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PROPOSED REMEDIAL ACTION PLAN
OPERABLE UNIT NO. 10
SITE 35 - CAMP GEIGER AREA FUEL FARM

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0232

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Prepared For:

DEPARTMENT OF THE NAVY
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Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
AST	aboveground storage tank
Baker	Baker Environmental, Inc.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPC	contaminant of potential concern
DCE	dichloroethene
DoN	Department of the Navy
FFA	Federal Facilities Agreement
FS	Feasibility Study
gpm	gallons per minute
HI	Hazard Index
ICR	Incremental Cancer Risk
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MTBE	methyl-tertiary-butyl-ether
MW	monitoring well
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCWQS	North Carolina Water Quality Standards
NPW	net present worth
O&M	operation and maintenance
OU	Operable Unit
PCB	polychlorinated biphenyl
ppb	parts per billion
PRAP	Proposed Remedial Action Plan
QI	Quotient Index
RA	risk assessment
RAA	remedial action alternative
RI	Remedial Investigation
ROD	Record of Decision
SGI	Supplemental Groundwater Investigation
SVOC	semivolatile organic compound

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TCE	trichloroethene
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
WQSV	water quality screening value

INTRODUCTION

This Proposed Remedial Action Plan (PRAP) is issued to describe the Marine Corps Base (MCB), Camp Lejeune's and the Department of the Navy's (DoN's) preferred remedial action for Operable Unit (OU) No. 10 at MCB, Camp Lejeune. OU No. 10 is also referred to as Site 35, the Camp Geiger Area Fuel Farm.

MCB, Camp Lejeune and the DoN are issuing this PRAP as part of the public participation responsibility under Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and the Federal Facilities Agreement (FFA) between MCB, Camp Lejeune, the DoN, the United States Environmental Protection Agency (USEPA) Region IV, and the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR). The purpose of this PRAP is to: identify the preferred remedial action alternatives for Site 35 and explain the rationale for the preferences; solicit public review of the alternatives; and provide information on how the public can be involved in the remedial action selection process.

This PRAP has been based on previous environmental investigations conducted at Site 35 under the Installation Restoration Program at MCB, Camp Lejeune. These investigations include, but are not limited to, a Remedial Investigation (RI), an Interim Remedial Action Feasibility Study (FS) for Surficial Groundwater in the Vicinity of the Fuel Farm, a Supplemental Groundwater Investigation (SGI), and a Comprehensive FS for Groundwater. Installation Restoration documents pertaining to Site 35 are contained within an administrative record file that is available for public review at the MCB, Camp Lejeune Installation Restoration Division Office (Building 67, Room 238) and at the Onslow County Library in Jacksonville, North Carolina. The DoN encourages the public to review the administrative record file in order to gain a more comprehensive understanding of Site 35.

The public is also encouraged to comment on information contained within the administrative record file and this PRAP. Public comments will be accepted by the DoN, USEPA Region IV, and NC DEHNR representatives listed at the end of this document. The public is encouraged to submit comments on this PRAP since the comments can influence the DoN's, USEPA's and State's preference. The 30-day public comment period will begin on a date to be determined. The DoN, with the assistance of the USEPA and the NC DEHNR, may modify the preferred alternative or select another remedial action based on new information or comments received from the public.

MCB, Camp Lejeune and the DoN, with the assistance of USEPA Region IV and the NC DEHNR, will select a final remedy for Site 35 only after the public comment period has ended and the information submitted during this time has been reviewed and considered. A Record of Decision (ROD) stating the selected remedial action plan for Site 35 will be prepared based upon the results of the SGI, FS, PRAP, and public comment period. The Final ROD may recommend a different remedial action than is presented in this PRAP depending upon public comments and any new information that may become available.

BACKGROUND INFORMATION

This section presents the following background information: a description of Camp Lejeune, a description of Site 35, the site history, and a summary of previous investigations.

Description of MCB, Camp Lejeune

Located in Onslow County, North Carolina, Camp Lejeune is a training base for the United States Marine Corps. The Base covers approximately 236 square miles and includes 14 miles of coastline. Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the Base.

OU No. 10 is one of 18 operable units located within Camp Lejeune. Operable units were developed at the Base to combine one or more individual sites that share a common element. OU No. 10 contains only one site, Site 35, which is otherwise known as the Camp Geiger Area Fuel Farm. Figure 1 depicts the location of OU No. 10 (Site 35) within Camp Lejeune.

Site Description

Site 35, Camp Geiger Area Fuel Farm, refers to a former fuel storage and dispensing facility that was located just north of the intersection of Fourth and "G" Streets. The Fuel Farm primarily consisted of five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, a fuel loading/unloading pad, an oil/water separator, and a distribution island. The facility actively served Camp Geiger and the New River Air Station from 1945 to 1995, when it was demolished to make way for the proposed U.S. Route 17 Bypass, a six-lane divided highway, to be constructed by the North Carolina Department of Transportation. Figure 2 depicts the approximate location of the highway which has not yet been constructed.

Figure 3 presents the approximate boundaries of the Site 35 study areas. Results of previous investigations expanded the study area beyond the confines of the former Fuel Farm. As shown, the RI and Interim FS focused on an area encompassing approximately 50 acres. The SGI and the Comprehensive FS focused on the northern and southern areas of concern which expanded the study area to approximately 150 acres. This PRAP is an extension of the SGI and the Comprehensive FS; the PRAP focuses on solvent-contaminated groundwater located in the southern area of concern.

Site History

Construction of Camp Geiger was completed in 1945, four years after construction of Camp Lejeune was initiated. Originally, the Fuel Farm ASTs were used for the storage of No. 6 fuel oil. An underground distribution line (now abandoned) 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 underground storage tank (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 1960s. At some unrecorded date, the facility was converted for storage of other petroleum products, including unleaded gasoline, diesel fuel, and kerosene.

From the date of this conversion until the facility was decommissioned in the spring of 1995, the ASTs at Site 35 were 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 were supplied by commercial carrier trucks which delivered product to fill ports located on the fuel loading/unloading pad located south of the ASTs. Six, short-run (120 feet maximum), underground fuel lines were utilized to distribute the product from the unloading pad to the ASTs.

During the lifetime of the facility, several releases of product occurred. Reports of a release from an underground distribution line near one of the ASTs date back to 1957-58. 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 reportedly migrated to the east and northeast toward Brinson Creek. Interceptor trenches were excavated and the captured fuel was ignited and burned.

Routinely, the ASTs at Site 35 supplied fuel to an adjacent dispensing pump that was supplied by an underground line. A leak in an underground line at the station was reportedly responsible for the loss of roughly 30 gallons per day of gasoline over an unspecified period. The leaking line was subsequently sealed and replaced.

In April 1990, an undetermined amount of fuel was discovered by Camp Geiger personnel along two unnamed drainage channels north of the Fuel Farm. Apparently, the source of the fuel, believed to be diesel or jet fuel, was an unauthorized discharge from a tanker truck that was never identified. The Activity reportedly initiated an emergency clean-up which included the removal of approximately 20 cubic yards of soil.

The Fuel Farm was decommissioned and demolished during the spring of 1995. The ASTs were emptied, cleaned, dismantled, and removed along with all concrete foundations, slabs on grade, berms and associated underground piping. The Fuel Farm was demolished to make way for the proposed U.S. Route 17 Bypass, a six lane divided highway, proposed by the North Carolina Department of Transportation.

In addition to the Fuel Farm dismantling, soil remediation activities were executed between the spring of 1995 and the spring of 1996 along the proposed highway right-of-way as per an Interim ROD for Soil executed on September 15, 1994.

Previous Investigations

Previous investigations conducted at Site 35 include the following:

- Initial Assessment Study (1983)
- Confirmation Studies (1984 and 1987)
- Focused Feasibility Study (1990)
- Comprehensive Site Assessment (1991)
- Interim Remedial Action for Soil (1993)
- UST Investigations (1994-1996)
- Remedial Investigation (1994)
- Interim Feasibility Study for Surficial Groundwater in the Vicinity of the Fuel Farm (1995)
- Supplemental Groundwater Investigation (1995)
- Comprehensive Feasibility Study (1997)

The results of the four most recent investigations/studies (the RI, Interim FS, SGI, and Comprehensive FS) are summarized below.

Remedial Investigation

The RI (Baker, 1994) was conducted to determine the nature and extent of potential contamination at Site 35. The RI field program was initiated in April 1994 and completed in October 1994. The following paragraphs briefly describe the results of soil, groundwater, surface water/sediment, and fish investigations.

Surface and Subsurface Soil

Relatively few detections of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) were observed in surface and subsurface soil samples obtained under the RI. The most significant contamination detected involved tetrachloroethane in subsurface soil at boring 35MW-30B located near the barracks southwest of the Fuel Farm. Pesticides were detected in surface soil samples only, but, are not deemed to be Site-related. No polychlorinated biphenyls (PCBs) were detected in surface soil samples. Detected inorganics were generally similar to background surface and subsurface soil concentrations at Camp Lejeune.

Groundwater

The nature and extent of groundwater contamination was determined for the upper and lower portions of the surficial aquifer, and the upper portion of the Castle Hayne aquifer.

Fuel and solvent-related groundwater contamination was observed in the upper and lower portions of the surficial aquifer. The limits of fuel and solvent-related groundwater contamination in the upper and lower portions of the surficial aquifer are shown in Figures 4 and 5, respectively. Fuel-related organic contaminants, when encountered, appeared more prevalent in the upper portion of the surficial aquifer. Conversely, solvent-related organic contaminants, when encountered, appeared more prevalent in the lower portion of the surficial aquifer. This is likely due to the fact that solvents are more dense compounds so they sink in groundwater.

The extent of fuel-related contamination was adequately defined based on the data obtained during the RI. At the time the RI was conducted, this contamination was limited to the area north of Fourth Street in the vicinity of suspected sources such as the Fuel Farm and the nearby former UST sites.

The extent of solvent-related contamination, however, was not completely defined by the RI. Based on RI data, solvent-related contamination appeared to extend from north of Fourth Street to Fifth Street. However, the RI did not extend beyond Fifth Street in the southerly direction. The source of this plume was not determine during the RI. A second smaller plume was identified in the vicinity of the Former Vehicle Maintenance Garage (Building TC474). The smaller plume appears to be adequately defined and the source of contamination appeared to be Building TC474 and the immediate vicinity.

Elevated levels of inorganic contaminants (total and dissolved) were detected in groundwater samples obtained from within the surficial aquifer. However, these inorganics results were similar to those obtained by Baker at other Camp Lejeune sites. The elevated total metals were believed to be caused by suspended particulates in the samples, and there does not appear to be a site-related inorganics problem at Site 35.

No substantial contamination was detected in the upper portion of the Castle Hayne Aquifer. This indicated that at the time the RI was conducted the suspected semi-confining layer that separates the surficial aquifer from the Castle Hayne Aquifer was serving as an aquitard.

Surface Water and Sediment

The sediment samples contained elevated concentrations of fuel-related contaminants and lead. Both the detected organics and inorganics appeared to be potentially site-related.

Surface water contamination was limited to a single detection of lead and zinc downstream of Site 35 at levels in excess of the Water Quality Screening Values (WQSVs) and the North Carolina Water Quality Standards (NCWQSs). No organic contaminants were detected in surface water samples.

Fish

A variety of organic and inorganic contaminants were detected in fillet and whole body samples analyzed under the RI. The most significant contaminants detected were the pesticides dieldrin and 4,4'-DDD, with a single detection of inorganic mercury.

Interim Feasibility Study for Surficial Groundwater in the Vicinity of the Fuel Farm

The purpose of the Interim FS (Baker, 1995) was to identify and evaluate remedial action alternatives for the contaminated surficial groundwater that was identified during the RI (see Figures 4 and 5). The Interim FS culminated with the execution of the Interim ROD For Surficial Groundwater for a Portion of Operable Unit No. 10 - Camp Geiger Area Fuel Farm, signed on September 5, 1995. The ROD recommended in situ air sparging treatment as a downgradient barrier along Brinson Creek. The location of the proposed in situ air sparging barrier is depicted in Figures 4 and 5. In July and August of 1996, a pilot-scale treatability study was conducted to assess the viability of in situ air sparging at Site 35. Based on the results of the study, another slightly different pilot-scale study (which has not yet been conducted) was recommended.

Supplemental Groundwater Investigation

The SGI (Baker, 1996) was conducted to further define the extent of contamination south of Fifth Street and on the northeast side of Brinson Creek. Field activities were conducted between July 1995 and October 1996. The following paragraphs describe the results of the soil, groundwater, and sediment investigations.

Soil

No fuel or solvent-related contamination was detected in any soil sample that was collected under the SGI.

Groundwater

Figures 6 and 7 depict the extent of groundwater contamination in the upper and lower portions of the surficial aquifer, respectively, as determined by the SGI. Analytical results identified two contaminant plumes: a solvent-related plume approximately 780-feet wide, and a fuel-related plume approximately 265-feet wide. Solvent-related contamination was predominant in the lower portion of the surficial

aquifer, and fuel-related contamination was predominant in the upper portion of the surficial aquifer. In addition, four metals (iron, manganese ,aluminum and antimony) were detected at levels that exceed regulatory limits.

A single sample was collected from a well that was installed into the upper portion of the Castle Hayne aquifer and analyzed for VOCs. No contamination was detected in this sample.

Sediment

Two samples were collected from each of the ten sampling locations along Brinson Creek and analyzed for TPH, mercury and zinc. TPH contamination was detected at nine of the ten sampling locations. The highest levels of TPH contamination were located adjacent to and downstream of Site 35.

Comprehensive Feasibility Study

The Comprehensive FS (Baker, 1997) was conducted to identify and evaluate remedial action alternatives for the contaminated shallow groundwater that was identified during the SGI. This PRAP recommends a preferred remedial action alternative based on the evaluation conducted in the Comprehensive FS.

SUMMARY OF SITE RISKS

During the RI and SGI, a human health risk assessment (RA) and an ecological RA were conducted to determine the potential risks associated with the chemical constituents detected at Site 35. The following subsections briefly summarize the findings of the human health and ecological RAs.

Human Health Risk Assessment

During the human health RA, Incremental Cancer Risk (ICR) and Hazard Index (HI) values were calculated to quantify the potential carcinogenic and noncarcinogenic risks at Site 35. Current and future potential receptors at the site included current military personnel, current recreational adults and children, future residents (i.e., children and adults), and future construction workers. Table 1 presents the contaminants of potential concern (COPCs) that were identified for each medium. The total site risk for each receptor was estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. The following algorithms defined the total site risk for the current and future potential receptor groups.

1. Current Military Personnel

    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs

2. Future Residents (Children and Adults)

    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation airborne of COPCs

    b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs

3. Future Construction Worker

   a. Incidental ingestion of COPCs in on-site subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs

4. Current Recreational Children and Adults

   a. Ingestion of COPCs in surface water and sediment + dermal contact with COPCs in surface water and sediment

   b. Ingestion of fish tissue (adults only)

Table 2 presents the total site ICR and HI values associated with current and future receptors. As shown, the total site ICR for future adult residents (4.3×10^{-3}) and future child residents (2.1×10^{-3}) exceeded the USEPA's upper bound risk range (1×10^{-4} to 1×10^{-6}) indicating an unacceptable potential carcinogenic risk. The total site risk was driven by future potential exposure to groundwater. The ICR values were driven by the presence of arsenic and beryllium. The total site HI for the future adult resident (44) and the future child resident (104) exceeded 1.0 indicating an unacceptable potential noncarcinogenic risk. The total site risk was driven by future potential exposure to groundwater. The HI values were driven by the presence of cis-1,2-dichlorothene, trichloroethene, benzene, antimony, arsenic, barium, chromium, cadmium, manganese, and vanadium.

In addition, the total site HI for the current recreational adult (1.8) slightly exceeded 1.0. This HI was due to potential exposure from fish fillet ingestion which is driven by the presence of mercury. However, the exposure parameters used to calculate risk from fish ingestion were very conservative; mercury was not found to be causing a risk in any other media at Site 35; and the fish collected at Site 35 are considered migratory and move along Brinson Creek, therefore this risk may not be due to contamination at the site. As a result, the risk from ingestion of fish may not be Site-related.

To supplement the human health RA conducted for the RI, an additional RA was conducted after the SGI for VOCs and metals in groundwater. COPCs were chosen qualitatively (if detected it was included) for VOCs and quantitatively for inorganic data. The COPCs selected are shown in Tables 3 and 4. These values were then added to organic values from the RI replacing the original inorganic data. The exposure scenario was future adult and child via ingestion and dermal contact with groundwater.

All detected VOCs were chosen as qualitative COPCs. The detected concentrations of these compounds were generally lower than those detected during the RI. The additional data suggested that the potential for adverse health effects to occur would not increase.

During the supplemental RA, carcinogenic and noncarcinogenic values inorganics were calculate for inorganics to replace the inorganic data from the initial RI. The total groundwater ICR for future child residents (1.4×10^{-4}) and adult residents (3.1×10^{-4}) slightly exceeded the USEPA's upper bound risk range (1×10^{-6} to 1×10^{-4}) indicating an unacceptable potential carcinogenic risk. These elevated ICR values were driven by the ingestion of trichloroethene and benzene (approximately 60 percent combined) in the groundwater. Arsenic contributed approximately 35 percent to the total ICR. It should be noted that arsenic is a naturally occurring element. In addition, there is no historical record of any use or disposal of arsenic at Site 35. When compared to the results of the original RA, the carcinogenic risk from groundwater was one order of magnitude less. Beryllium, the main driver of the previous carcinogenic risk calculations, was not detected during the SGI. As a result, the VOCs became the main contributors

to the ICR value. These results are shown in Table 5.

The total groundwater HI values for the future child resident (48) and the future adult resident (21) exceeded the USEPA's limit of 1.0 indicating an unacceptable potential noncarcinogenic risk. The ingestion pathway contributed over 90 percent to these elevated HI values. The total HI values for future adults and children were driven by benzene (approximately 37 percent) and trichloroethene (approximately 20 percent) from the RI organic data. The detected concentrations of VOCs from the initial investigation also drove the noncarcinogenic risk. These results are shown in Table 5.

Ecological Risk Assessment

Table 6 presents the COPCs that were evaluated during the ecological RA. Based on the RA results, metals and pesticides appeared to be the most significant Site-related COPCs that had the potential to affect the integrity of the aquatic and terrestrial receptors at Site 35. Although the American alligator has been observed at Site 35, potential adverse impacts to this species could not be quantitatively evaluated. The following paragraphs briefly describe the potential risks associated with the aquatic and terrestrial ecosystems.

Aquatic Ecosystem

Surface water quality showed exceedances of aquatic reference values for lead, mercury, and zinc. In addition, iron, cobalt and manganese were above the concentration that caused adverse impacts to aquatic species in a few studies. However, most of the studies did not meet the criteria for reliability, and other studies indicated that potential impacts to aquatic organisms did not occur at the concentrations detected in the surface water at Brinson Creek. For sediments, concentrations of lead and the organics dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, alpha-chlordane, and gamma-chlordane exceeded the aquatic reference values. In the surface water, mercury exceeded aquatic reference values in the upstream stations. Although these levels were indicative of a high potential for risk (Quotient Index [QI] > 100), mercury is not believed to be Site-related. Zinc only exceeded unity slightly and was only found at a single station. Lead had a single exceedance of the aquatic reference value by slightly greater than 10 indicating a moderate potential for risk to aquatic receptors. Lead also was found in the groundwater samples at similar levels and was believed to be Site-related.

In the sediments, lead exceeded the lower sediment aquatic reference value throughout Brinson Creek. The only exceedances of the higher sediment aquatic reference value occurred downstream of Site 35 with the highest QI of 137 representing a high potential for risk to aquatic receptors. The lead detected in the sediments is likely Site-related, the result of past reported surface spills/runoff and past and ongoing groundwater discharges to surface water.

Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek. The highest QI, 2,600 for dieldrin, represents a high potential for risk to aquatic receptors. There is no documented pesticide disposal or storage/preparation activities at Site 35. The pesticide levels detected in the sediments probably are a result of routine application in the general vicinity of Site 35.

Although the pesticides in the sediments were found at levels indicating contamination throughout the watershed, the highest levels were observed in the lower reaches of Brinson Creek. This deposition trend may be related to the higher organics in the sediments in the lower reach, which would accumulate more of these types of contaminants.

The fish community sampled in Brinson Creek was representative of an estuarine ecosystem with both freshwater and marine species present. In addition, the presence of blue crabs, grass shrimp, and crayfish support the active use of Brinson Creek by aquatic species.

The absence of pathologies observed in the fish collected from Brinson Creek indicated that the surface water and sediment quality may not adversely impact the fish community.

The benthic macroinvertebrate community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches and polychaetes and amphipods in the lower reaches. Species representative of both tolerant and intolerant taxa were present. Species richness and densities were representative of an estuarine ecosystem.

In summary, the aquatic community in Brinson Creek was representative of an estuarine community and did not appear to be significantly impacted by surface water and sediment quality.

Terrestrial Ecosystem

Surface soil quality indicated a potential for adversely impacting the terrestrial receptors that have direct contact with the surface soils. This adverse impact was primarily due to cadmium in the surface soils. Cadmium was detected at a relatively high concentration in only one out of ten surface soil samples. Therefore, any estimation of adverse effects on terrestrial receptors using this cadmium concentration is conservative.

There also appeared to be impacts to the terrestrial receptors due to copper in the fish tissue. Copper was not detected in the surface water but was detected in sediment samples collected downstream of Site 35 at concentrations lower than the sediment samples taken upstream of Site 35. As such, the copper in the fish tissue did not appear to be Site-related.

SCOPE AND ROLE OF ACTION

The response action for this PRAP focuses on the surficial aquifer at Site 35, and the fuel- and solvent-contaminated areas of concern that were identified during the SGI. Figures 6 and 7 depict these areas of concern. In particular, the response action addresses the southern portion of this groundwater contamination as it migrates in an east-southeasterly direction. The northern portion of the contamination, which migrates in a northeasterly direction toward Brinson Creek (see Figures 4 and 5), was already addressed as part of the RI and Interim FS. An in situ air sparging barrier along the future highway was proposed to prevent the contamination from further migrating into Brinson Creek.

SUMMARY OF ALTERNATIVES

Six remedial action alternatives (RAAs) were developed and evaluated for the contaminated groundwater at Site 35:

- RAA 1: No Action
- RAA 2: Site Controls and Long-Term Monitoring
- RAA 3: Natural Attenuation
- RAA 4: Extraction and Ex Situ Treatment
- RAA 5: In Situ Passive Treatment/Slurry Cut-Off Wall
- RAA 6: In Well Aeration and Off Gas Carbon Adsorption

The following paragraphs describe these alternatives.

RAA 1: No Action

Capital Cost:	$0
Annual Operation and Maintenance (O&M) Cost:	$0
Net Present Worth (NPW):	$0
Years to Implement:	None

Under the no action RAA, no remedial actions will be performed to reduce the toxicity mobility, or volume of contaminants identified in groundwater or to monitor subsurface conditions at Site 35. The no action alternative is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to provide a baseline for comparison with other RAAs that provide a greater level of response.

Since contaminants will remain at the site under this RAA, the lead agency is required to review the effects of this alternative at least once every five years.

RAA 2: Site Controls and Long-Term Monitoring

Capital Cost:	$36,000
Annual O&M Cost (Years 1-5):	$112,700
Annual O&M Cost (Years 6-30):	$62,800
NPW:	$1,220,000
Years to Implement:	30 years of groundwater monitoring (quarterly for 5 years and semiannually for 25 years)

Under RAA 2, no engineered remedial actions will be applied at Site 35. Instead, site controls and a long-term groundwater monitoring program will be implemented.

Site Controls

Site controls, or aquifer-use restrictions, will mitigate the potential for exposure to contaminated groundwater. The aquifer-use restrictions will include the regulation of supply well construction and the identification of restricted use areas in the Base Master Plan. The regulation of new supply wells will be the responsibility of the Activity department that provides potable water or that is tasked with protecting public health. Such restrictions will prohibit the construction of new potable water supply wells in the vicinity (approximately a one-mile radius) of the contaminant plume at Site 35. Construction of supply wells for fire protection will be considered on a case by case basis. To identify restricted use areas at the Activity, the Base Master Plan will include a long-term strategy for the development of groundwater resources. The Plan will clearly identify areas, such as Site 35, where the development of groundwater resources is prohibited.

Groundwater Monitoring

The purpose of the groundwater monitoring program is to track the contaminant plume's migration over time, identify any fluctuations in contaminant levels, and monitor the effectiveness of any other remedial

actions that may be implemented at Site 35. The monitoring program will include 2 wells in the Castle Hayne aquifer, 16 wells in the lower portion of the surficial aquifer, and 14 wells in the upper portion of the surficial aquifer. The groundwater samples will be collected and analyzed for VOCs on a quarterly basis. If groundwater quality appears to be improving, the monitoring frequency may be reduced from quarterly to semiannual. For cost estimating purposes, 5 years of quarterly sampling was assumed, followed by 25 years of semiannual sampling.

RAA 3: Natural Attenuation

Capital Cost:	$290,000
Annual O&M Cost (Years 1-5):	$251,000
Annual O&M Cost (Years 6-30):	$142,000
NPW:	$2,470,000
Years to Implement:	30 years of groundwater monitoring (quarterly for 5 years and semiannually for 25 years)

RAA 3 involves natural attenuation, otherwise known as intrinsic bioremediation, of the contaminated groundwater. The Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater (Wiedemeier, 1995) defines natural attenuation as follows:

> "The term 'natural attenuation' refers to naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants."

At Site 35, the daughter products of trichloroethene degradation reactions (e.g., dichloroethene and vinyl chloride) have been detected in the surficial aquifer. The existence of these daughter products provides strong evidence that the solvent contamination may be naturally biodegrading (i.e., naturally attenuating) at the site. Based on technical literature that strongly supports the natural attenuation of fuel contaminants in a variety of subsurface conditions, degradation of the fuel contamination is most likely occurring. As a result, natural attenuation appears to be a viable alternative for the contaminated groundwater at Site 35.

RAA 3 includes a treatability study, a long-term monitoring program, and fate and transport modeling updates, which are described below. Since contaminants will remain at the site under this RAA, the lead agency is required to review the effects of this alternative at least once every five years.

Treatability Study

The treatability study will be used to assess the ability of the naturally occurring subsurface processes at Site 35 to reduce the fuel and solvent contamination in toxicity, mobility, volume, and concentration. The treatability study will include the following:

- A laboratory microcosm study to determine if indigenous microbes are capable of degrading site contaminants, and the estimated rate of degradation.

- An initial round of soil and groundwater sampling to assess the impacts of natural attenuation at Site 35. Table 7 presents the analytical parameters for the soil and groundwater samples. Figure 8 identifies the sampling locations.

- Development of a baseline contaminant fate and transport model that takes into account the natural attenuation mechanism. This model will be used to predict contaminant plume reduction and changes in the chemical character of the plume.

Long-Term Groundwater Monitoring

Assuming the treatability study confirms that natural attenuation processes are occurring at Site 35, a long-term groundwater monitoring program will be implemented. This program will monitor contaminant levels and provide additional data to support contaminant fate and transport model updates. Table 7 presents the analytical parameters for the groundwater samples. Figure 8 identifies the sampling locations. The samples will be collected on a quarterly basis. If groundwater quality appears to be improving, the monitoring frequency may be reduced from quarterly to semiannual. For cost estimating purposes, 5 years of quarterly sampling was assumed, followed by 25 years of semiannual sampling.

Fate and Transport Modeling Updates

Under RAA 3, annual updates of the contaminant fate and transport model will be performed. These updates will be used to verify the assumptions of the initial modeling effort and to provide a means for regularly re-evaluating the effectiveness of natural attenuation over time.

RAA 4: Extraction and Ex Situ Treatment

Capital Cost:	$1,268,000
Annual Monitoring O&M Cost (Years 1-5):	$113,000
Annual Monitoring O&M Cost (Years 6-30):	$63,000
Annual Treatment System O&M Cost (Years 1-30):	$47,000
NPW:	$3,760,000
Years to Implement:	30 years of groundwater monitoring (quarterly for 5 years and semiannually for 25 years), and 30 years of system O&M

RAA 4 is a conventional pump and treat alternative which includes the installation of seven extraction wells in the shallow aquifer and the construction of a 40 gallon per minute (gpm) treatment facility.

Four extraction wells will be located in a line (with overlapping radii of influence) along the eastern edge of the contaminant plume to serve as a downgradient barrier. The radii of influence of these wells are expected to be approximately 120 feet each, and the pumping rates are expected to be 5 to 10 gpm each. Three extraction wells will be installed in the "hot spot" area of the plume to actively treat the highest contaminant concentrations. The radii of influence of these wells are expected to be approximately 80 feet each, and the pumping rates are expected to be 2 gpm each. (RAA 4 requires a pump test so that a better estimate of the expected radii of influence and pumping rates can be made.) All extraction wells will be screened from the semiconfining unit which is located approximately 40 feet below ground surface, to the water table which is located approximately 6 to 10 feet below ground surface.

The 40 gpm treatment facility will consist of air stripping and carbon adsorption for VOC removal, and coagulation/flocculation, clarification/sedimentation, and filtration for metals removal. Once treated, the groundwater will be discharged to Brinson Creek via an adjacent storm drain system which will be upgraded to accommodate the 40 gpm flow.

In addition to groundwater extraction and treatment, RAA 4 incorporates the site controls (i.e., aquifer-use restrictions) and long-term groundwater monitoring program identified in RAA 2. Until remediation levels are met, the lead agency is required to review the effects of this alternative at least once every five years.

RAA 5: In Situ Passive Treatment/Slurry Cut-Off Wall

Capital Cost:	$5,976,000
Annual O&M Cost (Years 1-5):	$130,430
Annual O&M Cost (Years 6-30):	$71,600
NPW:	$7,330,000
Years to Implement:	30 years of groundwater monitoring (quarterly for 5 years and semiannually for 25 years)

RAA 5 includes the construction of in situ passive treatment and slurry cut-off walls. This type of technology is referred to as a "funnel and gate" system. The slurry wall directs or funnels groundwater flow to the passive treatment wall gates that treat the groundwater as it passes through. The treatment gates consist of a vertical section of iron filings sandwiched between two vertical gravel sections. The iron filings facilitate the dechlorination of solvent-contaminated groundwater into non-toxic byproducts as groundwater flows through the gates.

Alternating sections of passive treatment wall and slurry wall will be installed as a vertical barrier beneath the ground surface. To effectively block contaminant migration, the walls are installed through the aquifer down to the confining unit. A 10:1 ratio is usually employed for the lengths of the treatment and slurry walls (i.e., 10 feet of slurry wall is constructed for every 1 foot of treatment wall).

Under RAA 5, two treatment/slurry cut-off walls will be constructed at the downgradient edges of the plume. One wall will be approximately 1,300 feet in length, with a total of 1,170 feet of funnel and 150 feet of gate. The other wall will be approximately 1,000 feet in length, with a total of 900 feet of funnel and 100 feet of gate. The treatment gates will be approximately nine feet wide and the slurry funnels will be approximately three feet wide. Prior to construction, a bench-scale test is required to determine the exact formulation of the iron material and composition of the slurry wall.

In addition to groundwater extraction and treatment, RAA 5 incorporates the site controls (i.e., aquifer-use restrictions) and long-term groundwater monitoring program identified in RAA 2. Until remediation levels are met, the lead agency is required to review the effects of this alternative at least once every five years.

RAA 6: In-Well Aeration and Carbon Off-Gas Treatment

Capital Cost:	$1,060,000
Annual Monitoring O&M Cost (Years 1-5):	$113,000
Annual Monitoring O&M Cost (Years 6-30):	$63,000
Annual Treatment System O&M Cost:	$72,000
NPW:	$3,350,000
Years to Implement:	30 years of monitoring (quarterly for 5 years and semiannually for 25 years), and 30 years of system O&M

RAA 6 involves the in-well aeration technology, otherwise known as in-well air stripping. This technology involves air injection into a groundwater well which results in an in-well air-lift pump effect. The pump effect causes the groundwater to flow in a circulation pattern: into the bottom of the well and out of the top of the well. As the groundwater circulates through the well, the injected air stream strips away VOCs. The VOCs are captured at the top of the well and treated via carbon adsorption.

Under RAA 6, ten aeration wells will be installed with overlapping radii of influence at Site 35. Seven wells will be located in a line along the eastern limit of the contaminant plume. These wells will intercept the contaminant plume and mitigate horizontal migration. Three wells will be installed in the "hot spot" area of the plume. These wells will actively treat the most contaminated portion of the plume. VOCs that are stripped within the aeration wells will be treated by a trailer mounted unit that will include a blower, knockout tank, vacuum pump, and vapor-phase carbon adsorption unit. Under RAA 6, two to three aeration wells will be connected to a single trailer mounted treatment unit, so three units will be required.

In addition to groundwater extraction and treatment, RAA 6 incorporates the site controls (i.e., aquifer-use restrictions) and long-term groundwater monitoring program identified in RAA 2. Until remediation levels are met, the lead agency is required to review the effects of this alternative at least once every five years.

EVALUATION OF ALTERNATIVES

This section summarizes the detailed evaluation of the remedial action alternatives. During the detailed evaluation, the RAAs were comparatively analyzed using seven USEPA evaluation criteria: overall protection of human health and the environment; compliance with applicable and relevant or appropriate requirements (ARARs); long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. Table 8 provides definitions of these evaluation criteria.

Overall Protection of Human Health and the Environment

RAA 1 (No Action), RAA 2 (Site Controls with Long-Term Monitoring), and RAA 3 (Natural Attenuation) are similar in that each involves no engineered treatment. However, RAA 1 does not provide for the overall protection of human health and the environment. RAA 2 and RAA 3 provide for the overall protection of human health and the environment through site controls and monitoring.

RAA 2 and RAA 3 differ in the manner in which natural attenuation processes are monitored and assessed. Under RAA 3, natural attenuation processes are monitored using protocols that were

specifically developed for natural attenuation. Under RAA 2, groundwater samples are analyzed for only the contaminants using contract laboratory protocol. In addition, RAA 3 employs an appropriate model that can be used to predict the effectiveness of natural attenuation. RAA 2 does not include model development.

RAA 4 (Extraction Wells and Ex Situ Treatment), RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall), and RAA 6 (In-Well Aeration and Off-Gas Adsorption) are all similar in that each applies an active treatment system to mitigate off-site migration of the contaminant plume. RAA 4 and 6 also include provisions to reduce contaminant mass through treatment near the "hot spot" area of the contaminated plume.

Compliance with ARARs

Under RAA 1 (No Action), RAA 2 (Site Controls with Long-Term Monitoring), and RAA 3 (Natural Attenuation) no active effort is made to reduce contaminant levels below federal and state standards. However, RAAs 1, 2, and 3 have the potential to meet federal and state standards over time. Under RAAs 1 and 2, the time frame for completion of the action is indefinite. After the initial assessment has been preformed, RAA 3 can provide a time frame for achieving remediation levels.

RAA 4 (Extraction Wells and Ex Situ Treatment), RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall), and RAA 6 (In-Well aeration and Off-Gas Adsorption) may meet federal and state ARARs within the particular zone of influence of each system. All of these RAAs rely on natural attenuation to reduce contamination levels upgradient of the particular zone of influence.

Installation of additional monitoring wells in the wetlands adjacent to Brinson Creek is required under RAAs 2, 3, 4, 5, and 6.

Treated air discharges are provisions of RAAs 4 and 6. Treated groundwater discharge is associated with RAA 4.

Long-Term Effectiveness and Permanence

In the case of all six RAAs, contamination will remain at the site and require a USEPA review on a five year basis. RAA 1 (No Action), RAA 2 (Site Controls with Long-Term Monitoring), and RAA 3 (Natural Attenuation) provide no active means of contaminant reduction, but rely on natural attenuation processes. Aquifer-use restrictions and groundwater monitoring associated with RAAs 2 and 3 provide a permanent means against direct human exposure.

RAA 4 (Extraction Wells and Ex Situ Treatment), RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall), and RAA 6 (In-Well Aeration and Off-Gas Adsorption) provide an active means for permanently reducing contamination in the surficial aquifer within the particular zone of influence of each system. The effectiveness of these three RAAs is roughly similar. RAAs 4, 5, and 6 assume natural attenuation may be reducing upgradient groundwater contamination.

Long-term management issues and O&M activities associated with monitoring and well maintenance are similar for RAAs 2, 3, 4, 5, and 6. RAAs 4 and 6 are similar in that both rely on mechanical systems and as such, have similar maintenance issues. Both RAAs 4 and 6 are potentially subject to clogging problems caused by inorganic precipitates . Both RAAs 4 and 6 will require equipment replacement over

the 30-year life of the project. The need for replacement of treatment components of RAA 5 during a 30-year project life is uncertain because the technology is relatively new.

Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA 1 (No Action), RAA 2 (Site Controls with Long-Term Monitoring), and RAA 3 (Natural Attenuation) provide no active means for the reduction of toxicity, mobility, or volume through treatment. RAAs 1, 2, and 3 all rely on the natural attenuation processes to reduce contaminant levels in groundwater.

RAA 4 (Extraction Wells and Ex Situ Treatment), RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall), and RAA 6 (In-Well Aeration and Off-Gas Adsorption) provide an active means for permanently reducing the toxicity, mobility or volume through treatment. RAAs 4, 5, and 6 intercept the contaminant plume and mitigate the horizontal migration contamination in the surficial aquifer. RAAs 4 and 6 reduce overall contaminant mass in the "hot spot" area.

Short-Term Effectiveness

Under RAA 1 (No Action), RAA 2 (Site Controls with Long-Term Monitoring), RAA 3 (Natural Attenuation), RAA 4 (Extraction Wells and Ex Situ Treatment), RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall), and RAA 6 (In-Well Aeration and Off-Gas Adsorption), workers associated with sampling activities, installation of treatment systems, and the construction of the U. S. Highway 17 Bypass, should be provided with protection against dermal contact with contaminated groundwater. During all drilling and excavation activities associated with RAAs 4, 5, and 6, air quality should be monitored. Gate construction activities associated with RAA 5 will require construction personnel to work in level B personnel protective equipment. The excavation where the gate is constructed is considered a confined space.

Under RAAs 1, 2, 3, and 5 there will be no increase in risk to the community during implementation of the remedial action. Under RAAs 4 and 6, contaminated media could be accidentally discharged. Plant controls are expected to limit such a release. RAA 5 will be the most disruptive to the Activity, due to the extensive excavation required to implement the action. Some disturbance of the wetlands adjacent to Brinson Creek will occur during the installation of monitoring wells under RAAs 2, 3, 4, 5, and 6.

Implementability

When assessing implementability, RAAs fall into two categories: those that involve engineered remedial actions, and those that involve no engineered remedial actions. The RAAs that do not include engineered remedial actions and rely solely on natural attenuation include: RAA 1 (No Action); RAA 2 (Site Controls with Long-Term Monitoring); and RAA 3 (Natural Attenuation). The most difficult of these RAAs to implement is RAA 3, because it requires a treatability study to be performed prior to implementing a long-term monitoring plan.

The RAAs that include engineered remedial actions are: RAA 4 (Extraction Wells and Ex Situ Treatment); RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall); and RAA 6 (In-Well Aeration and Off-Gas Adsorption). Technologies associated with RAAs 5 and 6 are proprietary. As such, a limited number of vendors can provide the equipment/materials. Of the three engineered remedial actions, RAA 4 will be the easiest to implement. The equipment used for groundwater treatment plants is readily available.

Cost

The present worth values of the RAAs, from least expensive to most expensive, are as follows:

RAA 1 (No Action)	$ 0
RAA 2 (Site Controls with Long-Term Monitoring)	$1,220,000
RAA 3 (Natural Attenuation)	$2,470,000
RAA 6 (In-Well Aeration and Off-Gas Adsorption)	$3,350,000
RAA 4 (Extraction Wells and Ex Situ Treatment)	$3,760,000
RAA 5 (In Situ Passive Treatment/Slurry Cut-Off Wall)	$7,330,000

THE PREFERRED ALTERNATIVE

Based on the detailed evaluation of remedial action alternatives, RAA 3 - Natural Attenuation was selected as the preferred alternative Thus, the Proposed Remedial Action Plan for Site 35 includes a natural attenuation treatability study, natural attenuation fate and transport modeling, and long-term groundwater monitoring. The natural attenuation alternative provides a remedy that is protective of human health and the environment, highly implementable, and cost effective.

Based on the current conditions at Site 35, the natural attenuation alternative will be protective of human health and the environment. There are no current unacceptable risks associated with exposure to groundwater in the surficial aquifer. Thus, there are no immediate threats to potential receptors at Site 35 and it is justifiable to leave the groundwater contamination in an untreated state. In addition, the daughter products of trichloroethene degradation reactions (e.g., dichloroethene and vinyl chloride) were detected in the surficial aquifer. The presence of these daughter products provides evidence that natural processes at the site are attenuating the chlorinated solvent contamination and that contaminant levels will naturally decrease over time. Conducting a natural attenuation treatability study and long-term monitoring of natural attenuation parameters should provide additional data to justify the natural reduction of contaminant concentrations over time. Although there were unacceptable future risks associated with the surficial aquifer, the site controls included under RAA 3 will deter the potential for future human exposure. In addition, an active engineered remedial action for surficial groundwater in the vicinity of the Fuel Farm (as it flows northeast toward Ballard Creek) is currently under design by Baker. It is scheduled for implementation in 1997.

Besides being protective of human health and the environment, the natural attenuation alternative is a highly implementable remedial action plan. There are no construction activities associated with natural attenuation and there are no mechanical O&M requirements. Because there are no construction activities, there will be minimal risks to construction workers and the community. Although the alternative requires long-term groundwater sampling and analysis, monitoring programs have been easily executed in this past.

Finally, the natural attenuation alternative is the most cost effective remedy for the contaminated groundwater. With the exception of RAA 1 (No Action) and RAA 2 (Site Controls and Long-Term Monitoring), RAA 3 (Natural Attenuation) was the least expensive alternative evaluated. RAA 1 and RAA 2, however, do not provide adequate protection to human health and the environment. The no action alternative allows contaminated groundwater to remain at levels exceeding standards with no means for determining if contaminant reductions are occurring. RAA 2 provides a long-term monitoring program, but it does not provide enough evidence to strongly support the claim that contaminant

reductions are naturally occurring. RAA 3, however, does support the argument that contaminant concentrations will naturally decrease over time, and it supports this argument at a reasonable cost.

COMMUNITY PARTICIPATION

A critical part of the selection of a remedial action alternative is community involvement. The following information is provided to solicit the community's input into the selection of a remedy for OU No. 10 (Site 35).

Public Comment Period

The 30-day public comment period for the proposed remedial action plan at Site 35 will begin and end on dates to be determined. Written comments should be sent to the following address:

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Bldg. N-26)
Norfolk, Virginia 23511-2699
Attn: Ms. Katherine Landman, Code 18232

or Commanding General
ACIS EMD (IRD)
Marine Corps Base
PSC Box 20004
Camp Lejeune, North Carolina 28542-0004

A public meeting will be held at the Onslow County Library in Jacksonville, North Carolina on a date to be determined. Representatives of the Navy, and their consultant, will be available at the meeting to answer questions and accept public comments on the proposed plan for Site 35. In addition, an overview of the site characterization will be presented.

Meeting minutes will be made available to the public through the information repositories at the libraries listed within this document. A responsiveness summary will be prepared at the conclusion of the comment period to summarize significant comments, criticisms, and new relevant information submitted to MCB, Camp Lejeune and the DoN during the comment period. The summary will include the responses to each issue and question raised at the public meeting. After the ROD is signed, MCB, Camp Lejeune and the DoN will publish a notice of availability of the ROD (including the responsiveness summary) in the Jacksonville and MCB, Camp Lejeune newspapers. A copy of the ROD will also be placed in each information repository.

Information Repositories

A collection of general information pertaining to all MCB, Camp Lejeune OUs and IR sites, including all administrative records, is available to the community for review at the following locations:

MCB, Camp Lejeune
Building 67, Room 238
Marine Corps Base
Camp Lejeune, NC 28542
(910) 451-5068

Hours:
M-F: 7:00 a.m.- 4:00p.m.
Closed Saturday and Sunday

Onslow County Library
58 Doris Avenue East
Jacksonville, NC 28540
(910) 455-7358

Hours:
M-Thu: 9:00 a.m.- 9:00 p.m.
F-Sat: 9:00 a.m.- 6:00 p.m.
Closed Sunday

Public Inquiries

Inquiries concerning the proposed remedy for Site 35 or other related issues may be directed to any one of the following points of contact:

Commanding General
AC/S EMD, (IRD)
Marine Corps Base
PSC Box 20004
Camp Lejeune, North Carolina 28542-0004
Attention: Mr. Neal Paul
(910) 451-5068

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Bldg. N-26)
Norfolk, Virginia 23511-2699
Attention: Ms. Katherine Landman, Code 18232
(804) 322-4818

Remedial Project Manager
U.S. EPA, Region IV
345 Courtland Street, NE
Atlanta, Georgia 30365
Attention: Ms. Gena Townsend
(404) 347-3016

N.C. Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
Superfund Section
P.O. Box 27687
Raleigh, North Carolina 27611-7687
Attention: Mr. Patrick Watters
(919) 733-2801

Community Information Line
Public Affairs Office
Marine Corps Base, PSC Box 2004
Camp Lejeune, North Carolina 28542-0004
Attention: Major Stephen Little
(910) 451-5782

Mailing List

If you are not on the mailing list and would like to receive future publications pertaining to Site 35 as they become available, please call or complete and mail a copy of this form to the point of contact listed below:

Commanding General
AC/S EMD (IRD)
Marine Corps Base
PSC Box 20004
Camp Lejeune, North Carolina 28542-0004
Attn: Mr. Neal Paul
(910) 451-5068

Name _____

Address _____

Affiliation _____

Phone (____)_____

TABLES

TABLE 1

CONTAMINANTS OF POTENTIAL CONCERN (COPCs) EVALUATED DURING THE HUMAN HEALTH RISK ASSESSMENT OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM PROPOSED REMEDIAL ACTION PLAN, CTO-0232 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPC	Environmental Medium					
	Surface Soil	Subsurface Soil	Ground-water	Surface Water	Sediment	Fish
VOCs						
Acetone						●
1,1,2,2-Tetrachloroethane						
Chloroform						
Methylene Chloride						
1,1,2-Trichloroethane						
1,1-Dichloroethane						
1,1-Dichloroethene			●			
2-butanone						
Benzene			●			
Carbon disulfide						
cis-1,2-Dichloroethene			●			
Ethylbenzene			●			
Methyl Tertiary Butyl Ether			●			
Tetrachloroethene						
Toluene			●			
trans-1,2-Dichloroethene			●			
Trichloroethene			●			
Xylenes (Total)			●			
SVOCs						
Benzo(a) pyrene						
Indeno(1,2,3-cd) pyrene						
Dibenz(a,h) anthracene						
Benzo(g.h,i) perylene	●					
4-Methylphenol						
2,4-Dimethylphenol						
Naphthalene			●			
Dibenzofuran			●			
Fluorene						
Anthracene						
Carbazole						
Diethylphthalate					●	
Di-n-butylphthalate						

TABLE 1 (Continued)

CONTAMINANTS OF POTENTIAL CONCERN (COPCs) EVALUATED DURING THE HUMAN HEALTH RISK ASSESSMENT OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM PROPOSED REMEDIAL ACTION PLAN, CTO-0232 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPC	Environmental Medium					
	Surface Soil	Subsurface Soil	Ground-water	Surface Water	Sediment	Fish
Bis(2-ethylhexyl)phthalate						
Phenol						
2-Methylnaphthalene			●			
2-Methylphenol						
Acenaphthene						
Phenanthene	●		●			
Carbazole						
Fluoranthene						
Pyrene						
Butylbenzlphthalate						
Benzo(a)anthracene						
Chrysene						
Benzo(b) fluoranthene	●	●				
Pesticides						
Aldrin						
gamma-BHC						
alpha-Chlordane					●	●
beta-BHC						●
Dieldrin	●				●	●
Endosulfan II	●				●	●
Endrin Ketone	●				●	●
Endrin Aldehyde	●				●	●
Endrin					●	●
delta-BHC			●			
gamma-Chlordane					●	
Heptachlor			●			●
Heptachlor Epoxide					●	
Methoxychlor					●	
4,4'-DDE					●	●
4,4'-DDT					●	●
4,4'-DDD	●				●	●
Inorganics						
Aluminum						●
Antimony			●	●		
Arsenic	●	●	●	●	●	
Barium			●		●	●

TABLE 1 (Continued)

CONTAMINANTS OF POTENTIAL CONCERN (COPCs) EVALUATED DURING THE HUMAN HEALTH RISK ASSESSMENT OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM PROPOSED REMEDIAL ACTION PLAN, CTO-0232 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPC	Environmental Medium					
	Surface Soil	Subsurface Soil	Ground-water	Surface Water	Sediment	Fish
Beryllium			●		●	
Cadmium			●			
Calcium						
Chromium			●	●	●	
Cobalt			●	●	●	
Copper					●	●
Lead	●	●	●	●	●	●
Magnesium						
Manganese	●		●	●	●	●
Mercury				●		●
Nickel			●		●	
Potassium						
Selenium					●	●
Silver			●			
Sodium						
Thallium		●	●	●	●	
Vanadium			●	●	●	
Zinc			●	●	●	●
Iron						

● Selected as COPC.

TABLE 2

TOTAL SITE RISK
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Surface Water		Sediment		Fish		TOTALS	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Future Child Resident	4.5E-05 (<1)	0.93 (1)	2.1E-03 (99)	103 (99)	NA	NA	NA	NA	NA	NA	2.1E-03	104
Future Adult Resident	2.7E-05 (<1)	0.10 (<1)	4.3E-03 (99)	44 (99)	NA	NA	NA	NA	NA	NA	4.3E-03	44
Future Construction Worker	1.2E-07 (100)	0.02 (100)	NA	NA	NA	NA	NA	NA	NA	NA	1.2E-07	0.02
Current Military Personnel	3.1E-06 (100)	0.09 (100)	NA	NA	NA	NA	NA	NA	NA	NA	3.1E-06	0.09
Current Recreational Child	NA	NA	NA	NA	1.1E-07 (27)	<0.01 (<1)	3.3E-07 (73)	0.01 (99)	NA	NA	4.4E-07	0.01
Current Recreational Adult	NA	NA	NA	NA	1.2E-07 (<1)	<0.01 (<1)	4.5E-07 (<1)	<0.01 (<1)	1.8E-05 (99)	1.8 (99)	1.9E-05	1.8

Notes:

Shading indicates an ICR value that exceeds the acceptable limit of 1E-04, or an HI value that exceeds the acceptable limit of 1.0.
ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
ND = Not Determined
NA = Not Applicable
( ) = Percent Contribution to Total Risk

TABLE 3

VOC GROUNDWATER DATA AND COPC SELECTION SUMMARY FROM THE SGI
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Compound	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tapwater COC Value[3] (µg/L)	Federal Health Advisories[4] (µg/L)		No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above COC	No. of Detects Above Health Advisories	
				10 kg Child	70 kg Adult						10 kg Child	70 kg Adult
Volatiles:												
Vinyl Chloride*	0.015	2	0.019	10	50	1/30	13	1	1	1	1	0
Acetone	700	NE	370	NE	NE	1/30	66J	0	NA	0	NA	NA
1,1-Dichloroethene*	7	7	0.044	1,000	4,000	3/30	4J - 6J	0	0	3	0	0
1,1-Dichloroethane*	700	NE	81	NE	NE	2/30	3J - 4J	0	NA	0	NA	NA
1,2-Dichloroethene (Total)	NE	70	5.5	3,000	11,000	18/30	2J - 1,200	NA	6	15	0	0
Trichloroethene*	2.8	5	1.6	NE	NE	12/30	4J - 740	12	11	12	NA	NA
Benzene*	1	5	0.36	NE	NE	4/30	2J - 4J	4	0	4	NA	NA
Tetrachloroethene*	0.7	5	1.1	1,000	5,000	1/30	2J	1	0	1	0	0
1,1,2,2-Tetrachloroethane*	NE	NE	0.052	NE	NE	2/30	17J - 23	NA	NA	2	NA	NA
Toluene*	1,000	1,000	75	2,000	7,000	2/30	2J - 4J	0	0	0	0	0

Notes:

[1] NCWQS = North Carolina Water Quality Standards for Groundwater
[2] MCL = Safe Drinking Water Act Maximum Contaminant Level
[3] USEPA Region III Contaminants of Concern (COC) Screening Criteria Table (1993, 1996)
[4] Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
NE - No Criteria Established
NA - Not Applicable
J - Estimated Value
* Retained as COPC

TABLE 4

INORGANIC GROUNDWATER DATA AND COPC SELECTION SUMMARY FROM THE SGI
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tapwater COC Value[3] (µg/L)	Federal Health Advisories[4] (µg/L)		No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above COC	No. of Detects Above Health Advisories	
				10 kg Child	70 kg Adult						10 kg Child	70 kg Adult
Aluminum	NE	50/200[5]	3,700	NE	NE	12/20	22.6J-520	NA	7/4	0	NA	NA
Antimony	NE	6	1.5	10	15	1/20	20J	NA	1	1	1	1
Arsenic*	50	50	0.045	NE	NE	7/20	3.2J-13.3	0	0	7	NA	NA
Barium	2,000	2,000	260	NE	NE	9/20	20.9J-98.4J	0	0	0	NA	NA
Calcium+	NE	NE	NE	NE	NE	20/20	6,380-142,000	NA	NA	NA	NA	NA
Cobalt	NE	NE	220	NE	NE	10/20	2.2J-16J	NA	NA	0	NA	NA
Iron*	300	300[5]	1,100	NE	NE	20/20	58.4J-40,400	14	14	10	NA	NA
Lead	15	15[6]	NE	NE	NE	8/20	1-15.4	1	1	NA	NA	NA
Magnesium+	NE	NE	NE	NE	NE	20/20	1,550J-4,990J	NA	NA	NA	NA	NA
Manganese*	50	50[5]	180	NE	NE	20/20	7.5J-275	5	5	1	NA	NA
Potassium+	NE	NE	NE	NE	NE	20/20	728J-4,400	NA	NA	NA	NA	NA
Selenium	50	50	18	NE	NE	2/20	2.6J-3.4J	0	0	0	NA	NA
Silver	18	NE	18	200	200	1/20	10.9	0	NA	0	0	0
Sodium+	NE	NE	NE	NE	NE	20/20	4,350J-31,900	NA	NA	NA	NA	NA

TABLE 4 (Continued)

INORGANIC GROUNDWATER DATA AND COPC SELECTION SUMMARY FROM THE SGI
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
				Federal Health Advisories[4] (µg/L)							No. of Detects Above Health Advisories	
Analyte	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tapwater COC Value[3] (µg/L)	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above COC	10 kg Child	70 kg Adult
Thallium*	NE	2	0.29	7	20	3/20	0.7J-1	NA	0	3	0	0
Vanadium	NE	NE	26	NE	NE	2/20	5.5J-9.1J	NA	NA	0	NA	NA
Zinc	2,100	5,000[5]	1,100	3,000	10,000	11/20	6.5J-29.5	0	0	0	0	0

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) USEPA Region III Contaminants of Concern (COC) Screening Criteria Table (1993, 1996)
(4) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
(5) SMCL = Secondary Maximum Contaminant Level
(6) Action Level for drinking water.
+ - Essential Nutrient
NE - No Criteria Established
NA - Not Applicable
J - Estimated Value
* Retained as COPC

TABLE 5

**TOTAL SITE GROUNDWATER RISK DETERMINED FROM THE SGI
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA**

Receptors	Rounds 2 and 3 Organics Groundwater		Low-Flow Purge Sampling Inorganics Groundwater		Total Groundwater Risk	
	ICR	HI	ICR	HI	ICR	HI
Future Child Resident	$9.1x10^{-5}$ (65)	37 (77)	$5.2x10^{-5}$ (35)	11 (23)	1.4E-04	48
Future Adult Resident	2.0E-04 (65)	16 (77)	1.1E-04 (35)	4.7 (23)	3.1E-04	21

Notes:

Shading indicates an ICR value that exceeds the acceptable limit of 1E-04, or an HI value that exceeds the acceptable limit of 1.0.

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Percent contribution to total risk

TABLE 6

CONTAMINANTS OF POTENTIAL CONCERN (COPCs) EVALUATED DURING THE ECOLOGICAL RISK ASSESSMENT OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM PROPOSED REMEDIAL ACTION PLAN, CTO-0232 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPC
VOCs
Acetone
Carbon Disulfide
Toluene
Xylene
SVOCs
Diethylphthlate
Bis(2-ethylhexylphthlate)
Benzo(b)fluorenthen
Benzo(g,h,i)perylene
Chrysene
Fluoranthene
Phenanthrene
Pyrene
Phenol
Pesticides
beta-BHC
Chlordane, total
4,4'-DDE
4,4'-DDD
4,4'-DDT
Dieldrin
Endosulfan II *
Endrin
Endrin Aldehyde
Endrin Ketone
Heptachlor Epoxide
Methoxychlor
Inorganics
Aluminum
Antimony
Arsenic
Barium
Beryllium

TABLE 6 (Continued)

CONTAMINANTS OF POTENTIAL CONCERN (COPCs) EVALUATED DURING THE ECOLOGICAL RISK ASSESSMENT OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM PROPOSED REMEDIAL ACTION PLAN, CTO-0232 MCB, CAMP LEJEUNE, NORTH CAROLINA

COPC
Cadmium
Chromium
Cobalt
Copper
Iron
Lead
Manganese
Mercury
Nickel
Selenium
Thallium
Vanadium
Zinc

TABLE 7

ANALYTICAL PARAMETERS FOR RAA 3: NATURAL ATTENUATION
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Matrix	Analysis	Method/Reference	Data Use	Recommended Frequency of Analysis	Field or Fixed-Base Laboratory
Soil	Total organic carbon (TOC)	SW9060 modified for soil samples	The rate of migration of petroleum contaminants in groundwater is dependent upon the amount of TOC in the aquifer matrix.	At initial sampling for the Treatability Study	Fixed-base
Soil Gas	Methane, O_2, CO_2	Field Soil Gas Analyzer	Useful for determining bioactivity in vadose zone.	At initial sampling and respiration testing for the Treatability Study	Field
Soil Gas	Fuel and Chlorinated VOCs	EPA Method TO-14	Useful for determining chlorinated and BTEX compounds in soil.	At initial sampling for the Treatability Study	Fixed-base
Water	VOCs	Contract Laboratory Protocol	Method of analysis includes BTEX and chlorinated solvents/byproducts, which are the primary target analytes for monitoring natural attenuation.	Each sampling round	Fixed-base
Water	Oxygen	Dissolved oxygen meter	Concentrations less than 1 mg/L generally indicate an anaerobic pathway.	Each sampling round	Field
Water	Nitrate	IC Method E300	Substrate for microbial respiration if oxygen is depleted.	Each sampling round	Fixed-base
Water	Iron (II) (Fe^{2+})	Colorimetric Hach Method #8146	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	Each sampling round	Field

TABLE 7 (Continued)

ANALYTICAL PARAMETERS FOR RAA 3: NATURAL ATTENUATION
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Matrix	Analysis	Method/Reference	Data Use	Recommended Frequency of Analysis	Field or Fixed-Base Laboratory
Water	Sulfate (SO_4^{2-})	IC Method E300	Substrate for anaerobic microbial respiration.	Each sampling round	Fixed-base
Water	Sulfate (SO_4^{2-})	Hach Method E300	Same as above.	Each sampling round	Field
Water	Methane, ethane, and ethene	Kampbell et al., 1989 or SW3810 Modified	The presence of CH_4 suggests BTEX degradation via methanogenesis. Ethane and ethene data are used where chlorinated solvents are suspected of undergoing biological transformation.	Each sampling round	Fixed-base
Water	Alkalinity	Hach alkalinity test kit model AL AP MG-L	General water quality parameter used (1) to measure the buffering capacity of groundwater, and (2) as a marker to verify that all site samples are obtained from the same groundwater system.	Each sampling round	Field
Water	Oxidation-reduction potential (ORP)	A2580B	The ORP of groundwater influences and is influenced by the nature of the biologically mediated degradation of contaminants; the ORP of groundwater may range from more than 800 mV to less than -400 mV.	Each sampling round	Field
Water	pH	Field probe with direct reading meter	Aerobic and anaerobic processes are pH-sensitive.	Each sampling round	Field
Water	Temperature	Field probe with direct reading meter	Well development.	Each sampling round	Field

TABLE 7 (Continued)

ANALYTICAL PARAMETERS FOR RAA 3: NATURAL ATTENUATION
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

Matrix	Analysis	Method/Reference	Data Use	Recommended Frequency of Analysis	Field or Fixed-Base Laboratory
Water	Conductivity	E120.1/SW9050, direct reading meter	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system.	Each sampling round	Field
Water	Major cations	SW6010	Can be used to evaluate other remedial actions.	Each sampling round	Field
Water	Chloride	IC Method E300	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system. Final product of chlorinated solvent reduction.	Each sampling round	Fixed-base
Water	Chloride (optional, see data use)	Hach Chloride test kit Model 8-P	As above, and to guide selection of additional data points in real time while in the field.	Each sampling round	Field
Water	Total Organic Carbon	SW9060	Used to classify plume and to determine if cometabolism is possible in the absence of anthropogenic carbon.	Each sampling round	Laboratory
Water	Hydrogen (H_2)[a/]	Equilibration with gas in the field. Determined with a reducing gas detector.	Determine terminal electron accepting process. Predicts the possibility for reductive dechlorination.	One round of sampling	Field

Reference: Wiedemeier, Todd, et al. 1996. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. Air Force Center for Environmental Excellence, Technology Transfer Division. Brooks Air Force Base, San Antonio, Texas.

TABLE 8

GLOSSARY OF EVALUATION CRITERIA
OU NO. 10, SITE 35 - CAMP GEIGER AREA FUEL FARM
PROPOSED REMEDIAL ACTION PLAN, CTO-0232
MCB, CAMP LEJEUNE, NORTH CAROLINA

- **Overall Protection of Human Health and the Environment** - addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment engineering or institutional controls.
- **Compliance with ARARs/TBCs** - addresses whether or not an alternative will meet the applicable or relevant and appropriate requirements (ARARs), criteria to-be-considered (TBCs), and other federal and state environmental statutes, and/or provide grounds for invoking a waiver.
- **Long-Term Effectiveness and Permanence** - refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once cleanup goals have been met.
- **Reduction of Toxicity, Mobility, or Volume Through Treatment** - refers to the anticipated performance of the treatment options that may be employed within an alternative.
- **Short-Term Effectiveness** - refers to the speed with which the alternative achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment that may occur during the construction and implementation period.
- **Implementability** - refers to the technical and administrative feasibility of an alternative, including the availability of materials and services required to implement the chosen solution.
- **Cost** - includes capital and operation and maintenance costs. For comparative purposes, present worth values are provided.

FIGURES

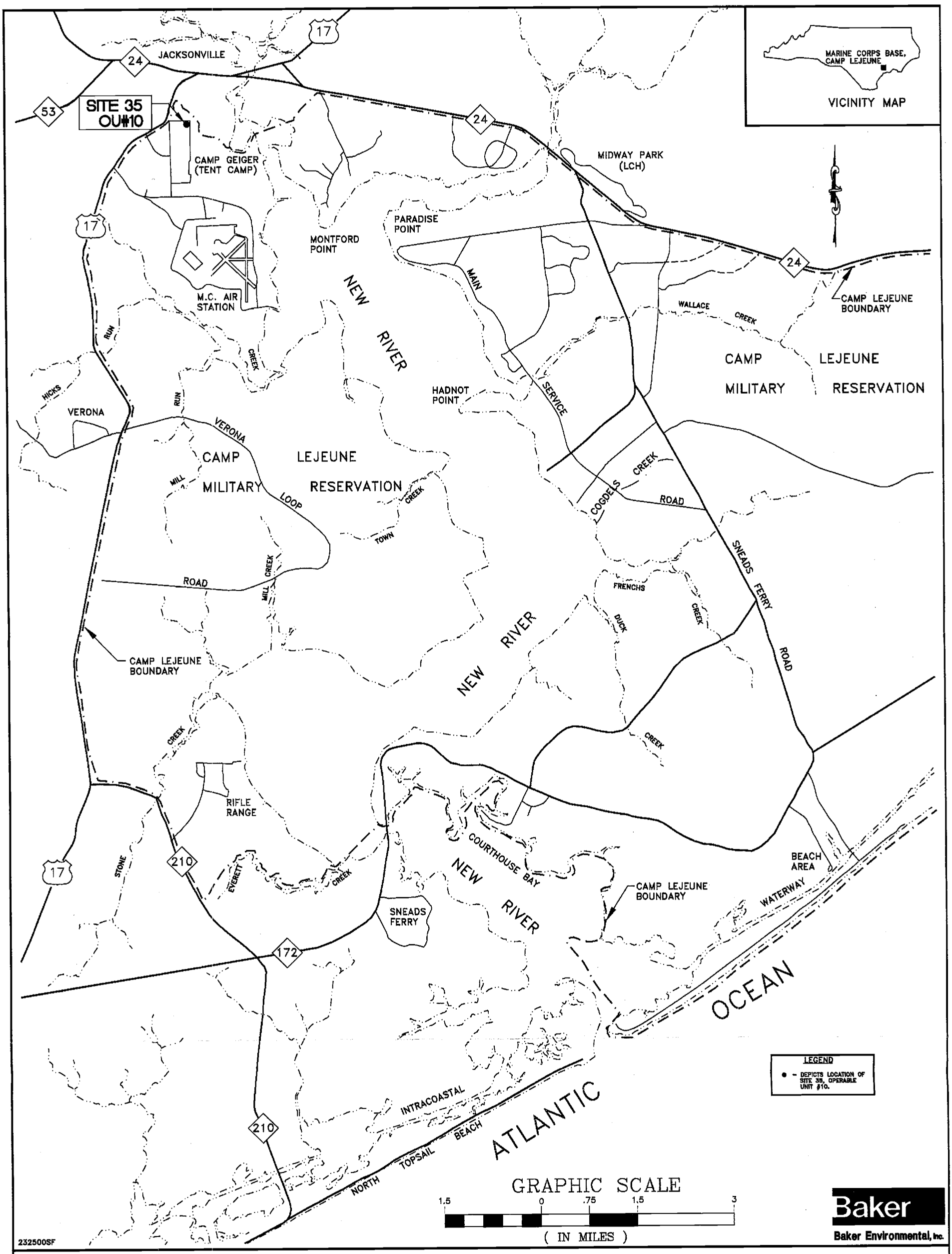

FIGURE 1
CAMP LEJEUNE AND SITE 35
LOCATION MAP
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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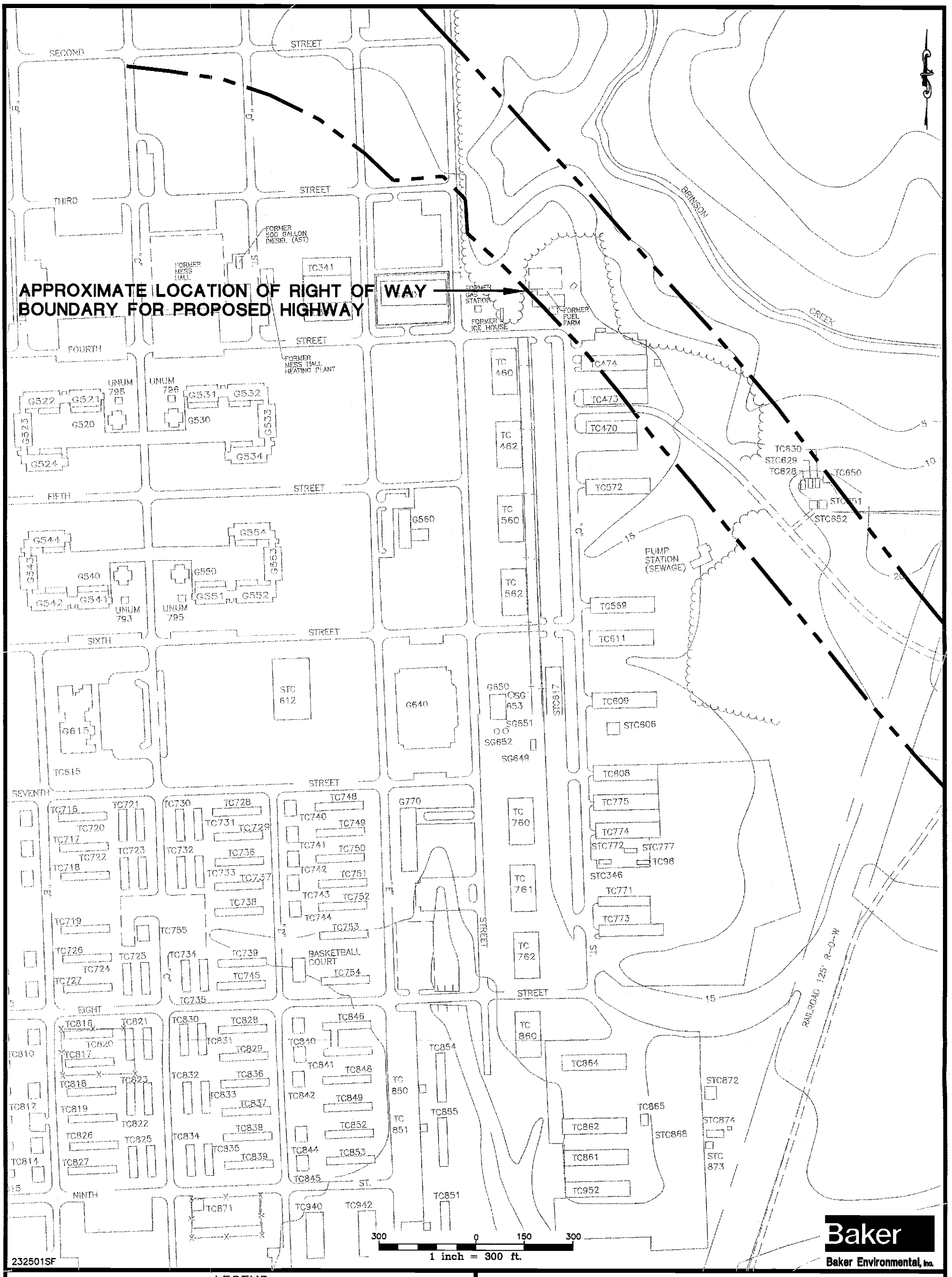
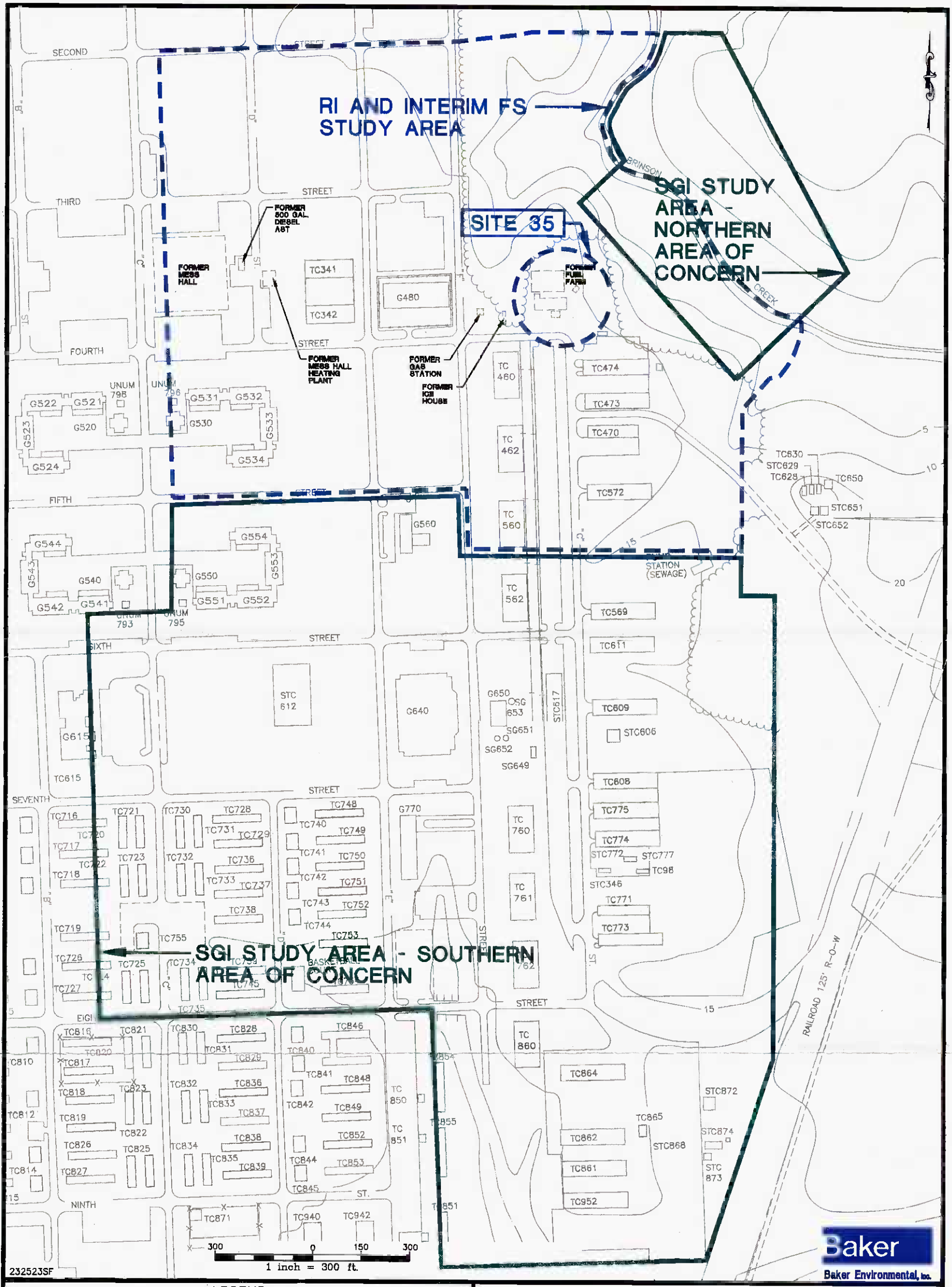


LEGEND

- 10 — SURFACE ELEVATION CONTOUR
- —x— FENCE
- STRUCTURE
- TREE LINE
- APPROXIMATE LIMITS OF U.S. HIGHWAY 17 BYPASS

SOURCE: LANTDIV, OCT. 1991

FIGURE 2
LOCATION OF PROPOSED HIGHWAY RIGHT-OF-WAY
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER - 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 10 — SURFACE ELEVATION CONTOUR
- EDGE OF PAVEMENT
- —x— FENCE
- STRUCTURE
- TREE LINE
- ABANDONED RAILROAD
- UNIMPROVED ROAD/ PARKING LOT

SOURCE: LANTDIV, OCT. 1991

FIGURE 3
SITE PLAN
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER - 0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Baker Environmental, Inc.

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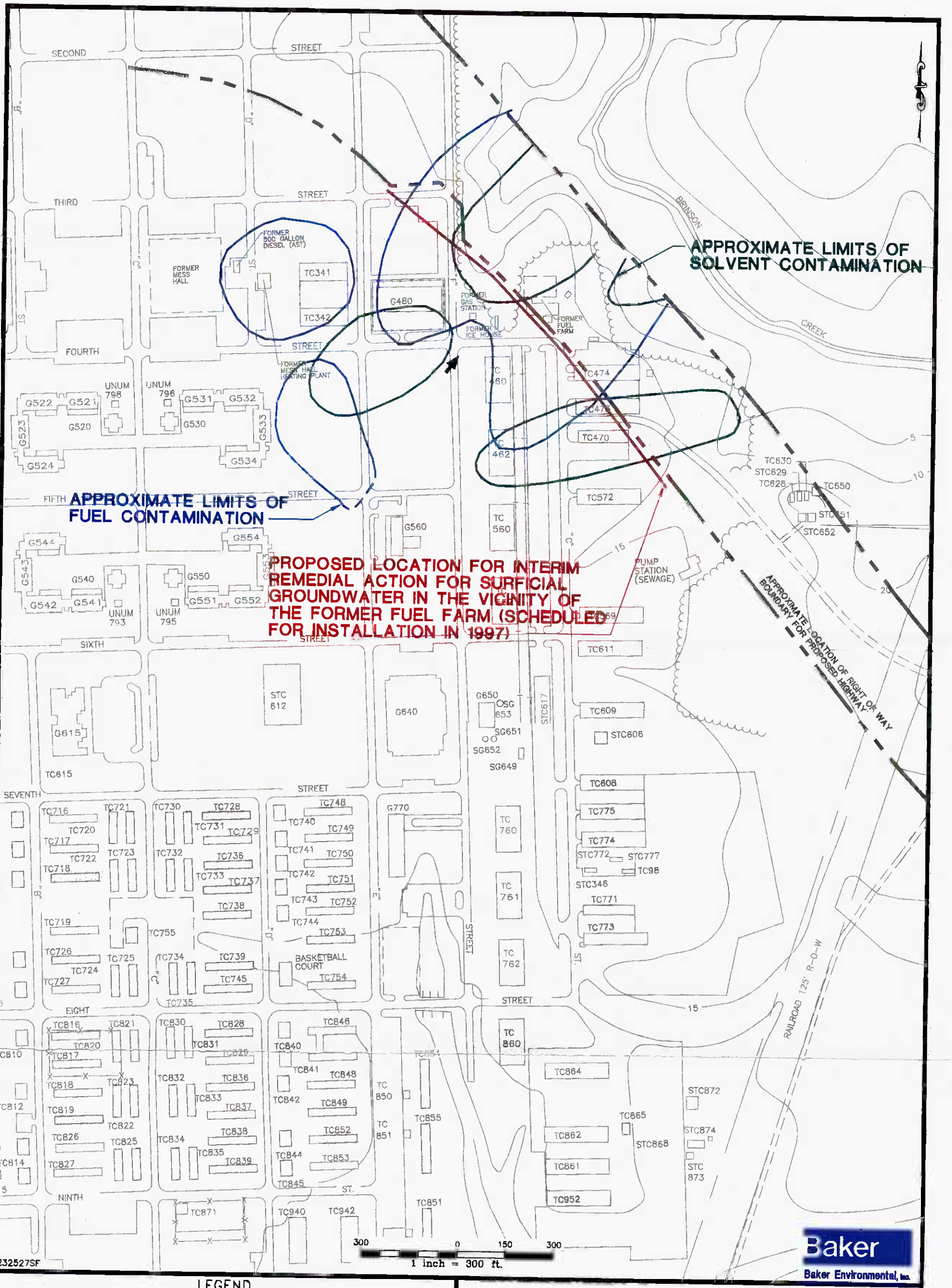


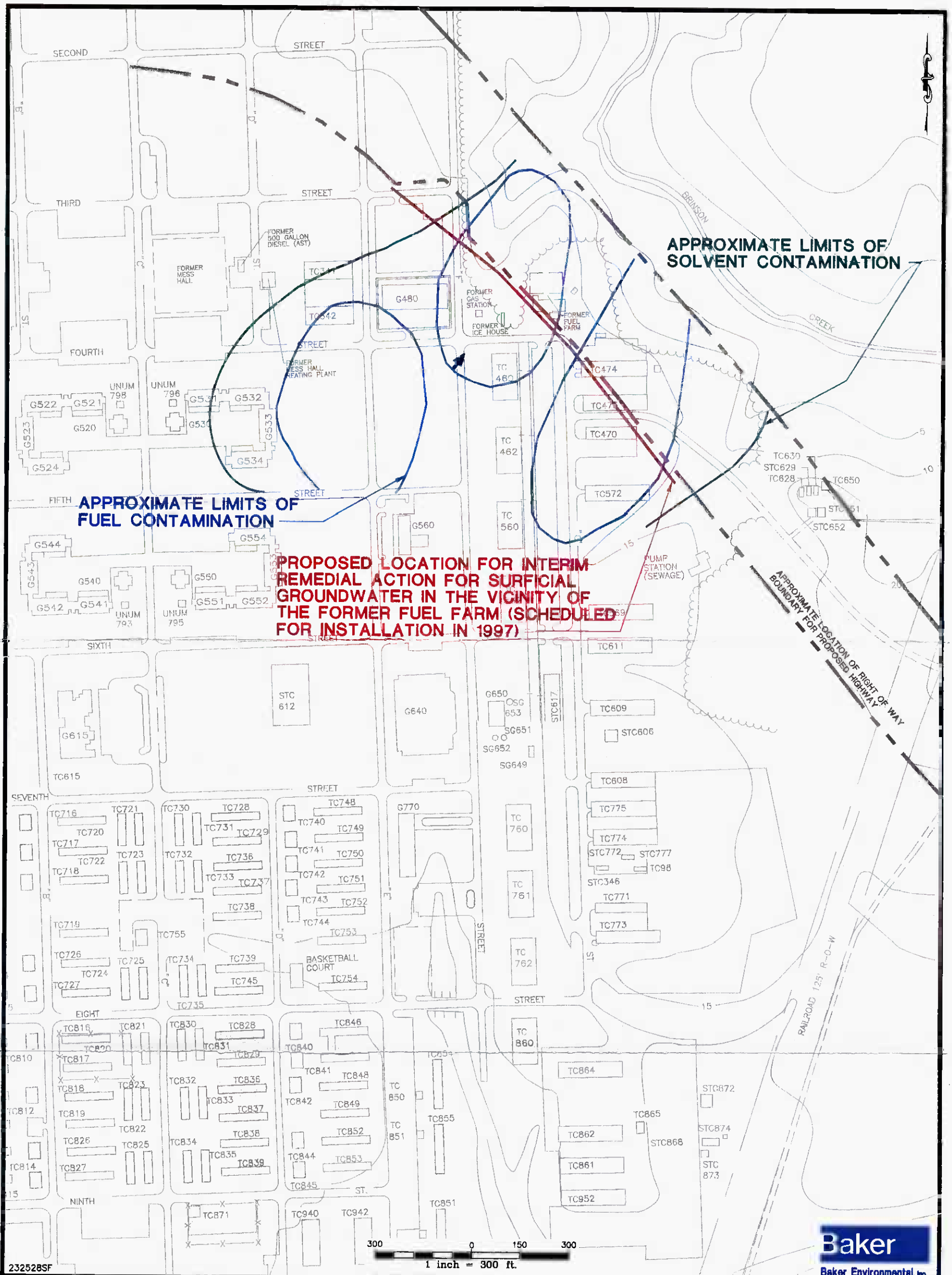
LEGEND

- 10 — SURFACE ELEVATION CONTOUR
- —x— FENCE
- APPROXIMATE LIMITS OF FUEL CONTAMINATION
- APPROXIMATE LIMITS OF SOLVENT CONTAMINATION
- APPROXIMATE LIMITS OF U.S. HIGHWAY 17 BYPASS
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, OCT. 1991

FIGURE 4
RI/INTERIM FS RESULTS
UPPER PORTION OF THE SURFICIAL AQUIFER
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Baker Environmental, Inc.



LEGEND

- 10 — SURFACE ELEVATION CONTOUR
- x — FENCE
- APPROXIMATE LIMITS OF FUEL CONTAMINATION
- APPROXIMATE LIMITS OF SOLVENT CONTAMINATION
- APPROXIMATE LIMITS OF U.S. HIGHWAY 17 BYPASS
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, OCT. 1991

FIGURE 5
RI/INTERIM FS RESULTS
LOWER PORTION OF THE SURFICIAL AQUIFER
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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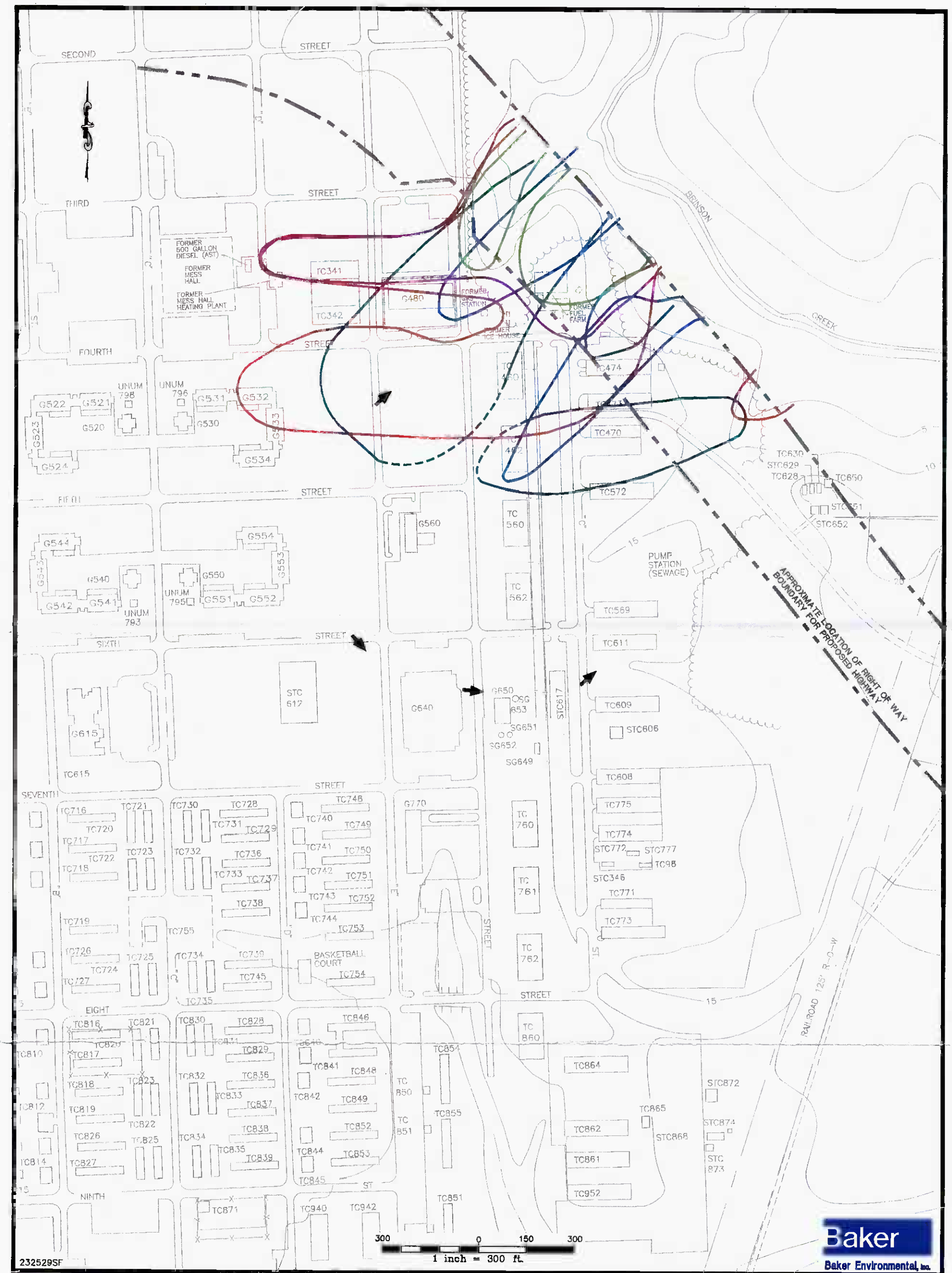


LEGEND

ISOCONCENTRATION LINES:

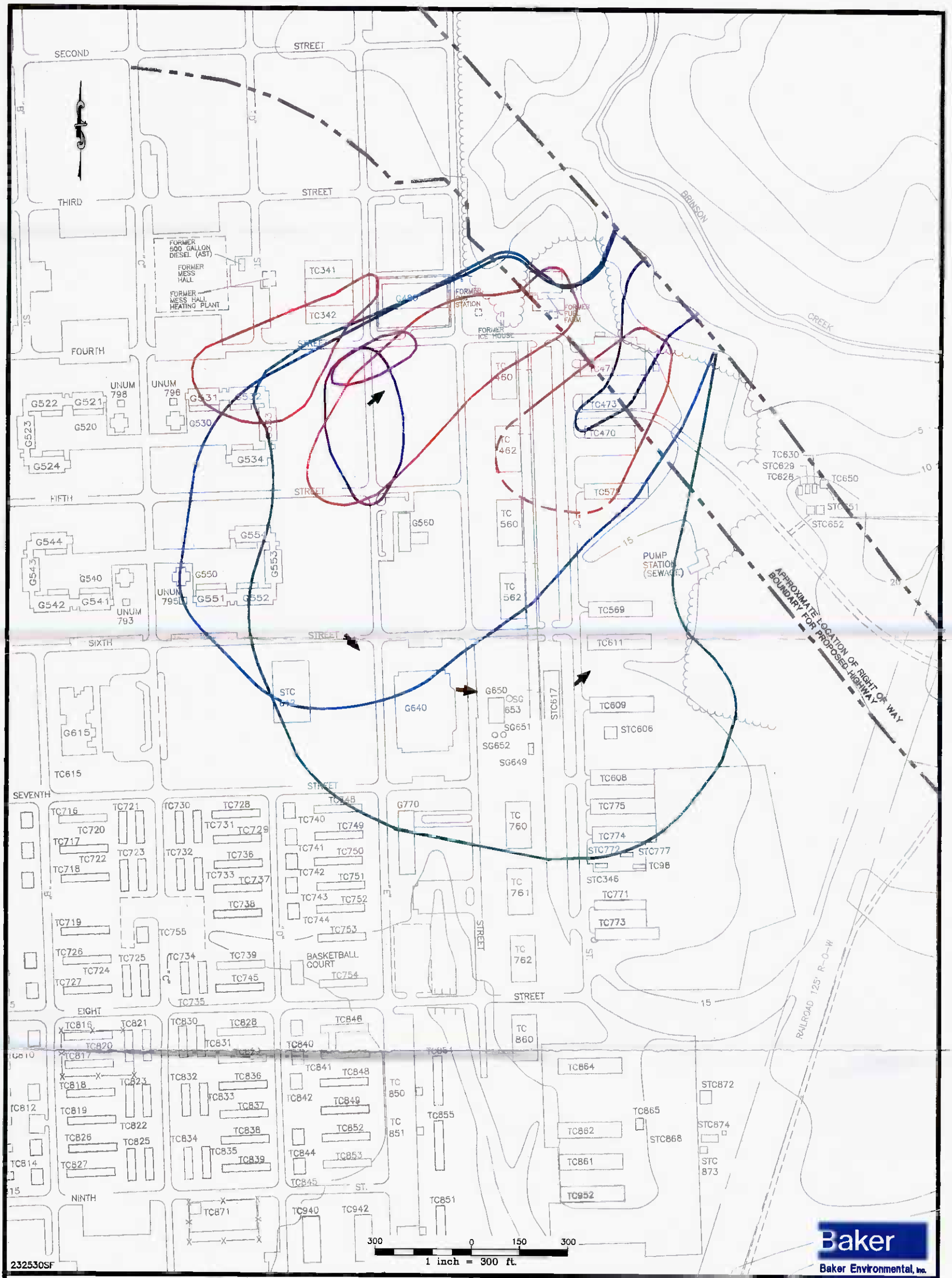
MTBE	200 PARTS PER BILLION (ppb)
XYLENES	530 ppb
ETHYLBENZENE	29 ppb
BENZENE	1 ppb
TOTAL DCE	70 ppb
TCE	2.8 ppb

APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, OCT. 1991

Baker Environmental, Inc.

FIGURE 6
SGI/COMPREHENSIVE FS RESULTS
UPPER PORTION OF THE SURFICIAL AQUIFER
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

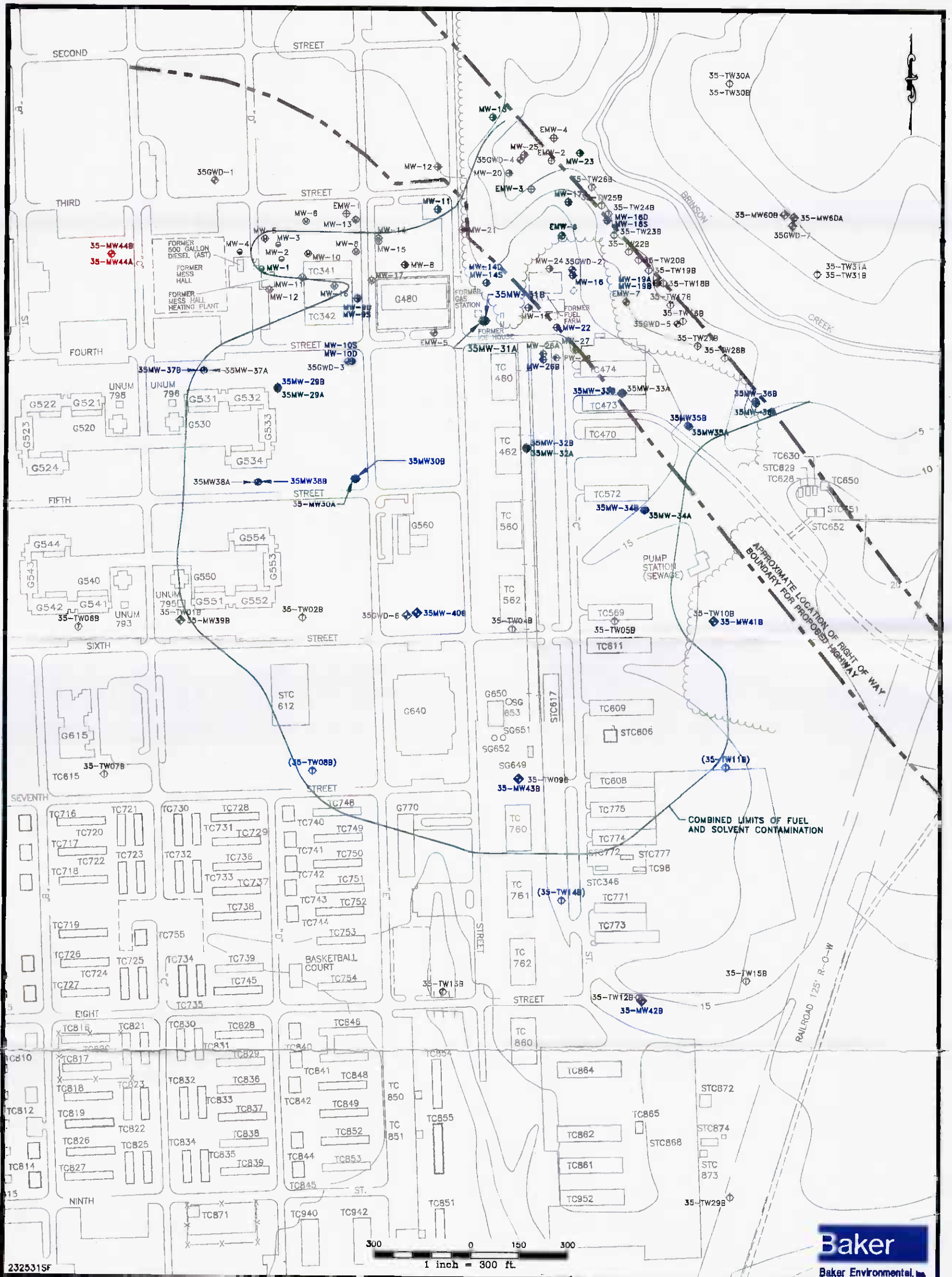
ISOCONCENTRATION LINES:

MTBE	200 PARTS PER BILLION (ppb)
ETHYLBENZENE	29 ppb
BENZENE	1 ppb
TOTAL DCE	70 ppb
TCE	2.8 ppb

APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, OCT. 1991

FIGURE 7
SGI/COMPREHENSIVE FS RESULTS
LOWER PORTION OF THE SURFICIAL AQUIFER
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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LEGEND

- 35-MW30A — WELL INSTALLED IN THE UPPER PORTION OF THE SURFICIAL AQUIFER
- 35-MW30B — WELL INSTALLED IN THE LOWER PORTION OF THE SURFICIAL AQUIFER
- (35-TW08B) — PROPOSED ADDITIONAL INTERMEDIATE WELL
- 35-MW44B / 35-MW44A — PROPOSED UPGRADIENT WELL CLUSTER

NOTE: HIGHLIGHTED WELLS WILL BE MONITORED FOR NATURAL ATTENUATION PARAMETERS.

SOURCE: LANTDIV, OCT. 1991

FIGURE 8
THE PREFERRED ALTERNATIVE
RAA 3 – NATURAL ATTENUATION
SITE 35, CAMP GEIGER AREA FUEL FARM
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA