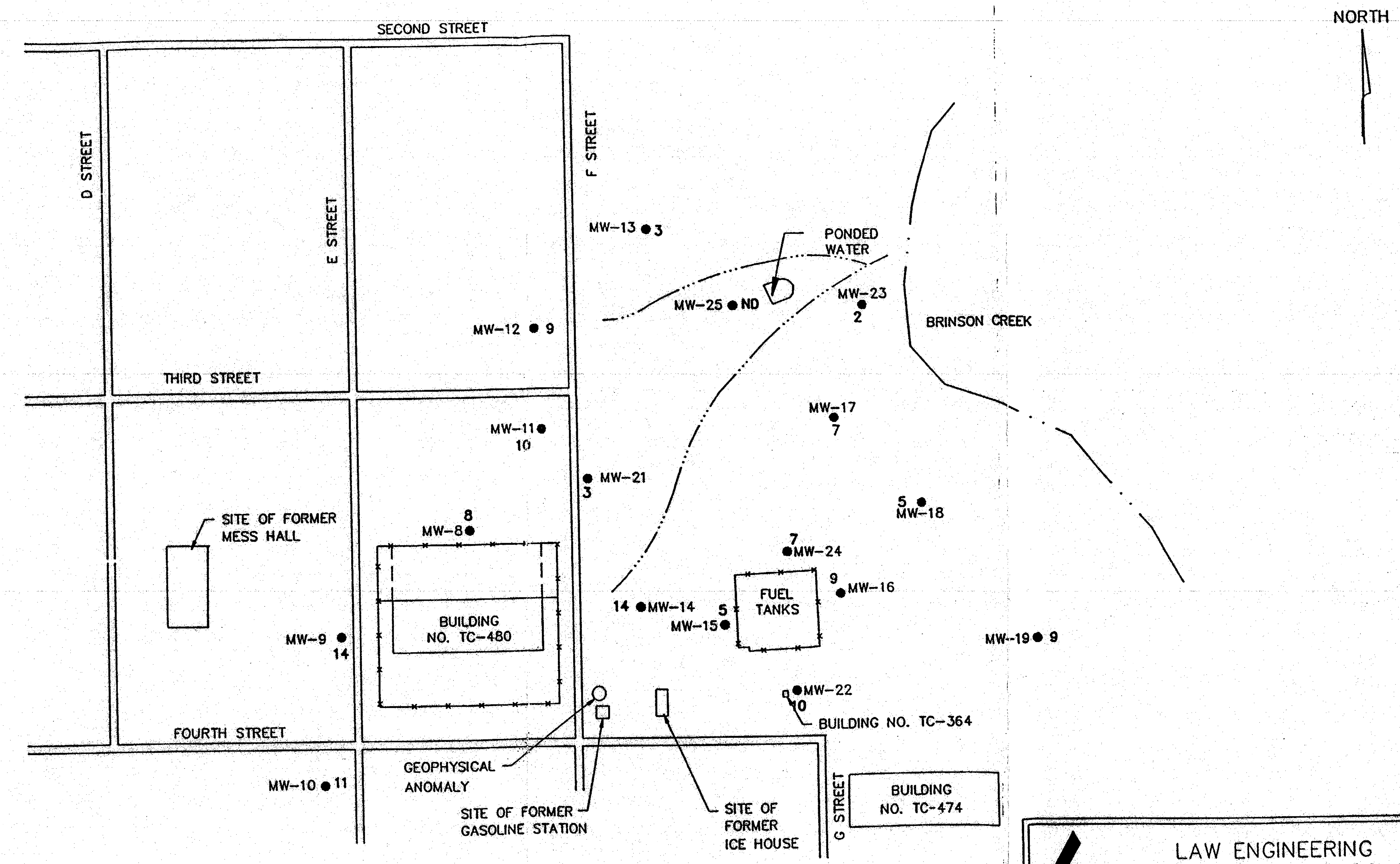
—×——×—	FENCE
■EMW-1	LOCATION OF PRE-EXISTING MONITORING WELL
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
8	CONCENTRATION OF TOTAL LEAD IN ug/L
ND	NONE DETECTED
·······—····	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOTAL LEAD CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WDD	JOB: J47590-6014
APPROVAL: WDD	DWG: 4.11

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

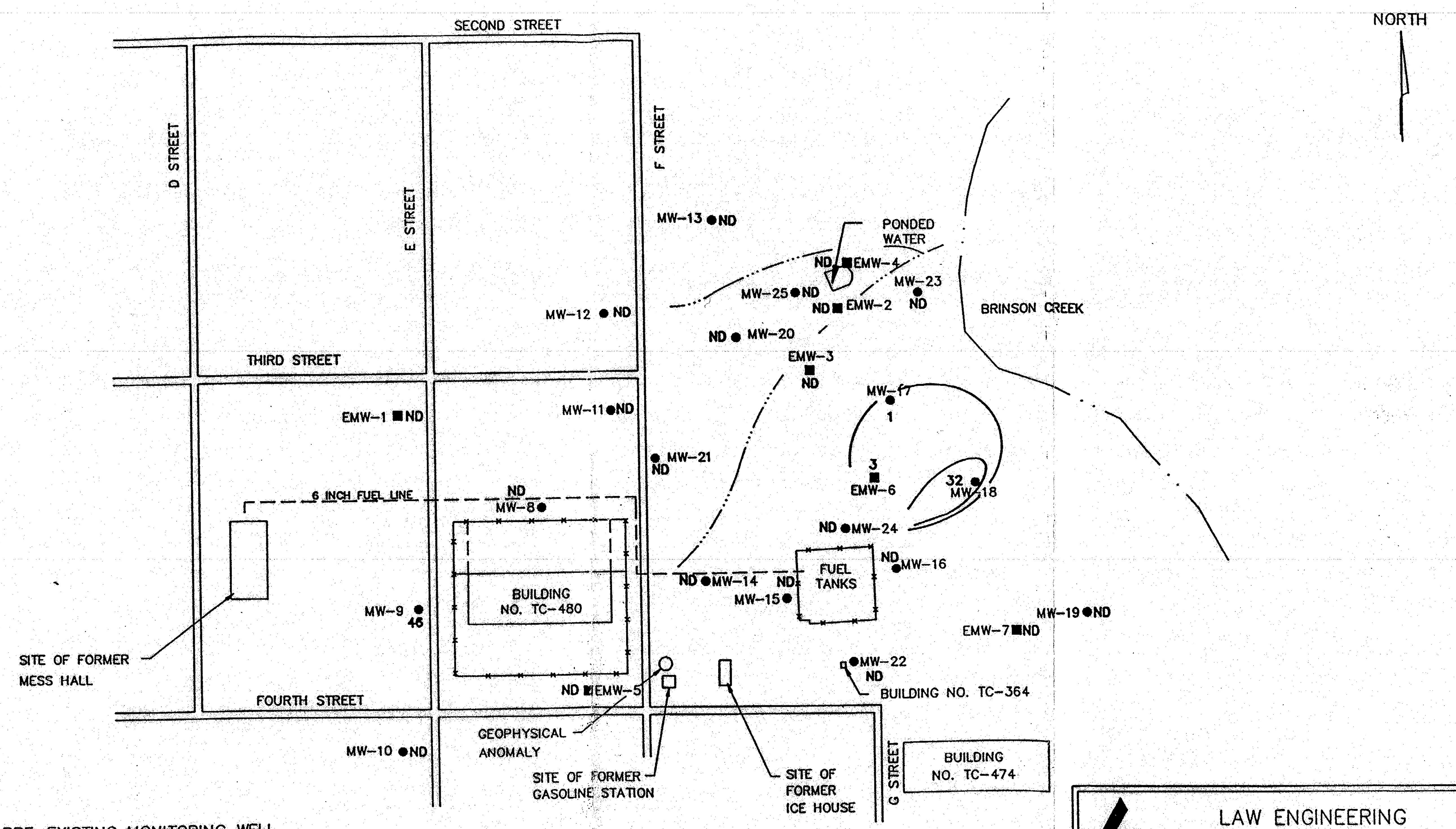
—×—×—	FENCE
●MW-1	LOCATION OF LAW ENGINEERING MONITORING WELL
14	CONCENTRATION OF TOTAL LEAD IN ug/L
ND	NONE DETECTED
—··—··—	TRANSITORY STREAM
— · · —	PERENNIAL STREAM

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

TOTAL LEAD CONCENTRATIONS
WATER SAMPLES FROM DEEP SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK: DCC	SCALE: 1"=150'
ENG CHECK: WEDixon	JOB: J47590-6014
APPROVAL: WEDixon	DWG: 4.12

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91



LEGEND

- ─×──×─ FENCE
- ■EMW-1 LOCATION OF PRE-EXISTING MONITORING WELL
- ●MW-1 LOCATION OF LAW ENGINEERING MONITORING WELL
- 46 CONCENTRATION OF MTBE IN ug/L
- ND NONE DETECTED
- ─·····─·· TRANSITORY STREAM
- ── · · ── PERENNIAL STREAM

J6014215

LAW ENGINEERING
RALEIGH, NORTH CAROLINA

DRAWN: DCC	DATE: NOV. 1991
DFT CHECK:	SCALE: 1"=150'
ENG CHECK:	JOB: J47590-6014
APPROVAL:	DWG: 4.13

MTBE CONCENTRATIONS
WATER SAMPLES FROM SHALLOW SCREENED INTERVAL
CAMP GEIGER FUEL FARM
CAMP LEJEUNE, NORTH CAROLINA

REFERENCE: JAMES E. STEWART AND ASSOC.; SHT 1&2 OF 2; 9/13/91

APPENDIX B
UNDERGROUND STORAGE TANK (UST) SITE CHECK, INVESTIGATION REPORT (ATEC, 1992)

Environmental
Consulting Services

ĀTEC®

ATEC Promises

- To be totally responsive to our client's wants and needs with a constant sense of urgency.
- To perform high quality services with technically superior personnel.
- To perform all assignments for a reasonable fee and within budget.
- To communicate with our client frequently so there will be no surprises.
- To complete our assignments and deliver reports when promised.
- To review reports with our client to be sure there are no misunderstandings.
- To deliver accurate invoices to our client within seven (7) days after the completion of the assignment or as required by the client.
- To follow-up with the client to be sure services completely satisfied his wants and needs.

CONTRACT NUMBER: N62470-90-D-7665

UNDERGROUND STORAGE TANK (UST) SITE CHECK INVESTIGATION REPORT
FORMER MESS HALL HEATING PLANT UST
MARINE CORPS BASE
CAMP GEIGER, NORTH CAROLINA
ATEC PROJECT NUMBER: 26-07-92-00142

FOR:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA 23511-6287

ATEC Associates, Inc.
2551 Eltham Avenue, Suite Z
Norfolk, Virginia 23513-2511
[804] 857-6765, FAX # [804] 857-6283

September 24, 1992

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia 23511-6287

Attention: George Aiken, P.E.

RE: Contract Number: N62470-90-D-7665
Underground Storage Tank (UST) Site Check
Former Mess Hall Heating Plant UST
Marine Corps Base
Camp Geiger, North Carolina
ATEC Project Number: 26-07-92-00142

Dear Mr. Aiken:

ATEC Associates, Inc. has appreciated the opportunity to conduct an Underground Storage Tank (UST) Site Check of the Former Mess Hall Heating Plant UST, located at the Camp Geiger area of Marine Corps Base (MCB), Camp Lejeune, North Carolina. The purpose of the assessment is to investigate the possible release of number six heating fuel into the soils and groundwater at the site.

ATEC identified soil contamination by Total Petroleum Hydrocarbons (TPH) above the North Carolina Department of Environment, Health, and Natural Resources action level of 10 parts per million (ppm) at all of the three well locations. Groundwater contamination by Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX) and TPH were also identified at the three well locations.

ATEC recommends that the UST and its associated lines be removed as soon as possible. When UST removal is conducted, soil samples from the UST excavation should be analyzed for petroleum hydrocarbon content. Once this investigation is completed, the need for further action can be assessed.

If there are any questions concerning this report, please contact this office.

Very truly yours,
ATEC ASSOCIATES, INC.

Kevin Davis

Kevin Davis
Geologist/Project Manager

Roland E. Dubbe

Roland E. Dubbe', P.E.
Vice President/District Manager

EXECUTIVE SUMMARY

ATEC Associates, Inc. has conducted an underground storage tank (UST) Site Check of the Former Mess Hall Heating Plant UST located at the Camp Geiger area of Marine Corps Base (MCB), Camp Lejeune, North Carolina. The Site Check was performed to comply with both Federal and North Carolina UST regulations.

The now abandoned UST was used to supply number six heating fuel to the boilers of an adjacent heating plant which is now demolished. The size and construction of the UST are unknown. The installation date of the tank is approximately 1941. A suspected release from the UST was documented in a subsurface investigation performed by Law Engineering in November of 1991. Laboratory analysis of a soil sample for Total Petroleum Hydrocarbons obtained adjacent to the UST quantified a contaminant level of 8400 ppm.

ATEC investigated the potential release of petroleum hydrocarbons at the site by installing three groundwater monitoring wells at the site. Soil samples from the three well locations were collected and analyzed for Total Petroleum Hydrocarbons (TPH) and for Benzene, Tolune, Ethylbenzene, and Total Xylenes (BTEX). This investigation revealed that TPH levels in the soil samples ranged from 110 to 2,000 parts per million (ppm). High BTEX constituents were detected at well locations MW-1 and MW-2. Groundwater samples from the three well locations were collected and analyzed for TPH and for Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX). This investigation revealed that TPH levels in the groundwater samples ranged from <1 ppm to 5 ppm. In addition, the BTEX constituents were detected in the groundwater samples. Based upon this information gathered during the UST Site Check, high levels of contamination caused by a suspected release of petroleum hydrocarbons from the Former Mess Hall Heating Plant UST appears to be present in both the soils and groundwater in the area of the tank.

ATEC recommends that the Former Mess Hall Heating Plant UST and its associated lines be removed as soon as possible due to the age and inactivity of the tank. When UST removal is conducted, soil samples from the UST excavation pit should be analyzed for petroleum hydrocarbon content. Once soil samples from the UST excavation pit have been analyzed, the need for further action can be assessed.

TABLE OF CONTENTS

UNDERGROUND STORAGE TANK (UST) SITE CHECK
INVESTIGATION REPORT
FORMER MESS HALL HEATING PLANT UST
MARINE CORPS BASE
CAMP GEIGER, NORTH CAROLINA
ATEC PROJECT NUMBER: 26-07-92-00142

1.0 INTRODUCTION

ATEC Associates, Inc. was contracted to perform an underground storage tank (UST) Site Check of the Former Mess Hall Heating Plant UST located at the Camp Geiger area of Marine Corps Base (MCB), Camp Lejeune, North Carolina. Site Checks are to be conducted at various Marine facilities at UST locations where releases are suspected to have occurred. The Site Checks are needed to comply with both the U.S. Environmental Protection Agency (EPA) and North Carolina UST regulations. This investigation report details the work performed at the project site and the information obtained through this investigation.

The project site is located adjacent to Building TC-341 at Camp Geiger MCB (Figure 1). ATEC installed three wells around the Former Mess Hall Heating Plant UST. The three wells were installed under Well Construction Permit No. 66-0264-WM-0274, which was issued on May 20, 1992 by the State of North Carolina Department of Environment, Health, and Natural Resources (DEHNR). A copy of this permit and copies of the completed Well Construction Records are included in Appendix A.

The now abandoned UST was used to supply number six heating fuel to the boilers of an adjacent heating plant which is now demolished (Figure 2). The size and construction of the UST are unknown. The installation date of the tank is approximately 1941. A suspected release from the UST was documented by a subsurface investigation performed by Law Engineering in November of 1991. Laboratory analysis of a soil sample for Total Petroleum Hydrocarbons obtained adjacent to the UST quantified a contaminant level of 8400 ppm.

2.0 SITE ASSESSMENT

To obtain the information necessary to describe and evaluate the project site geology and the extent of contamination, ATEC installed three groundwater monitoring wells and analyzed soil samples from the three well locations. Prior to the installation of the monitoring wells, the well locations were cleared for underground utilities by MCB personnel.

2.1 Area Geology

The project site is located within the Atlantic Coastal Plain physiographic province, which consists of a wedge of stratified, unconsolidated and semi-consolidated sediments that dip and thicken eastward. These sediments consist primarily of sand, clay, silt and gravel, with variable amounts of shell material, that range in age from Cretaceous to Recent (Holocene). Unconformably underlying the Coastal Plain sediments is a basement rock surface composed of massive igneous rocks and highly deformed metamorphic rocks that range in age from Precambrian to lower Paleozoic. The basement surface forms the basal limit of the Coastal Plain hydrogeologic system, which consists of a surficial, unconfined water table aquifer and seven deeper level confined to semi-confined aquifers separated by intervening aquitards (less permeable units) (Meng and Harsh, 1988; Hamilton and Larson, 1989).

Topographically, the project site is at an elevation of approximately 20 feet above mean sea level (USGS, 1971). Topographic relief across the site is relatively slight. Based on topographic map interpretation, surface drainage at the project site flows to the east, toward Brinson Creek, a tributary of the New River. However, human activities at the site, such as construction and grading may have affected the natural surface water drainage.

2.2 Soil Boring and Soil Sampling Program

On June 1 and 2, 1992, ATEC drilled three soil borings at the project site. These borings were converted to monitoring wells (Figure 2). The soil borings were advanced using a Mobil B-57 truck-mounted drill rig with 10-inch diameter hollow stem augers. The augers and sampling tools were decontaminated between borings using a pressure washer to minimize the potential of cross-contamination. During the soil boring activities, soil samples were collected with split spoon samplers at 0 to 2 feet, 2 to 4 feet, 4 to 6 feet, 8 to 10 feet, 13 to 15 feet, and 18 to 20 feet. Soils encountered at each of the well locations consisted of a surficial brown to gray silty sand to 4 feet below the ground surface (BGS), underlain by a brown to gray medium sand to 10 feet BGS. Greenish gray, fine to medium sands were encountered from 13 to 15 feet BGS, followed by greenish gray to gray medium sands from 18 to 20 feet. Soil boring logs are included in Appendix B.

Each split spoon sample was collected in a clean sample jar, leaving ample head space in the jar. The samples were then screened in the field for the presence of petroleum hydrocarbons with a Photoionization Detector (PID). The results of this screening yielded readings that ranged from 0 part per million (ppm) up to a maximum of 119 ppm at the MW-2 location.

A separate soil sample for laboratory analysis was collected from each boring at the approximate depth of the water table. A duplicate soil sample was taken at the MW-2 location and marked "MWS-4". These soil samples were analyzed in the laboratory for Total Petroleum Hydrocarbons (TPH) using EPA Method 8015 (California modified) and for Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX) using EPA Method 8020. The limit set by the DEHNR is 10 ppm for TPH in soil. No limits are established for BTEX concentrations in soil. As shown in Table 1, the laboratory results indicate the presence of TPH contamination at all three well locations at levels above the DEHNR action level of 10 ppm (Figure 3).

Table 1: Laboratory Results of Soil Analyses

Sample No.	TPH 8015 mg/kg	BTEX ug/kg
MWS-1	140	Benzene 6 Toluene 52 Ethylbenzene 55 Total Xylenes 42
MWS-2	2,000	Benzene <20 Toluene 130 Ethylbenzene 2300 Total Xylenes 3100
MWS-3	110	Benzene <5 Toluene <5 Ethylbenzene <5 Total Xylenes <5
MWS-4 (Duplicate of MWS-2)	1,200	Benzene <50 Toluene <50 Ethylbenzene 750 Total Xylenes 1200

Note: mg/kg is numerically equivalent to parts per million (ppm)
ug/kg is numerically equivalent to parts per billion (ppb)

2.3 Monitoring Well Installation

On June 1 and 2, 1992, ATEC installed three groundwater monitoring wells at the project site. The monitoring well locations are shown in Figure 2. During the drilling activities, the water table was encountered at approximately 8 feet BGS.

The wells were constructed with 10 feet of 0.010 inch slotted schedule 40 polyvinyl chloride (PVC) screen and 10 feet of PVC riser. A Number 2 industrial sand was used to create a filter pack around the well casings to 2 feet above the well screen. A one foot thick annular seal of bentonite pellets was placed above the sand filter pack and concrete grout was placed above the bentonite seal to the surface to protect the wells from infiltrating surface waters. Concrete pads, steel posts and protective covers were set above the wells to protect them from damage. A well identification tag, including construction data, was installed on each well. Well completion data is included with the soil boring logs in Appendix B.

2.4 Groundwater Sampling Program

The three groundwater monitoring wells were developed by pumping a minimum of five well bore volumes of groundwater to remove fine silt and clay particles present in the wells and to remove stagnant standing water. New development hose and sampling tubing was used for each well to minimize the potential for cross-contamination between wells. Prior to surveying each well, water levels were measured using an oil/water interface probe, which can detect the presence of free phase product. At the time of the survey, none of the monitoring wells contained free product.

The three wells were sampled on June 6, 1992. The static water table prior to purging was measured between 9.08 feet and 9.88 feet below the top of the well casings. The groundwater samples were collected at a depth of approximately one foot below the water table. A duplicate sample was obtained from MW-2 and labeled as "MW-4". No trip blanks were prepared. The water samples were analyzed in the laboratory for TPH using EPA Method 8015 (California modified) and for BTEX using EPA Method 8020. As shown in Table 2, the results of the TPH analyses for groundwater from the wells ranged from <1 ppm to 5 ppm. The DEHNR has not set limits for TPH in groundwater. Concentrations of the BTEX constituents also were detected in groundwater at MW-2 (Figure 4). Allowable levels of BTEX in groundwater are available in Subchapter 2L, Section 0.200 of the North Carolina Administrative Code, "Classifications and Water Quality Standards

Applicable to the Groundwaters of North Carolina" and are as follows: Benzene 0.001 ppm (1 parts per billion (ppb)), Toluene 1.0 ppm (1,000 ppb), Ethylbenzene 0.029 ppm (29 ppb), and Total Xylenes 0.4 ppm (400 ppb). The benzene limit was exceeded at MW-2.

Table 2: Laboratory Results of Groundwater Analyses

Sample No. (Well No.)	TPH mg/L	BTEX ug/L
MW-1	5	Benzene <1 Toluene <1 Ethylbenzene <1 Total Xylenes <1
MW-2	3	Benzene 2 Toluene 1 Ethylbenzene 27 Total Xylenes 4
MW-3	<1	Benzene <1 Toluene <1 Ethylbenzene <1 Total Xylenes <1
MW-4 (Duplicate of MW-2)	2	Benzene 1 Toluene <1 Ethylbenzene 25 Total Xylenes 5

Note: mg/L is numerically equivalent to parts per million (ppm)
ug/L is numerically equivalent to parts per billion (ppb)

2.5 Groundwater Flow Direction

Groundwater flow at the project site was expected to mimic the surface drainage pattern, with groundwater flowing to the east, toward Brinson Creek. A survey of the monitoring wells and groundwater level elevations was conducted to determine the actual direction of groundwater flow at the project site. The wells were surveyed for future reference - survey needs to be tied into established "permanent" benchmarks from the elevation of a fire hydrant (identification tag 6-16-6) located east of the site adjacent to a railroad spur, using mean sea level (MSL) as datum. Table 3 lists the measured elevations. Groundwater flow was determined to be toward the east, as shown in Figure 5.

Table 3: Monitoring Well Elevations

Benchmark (Fire hydrant) Elevation = 18.08 feet above MSL

Well Number	Casing (feet MSL)	Elevation Water Table (feet)	Water Table Depth To (feet MSL)	Elevation
MW-1		20.15	9.08	11.07
MW-2		20.68	9.88	10.8
MW-3		20.06	9.31	10.75

The velocity of groundwater flow at the project site was calculated to provide a general estimate of how rapidly groundwater, and any associated contamination, would migrate away from the USTs. The following standard equation based on Darcy's law of groundwater flow was used to estimate the groundwater velocity:

$$V = (K/n)\ (dh/dl);$$

where V = rate of groundwater flow (ft/day)

dh/dl = measured water table gradient (0.005 ft/ft)

K = assumed hydraulic conductivity (0.28 ft/day for fine sands)

n = assumed porosity factor (0.30)

The rate of groundwater flow in the water table aquifer was calculated using an assumed porosity of 30 percent, a measured water table gradient of 0.005 ft/ft, and an assumed hydraulic conductivity of 0.28 ft/day for a fine sand aquifer (Fetter, 1980). The calculated velocity is approximately 0.005 ft/day or 2 ft/year. This analysis shows that groundwater contamination would migrate away from the UST area toward the east. However, as an aquifer pumping or slug test was not conducted at this site, this calculated value represents only a rough estimate of the true groundwater flow velocity. This estimated velocity also does not necessarily correspond with the rate of contaminant movement, as contaminant characteristics greatly affect their rate of movement.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The Former Mess Hall Heating Plant UST, which contained number six heating fuel, is located adjacent to Building TC-341. The UST was installed in the early 1940's. Based upon the information gathered during the UST Site Check, high levels of contamination caused by a suspected release of petroleum hydrocarbons from the UST are present at the site. This investigation revealed the presence of both soil and groundwater contamination around the UST.

ATEC recommends that the UST and its associated lines be removed as soon as possible due to the systems age, construction, and inactivity. If UST removal is conducted, soil samples from the UST excavation pit should be analyzed for petroleum hydrocarbon content. Once this investigation is completed, the need for further action can be assessed.

4.0 QUALIFICATIONS

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with customary principles and practices in the fields of environmental science and engineering. This warranty is in lieu of all other warranties either expressed or implied. This company is not responsible for the independent conclusions, opinions or recommendations made by others based on the field exploration and laboratory test data presented in this report.

The work performed in conjunction with this assessment and the data developed, are intended as a description of available information at the dates and locations given. This report does not warrant against future operations or conditions nor does it warrant against operations present of a type or at a location not investigated.

5.0 REFERENCES

Fetter, C. W., 1980. Applied Hydrogeology, Charles E. Merrill Publishing Co.: Columbus, Ohio

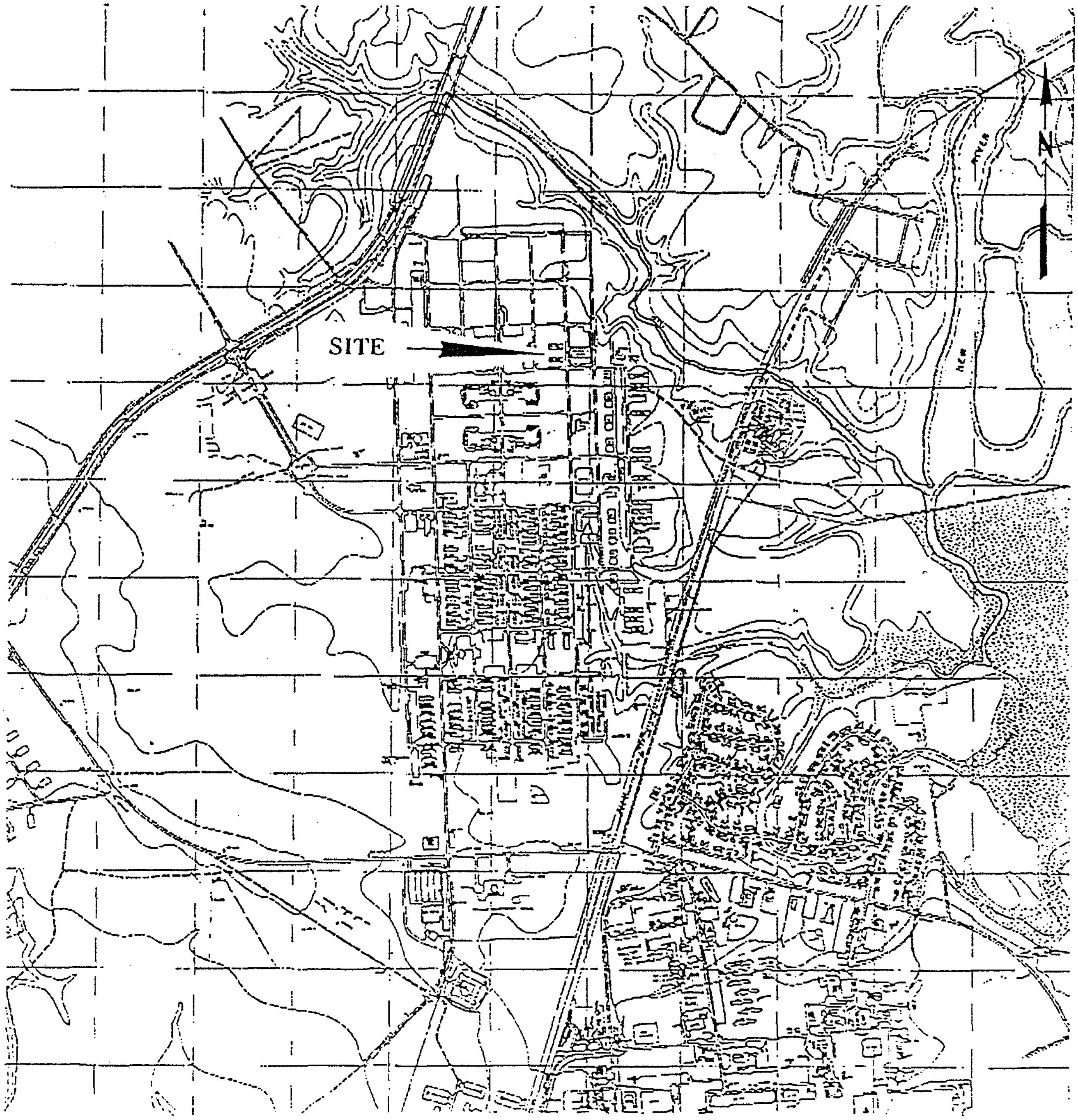
Hamilton, P. A. and J. D. Larson, 1988. Hydrogeology and Analysis of the Ground-Water Flow System in the Coastal Plain of Southeastern Virginia. U. S. Geological Survey, Water-Resources Investigations Report, 87-4240.

Meng, A. A. and J. G. Harsh, 1988. Hydrogeologic Framework of the Virginia Coastal Plain. U. S. Geological Survey Professional Paper 1404-C.

Mixon, R. B., C. R. Berquist, Jr., W. L. Newell, and F. G. Johnson, 1989. Geologic Map and Generalized Cross Sections of the Coastal Plain and Adjacent Parts of the Piedmont, Virginia. United States Geological Survey, Miscellaneous Investigations Series, Map I-2033.

U. S. Geological Survey, 7.5 Minute Topographic Map Series, Jacksonville South, North Carolina quadrangle, 1952, photo inspected 1971.

FIGURES



ATEC Associates, Inc.

Norfolk, Virginia

FIGURE 1 SITE VICINITY MAP

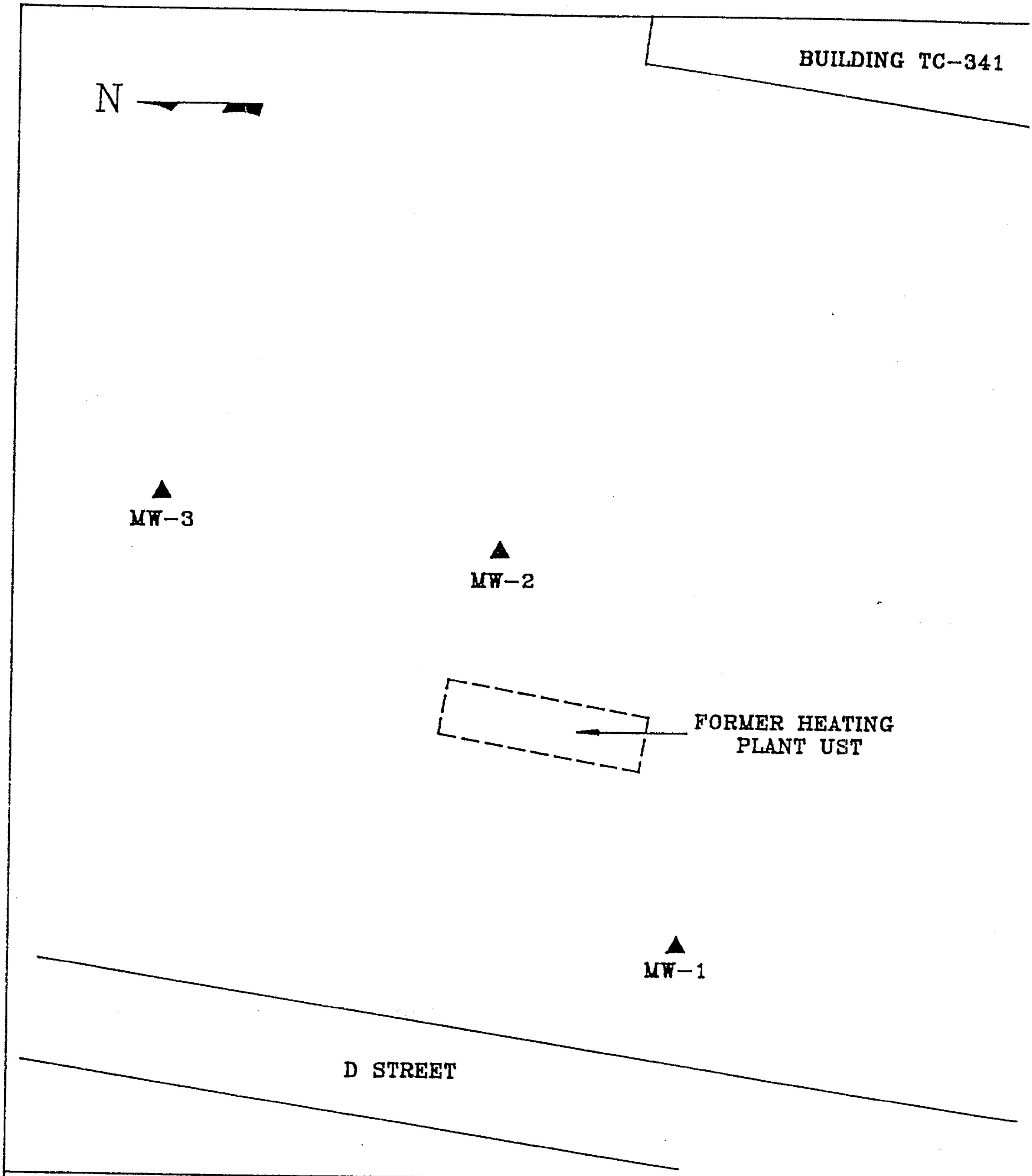
JOB NAME: FORMER MESS HALL HEATING PLANT US

JOB NO.: 26-07-92-00142

CLIENT: U.S. NAVY

SCALE: 1:18,000

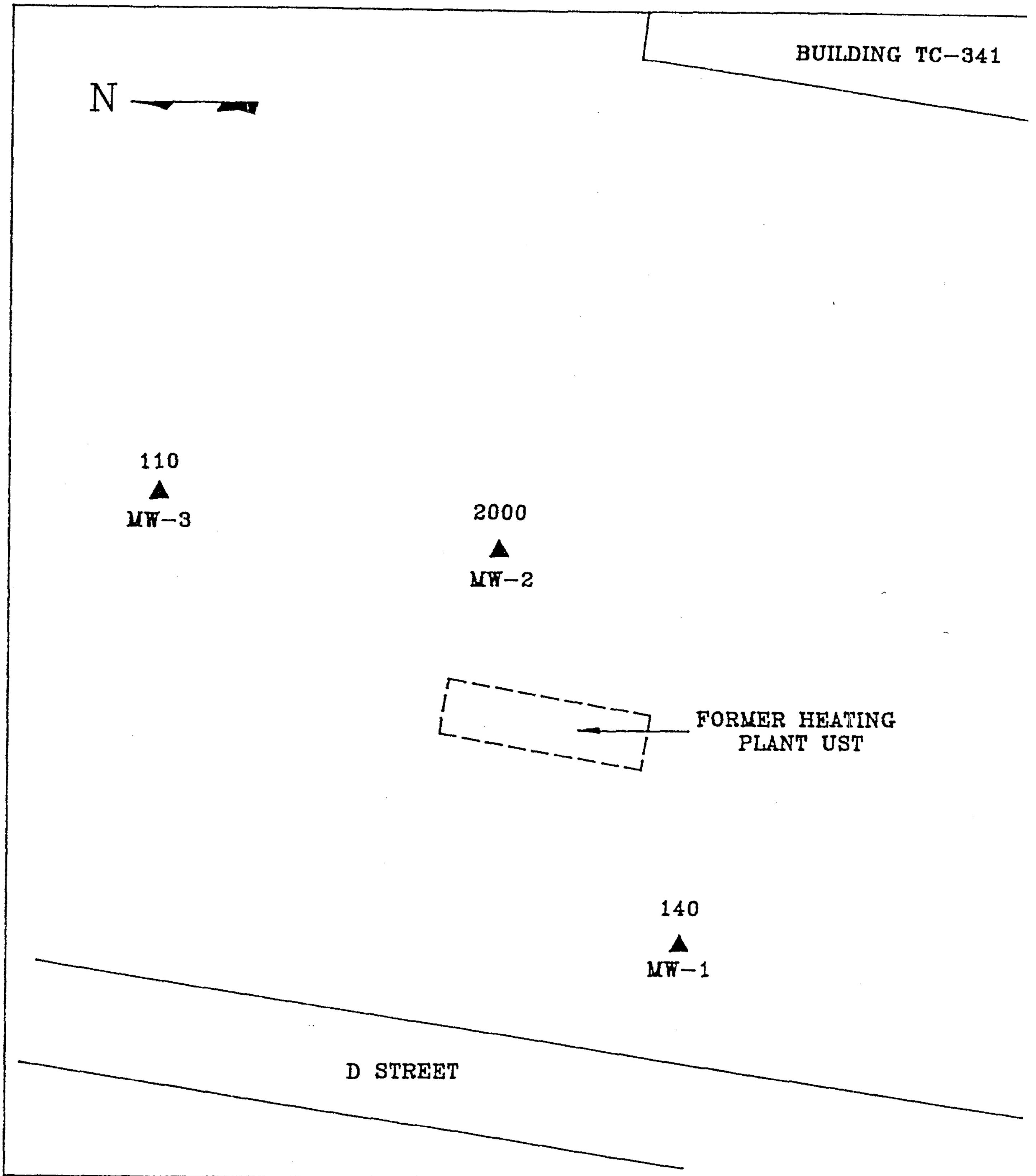
SOURCE: UNKNOWN DATE: JUNE, 1992



ĀTEC Associates, Inc.
Norfolk, Virginia

FIGURE 2 SITE DESCRIPTION MAP

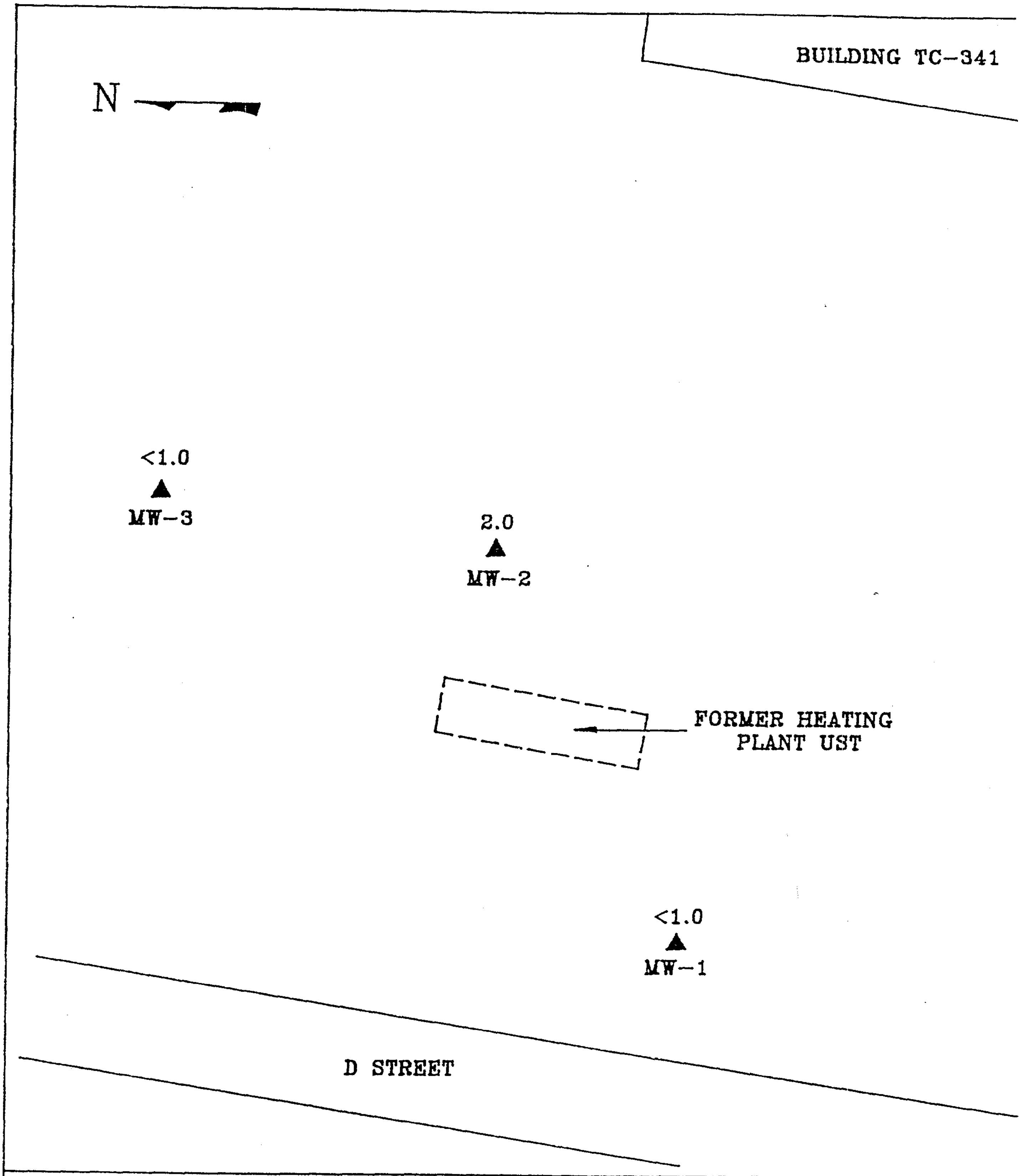
JOB NAME: FORMER MESS HALL HEATING PLANT UST
JOB NO.: 26-07-92-00142
DATE: JUNE, 1992
CLIENT: U.S. NAVY
SCALE: 1 INCH = 20 FEET
DRAWN BY: WKP



ATEC Associates, Inc.
Norfolk, Virginia

FIGURE 3 SOIL TPH CONCENTRATION MAP (ppm)

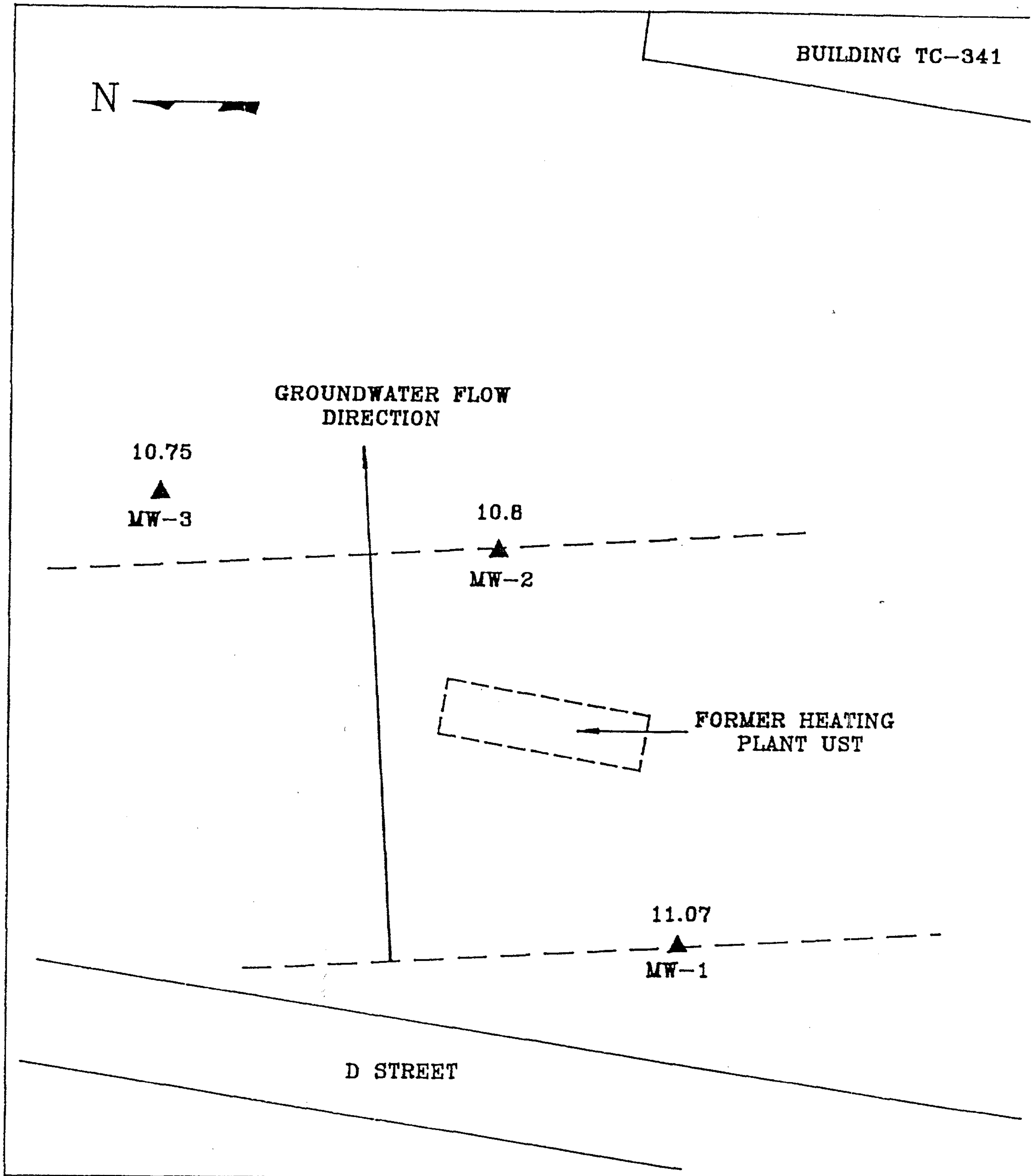
JOB NAME: FORMER MESS HALL HEATING PLANT UST
JOB NO.: 26-07-92-00142
DATE: JUNE, 1992
CLIENT: U.S. NAVY
SCALE: 1 INCH - 20 FEET
DRAWN BY: WKP



ĀTEC Associates, Inc.
Norfolk, Virginia

FIGURE 4 GROUNDWATER BENZENE CONCENTRATION MAP (ppb)

JOB NAME: FORMER MESS HALL HEATING PLANT UST
JOB NO.: 26-07-92-00142
DATE: JUNE, 1992
CLIENT: U.S. NAVY
SCALE: 1 INCH = 20 FEET
DRAWN BY: WKP



ATEC Associates, Inc.
Norfolk, Virginia

FIGURE 5 POTENTIOMETRIC SURFACE MAP (ft)

JOB NAME: FORMER MESS HALL HEATING PLANT UST
JOB NO.: 26-07-92-00142
DATE: JUNE, 1992
CLIENT: U.S. NAVY
SCALE: 1 INCH = 20 FEET
DRAWN BY: WKP

APPENDIX A

WELL CONSTRUCTION PERMIT

JOB # = 00043

RECEIVED
MAY 26 1992

COPY

NORTH CAROLINA
ENVIRONMENTAL MANAGEMENT COMMISSION
DEPARTMENT OF ENVIRONMENT, HEALTH AND NATURAL RESOURCES
RALEIGH, NORTH CAROLINA

PERMIT FOR THE CONSTRUCTION OF A WELL OR WELL SYSTEM

In accordance with the provisions of Article 7, Chapter 87, North Carolina General Statutes, and other applicable Laws, Rules and Regulations.

PERMISSION IS HEREBY GRANTED TO

United States Marine Corps

FOR THE CONSTRUCTION OF three monitor wells, which will be exposed to the Surficial Aquifer, and which will be located at the Camp Geiger Mess Hall, near Building TC-480, Camp Geiger, Onslow County, in accordance with the application dated May 6, 1992, and in conformity with specifications and supporting data, all of which are filed with the Department of Environment, Health and Natural Resources and are considered a part of this Permit.

This Permit is for well construction only, and does not waive any provisions or requirements of the Water Use Act of 1967, or any other applicable laws or regulations. Well construction shall be in compliance with the North Carolina Well Construction Regulations and Standards.

This Permit will be effective from the date of its issuance until November 20, 1992, and shall be subject to other specified conditions, limitations, or exceptions as follows:

1. The well(s) shall be located and constructed as shown on the attachments submitted as part of the permit application.
2. This permit does not imply that you will be eligible for reimbursement of any costs associated with well installation from the Leaking petroleum Underground Storage Tank Trust Fund.

If any requirements or limitations of this Permit are unacceptable, you have the right to an adjudicatory hearing upon written request within 30 days. The request must be in the form of a written petition, conforming to Chapter 150B of the North Carolina General Statutes, and filed with the Office of Administrative Hearings, Post Office Drawer 27447, Raleigh, North Carolina 27611-7447. Unless such demand is made, this permit is final and binding.

Permit issued this the 20th day of May 1992.

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

Original Signed By
RICK SHIVER
FOR

A. Preston Howard, Jr., P.E., REGIONAL SUPERVISOR
Division of Environmental Management
By Authority of the Environmental Management Commission

PERMIT NO. 66-0264-WM-0274
APH/RSS/CDR/lfc
cc: ATEC Associates, Inc.
Perry Nelson
WiRO-GWS

GWPERMIT\WM0274.GWS
05/20/92

APPENDIX B

SOIL BORING AND WELL COMPLETION DATA

North Carolina - Department of Environment, Health, and Natural Resources
Division of Environmental Management - Groundwater Section
P.O. Box 29535 - Raleigh, N.C. 27626-0535
Phone (919) 733-3221

FOR OFFICE USE ONLY
QUAD. NO. ______ SERIAL NO. ______
Lat. ______ Long. ______ RO ______
Minor Basin ______
Basin Code ______
Header Ent. ______ GW-1 Ent. ______

WELL CONSTRUCTION RECORD

RILLING CONTRACTOR: ATEC Associates, Inc.

DRILLER REGISTRATION NUMBER: 696

STATE WELL CONSTRUCTION PERMIT NUMBER: 66-0264-WM-0274

WELL LOCATION: (Show sketch of the location below)
Nearest Town: Jacksonville, NC County: Onslow

(Road, Community, or Subdivision and Lot No.)

2. OWNER Environmental Management Department
ADDRESS Camp Lejeune, Marine Corps Base
(Street or Route No.)
North Carolina 28542-5001
City or Town State Zip Code

DATE DRILLED ______ USE OF WELL MONITOR
TOTAL DEPTH 20 ft
5. CUTTINGS COLLECTED YES ☒ NO ☐
DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
STATIC WATER LEVEL Below Top of Casing: ______ FT.
(Use "+" if Above Top of Casing)
8. TOP OF CASING IS ______ FT. Above Land Surface*
asing Terminated at/or below land surface is illegal unless a variance is issued accordance with 15A NCAC 2C .0118
9. YIELD (gpm): N/A METHOD OF TEST ______
WATER ZONES (depth): N/A
11. CHLORINATION: Type N/A Amount ______
CASING:

Depth From	To		Diameter	Wall Thickness or Weight/Ft.	Material
From	To	Ft.			
From	To	Ft.			
From	To	Ft.			

GROUT:

Depth From	To		Material	Method
From	To	Ft.		
From	To	Ft.		

SCREEN:

Depth From	To		Diameter		Slot Size		Material
From	To	Ft		in.		in.	
From	To	Ft.		in.		in.	
From	To	Ft.		in.		in.	

15 SAND/GRAVEL PACK:

Depth From	To		Size	Material
From	To	Ft.		
From	To	Ft.		

DEPTH From	To	DRILLING LOG Formation Description

If additional space is needed use back of form

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)

See attachments for well locations, construction, and formation descriptions.

REMARKS: ______

I HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

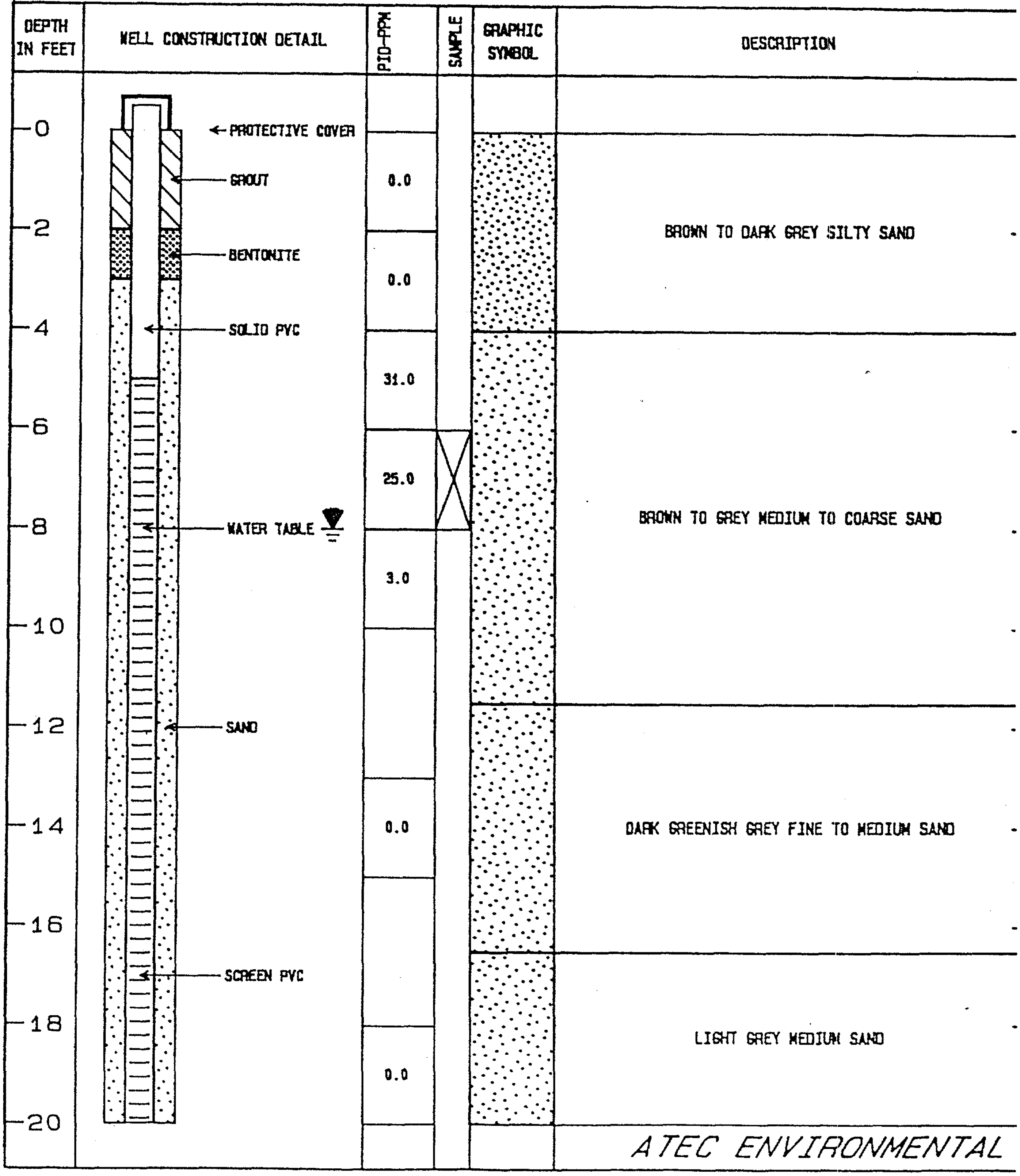
ATEC Associates, Inc. Kevin Davis 6/1/92
SIGNATURE OF CONTRACTOR OR AGENT DATE

GW-1 REV 9/91

BORING LOG

Project: FORMER HEATING PLANT UST
Location: CAMP GEIGER, N.C.
Job No.: 26-07-92-00142
Geologist: KEVIN DAVIS
Client: U.S. NAVY

Hole/Well No.: MW-1
Diameter of Well Casing: 4 inches
Total Depth of Hole: 20 feet
Date Started: 6/1/92
Date Completed: 6/1/92



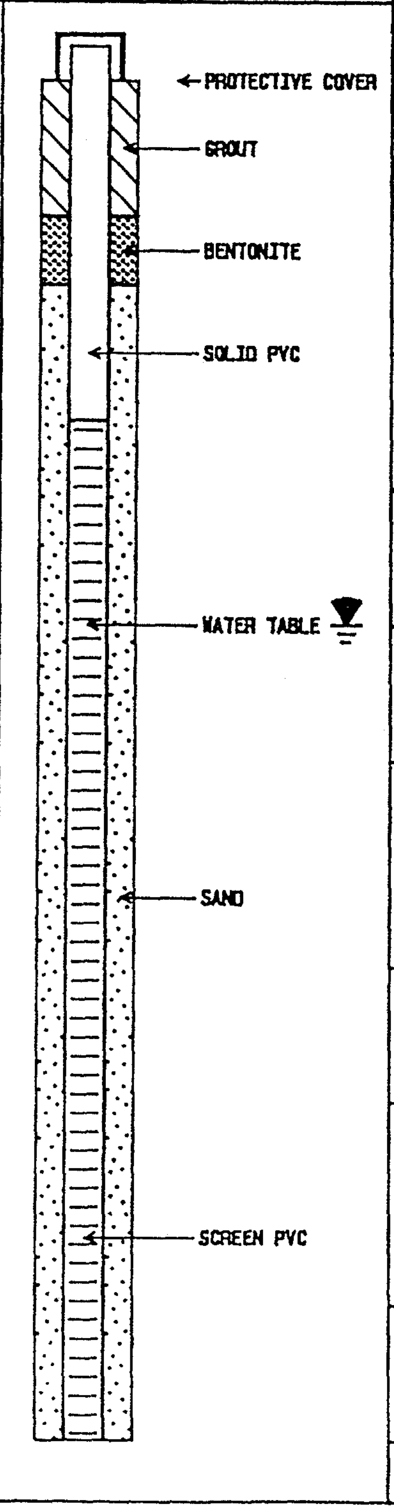
ATEC ENVIRONMENTAL

BORING LOG

Project: FORMER HEATING PLANT UST
Location: CAMP GEIGER, N.C.
Job No.: 26-07-92-00142
Geologist: KEVIN DAVIS
Client: U.S. NAVY

Hole/Well No.: MW-2
Diameter of Well Casing: 4 inches
Total Depth of Hole: 20 feet
Date Started: 6/2/92
Date Completed: 6/2/92

WELL CONSTRUCTION DETAIL



DEPTH IN FEET	PID-PPM	SAMPLE	DESCRIPTION
0	0.0		DARK GREY TO LIGHT GREY SILTY SAND
2	85.0		
4	119		BROWN TO GREY MEDIUM SAND
6	102	☒	
8	76.0		
10			
12			DARK GREENISH GREY FINE TO MEDIUM SAND
14	0.0		
16			GREY MEDIUM SAND
18	0.0		
20			

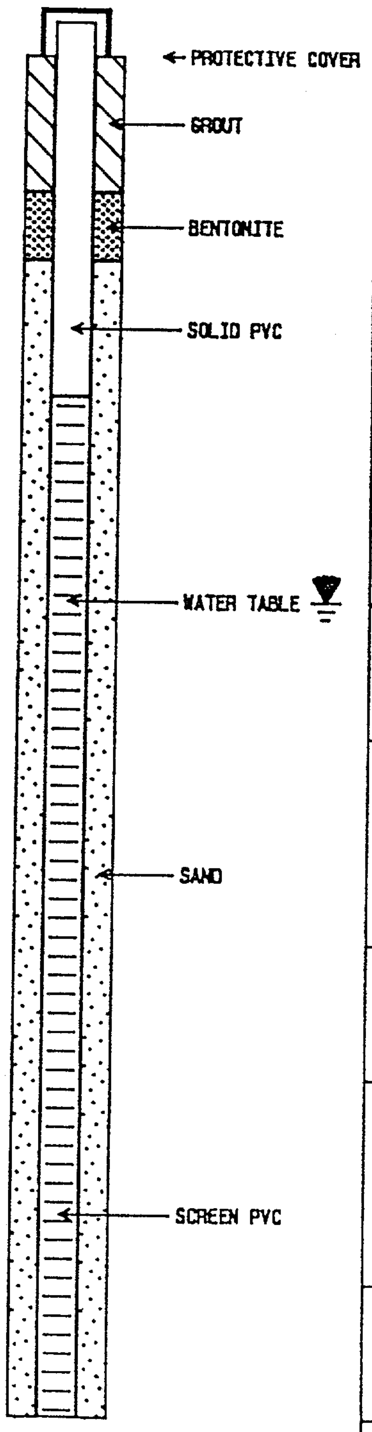
ATEC ENVIRONMENTAL

BORING LOG

Project: FORMER HEATING PLANT UST
Location: CAMP GEIGER, N.C.
Job No.: 26-07-92-00142
Geologist: KEVIN DAVIS
Client: U.S. NAVY

Hole/Well No.: MW-3
Diameter of Well Casing: 4 inches
Total Depth of Hole: 20 feet
Date Started: 6/2/92
Date Completed: 6/2/92

WELL CONSTRUCTION DETAIL



DEPTH IN FEET	PID-PPM	SAMPLE	GRAPHIC SYMBOL	DESCRIPTION
0	0.0			BROWN SILTY SAND
2	6.0			BROWN SILTY CLAYEY SAND
4	4.0			BROWN TO GREY MEDIUM TO COARSE SAND
6	5.0	☒		
8	0.0			
10				
12				GREENISH GREY FINE TO MEDIUM SAND
14	0.0			
16				GREENISH GREY MEDIUM SAND
18	0.0			
20				

ATEC ENVIRONMENTAL

APPENDIX C

LABORATORY RESULTS, CHAIN-OF-CUSTODY FORMS,

AND

REQUEST FOR ANALYSIS FORMS

ATEC Environmental Consultants
Division of ATEC Associates, Inc.
9020 Mendenhall Court, Suite D
Columbia, Maryland 21045-4716
(301) 381-0655, FAX #(301) 381-9302

Solid & Hazardous Waste Site Assessments
Remedial Design & Construction
Underground Tank Management
Asbestos Surveys & Analysis
Hydrogeologic Investigations & Monitoring
Analytical Testing / Chemistry
Industrial Hygiene / Hazard Communication
Environmental Audits & Permitting
Exploratory Drilling & Monitoring Wells

June 19, 1992

ATEC Associates, Inc.
2551 Eltham Ave.
Suite Z
Norfolk, VA 23513
Attn: Kevin Davis

Client Project: Tank No TC-341
Matrix of Samples: Water
Sampled By: KD
Date Samples Collected: 06/04/92
Date Samples Received: 06/08/92
Date Samples Analyzed: 06/08/92
Analytical Equipment: O.I. Corporation GC System Purge and Trap photoionization detector.
Analytical Method: SW 846 8020

ATEC Chem Lab Job # 31-08-92-00360

PURGEABLE AROMATICS (BTEX) ANALYTICAL RESULTS

Client Sample: MW-1
ATEC Chem Lab Sample # 921616

Analyte	CAS Number	Concentration (ug/L)	Quantitation Limit (ug/L)
Benzene	71-43-2	<1	1
Toluene	108-88-3	<1	1
Ethylbenzene	100-41-4	<1	1
Xylene	1330-20-7	<1	1

Client Sample: MW-2
ATEC Chem Lab Sample # 921617

Analyte	CAS Number	Concentration (ug/L)	Quantitation Limit (ug/L)
Benzene	71-43-2	2	1
Toluene	108-88-3	1	1
Ethylbenzene	100-41-4	27	1
Xylene	1330-20-7	4	1

Client Project: Tank No TC-341
ATEC Chem Lab Job # 31-08-92-00360

PURGEABLE AROMATICS (BTEX) ANALYTICAL RESULTS

Client Sample: MW-3
ATEC Chem Lab Sample # 921618

Analyte	CAS Number	Concentration (ug/L)	Quantitation Limit (ug/L)
Benzene	71-43-2	<1	1
Toluene	108-88-3	<1	1
Ethylbenzene	100-41-4	<1	1
Xylene	1330-20-7	<1	1

Client Sample: MW-4
ATEC Chem Lab Sample # 921619

Analyte	CAS Number	Concentration (ug/L)	Quantitation Limit (ug/L)
Benzene	71-43-2	1	1
Toluene	108-88-3	<1	1
Ethylbenzene	100-41-4	25	1
Xylene	1330-20-7	5	1

Analyst: Donna Gajewski
Verified: Tony Kosiba
Date Verified: 06/18/92

Respectfully submitted,

Environmental/Analytical Testing Division

ATEC Environmental Consultants
Division of ATEC Associates, Inc.
9020 Mendenhall Court, Suite D
Columbia, Maryland 21045-4716
(301) 381-0655, FAX #(301) 381-9302

Solid & Hazardous Waste Site Assessments
Remedial Design & Construction
Underground Tank Management
Asbestos Surveys & Analysis
Hydrogeologic Investigations & Monitoring
Analytical Testing / Chemistry
Industrial Hygiene / Hazard Communication
Environmental Audits & Permitting
Exploratory Drilling & Monitoring Wells

June 18, 1992

ATEC Associates, Inc.
2551 Eltham Ave.
Suite Z
Norfolk, VA 23513
Attn: Kevin Davis

Client Project: Tank No TC-341
Sampled By: KD
Matrix of Samples: Soil
Date Samples Collected: 06/01/92 & 06/02/92
Date Samples Received: 06/08/92
Date Samples Analyzed: 06/08/92
Analytical Equipment: O.I. Corporation GC System Purge and Trap photoionization detector.
Analytical Method: SW 846 8020

ATEC Chem Lab Job # 31-08-92-00360

PURGEABLE AROMATICS (BTEX) ANALYTICAL RESULTS

Client Sample: MWS-1
ATEC Chem Lab Sample # 921612

Analyte	CAS Number	Concentration (ug/Kg)	Quantitation Limit (ug/Kg)
Benzene	71-43-2	6	5
Toluene	108-88-3	52	5
Ethylbenzene	100-41-4	55	5
Xylene	1330-20-7	42	5

Client Sample: MWS-2
ATEC Chem Lab Sample # 921613

Analyte	CAS Number	Concentration (ug/Kg)	Quantitation Limit (ug/Kg)
Benzene	71-43-2	<20	20
Toluene	108-88-3	130	20
Ethylbenzene	100-41-4	2,300	20
Xylene	1330-20-7	3,100	20

Client Project: Tank No TC-341
ATEC Chem Lab Job # 31-08-92-00360

PURGEABLE AROMATICS (BTEX) ANALYTICAL RESULTS

Client Sample: MWS-3
ATEC Chem Lab Sample # 921614

Analyte	CAS Number	Concentration (ug/Kg)	Quantitation Limit (ug/Kg)
Benzene	71-43-2	<5	5
Toluene	108-88-3	<5	5
Ethylbenzene	100-41-4	<5	5
Xylene	1330-20-7	<5	5

Client Sample: MWS-4
ATEC Chem Lab Sample # 921615

Analyte	CAS Number	Concentration (ug/Kg)	Quantitation Limit (ug/Kg)
Benzene	71-43-2	<50	50
Toluene	108-88-3	<50	50
Ethylbenzene	100-41-4	750	50
Xylene	1330-20-7	1,200	50

Analyst: Donna Gajewski
Verified: Tony Kosiba
Date Verified: 06/18/92

Respectfully submitted,

Environmental/Analytical Testing Division

ATEC Environmental Consultants
Division of ATEC Associates, Inc.
9020 Mendenhall Court, Suite D
Columbia, Maryland 21045-4716
(301) 381-0655, FAX #(301) 381-9302

Solid & Hazardous Waste Site Assessments
Remedial Design & Construction
Underground Tank Management
Asbestos Surveys & Analysis
Hydrogeologic Investigations & Monitoring
Analytical Testing / Chemistry
Industrial Hygiene / Hazard Communication
Environmental Audits & Permitting
Exploratory Drilling & Monitoring Wells

June 12, 1992

ATEC Associates, Inc.
2551 Eltham Ave.
Suite Z
Norfolk, VA 23513
Attn: Kevin Davis

Client Project: Tank No TC-341
Sampled By: KD
Matrix of Samples: Soil
Date Samples Collected: 06/01/92 & 06/02/92
Date Samples Received: 06/08/92
Date Samples Analyzed: 06/11/92
Analytical Equipment: O.I. Corporation GC System Purge and Trap flame ionization detector.
Analytical Method: SW 846 8015 Modified

ATEC Chem Lab Job # 31-08-92-00360

TOTAL PETROLEUM HYDROCARBON ANALYTICAL RESULTS

Client Sample	ATEC Chem Lab Sample		Concentration (mg/Kg)	Quantitation Limit (mg/Kg)
MWS-1	921612	*	140	1
MWS-2	921613	**	2,000	1
MWS-3	921614	*	110	1
MWS-4	921615	**	1,200	1

* Calculations based on a Diesel Standard.
** Calculations based on a Gasoline Standard.

Analyst: Donna Gajewski
Verified: Tony Kosiba
Date Verified: 06/11/92

Respectfully submitted,

Environmental/Analytical Testing Division

ATEC Environmental Consultants
Division of ATEC Associates, Inc.
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June 11, 1992

ATEC Associates, Inc.
2551 Eltham Ave.
Suite Z
Norfolk, VA 23513
Attn: Kevin Davis

Client Project: Tank No TC-341
Matrix of Samples: Water
Sampled By: KD
Date Samples Collected: 06/04/92
Date Samples Received: 06/08/92
Date Samples Analyzed: 06/09/92
Analytical Equipment: O.I. Corporation GC System Purge and Trap flame ionization detector.
Analytical Method: SW 846 8015 Modified

ATEC Chem Lab Job # 31-08-92-00360

TOTAL PETROLEUM HYDROCARBON ANALYTICAL RESULTS

Client Sample	ATEC Chem Lab Sample	Concentration (mg/L)	Quantitation Limit (mg/L)
MW-1	921616	* 5	1
MW-2	921617	* 3	1
MW-3	921618	<1	1
MW-4	921619	* 2	1

* Calculations based on a Diesel Standard.

Analyst: Donna Gajewski
Verified: Tony Kosiba
Date Verified: 06/11/92

Respectfully submitted,

Environmental/Analytical Testing Division

REQ T FC

F ontro
C/C Control No. 1v 02

ATEC®

Environmental Consultants

Division of ATEC Associates of Va., Inc.
2551 Eltham Avenue, Suite Z
Norfolk, Virginia 23513-2511
(804) 857-6765, FAX # (804) 857-6283

92-00360
#11

DATE SAMPLES SHIPPED 6/5/92
LAB DESTINATION ATEC Columbia
LABORATORY CONTACT Tony Kosiba
SEND LAB REPORT TO ATEC NorfolK

SAMPLING PROGRAM Tank No TC-341

DATE REPORT REQUIRED normal turnaround
PROJECT CONTACT Kevin Davis
PURCHASE ORDER NO.
PROJECT CONTACT PHONE NO. (804) 857-6765

Sample Number	Sample Type	Sample Quantity	Preservative	Req't. Testing Program	Special Instructions
MWS-1	soil	1x4oz	Cool to 4°C	TPH 8015 revised	921612
MWS-2	↓	↓	↓	+BTEX ↓	613
MWS-3	↓	↓	↓	↓	614
MWS-4	↓	↓	↓	↓	615
MW-1	water	2x40ml	↓	TPH 8015 revised	616
MW-2	↓	↓	↓	+BTEX ↓	617
MW-3	↓	↓	↓	↓	618
MW-4	↓	↓	↓	↓	619
					1530

6/6
6/7

TURNAROUND TIME REQUIRED: (Rush must be approved by appropriate Manager.) NORMAL ✓ RUSH ____ (Subject to rush surcharge)

POSSIBLE HAZARD IDENTIFICATION: (Please indicate if sample(s) are hazardous materials and/or suspected to contain high levels of hazardous substances.)

NONHAZARD ✓ FLAMMABLE ____ SKIN IRRITANT ____ HIGHLY TOXIC ____ BIOLOGICAL ____ OTHER ____ (Please Specify)

SAMPLE DISPOSAL: (Please indicate disposition of sample following analysis.) RETURN TO CLIENT ____ DISPOSAL BY LAB ✓

FOR LAB USE ONLY

RECEIVED BY ____ DATE/TIME ____

WHITE - Original - to accompany samples