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FINAL

FEASIBILITY STUDY
OPERABLE UNIT NO. 4
(SITES 41 AND 74)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0212

Prepared For:

DEPARTMENT OF THE NAVY
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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	area of concern
ARARs	Applicable or Relevant and Appropriate Requirements
AT	averaging time
AWQC	Federal Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
bgs	below ground surface
BOD	biochemical oxygen demand
CAIS	Chemical Agent Identification Sets
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	contaminant of concern
CSF	cancer slope factor
CWA	Clean Water Act
CWM	chemical warfare materiel
DON	Department of the Navy
DOT	Department of Transportation
ED	exposure duration
EF	exposure frequency
ER-L	effects range - low
ER-M	effects range-median
FFA	Federal Facilities Agreement
FS	Feasibility Study
gpm	gallons per minute
GW	groundwater
HA	Health Advisory
IR	ingestion rate
L/day	liters per day
LANTDIV	Atlantic Division Naval Facilities Engineering Command
MCB	Marine Corps Base
MCL	maximum contaminant level
mg/kg	milligram per kilogram
mg/L	milligram per liter

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

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
NCAC	North Carolina Administrative Code
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
O&M	operating and maintenance
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
POL	petroleum, oil, and lubricant
POTW	publicly owned treatment works
PRAP	Proposed Remedial Action Plan
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RGO	remediation goal option
RI/FS	Remedial Investigation/Feasibility Study
RL	remediation level
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SO	soil
SSV	sediment screening values
TEU	Technical Escort Unit
TRC	Technical Review Committee
TSCA	Toxic Substances Control Act
TSS	total suspended solids
USACMDA	United States Chemical Materiel Destruction Agency
USEPA	United States Environmental Protection Agency
UXO	unexploded ordnance
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

INTRODUCTION

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

The Fiscal Year 1994 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 27 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. This report documents the FS completed for two of these sites: Site 41 and Site 74. These two sites comprise Operable Unit (OU) No. 4 at MCB Camp Lejeune. Site 69, the Rifle Range Chemical Dump, was originally included in OU No. 4. However, this site has now been separated into its own operable unit, OU No. 14, to enable additional field investigation work to be performed prior to completion of the RI/FS. The purpose of this FS is to select a remedy for OU No. 4 that is protective of human health and the environment, attains Federal and State requirements, and is cost effective.

This Feasibility Study (FS) has been conducted in accordance with the requirements delineated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 300.430]. The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this document. This FS has been based on data collected during the RI conducted at Sites 41 and 74 (Baker, 1994).

Site Description and History

MCB Camp Lejeune is located within the Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. The military reservation 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 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.

Sites 41 and 74 have a reported history of chemical warfare material (CWM) disposal. The CWM suspected at MCB Camp Lejeune are chemical agent identification sets (CAIS).

CAIS were produced in large quantities (110,000 sets) and various configurations by the U.S. Army to train soldiers and sailors in the identification of actual chemical warfare agents and in the proper actions upon identification (U.S. Army, 1993). The sets contain vials (ampules) or bottles of agent. The agents used in these sets could contain blister agents [mustard (H) and lewisite (L)], nerve agents

(GA, GB and VX), blood agents [hydrogen cyanide (AC) and cyanogen chloride (CK)], and choking agent [phosgene (CG)].

There are several different types of CAIS. Unfortunately, the types of CAIS used at MCB Camp Lejeune are unknown. In addition, there is a lack of information to properly identify the quantity or disposal methods associated with the CAIS. With respect to disposal, it is not known whether the CWM was destroyed (via burning or detonation) prior to disposal. Existing information, however, does mention that drums were used during disposal.

The following provides a description and history of the sites.

Site 41

Site 41, Camp Geiger Dump near the Former Trailer Park, is located east of Highway 17 within the Camp Geiger area of MCB Camp Lejeune. The site encompasses approximately 30 acres and is situated in a topographically high area. Most of the site is heavily wooded and vegetated. Drainage from the site is received by Tank Creek to the south and an unnamed tributary to the north.

The surface of the site is littered with construction or demolition debris. Two seeps were also noted. The seeps are located along the northern and eastern boundaries of the disposal area. The seeps have an orange color appearance due to the presence of iron. The seeps flow into the unnamed tributary.

Site 41 is underlain by silty sand, with discontinuous layers of sand, clayey sand, sandy clay, silt, and clay to a depth between 11 and 29 feet bgs. No continuous groundwater retarding layer was encountered beneath the site. The upper unit of the Castle Hayne, consisting of shelly sand, was encountered beneath the silty sands. Shallow groundwater flow at the site is radial from the mound or fill area. Groundwater flow within the Castle Hayne appears linear and is toward the southeast.

Site 41 was used as an open burn dump from 1946 to 1970. The dump received construction debris; petroleum, oil and lubricant (POL) wastes, mirex (a pesticide), solvents, batteries, and ordnance. In addition, CWM (most likely CAIS kits) was reportedly taken to the site for disposal.

Site 74

Site 74, Mess Hall Grease Pit Disposal Area, is located approximately one-half mile east of Holcomb Boulevard in the northeast section of MCB Camp Lejeune. Site 74 consists of two areas of concern (AOC) in a remote area of MCB Camp Lejeune: the former grease pit disposal area; and a former pest control area. Both areas of concern are heavily wooded, overgrown with vegetation, and flat. The former disposal area is approximately 5 acres in size and the former pest control area is less than one acre in size based on historical photographs. The grease pit area and pest control area are separated by a dirt road and are situated approximately one-quarter mile apart. There are no structures in the area that are associated with the operation of the facility with the exception of an operational supply well (HP-654). This supply well is not contaminated. Site 74 has been fenced as part of MCB Camp Lejeune's institutional controls.

Site 74 is underlain by sand and silty sand. No groundwater retarding layer was encountered beneath the site; however, the subsurface investigations were primarily limited to a depth of approximately 20 to 25 feet below ground surface.

The site was used as a disposal area from the early 1950s until 1960. Grease was reportedly disposed of in trenches. It was reported that a volatile substance was sometimes used to ignite the grease. Drums containing PCBs and "pesticide soaked bags" were also reportedly disposed in trenches. One internal memorandum reports that drums, which were supposed to be taken to Site 69 for disposal, were disposed at Site 74 instead. There are no known disposal activities associated with the former pest control area. Contamination at this area is likely due to routine pesticide storage and handling activities.

Historical photographs of the former grease pit disposal area depict extensive trenching activities, which corresponds to the history of this site. Currently, there are no apparent signs of disposal with the exception of one area within the grease pit disposal area where a small depression in the ground surface was observed. The former pest control area is believed to have been used for the storage and handling of pesticides for pest control. Historical photographs depict a building, which probably served the purpose of housing pesticides. This building, including the foundation, is not discernable.

Remedial Investigations

The RI field investigations were initiated in January 1994 and completed in March 1994. In August 1994, selected monitoring wells at both sites were sampled using a low-flow purging technique for purposes of obtaining representative groundwater samples for subsequent total and dissolved metals analysis. In addition, a second round of surface water and sediment samples were collected at Site 41 to better characterize potential ecological impacts. Data collected during the RI were evaluated to assess the potential for human health and ecological risks.

Conclusions

Site 41

1. Polycyclic aromatic hydrocarbons (PAHs) detected in soil may be the result of reported burning operations during disposal activities. The extent of this contamination is within the central portion of the former disposal area. PAHs were not detected in groundwater.

2. Pesticides were detected in most soil samples; however, the pesticide levels are within base-wide concentrations which are indicative of historical pest control spraying. Low levels of pesticides were detected at isolated areas within the shallow aquifer and the upper portion of the Castle Hayne aquifer, indicating that pesticides have migrated to a limited extent from the soil matrix to shallow groundwater.

3. Although there were many background exceedances associated with the metals results, the data do not suggest a gross metals contamination problem in either the surface or subsurface soils at the site. The majority of elevated metals concentrations exceeded the twice background levels by less than an order of magnitude.

4. Total iron and manganese were detected above NCWQS and Federal secondary maximum contaminant levels (MCLs) in most of the monitoring wells sampled during the first round of the RI field investigation. Total lead was also detected above the NCWQS and the USEPA Action Level in most of the wells. Monitoring well 41GW11, which is located in the central portion of the former disposal area, exhibited the highest levels of lead, iron, and manganese. This first round of samples was collected via EPA-approved bailing techniques.

Due to the concern that turbidity may have influenced the first round (bailed) samples, selected shallow monitoring wells were resampled (round two) using the EPA-recommended low-flow purging technique, which is designed to minimize the amount of surging produced during sampling. Significantly lower metals concentrations were detected during this second round. However, the concentrations of lead, iron and manganese detected in well 41GW11, during round two, still exceeded drinking water standards.

5. Shallow groundwater is apparently discharging from the landfill via two seeps. Surface water samples collected from the seeps have exhibited elevated levels of iron, lead, and manganese. However, the unnamed tributary and Tank Creek do not appear to be significantly impacted by the site or seep discharges. Downstream surface water samples exhibited slightly higher iron and lead levels than upstream samples. Sediment samples along the seep pathway primarily exhibited pesticides above EPA Region IV screening values. High iron concentrations were detected in the seep sediments, suggesting that much of the iron in the seep surface water is being deposited in the sediments through oxidation and precipitation.

6. No chemical agents were detected during borehole monitoring conducted by the U.S. Army Technical Escort Unit (TEU). In addition, no chemical surety degradation compounds were detected in soil samples. However, buried CWM, PCBs, and other wastes areas that were not detected by the soil boring program could still be present within the former disposal area.

7. Under current exposure pathways, there are no adverse human health risks mainly because the site is in a remote area, and there is no exposure pathway associated with the groundwater (i.e., no water supply wells are currently located near the site).

8. Under future potential exposure pathways involving residential use, adverse human health risks would result primarily due to metal concentrations in groundwater. However, future residential use of the area is unlikely since the site is suspected of containing buried CWM. In addition, there are no plans to use this area for residential housing.

9. No adverse human health risks were calculated for the future construction worker. However, buried CWM, if present, would still pose a risk to a construction worker at the site.

10. The risk analysis for environmental media concentrations and terrestrial intake models did not indicate that there are significant ecological risks associated with Site 41 to terrestrial receptors and aquatic receptors in the unnamed tributary and Tank Creek.

11. Based on the results of the human health and ecological risk assessments, there are no areas of concern associated with soils or sediment that require remediation. However, institutional controls are considered in the FS to restrict site access and land use because of the unacceptable risk calculated for the residential use scenario as well as the suspected buried CWM.

12. Remediation of the groundwater and seep discharges is considered in the FS because there were some exceedances of State and Federal ARARs. In addition, the seep discharge may pose a future potential threat to the environment and habitat along the unnamed tributary.

Site 74

1. Soil at the former pest control area exhibited pesticides above base background levels, indicating that former pest control activities have resulted in soil contamination. The extent of soil contamination at the former pest control area is limited.

2. Low levels of pesticides were detected in shallow groundwater at the pest control area; however, the levels are below State and Federal drinking water standards.

3. Soil and groundwater at the former grease pit disposal area have not been significantly impacted by former disposal activities. Although organic and inorganic contaminants were detected in soil, the low concentrations and infrequent distribution of the contaminants do not suggest that there is a source area associated with former disposal areas.

4. The subsurface conditions at the former grease pit disposal area are unknown since no intrusive investigations (e.g., trenching) could be conducted due to suspected buried CWM. Therefore, the background information, which indicated that PCBs and other wastes were disposed at the site, cannot be verified.

5. No chemical agents were detected during borehole monitoring conducted by the U.S. Army TEU. In addition, no chemical surety degradation compounds were detected in soil samples. However, buried CWM, PCBs, and other wastes areas that were not detected by the soil boring program could still be present within the former disposal area.

6. During the first round of sampling, shallow groundwater exhibited total manganese, iron, lead, and chromium above State and Federal drinking water standards. The contaminant levels and distribution are very similar to other sites investigated at MCB Camp Lejeune, indicating that the shallow geologic conditions and round one sampling methods (bailing) may have elevated the concentrations of total metals, rather than a specific disposal event. Due to the concern that turbidity may have influenced the first round of samples, two shallow monitoring wells were resampled using the EPA recommended low-flow purging technique, which is designed to minimize the amount of surging produced during sampling. The low-flow sampling results (round two) showed much lower total metals concentrations than those detected during the first round of sampling. During round two, only iron exceeded the State and Federal drinking water standards. Dissolved (filtered samples) metals in shallow groundwater were not elevated during the low-flow sampling event.

7. Under current exposure pathways, there are no adverse human health risks associated with the site (i.e., the shallow groundwater is not currently being used for any purpose).

8. Under future potential exposure pathways involving residential use, adverse human health risks would result due to groundwater usage. However, future residential use of the area is unlikely since the site is suspected of containing buried CWM.

9. No adverse human health risks were calculated for the future construction worker. However, buried CWM, if present, would still pose a risk to a construction worker at the site.

10. The risk analysis for environmental media concentrations and terrestrial intake models indicated that there are no significant ecological risks associated with Site 74 to aquatic and terrestrial receptors.

11. Based on the results of the human health and ecological risk assessments, there are no areas of concern associated with the soils that require remediation. However, institutional controls are considered in the FS to restrict site access and land use because of the unacceptable risk calculated for the residential use scenario as well as the suspected buried CWM.

Areas of Concern Requiring Remediation and/or Institutional Controls

The results of the baseline human health RA and the ecological risk assessment were evaluated to determine the areas of concern (AOC) within OU No. 4 that may warrant remediation or institutional controls to protect the public health and the environment. This determination is presented below for each site.

Site 41 Areas of Concern

Under current use of the site, these media do not present unacceptable risks to human health. However, shallow groundwater, seep surface water, and soil (including the landfill material) are media at Site 41 that could potentially pose unacceptable future human health risks, such as under a residential land use scenario, as well as potential ecological risks. For example, concentrations of several groundwater constituents, primarily metals, have exceeded federal and State drinking water standards in some wells. Therefore, future consumption of groundwater at the site could result in an unacceptable risk to human health.

Shallow groundwater and seep surface water have been combined as one area of concern because of their hydraulic connection to one another (the seeps are believed to be groundwater discharge from the site). Shallow groundwater within the central portion of the former disposal area has exhibited elevated total metals (mainly lead, iron, and manganese) and to a limited degree, dissolved metals (primarily iron). Although there is no current human receptor associated with shallow groundwater, future potential exposure to groundwater could occur, albeit unlikely, under a residential land use scenario.

With respect to the seeps, ecological receptors that could be exposed to the seep discharges may be at risk. Seep surface water has exhibited total metals which exceed Federal ambient water quality criteria (AWQC) for the protection of aquatic organisms. However, due to the nature of the seeps, the seeps do not serve the purpose of providing an ecological habitat.

The impact of these seeps to the receiving stream, the unnamed tributary, does not appear to be problematic. The unnamed tributary provides a habitat for aquatic organisms, mammals, and reptiles. Metal concentrations of surface water and sediment samples collected upstream and downstream of the seep discharges are similar to each other and to other streams throughout MCB Camp Lejeune. Although the unnamed tributary is not included as an area of concern, monitoring of this surface water should be considered as a part of the overall remedy at this site.

The following objectives have been identified for shallow groundwater and seep surface water at Site 41:

- Prevent future potential exposure to contaminated groundwater.
- Protect uncontaminated groundwater for future potential beneficial use.
- Restore contaminated groundwater for future potential beneficial use.
- Protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge.

For purposes of the FS, soil and the landfill material have been combined together to form a second AOC. These media do not currently result in unacceptable human health risks, but may result in unacceptable risks under a future potential scenario involving residential land use or construction. The fact that the site is suspected to contain CWM results in a risk from a safety as well as a health standpoint.

The following remedial action objective has been identified for soil at Site 41:

- Prevent future potential exposure to contaminated soil (including landfill materials).

Site 74 Areas of Concern

Shallow groundwater and soil (including the landfill material) are media at Site 74 which could potentially pose unacceptable future human health risks. As mentioned previously, these media do not present unacceptable risks to human health or the environment, at present.

Shallow groundwater has exhibited elevated total metals (mainly lead, iron, and manganese) and to a limited degree, pesticides. Although there is no current human receptor associated with shallow groundwater, future potential exposure to groundwater could occur, albeit unlikely, under a residential land use scenario.

The following objective has been identified for shallow groundwater at Site 74:

- Prevent future potential use of the shallow groundwater.

Soil, including the landfill material, has also been identified as an area of concern. Exposure to soil does not currently result in unacceptable human health risks, but may result in unacceptable risks under a future potential scenario involving residential land use or construction. The fact that the site is suspected to contain CWM results in a risk from a safety as well as a health standpoint.

The following remedial action objective has been identified for soil at Site 74:

- Prevent future potential exposure to contaminated subsurface soil (including landfill materials).

DETAILED ANALYSIS OF SITE 41 REMEDIAL ALTERNATIVES

Typically in a feasibility study, an initial group of potential remedial alternatives is developed that undergoes a screening based on effectiveness, implementability, and cost. The purpose of this screening is to reduce the number of alternatives that are subsequently evaluated as part of the detailed analysis. However, since only a limited number of alternatives have been developed for each medium at the three sites, the preliminary screening tier was not performed.

The detailed analysis of alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988b) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the Record of Decision (ROD) by addressing comments received after the FS and Proposed Remedial Action Plan (PRAP).

Site 41 Soil (SO) Alternatives

The soil remedial alternatives developed for Site 41 are listed below:

- Alternative 41SO-1 - No Action
- Alternative 41SO-2 - Institutional Controls

Although a capping alternative is often considered for former landfill sites, a capping alternative was not developed for this site because of implementability and effectiveness concerns. Results of the human health assessment indicate that the surface soils currently do not pose an unacceptable risk to base personnel. Therefore, a cap is not necessary to eliminate contact with the surface soil. The installation of a low-permeability cap would require extensive clearing, grubbing, and regrading activities that would disturb the landfill contents. Since the landfill may contain Chemical Warfare Material (CWM) and other wastes, construction of a cap would pose a significant risk to human health and the environment during construction. Furthermore, because the site is heavily vegetated, regrowth of vegetation following cap installation could puncture the cap, causing a long-term operational concern. Control of vegetation regrowth through the cap could require the application of an herbicide, which could pose additional environmental and human health risks. Finally, the waste materials are not underlain by a continuous low-permeability liner, and the water table is very close to the ground surface. These conditions would limit the ability of cap to protect groundwater. Any contaminants present in the landfill could continue to leach to groundwater even after the cap is installed. For these reasons, capping technologies were eliminated from further consideration in the FS.

Alternative 41SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 41, which was used as an open burn dump from 1946 to 1970.

Cost: There are no costs associated with this alternative.

Alternative 41SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site, which was used as an open burn dump from 1946 to 1970. These institutional controls would involve designation of the area as a restricted, or limited-use area. Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area as well as invasive construction activities. If additional control is needed, several warning signs could be posted around the site to indicate that wastes are buried at the site and that construction activities are prohibited within the area.

Although unlikely, potential contamination present in the landfill could, in the future, act as a significant source of groundwater, surface water, and sediment contamination. Contaminant trends could be analyzed using analytical results from groundwater and surface water/sediment monitoring programs (included under Alternative 41GW-2) to assess whether any portion of the landfill is acting as a source of groundwater contamination over the long term.

Cost: The are essentially no capital or operation and maintenance costs associated with this alternative. Labor costs to revise the Base Master Plan have not been estimated.

Site 41 Groundwater (GW) Alternatives

The groundwater remedial alternatives developed for Site 41 and evaluated are listed below:

- Alternative 41GW-1 - No Action
- Alternative 41GW-2 - Institutional Controls and Monitoring
- Alternative 41GW-3 - Seep Collection and Treatment with Institutional Controls and Monitoring
- Alternative 41GW-4 - Groundwater Extraction and Treatment with Institutional Controls and Monitoring

With respect to treatment of the collected water, two subalternatives were developed under Alternatives 41GW-3 and 41GW-4 as follows:

- Subalternatives 41GW-3a and 41GW-4a - Physical/Chemical Treatment
- Subalternatives 41GW-3b and 41GW-4b - Constructed Wetlands Treatment

Alternative 41GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat potentially contaminated groundwater and associated surface water at Site 41.

Shallow groundwater generally flows radially from the center of the site, whereas deeper groundwater in the Castle Hayne Aquifer flows in a southeasterly direction. Groundwater on site currently is not used for any purpose. Potable water throughout the Base is supplied by wells located in the mid and lower regions of the Castle Hayne Aquifer. The shallow aquifer is not used as a potable water supply on Base. However, both the shallow and upper Castle Hayne Aquifers are classified as GA waters under the North Carolina Water Quality Standards (NCWQS), which are current or potential sources of drinking water. There are no groundwater production wells located immediately downgradient of the site. The nearest downgradient supply wells (wells MCAS-4150 and MCAS-500 are located approximately 1.1 miles southeast of the site (Baker, 1994).

Two shallow seeps are present at the site, which originate along the northern and eastern edges of the site (near the top of the landfill). Both seeps, which would not be remediated under this alternative, discharge into the unnamed tributary.

Cost: There are no costs associated with this alternative.

Alternative 41GW-2 - Institutional Controls and Monitoring

Under this alternative, a groundwater, surface water, and sediment sampling program would be initiated for the site. Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius of the site.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $38,500
- Net present worth (30-year): $592,000

Alternative 41GW-3 - Seep Collection and Treatment with Institutional Controls and Monitoring

The main intent of this alternative is to provide protection of ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge (RAO Number 4) through collection and treatment of the seep water.

This alternative includes collection of the seeps in subsurface drains and routing by gravity flow to a treatment system prior to discharge to an existing waterway (unnamed tributary). This alternative includes two subalternatives for treatment of the seep water as follows:

- Subalternative 41GW-3a - Physical/Chemical Treatment
- Subalternative 41GW-3b - Constructed Wetlands Treatment

The conceptual design developed for this alternative includes the following:

- Installation of a total of approximately 400 linear feet of seep collection trenches along the north and east seeps.

- Installation of approximately 900 linear feet of gravity flow subsurface conduit.

- Construction of a physical chemical/treatment plant (Subalternative 41GW-3a) or a constructed wetlands treatment system (Subalternative 41GW-3b).

- Access road upgrade into the site.

- Extension of electrical service to the physical/chemical treatment plant (Subalternative 41GW-3a).

As with Alternative 41GW-2, a groundwater, surface water, and sediment sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. For sediments, which require a lower sampling frequency, it was assumed that a round of sediment samples would be collected once every three years.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius from the site, as described under Alternative 41GW-2.

Cost: The estimated costs of the two subalternatives included under this alternative are as follows:

<u>Subalternative 41GW-3a</u>

- Capital: $618,000
- Annual operation and maintenance: $82,000
- Net present worth (30-year): $1,878,000

<u>Subalternative 41GW-3b</u>

- Capital: $264,000
- Annual operation and maintenance: $49,800
- Net present worth (30-year): $1,029,000

Alternative 41GW-4 - Groundwater Extraction and Treatment with Institutional Controls and Monitoring

This alternative is intended to provide collection and treatment of shallow groundwater in order to: protect uncontaminated groundwater for future potential beneficial use (RAO Number 2); restore contaminated groundwater for future potential beneficial use (RAO Number 3); and protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge (RAO Number 4).

The conceptual design developed for this alternative includes the following:

- Installation of a total of three shallow groundwater extraction wells along the eastern edge of the landfill between the north and east seeps.

- Installation of approximately 1,200 linear feet of influent and effluent subsurface piping.

- Construction of a physical chemical/treatment plant (Subalternative 41GW-4a) or a constructed wetlands treatment system (Subalternative 41GW-4b).

- Access road upgrade into the site.

- Extension of electrical service to the physical/chemical treatment plant (Subalternative 41GW-4a).

The groundwater extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the shallow aquifer (i.e., NCWQS) in Section 2.0. If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time. The re-evaluation would be conducted according to the Correction Action requirements of the DEHNR Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina (15A NCAC 2L.0106). Under this regulation, the DEHNR Director may authorize termination of the corrective action if it can be demonstrated that continuation of the action would not result in a significant reduction in the concentrations of contaminants and if certain other environmental criteria can be met.

As with Alternative 41GW-2, a groundwater, surface water, and sediment sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. For sediments, which require a lower sampling frequency, it was assumed that a round of sediment samples would be collected once every three years.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius from the site, as described under Alternative 41GW-2.

Cost: The estimated costs of the two subalternatives included under this alternative are as follows:

Subalternative 41GW-4a

- Capital: $675,000
- Annual operation and maintenance: $83,500
- Net present worth (30-year): $1,959,000

Subalternative 41GW-4b

- Capital: $938,000
- Annual operation and maintenance: $61,800
- Net present worth (30-year): $1,887,000

DETAILED ANALYSIS OF SITE 74 REMEDIAL ALTERNATIVES

Site 74 Soil (SO) Alternatives

The soil remedial alternatives developed for Site 74 are listed below:

- Alternative 74SO-1 - No Action
- Alternative 74SO-2 - Institutional Controls

Similarly to Site 41, a capping alternative was not developed for this site for the reasons presented for Site 41.

Alternative 74SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 74, which was used as a grease pit and disposal area from the early 1950s to 1960.

Cost: There are no costs associated with this alternative.

Alternative 74SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site. These institutional controls would involve designation of the area as a restricted, or limited-use area.

Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area as well as invasive construction activities. If additional control is necessary, warning signs could be posted around the site to indicate that wastes are buried at the site and that construction activities are prohibited within the area.

Cost: The are essentially no capital or operation and maintenance costs associated with this alternative. Labor costs to revise the Base Master Plan have not been estimated.

Site 74 Groundwater (GW) Alternatives

The groundwater remedial alternatives developed for Site 74 and evaluated are listed below:

- Alternative 74GW-1 - No Action
- Alternative 74GW-2 - Institutional Controls and Monitoring

Alternative 74GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat groundwater at Site 74.

Groundwater contamination generally consists of total metals concentrations of chromium, lead, iron, and manganese detected in unfiltered samples collected from the shallow aquifer. Since no sources of these metals were identified within the landfill, the elevated total metals concentrations are most likely a result of turbidity (i.e., suspended solids) in the wells rather than from actual leaching of contaminants from the soils to groundwater.

A potable water supply well, Supply Well HP-654, is located in the Castle Hayne Aquifer near the center of the site. This well is periodically sampled for full organic and inorganic analysis, and no contamination has been detected in the well to date.

Cost: There are no costs associated with this alternative.

Alternative 74GW-2 - Institutional Controls and Monitoring

Description: Under this alternative, a groundwater sampling program would be initiated for the site. Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells on site.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $22,300
- Net present worth (30-year): $342,000

1.0 INTRODUCTION

This Feasibility Study (FS) has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy (DON) Atlantic Division Naval Facilities Engineering Command (LANTDIV) Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. Contract Task Order 0212 is a Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit No. 4 at Marine Corps Base (MCB), Camp Lejeune. This FS has been conducted in accordance with the requirements delineated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 300.430]. These NCP regulations were promulgated under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. The USEPA's document <u>Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA</u> (USEPA, 1988a) has been used as guidance for preparing this document.

MCB, Camp Lejeune was placed on the National Priorities List (NPL) on October 4, 1989 (54 Federal Register 41,015, October 4, 1989). The United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR) and DON then entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA is to ensure that environmental impacts associated with past and present activities at the MCB, Camp Lejeune are thoroughly investigated and appropriate CERCLA Response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and the environment (FFA, 1989).

The Fiscal Year 1995 Site Management Plan for MCB, Camp Lejeune, a primary document identified in the FFA, identifies 27 sites requiring RI/FS activities. This report documents the FS completed for the following two sites:

- Site 41, Camp Geiger Dump near the Former Trailer Park
- Site 74, Mess Hall Grease Pit Disposal Area

These two sites share common characteristics so that they comprise Operable Unit (OU) No. 4 at MCB, Camp Lejeune. Site 69, the Rifle Range Chemical Dump, was originally included with this OU. However, Site 69 has now been separated into its own operable unit, OU No. 14, to allow the nature and extent of groundwater contamination to be better defined (through additional field work) before the RI/FS is completed.

This FS has been based on data collected during the RI conducted at Sites 41 and 74 (Baker, 1994). Field investigations at these sites began in January 1994 and continued through May 1994. Additional sampling of groundwater and surface water/sediments was conducted in August, 1994. Results of the field investigations are summarized in the RI Report under separate cover (Baker, 1994).

1.1 Purpose and Organization of the Report

1.1.1 Purpose of the Feasibility Study

The purpose of the FS for OU No. 4 is to identify remedial alternatives that are protective of human health and the environment, attain Federal and State requirements that are applicable or relevant and appropriate, and are cost-effective. In general, the FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated, such that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. The FS involves two major phases:

- Development and screening of remedial action alternatives, and
- Detailed analysis of remedial action alternatives.

The first phase includes the following major activities:

1. Developing remedial action objectives and remediation levels
2. Developing general response actions
3. Identifying volumes or areas of affected media
4. Identifying and screening potential technologies and process options
5. Evaluating process options
6. Assembling alternatives
7. Defining alternatives
8. Screening and evaluating alternatives.

Section 121(b)(1) of CERCLA requires that an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant be conducted. In addition, according to CERCLA, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management of alternatives to alternatives which involve treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no-action alternative should also be developed.

The second major phase of the FS consists of: (1) evaluating the potential alternatives in detail with respect to nine evaluation criteria to address statutory requirements and preferences of CERCLA; and (2) performing a comparison analysis of the evaluated alternatives.

1.1.2 Report Organization

This FS Report is organized in six sections. The Introduction (Section 1.0) presents the purpose of the report, a brief discussion of the FS process, and pertinent site background information including a summary of the nature and extent of contamination at OU No. 4. Human health and ecological risks are also presented in Section 1.0. Section 2.0 contains the remedial action objectives and remediation levels that have been established for the operable unit. Section 3.0 contains the identification of general response actions, and the identification and preliminary screening of the remedial action technologies and process options. Sections 4.0 and 5.0 contain the development, detailed analysis, and comparison of remedial action alternatives for Sites 41 and 74, respectively. The detailed analysis is based on a set of nine criteria including short- and long-term effectiveness, implementability, cost, state and local acceptance, compliance with applicable regulations, and overall protection of human health and the environment. The references are listed in Section 6.0.

1.2 Site Background Information

Background information pertaining to OU No. 4 is presented below. Section 1.2.1 provides a description and history of the two sites. The nature and extent of contamination at each site is described in Section 1.2.2. Additional details pertaining to this operable unit can be found in the RI Report (Baker, 1994).

1.2.1 Site Description and History

Operable Unit No. 4 consists of Sites 41 and 74, which may have a reported history of chemical warfare material (CWM) disposal. The CWM suspected at MCB Camp Lejeune are chemical agent identification sets (CAIS). [The following information about CAIS was obtained directly from documents published by the U.S. Army Chemical Material Destruction Agency (USACMDA).] There are various classifications associated with disposal of CWM. Based on a report published by USACMDA, the sites at MCB Camp Lejeune were classified as "Classification 3 - Suspected Burial" (USACMDA, 1993). A classification 3 site is a site at which one or more of the following conditions apply:

- The normal duty activities performed on this site indicate a strong suspicion that buried CWM may still exist, even though they are indicated in literature as destroyed. An example would be a burn pit where not all of the munitions may have been consumed even though the period literature indicated that they were.

- Chemical weapons were known to be disposed of on this site, but period literature indicates that the site was cleared. The period definition of cleared, and the technology for clearing such locations at that time, may lead to the conclusion that not everything was removed.

- The site is a known chemical range, but the literature is unclear as to whether chemical agent was applied to the site by spraying (such that there would be no buried ordnance) or by range firing/bombing.

Based on information collected during the RI, which may not have been available at the time the USACMDA report was published, Site 41 may actually be classified as a Class 2 site (Likely Burial), and Site 74 may actually be classified as a Class 4 site (Possible Burial).

A Class 2 site is a site in which the following conditions apply:

- The burial of CWM has been reported. (Applies to Site 41)

- The firing of chemical weapons under range conditions (as opposed to static firing under test conditions) has been reported. (Does not apply to Site 41)

- The disposal of chemical weapons by dumping in shallow water has been reported. (Does not apply to Site 41)

A Class 4 site is a site in which the following conditions apply:

- Although no literature exists, which indicates burial was actually conducted, the activities and timeframe of the operations on the site indicate that burial of chemical weapons is a possibility. (Applies to Site 74)

- The normal duty activities performed on this site indicate some possibility that chemical weapons may have been buried as there exists no literature that documents their fate. (Applies to Site 74)

- There is enough literature to indicate that CAIS or chemical weapons were used extensively at the site in such a way that (although the literature does not indicate it) some chemical material may be present. (Does not apply to Site 74)

With respect to the criteria for a Class 2 site, a background report has indicated the burial of "gas" at Site 41 (Eakes, 1982). The report also indicated that agents may be at the site. Although no direct association of agent disposal has been identified for Site 74, background information referencing the disposal of wastes at Site 74 has indicated that "some drums may have been left over from a burial/disposal incident at the Rifle Range Chemical Dump (Site 69)." This reference indicates the possibility that CWM may also be present at Site 74.

CAIS were produced in large quantities (110,000 sets) and various configurations by the U.S. Army to train soldiers and sailors in the identification of actual chemical warfare agents and in the proper actions upon identification (U.S. Army, 1993). The sets contain vials (ampules) or bottles of agent. The agents used in these sets could contain blister agents [mustard (H) and lewisite (L)], nerve agents (GA, GB and VX), blood agents [hydrogen cyanide (AC) and cyanogen chloride (CK)], and choking agent [phosgene (CG)].

There are several different types of CAIS. One variety of CAIS was an instructional "sniff set" that contained agent impregnated charcoal. It was intended for use indoors to instruct military personnel in recognizing the odors of chemical agent. This type of set contained only small amounts of chemical agent. A second major variety of CAIS, designed for use outdoors, consisted of agent (pure or in solution) in sealed pyrex tubes. The gas tubes would be detonated, creating an agent cloud. Soldiers would then try to identify the agent based on its odor and other characteristics. These typically contained more agent then the instructional "sniff sets" and could produce a much greater hazard. A third major variety of CAIS were those containing bulk mustard. These CAIS were used in decontamination training by purposely contaminating the terrain or equipment with mustard, and then teaching the soldiers how to don the correct protective clothing and decontaminate the area or equipment. These CAIS contained relatively large quantities of pure mustard.

Unfortunately, the types of CAIS used at MCB Camp Lejeune are unknown. However, drums containing calcium hypochlorite, a decontaminant, have been identified at the base. Therefore, it is possible that the third variety of CAIS mentioned above (i.e., CAIS containing pure mustard) may have been used at MCB Camp Lejeune. Based on "best professional judgements" made by personnel at the USACMDA, CAIS at MCB Camp Lejeune most likely did not contain nerve agents. However, a memo with a hand-drawn sketch of Site 69 identified that "mustard or nerve gas" was disposed of at two locations within the site (Scudder, 1982).

In summary, there is a good likelihood that CWM are present at Sites 41 and 74. However, there is a lack of information to properly identify the amount, types, or disposal methods associated with CAIS disposal. With respect to disposal, it is not known whether the CWM was destroyed (via burning or detonation) prior to disposal. Existing information, however, does mention that drums were used during disposal.

Because both sites may contain CWM, they have been combined into OU No. 4. The sites are not situated in close proximity to each other. The following sections provide a description and history of the sites.

1.2.1.1 <u>Site 41</u>

Site 41, Camp Geiger Dump near the Former Trailer Park, is located east of Highway 17 within the Camp Geiger area of MCB Camp Lejeune (see Figure 1-1). As depicted in Figure 1-2, the site encompasses approximately 30 acres and is situated in a topographically high area. The topographic elevation lines shown in Figure 1-2, and in all other figures, represent elevations in feet referenced to mean sea level. The central portion of the site is flat. Most of the site is heavily wooded and vegetated. Only one area of the site, which is essentially the middle area, is somewhat clear of trees. The northern boundary of the fill area is evidenced by an abrupt five to ten foot high change in elevation across the north central portion of the site. The "cleared" area described earlier is situated just south of this "highwall." Several dirt roads bisect the site. Drainage is poor as evidenced by numerous ponding areas. Drainage from the site is received by Tank Creek to the south and an unnamed tributary to the north. The unnamed tributary flows in a southeast direction around the northeastern and eastern border of the site until it discharges into Southwest Creek. Tank Creek flows in a southeast direction and also discharges into Southwest Creek.

The surface of the site is littered with construction or demolition debris. This material consists mainly of sheet metal, steel I-beams, plastic wire, wood, and concrete. This same material was observed in the subsurface below uprooted trees (i.e., subsurface contents were observed below the root system of large uprooted trees). A few rusted empty drums were also noted throughout the site, including one drum which indicated "dry cleaning solvent." Two seeps were also noted. The seeps are located below the highwall described earlier and have an orange color appearance. A sheen was also noted on the seeps. The seeps flowed northward toward the unnamed tributary. Several circular depressions (approximately 5 to 7 foot radius and 2 to 3 feet in depth) were noted throughout the site area. Based on discussions with ordnance specialists from the U.S. Army Technical Escort Unit (TEU), these depressions may have been formed by exploding ordnance.

Site 41 is underlain by silty sand, with discontinuous layers of sand, clayey sand, sandy clay, silt, and clay to a depth between 11 and 29 feet below ground surface (bgs). No continuous groundwater retarding layer was encountered beneath the site. The upper unit of the Castle Hayne was encountered beneath the silty sands. Shallow groundwater flow at the site is radial from the mound or fill area; however, the predominant flow direction is towards the southeast. Shallow groundwater discharges to the unnamed tributary to the north and east, and Tank Creek to the south. Groundwater flow within the Castle Hayne appears linear and is toward the southeast, based on measured groundwater levels.

Site 41 was used as an open burn dump from 1946 to 1970. The dump received construction debris, petroleum, oil, and lubricant (POL) wastes, mirex (a pesticide), solvents, batteries, and ordnance. In addition, CWM (most likely CAIS kits) was reportedly taken to the site for disposal.

Previous investigations under the Installation Restoration Program involved the installation of five shallow monitoring wells installed around the perimeter of the site, and a limited number of surface water and sediment samples collected from Tank Creek and the unnamed tributary. Low levels 1.1 μg/L of 1,2-dichloroetheylene (1,2-DCE), benzene (0.3 μg/L), and dichlorodifluoromethane (8 μg/L) were detected in one monitoring well. This well (41GW2) is situated in the south central portion of what is believed to be fill material. Some of the surface water samples revealed low levels of the pesticides aldrin (maximum concentration of 0.015 μg/L) and BHC (maximum concentration of 0.047 μg/L). Sediment samples revealed low levels of chromium (maximum concentration of 5.09 mg/kg), lead (maximum concentration of 12.1 mg/kg), and 2,4,6-trinitrotoluene (2,4,6-TNT at 0.357 μg/kg).

1.2.1.2 Site 74

Site 74, Mess Hall Grease Pit Disposal Area, is located approximately one-half mile east of Holcomb Boulevard in the northeast section of MCB Camp Lejeune (see Figure 1-1). Site 74 consists of two areas of concern (AOC) in a remote area of MCB Camp Lejeune: the former grease pit disposal area; and a former pest control area (see Figure 1-3). Both areas of concern are heavily wooded, overgrown with vegetation, and flat. The former disposal area is approximately 5 acres in size, and the former pest control area is less than one acre in size based on historical photographs. West of the pest control AOC is an area that may also have been used for disposal, based on mounded materials noted in historical photographs. This area encompasses approximately 4 acres. Presently, this area is flat, wooded, and there are no signs of the soil mounds which were present in historical photographs. Henderson Pond, which is the only surface water body associated with the site, is situated south of the former pest control area. The grease pit area and pest control area are separated by a dirt road and are situated approximately one-quarter mile apart. There are no structures in the area that are associated with the operation of the facility with the exception of an operational supply well (HP-654). Previous sampling and analysis indicates that this supply well is not contaminated. Military training exercises are conducted in the area. Site 74 has been fenced to prevent access to the site.

Site 74 is underlain by sand and silty sand. No groundwater retarding layer was encountered beneath the site; however, the subsurface investigations were primarily limited to a depth of approximately 20 to 25 feet bgs. Based on other nearby environmental investigations (e.g., Site 82 located approximately one and one-half mile south of Site 74), no retarding layer was encountered until a depth of approximately 220 to 230 feet bgs. In addition, the Castle Hayne aquifer was identified at a depth of approximately 90 to 100 feet, based on encountering a shell and limestone unit. The deep subsurface geologic conditions at Site 74 are believed to be similar to those described above for Site 82.

The site was used as a disposal area from the early 1950s until 1960. Grease was reportedly disposed of in trenches. It was reported that a volatile substance was sometimes used to ignite the grease. Drums containing PCBs and "pesticide soaked bags" were also reportedly disposed in trenches. One internal memorandum reports that drums which were supposed to be taken to Site 69 for disposal were disposed at Site 74 instead in the trenches. Since the report was rather vague as to the contents of these drums, the site is being handled as a site where CWM may be present in buried drums, since it has been well documented that CWM have been taken and disposed at Site 69.

There are no known disposal activities associated with the former pest control area. Unlike the grease disposal area, there is no evidence to suggest that this area should be considered a Class 4 CWM site. Contamination at this area is likely due to routine pesticide storage and handling activities.

Historical photographs of the former grease pit disposal area depict extensive trenching activities, which corresponds to the history of this site. Currently, there are no apparent signs of disposal with the exception of one area within the grease pit disposal area where a small depression in the ground surface was observed. At the bottom of the depression was a drum fragment. It is possible that the depression occurred as a result of subsidence due to buried materials. The former pest control area is believed to have been used for the storage and handling of pesticides for pest control. Historical photographs depict a building which probably served the purpose of housing pesticides. This building, including the foundation, is not discernable.

Previous investigations conducted under the IR Program were conducted at the former grease pit disposal area and pest control area; however, these investigations involved only a limited number of soil and groundwater samples. The investigation involved collecting two soil samples from the pest control area and the installation of three monitoring wells at the former grease pit disposal area. Low levels of pesticides were detected at concentrations which would be considered equivalent to pesticide concentrations throughout MCB Camp Lejeune (maximum concentration was 260 μg/kg for dichlorodiphenyl/trichlorethane (DDT)). Low levels of the pesticides dichlorodiphenyl/dichloroethane (DDD) and DDT were detected in one shallow aquifer monitoring well.

1.3 Remedial Investigations

The RI field investigations were initiated in January 1994 and completed in March 1994. In August 1994, selected monitoring wells at both sites were sampled using a low-flow purging technique for purposes of obtaining representative groundwater samples for subsequent total (unfiltered) and dissolved (filtered) metals analysis. In addition, a second round of surface water and sediment samples was collected at Site 41 to better characterize potential ecological impacts. A summary of the RI field program is provided below for each site.

1.3.1 Site 41

The RI at Site 41 involved a preliminary geophysical survey to characterize the site with respect to buried material. Determining the potential areas of buried drums was important from the standpoint that this RI would not deliberately encounter buried drums since these drums could potentially contain CWM such as mustard gas, based on background information. Following this survey, the boundary of the former fill area was estimated. The estimated boundary correlated with historical photographs, which showed activities at this site. The area of buried material delineated via the geophysical investigation "fits" within the area of concern identified in the aerial photographs.

Twenty-four test borings were augered in areas suspected of waste disposal. All test boring locations were screened in the field via geophysical methods in order to avoid encountering buried drums. In addition, the samples were screened by the U.S. Army TEU for chemical surety agents. Surface and subsurface soil samples were collected and analyzed for full TCL organic, compounds TAL inorganic analytes, chemical surety degradation compounds, and ordnance constituents. In addition to this investigation, shallow test borings were hand augered downslope of the former dump in order to evaluate off-site migration of contamination from surface runoff. Shallow test borings were also hand augered on site near surficial disposal areas. These areas included areas where surficial debris or anomalies were noted during a site reconnaissance (i.e., construction debris, drum fragments, etc.).

The groundwater investigation involved the installation of shallow (13 to 21 feet bgs) and upper Castle Hayne (37 to 50 feet bgs) monitoring wells throughout the site area, and in assumed downgradient and upgradient locations. Two rounds of groundwater samples were collected (approximately two months apart) and analyzed for full TCL organic compounds and TAL inorganic analytes. As previously noted, selected monitoring wells (wells 41-GW02, 41-GW07, and 41-GW10) were sampled in August 1994 using a low-flow purging technique for purposes of obtaining representative groundwater samples for subsequent total (unfiltered) and dissolved (filtered) metals analysis.

Two rounds of surface water and sediment samples were collected from the unnamed tributary, Tank Creek, and from two seeps which were noted during the site reconnaissance. During the first sampling round in February 1994, all surface water and sediment samples were analyzed for full TCL organics and TAL inorganics. A second round of surface water and sediment samples was collected at Site 41 in August 1994 to better characterize potential ecological impacts. The surface water samples were analyzed for both total (unfiltered) and dissolved (filtered) metals, pesticides, and PCBs.

1.3.2 Site 74

The RI at Site 74 focused on characterizing the nature and extent of soil and groundwater contamination at the former grease pit disposal area and pest control area. Soil sampling grids were established throughout the former grease pit disposal area, the pest control area, and the potential disposal area due west of the pest control area. Surface and subsurface soil samples were collected from each test boring and analyzed for full TCL organics and TAL inorganics. All samples were screened in the field for chemical surety agents by the U.S. Army TEU. The test borings were augered until groundwater was encountered (between 4 and 19 feet bgs). Two or three soil samples were collected from each boring. Test borings were also augered for purposes of constructing shallow monitoring wells. A total of six monitoring wells were installed between the three suspected disposal areas. One round of groundwater samples was collected and analyzed for full TCL organics and TAL inorganics. A second round of samples was collected in August 1994 from two monitoring wells using a different sampling technique (i.e., low-flow) in order to better assess total metals concentrations in the groundwater.

Three surface water and sediment samples were collected from Henderson Pond and analyzed for full TCL organics and TAL inorganics.

1.4 <u>Nature and Extent of Contamination</u>

A brief summary of the nature and extent of contamination is provided in the following subsections for Sites 41 and 74. This summary focuses on the primary problems at each site and is not intended to address in detail all media or results. Detailed findings and evaluation of data are presented in Section 4.0 of the RI Report (Baker, 1994).

1.4.1 Site 41

1.4.1.1 Soil

Surface soil sampling results are summarized in Tables 1-1 and 1-2 for organic contaminants and inorganics, respectively. Subsurface soil sampling results are summarized in Tables 1-3 and 1-4 for organic contaminants and inorganics, respectively.

Soil contamination was dominated by polycyclic aromatic hydrocarbons (PAHs) and low levels of pesticides, PCBs, and volatiles. The majority of the PAH contamination was detected in onsite surface soil where contaminant levels exceeded one part per million (i.e., greater than 1,000 μg/kg) in a few samples. PAH contamination in the surface soil is primarily located in the central and eastern portions of the former dump area, as shown in Figure 1-4. PAH contamination was also evident in subsurface soil, but at lower levels. The concentrations of PAHs in subsurface soils, shown in Figure 1-5, were detected in the hundred parts per billion range. Although PAHs are present in onsite surface and subsurface soil, groundwater was not contaminated with PAHs. In addition, off-site migration of PAHs was limited. None of the downslope soil samples exhibited PAHs. The source of the PAHs in soil is believed to be due to historical open burning operations.

Pesticides were detected in most of the surface soil samples collected from the former dump area, including downslope surface soil samples. Pesticides were also detected in subsurface soil samples, but primarily limited to the dump area (only one downslope subsurface soil sample exhibited pesticides). The pesticide levels detected in soil are similar to pesticide levels detected at other areas within MCB Camp Lejeune.

Volatile organics including benzene (maximum concentration of 1.0 μg/kg), chlorobenzene (100 μg/kg), ethylbenzene (58 μg/kg), and TCE (1.0 μg/kg) were detected in subsurface soil, but not at elevated concentrations. Chlorobenzene was detected more frequently than the other VOCs. Toluene (maximum concentration of 4 μg/kg) was the only VOC detected in surface soil. The VOCs in soil are likely a result of localized spills.

Surface soil contamination also consisted of low levels of Aroclor 1242 (82.9 μg/kg) and Aroclor 1260 (58.2 μg/kg) at two locations within the former dump. PCB constituents were also detected in subsurface samples collected from the same sampling location which exhibited surficial contamination. Aroclor 1254 was detected in soil boring SB19 at 36.7 μg/kg, and Aroclor 1260 was detected in soil boring SB23 at 34.6 μg/kg. Two other nearby sampling locations (Soil borings SB16 and GW11) also exhibited low levels of Aroclor 1260 (317 μg/kg) and Aroclor 1254 (214 μg/kg), respectively. These four borings are located in the central portion of the dump area. No PCBs were detected in groundwater indicating that vertical migration to the water table has not occurred.

As shown in Tables 1-2 and 1-4, the concentrations of a number of inorganic constituents exceeded twice the average background concentration for the base. An ongoing soil background database is being developed for MCB Camp Lejeune to support RI/FS efforts. At present, the database is limited to 17 surface and 6 subsurface soil samples collected as part of remedial investigations conducted to date at MCB Camp Lejeune. The average base-specific inorganic background soil concentrations were estimated using analytical data from the current database. Comparing the results for surface and subsurface soils, there appears to be little correlation between elevated metals concentrations in the surface and subsurface soils. For surface soils, chromium, iron, and vanadium were the predominant metals that exceeded background levels. In contrast, zinc, barium, manganese, arsenic, and lead were the major subsurface metals that exceeded twice the background levels. Although there were many background exceedances associated with the metals results, the data do not suggest a gross metals contamination problem at the site. The majority of elevated metals concentrations exceeded the twice background levels by less than an order of magnitude. In addition, the calculated background concentrations may increase as the database is expanded.

1.4.1.2 Groundwater

VOC contamination in shallow groundwater was detected in shallow wells 41GW09, 41GW10, and 41GW11. The VOCs included chloroform (1.36 to 3.17 μg/L in wells 41GW9 and 41GW10), benzene (2.67 μg/L in well 41GW11), chlorobenzene (1.49 μg/L in well 41GW11), and total xylenes (1.03 μg/L in well 41GW11). Well 41GW11 is located at the center of the former disposal area in the fill material. Naphthalene, a semivolatile organic, was detected in this well at a concentration of 3 μg/L. Low levels of 1,2-DCE (1.22 μg/L) and 1,1,1-trichloroethane (19 μg/L) were detected in deep well 41GW11DW. Chloroform (1.02 μg/L) and dibromochloromethane (1.27 μg/L) were detected in deep well 41GW12DW. A summary of the Site 41 groundwater results is provided in Table 1-5.

Metals detected during the first two sampling rounds were widely distributed in shallow groundwater, as shown in Figures 1-6 and 1-7 for Round 1 (February 1994) and Round 2 (April 1994), respectively. Elevated levels of total (unfiltered) metals during these sampling rounds included: lead (maximum concentration of 9,340 μg/L in well 41GW11), chromium (maximum concentration of 176 μg/L in well 41GW10), manganese (maximum concentration of 2,110 μg/L in well 41GW11), and iron (maximum concentration of 155,000 μg/L in well 41GW11). Well GW11, which is located in the center of the dump, exhibited the highest levels of total metals. As shown in Table 1-5, 9 out of 18 groundwater samples exceeded the NCWQS for chromium, and 10 of 18 samples exceeded the NCWQS for lead. As also indicated in Table 1-5, iron concentrations exceeded the NCWQS in all samples, and manganese levels exceeded the NCWQS value in 14 samples.

In August 1994, shallow monitoring wells 41GW02, 41GW07, 41GW10, and 41GW11, which contained the highest combined concentrations of chromium and lead, were resampled using a low-flow purging technique. The low-flow purging technique was designed to collect a groundwater sample that is more representative of actual conditions compared to samples collected in previous rounds using much higher pumping rates (causing more suspended solids in the sample). As shown in Table 1-6 and Figure 1-7, the low-flow sampling results showed much lower total metals concentrations than those detected in the previous sampling rounds. For example, the lead concentration in well 41GW11 decreased from 12,600 μg/L in the April 1994 sample to 26.3 μg/L in the low-flow sample. Furthermore, chromium concentrations in all four wells sampled using the low-flow method decreased from levels exceeding 100 μg/L to non-detected values. Based on these results, the elevated concentrations of total metals detected in the first two sampling rounds appear to be largely the result of turbidity in the sample resulting from sampling procedures rather than from actual leaching of contamination from soils to groundwater. With the exception of iron and manganese, lead was the only inorganic constituent that exceeded its NCWQS and MCL value during the low-flow sampling round. Although lead was detected at 26.3 μg/L in the unfiltered sample from well 41GW11, it was not detected in the filtered sample. This result suggests that lead, in its dissolved form, may not be migrating through soil and groundwater, and that the elevated concentration detected in the unfiltered sample could still be the result of elevated turbidity in the sample. This conclusion is also supported by the fact that a source of lead contamination was not identified in the subsurface soils, and that lead typically exhibits a very low mobility in the environment due to its high adsorptive affinity for soils.

During the low-flow sampling round, iron concentrations exceeded the NCWQS in all four wells, and manganese exceeded the NCWQS in three of the wells. Elevated iron and manganese concentrations in excess of their NCWQS values have been detected throughout the base in both the shallow and Castle Hayne aquifers. Therefore, the iron and manganese concentrations detected in the shallow groundwater at Site 41 may be largely due to high background levels rather than associated with a site-related metals source.

The pesticides alpha-BHC, beta-BHC, and DDD were detected at trace levels in shallow wells 41GW02, 41GW09, and 41GW11. Their presence could be due to suspended fines in the sample, or vertical migration via leaching.

Deep groundwater (i.e., the Castle Hayne Aquifer) exhibited mainly total iron and manganese levels above NCWQSs, as shown in Figures 1-8 and 1-9 for Round 1 (February 1994) and Round 2 (April 1994), respectively. Similarly to the shallow groundwater, these metals are believed to be elevated naturally, and not due to site activities. The results of a Wellhead Monitoring Study performed in 1992 on 75 water supply wells indicated a base-wide average iron concentration of 1,400 μg/L, with concentrations ranging from 310 μg/L to 9,800 μg/L (Greenhorne & O'Mara, 1992). The average manganese concentration detected was approximately 78 μg/L, with concentrations ranging from 50 μg/L to 120 μg/L. As shown in Figure 1-9, lead was detected in the unfiltered samples collected from three of the deep wells during Round 2, and cadmium appeared in two of the wells. All detections of these constituents exceeded their respective NCWQS and MCL standards. These inorganics were not detected in any of the deep wells during Round 1 nor were they detected in the filtered samples from both rounds. In addition, the lead and cadmium concentrations detected in Round 2 do not correlate with the southeast direction of groundwater flow in the Caste Hayne Aquifer. Lead and cadmium were detected in two upgradient wells (41GW6DW and 41GW9DW) but were not found in wells 41GW4DW and 41GW12DW, which can be considered downgradient of the site. Thus, it appears that the elevated lead and cadmium concentrations detected in the unfiltered sample are not site-related and could be the result of elevated turbidity in the sample.

1.4.1.3 <u>Surface Water/Sediments</u>

As previously mentioned, two seeps are present on site, which discharge into the unnamed tributary of Tank Creek. The seeps apparently are the result of groundwater discharging from the former dump area. One seep is located in the eastern portion of the site and flows into the unnamed tributary. The second seep is located in the north central portion of the site and also flows to the unnamed tributary.

Surface water sampling results are summarized in Table 1-7. Surface water sampling results for TAL metals are shown in Figures 1-10 and 1-11 for Round 1 (February 1994) and Round 2 (August 1994), respectively. Surface water samples collected from the seeps primarily contained elevated levels of iron (maximum concentration of 14,100 μg/L) and manganese (maximum concentration of 209 μg/L). Table 1-8 presents a comparison of total metal concentrations within the northern seep, eastern seep, and unnamed tributary, and with the upstream and downstream averages determined for the unnamed tributary. This table, which presents the August 1994 results, shows that concentrations of lead, iron, and manganese within the seeps are higher than concentrations in the unnamed tributary, particularly for the eastern seep. A comparison of the average upstream lead concentration to the average downstream level indicates that the seeps may have a slight impact on unnamed tributary.

A comparison of total (unfiltered samples) and dissolved (filtered samples) metals within the northern and eastern seeps, and in the unnamed tributary is presented in Table 1-9. Total iron values detected in unfiltered samples were an order-of-magnitude higher than iron levels found in filtered samples, suggesting that part of the total iron values may be attributable to turbidity in the surface water. Lead was detected in most unfiltered surface water samples from the seeps and downstream in the unnamed tributary, but was not detected in the filtered samples. These data suggest that the lead may be associated with suspended or colloidal matter in the water rather than dissolved species. Metals present as suspended or colloidal solids are generally not considered to be bioavailable to aquatic organisms.

Pesticides in surface water were detected at only one sampling location in the unnamed tributary during Round 1. Lindane and DDT were detected at 0.020 µg/L and 0.030 µg/L, respectively, at location 41-UN-SW02. During Round 2, heptachlor was the only pesticide detected. It was detected at 0.055 µg/L at sampling location 41-UN-SW20. Since there appears to be no site-related pattern associated with these pesticide detections, the source of the pesticides is most likely a result of past pest control activities.

Sediment sampling results are summarized in Table 1-10. Sediment sampling results for pesticides are shown in Figures 1-12 and 1-13 for Round 1 (February 1994) and Round 2 (August 1994), respectively. Pesticides were detected in the unnamed tributary, Tank Creek, and seep sediments. Pesticide levels above the NOAA sediment screening criteria (ER-L and ER-M) were detected in upstream as well as downstream locations, suggesting the source of the pesticides is due to historical pest control activities.

Sediment sampling results for TAL metals are shown in Figures 1-14 and 1-15 for Round 1 (February 1994) and Round 2 (August 1994), respectively. As shown in the figures, iron and manganese concentrations in the seep sediments, particularly in the eastern seep, are generally an order of magnitude or more higher than in the unnamed tributary. Thus, it appears that significant portions of these inorganics are precipitating out of the surface water and accumulating in the seep sediments before reaching the unnamed tributary. The oxidation and precipitation of iron is evident from the brownish-orange color observed in the water and sediment in the eastern seep. As shown in Table 1-10, the lead concentration exceeded the NOAA sediment screening criterion (ER-L) in 2 out of 28 samples.

A few sediment samples from Tank Creek and the unnamed tributary exhibited PAHs. The PAHs in sediment were present in one location, which is adjacent to U.S. Highway 17. Runoff from the highway may be the source of the PAHs at this location.

PCBs, consisting of Aroclor 1248 and 1254, were detected at low levels in a sediment sample collected from the eastern seep. Concentrations of Aroclor 1242 exceeded the NOAA sediment screening criterion (ER-L) in 3 out of 28 samples. PCBs were not encountered in the northern seep.

The ordnance constituent 1,3,5-trinitrobenzene (1,390 µg/kg) and TCE (2 µg/kg) were detected in sample location 41-UN-SD14.

1.4.2 Site 74

1.4.2.1 Soil

Soil was the medium most impacted by former disposal operations at Site 74. Surface soil sampling results are summarized in Tables 1-11 and 1-12 for organic contaminants and inorganics, respectively. Subsurface soil sampling results are summarized in Tables 1-13 and 1-14 for organic contaminants and inorganics, respectively.

Pesticides were detected throughout the site area, but were most elevated in the former pest control area. Positive detections of pesticides in surface soils are shown in Figure 1-16. In the former pest control area, DDE (maximum concentration of 3,700 μg/kg), DDT (maximum concentration of 3,840 μg/kg), DDE (maximum concentration of 1,730 μg/kg), alpha-chlordane (1,160 μg/kg), and gamma-chlordane (maximum concentration of 1,680 μg/kg) were detected well above background levels. The extent of this contamination is primarily limited to the surface soil. Although pesticides were also detected in subsurface soil, the concentration levels were not significantly elevated relative to the surface soil.

Soil contamination within the former grease pit disposal area included TCE (maximum concentration of 8 μg/kg), total xylenes (maximum concentration of 6 μg/kg), and toluene (maximum concentration of 3 μg/kg). Although some low levels of VOCs were detected in surface soils, groundwater has not been impacted with volatiles. PAHs were also detected at low levels in a limited number of samples. The PAHs could potentially be present due to the burning operations, which reportedly was conducted to destroy the grease. The extent of both PAH and VOC contamination is limited. Pesticides were also detected in this area, but at levels equivalent to pesticide levels typically observed throughout MCB Camp Lejeune.

1.4.2.2 Groundwater

Groundwater sampling results for Site 74 are summarized in Table 1-15. As shown in Figure 1-17, on-site shallow groundwater exhibited total manganese, lead, and chromium above Federal MCLs and NCWQSs in only a limited number of wells, whereas iron exceeded the its NCWQS and MCL in every well. The distribution of these contaminants does not suggest a source area. The contaminant levels and distribution are very similar to other sites investigated at MCB Camp Lejeune, indicating that the shallow geologic conditions and sampling methods may have elevated the concentration of total metals rather than a specific disposal event. Upgradient well 74GW03A also exhibited these metals, including lead, at higher concentrations than wells located closer to the site. In August 1994, shallow monitoring wells 74GW03A and 74GW07 were resampled using the low-flow purging technique. As shown in Table 1-6 and Figure 1-14, the low-flow sampling results showed much lower total metals concentrations than those detected in the previous sampling round. Only iron, which is elevated throughout the base, exceeded its NCWQS and MCL (secondary) during this round. This comparison supports the conclusion that the elevated total metals detected in some of the shallow groundwater samples are a result of turbity in the well rather than of past disposal activities. Dissolved (filtered samples) metals in shallow groundwater were not elevated.

Shallow groundwater under the former pest control area exhibited low levels of alpha-chlordane, gamma-chlordane, lindane (gamma-BHC), and endosulfan. The detected concentrations were below Federal MCLs and/or NCWQS. Monitoring well 74GW2, located east of the grease pit and northwest of the former pest control area, exhibited heptachlor at 0.01J µg/L (the NCWQS for heptachlor is 0.008 µg/L).

1.4.2.3 Surface Water/Sediment

Surface water samples collected from Henderson Pond exhibited metals. Lead was the only constituent which exceeded the Federal AWQC (chronic). Low levels of pesticides (DDE, DDT, endosulfan II, methoxychlor, and endrin aldehyde) were detected in all three sediment sampling locations, but at levels below the EPA Region IV sediment screening values. The source of the pesticides could be due to historical pest control applications since the pesticide levels are similar to levels detected in sediments throughout the base. TCE was detected in two sediment samples; one collected from the northern portion of the pond and the other collected from the southern portion of the pond. The source of the TCE is unknown. TCE was not detected in surface water or groundwater at the site.

1.5 Human Health Risk Assessment

The baseline human health risk assessment was based on possible exposure pathways under current and future potential exposure scenarios. Under current conditions, the exposed population considered base personnel who may be exposed to site contaminants during military training operations (both sites are in remote areas of the base where military training occurs). The exposure medium is primarily associated with surface soil. Groundwater was not considered as an exposure medium under current conditions since the base is serviced by a public (base) water supply system. In addition, there are no supply wells which have been impacted by either site. Future potential exposure scenarios involved construction activities and residential use. For the residential scenario, groundwater and surface soil were identified as exposure media. It should be noted that the future residential exposure pathway to soil or groundwater is extremely unlikely given that both sites are suspected of containing buried CWM. For the future construction pathway, subsurface soil was identified as the exposure medium.

1.5.1 Site 41

The total site ICR estimated for current military personnel (6E-07) was less than the USEPA's target risk range (1E-04 to 1E-06). Additionally, the total HI value estimated for this receptor was less than unity. The total site ICR estimated for future residential children (6E-04) and adults (1E-03) exceeded the USEPA's upper bound risk range (1E-04). The total site ICR estimated for future construction workers (1E-07) was less than the USEPA's target risk range of 1E-04 to 1E-06. Additionally, the total site HI for future residential children (16) and adults (8) exceed unity. The total site HI estimated for the future construction worker (0.2) did not exceed unity. However, buried CWM, if present, would still pose a risk to a construction worker at the site. The total site risk was driven by future potential exposure to shallow groundwater, based on total metals analysis.

1.5.2 Site 74

The total site ICR estimated for current military personnel (8E-08) was less than the lower bound USEPA's target risk range (1E-06). Additionally, the total HI value estimated for this receptor was less than unity. Under the future potential risk exposure scenario, the total site ICR estimated for children (2E-04) and adults (3E-04) exceeded the USEPA's upper bound risk range (1E-04). The total site ICR estimated for construction workers (2E-08) was less than the USEPA's target risk range of 1E-04 to 1E-06. Additionally, the total site HI for children (8) and adults (3) exceed unity. The total site HI estimated for the construction worker (<0.01) did not exceed unity. However, buried CWM, if present, would still pose a risk to a construction worker at the site. The total site risk under the future potential exposure scenarios was driven by exposure to shallow groundwater, based on total metals analysis.

1.6 Ecological Risk Assessment

Overall, metals and pesticides appear to be the most significant site-related COPCs that have the potential to affect the integrity of the aquatic ecosystems at OU No. 4. For the terrestrial ecosystems, metals appear to be the most significant site-related COPCs that have the potential to affect terrestrial receptors at OU No. 4.

Potential adverse impacts to threatened or endangered species are low due to the absence of critical habitats or noted observations at Sites 41 and 74. Biohabitat maps did not indicate a significant impact to ecological resources on or near the two sites.

1.6.1 Site 41

Aluminum, copper, iron, lead, mercury, and zinc exceeded surface water ARVs and lead, silver, zinc, 4,4'-DDD, 4,4'DDT, 4,4'-DDE, dieldrin, alpha-chlordane, and gamma-chlordane exceeded the sediment ARVs. The surface water and sediments with the greatest potential impact to aquatic receptors are associated with the two seeps and their drainage channels to the unnamed tributary to Tank Creek. The surface waters of the unnamed tributary and Tank Creek do not show significant potential for impact to aquatic receptors from COPC concentrations except for aluminum and iron. However, these COPCs lacked an upstream to downstream concentration gradient in the tributary and the creek. The sediments of the unnamed tributary and Tank Creek do not show a significant potential for impact to aquatic receptors from COPC concentrations due to the lack of upstream to downstream concentration gradients that would indicate a source area for COPCs on site.

The seeps and drainage channels to the unnamed tributary do not represent a significant habitat for aquatic receptors. Although the seeps were flowing during various site visits, extended drought conditions could result in more transitory conditions. While it is recognized that these systems will support some tolerant species, the natural conditions that exist in both the seeps and the drainage channel are not conducive to attainment of a diverse and stable aquatic community. The populations that would occur in both the seeps and the drainage channels at the site would exhibit high temporal and spacial variability in both diversity and densities due to the natural conditions that exist. This type of natural variability has been recognized as one of the most significant components of the uncertainty associated with ecological risk assessments. Because there is no point of departure (e.g., 1×10^{-6} for human health carcinogenic risk) for determining when an ecosystem has been impacted by site conditions versus when an ecosystem is exhibiting natural temporal and spatial fluctuations, the high natural variability of ecosystems that exists in drainage channels and seeps makes it difficult to quantify site impacts to the ecological integrity of these systems.

The potential for impacts to the integrity of aquatic receptors in the seeps and drainage channels warranted additional investigation of these ecosystems. Subsequently, additional surface water and sediment analysis for metals in the seeps was initiated. Results of this analysis have indicated that dissolved metals in surface water were generally lower than total metals for aluminum, arsenic, barium, copper, iron, lead, and mercury. It has been established that the dissolved fraction of the sample represents the most bioavailable form of the metal and is a more accurate indication of potential risks to ecological receptors. Based on the levels of dissolved metals, the seeps are not adversely impacting the aquatic ecosystems of the unnamed tributary and Tank Creek.

Comparison of surface soils and soil toxicity studies indicate that beryllium, chromium, copper, iron, lead, manganese, and zinc were detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species at Site 41. However, based on the comparison of chronic daily intakes and terrestrial reference values, there does not appear to be an impact to terrestrial organisms including rabbits, deer, quail, fox, and raccoon from the site. This analysis included exposure to surface waters of the seeps, unnamed tributary, and Tank Creek, which supports that conclusion that any potential impacts from the seeps are limited to only aquatic receptors in the seeps themselves.

1.6.2 Site 74

Aluminum and lead exceeded the ARVs in surface water. There were no COPCs detected that exceeded any sediment ARVs. Aluminum was detected at concentrations below both the median and average base-wide concentrations, while lead was detected at concentrations above both the base-wide average and median concentrations, but the quotient ratio was not indicative of a significant potential for impact to surface water aquatic receptors. For surface soils, chromium at the site exceeded soil toxicity reference levels. Based on the comparison of chronic daily intakes and terrestrial reference values, there appears to be a small potential for adverse affect to terrestrial organisms due to manganese for the quail and rabbit. There does not appear to be an impact to terrestrial organisms based on the comparison of chronic daily intakes and terrestrial reference values for the fox and deer receptors.

1.7 <u>Conclusions</u>

1.7.1 Site 41

1. Polycyclic aromatic hydrocarbons (PAHs) detected in soil may be the result of reported burning operations during disposal activities. The extent of this contamination is within the central portion of the former disposal area. PAHs were not detected in groundwater.

2. Pesticides were detected in most soil samples; however, the pesticide levels are within base-wide concentrations which are indicative of historical pest control spraying. Low levels of pesticides were detected at isolated areas within the shallow aquifer and the upper portion of the Castle Hayne aquifer, indicating that pesticides have migrated to a limited extent from the soil matrix to shallow groundwater.

3. Although there were many background exceedances associated with the metals results, the data do not suggest a gross metals contamination problem in either the surface or subsurface soils at the site. The majority of elevated metals concentrations exceeded the twice background levels by less than an order of magnitude.

4. Total iron and manganese were detected above NCWQS and Federal secondary maximum contaminant levels (MCLs) in most of the monitoring wells sampled during the first round of the RI field investigation. Total lead was also detected above the NCWQS and the USEPA Action Level in most of the wells. Monitoring well 41GW11, which is located in

the central portion of the former disposal area, exhibited the highest levels of lead, iron, and manganese. This first round of samples was collected via EPA-approved bailing techniques. Due to the concern that turbidity may have influenced the first round (bailed) samples, selected shallow monitoring wells were resampled (round two) using the EPA-recommended low-flow purging technique, which is designed to minimize the amount of surging produced during sampling. Significantly lower metals concentrations were detected during this second round. However, the concentrations of lead, iron and manganese detected in well 41GW11, during round two, still exceeded drinking water standards.

5. Shallow groundwater is apparently discharging from the landfill via two seeps. Surface water samples collected from the seeps have exhibited elevated levels of iron, lead, and manganese. However, the unnamed tributary and Tank Creek do not appear to be significantly impacted by the site or seep discharges. Downstream surface water samples exhibited slightly higher iron and lead levels than upstream samples. Sediment samples along the seep pathway primarily exhibited pesticides above EPA Region IV screening values. High iron concentrations were detected in the seep sediments, suggesting that much of the iron in the seep surface water is being deposited in the sediments through oxidation and precipitation.

6. No chemical agents were detected during borehole monitoring conducted by the U.S. Army Technical Escort Unit (TEU). In addition, no chemical surety degradation compounds were detected in soil samples. However, buried CWM, PCBs, and other wastes areas that were not detected by the soil boring program could still be present within the former disposal area.

7. Under current exposure pathways, there are no adverse human health risks mainly because the site is in a remote area, and there is no exposure pathway associated with the groundwater (i.e., no water supply wells are currently located near the site).

8. Under future potential exposure pathways involving residential use, adverse human health risks would result primarily due to metal concentrations in groundwater. However, future residential use of the area is unlikely since the site is suspected of containing buried CWM. In addition, there are no plans to use this area for residential housing.

9. No adverse human health risks were calculated for the future construction worker. However, buried CWM, if present, would still pose a risk to a construction worker at the site.

10. The risk analysis for environmental media concentrations and terrestrial intake models did not indicate that there are significant ecological risks associated with Site 41 to terrestrial receptors and aquatic receptors in the unnamed tributary and Tank Creek.

11. Based on the results of the human health and ecological risk assessments, there are no areas of concern associated with soils or sediment that require remediation. However, institutional controls are considered in the FS to restrict site access and land use because of the unacceptable risk calculated for the residential use scenario as well as the suspected buried CWM.

12. Remediation of the groundwater and seep discharges is considered in the FS because there were some exceedances of State and Federal ARARs. In addition, the seep discharge may pose a future potential threat to the environment and habitat along the unnamed tributary.

1.7.2 Site 74

1. Soil at the former pest control area exhibited pesticides above base background levels, indicating that former pest control activities have resulted in soil contamination. The extent of soil contamination at the former pest control area is limited.

2. Low levels of pesticides were detected in shallow groundwater at the pest control area; however, the levels are below State and Federal drinking water standards.

3. Soil and groundwater at the former grease pit disposal area have not been significantly impacted by former disposal activities. Although organic and inorganic contaminants were detected in soil, the low concentrations and infrequent distribution of the contaminants do not suggest that there is a source area associated with former disposal areas.

4. The subsurface conditions at the former grease pit disposal area are unknown since no intrusive investigations (e.g., trenching) could be conducted due to suspected buried CWM. Therefore, the background information, which indicated that PCBs and other wastes were disposed at the site, cannot be verified.

5. No chemical agents were detected during borehole monitoring conducted by the U.S. Army TEU. In addition, no chemical surety degradation compounds were detected in soil samples. However, buried CWM, PCBs, and other wastes areas that were not detected by the soil boring program could still be present within the former disposal area.

6. During the first round of sampling, shallow groundwater exhibited total manganese, iron, lead, and chromium above State and Federal drinking water standards. The contaminant levels and distribution are very similar to other sites investigated at MCB Camp Lejeune, indicating that the shallow geologic conditions and round one sampling methods (bailing) may have elevated the concentrations of total metals, rather than a specific disposal event. Due to the concern that turbidity may have influenced the first round of samples, two shallow monitoring wells were resampled using the EPA recommended low-flow purging technique, which is designed to minimize the amount of surging produced during sampling. The low-flow sampling results (round two) showed much lower total metals concentrations than those detected during the first round of sampling. During round two, only iron exceeded the State and Federal drinking water standards. Dissolved (filtered samples) metals in shallow groundwater were not elevated during the low-flow sampling event.

7. Under current exposure pathways, there are no adverse human health risks associated with the site (i.e., the shallow groundwater is not currently being used for any purpose).

8. Under future potential exposure pathways involving residential use, adverse human health risks would result due to groundwater usage. However, future residential use of the area is unlikely since the site is suspected of containing buried CWM.

9. No adverse human health risks were calculated for the future construction worker. However, buried CWM, if present, would still pose a risk to a construction worker at the site.

10. The risk analysis for environmental media concentrations and terrestrial intake models indicated that there are no significant ecological risks associated with Site 74 to aquatic and terrestrial receptors.

11. Based on the results of the human health and ecological risk assessments, there are no areas of concern associated with the soils that require remediation. However, institutional controls are considered in the FS to restrict site access and land use because of the unacceptable risk calculated for the residential use scenario as well as the suspected buried CWM.

SECTION 1.0 TABLES

TABLE 1-1

ORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
1,4-Dichlorobenzene	180J	1/46
2-Methylnaphthalene	55J	1/46
Acenaphthene	91J - 380J	2/46
Anthracene	41J - 510	3/46
Benzo(a)anthracene	130J - 2,400	4/46
Benzo(a)pyrene	40J - 2,000	5/46
Benzo(b)fluoranthene	38J - 2,500	6/46
Benzo(g,h,i)perylene	46J - 1,600	4/46
Benzo(k)fluoranthene	50J - 1,700	6/46
bis(2-chloroethyl)ether	57J - 220J	6/46
bis(2-ethylhexyl)phthalate	42J - 580J	12/46
Carbazole	44J - 330J	2/46
Chrysene	49J - 2,300	6/46
Dibenzofuran	130J	1/46
Dibenz(a,h)anthracene	57J	1/46
di-n-Butylphthalate	42J - 230J	13/46
Fluoranthene	40J - 200J	6/46
Fluorene	79J - 280J	2/46
Indeno(1,2,3-cd)pyrene	71J - 76J	2/46
Naphthalene	70J	1/46
Phenanthrene	72J - 2,600	6/46
Pyrene	50J - 2,300J	7/46
Methylene chloride	2J - 5J	13/46
Acetone	3J - 2,800	11/46
Toluene	1J - 4J	3/46
beta-BHC	4.72NJ	1/46

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-1 (Continued)

ORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
delta-BHC	0.03NJ	1/46
Lindane (gamma-BHC)	0.22NJ	1/46
Heptachlor	0.3NJ - 7.16J	5/46
Heptachlor epoxide	0.56NJ - 9.6NJ	5/46
Dieldrin	0.2NJ - 13.03NJ	17/46
4,4-DDE	0.12J - 87.6J	34/46
Endrin	1.47NJ - 2.93J	5/46
Endosulfan II	0.45NJ - 5.01J	13/46
4,4-DDD	0.37J - 92J	19/46
Endosulfan sulfate	0.32J	1/46
4,4-DDT	0.37J - 277	29/46
Methoxychlor	1.41J - 3.28NJ	3/46
Endrin ketone	0.44NJ	1/46
Endrin aldehyde	0.61J - 1.37J	7/46
alpha-chlordane	0.08J - 42.7J	16/46
gamma-chlordane	0.06NJ - 93.5J	16/46
Aroclor 1242	82.9J	1/46
Aroclor 1260	58.4J	1/46
1,3-Dinitrobenzene	824NJ	1/46

Note: Concentrations expressed in microgram per kilogram (μg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-2

INORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil				
	Average Base-Specific Background[(1)] Concentration Range	Twice the Average Base Background Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	2,435.66	4,871.32	878 - 17,400J	46/46	13
Arsenic	0.38	0.76	0.671 - 4.42	19/46	16
Barium	8.79	17.58	3.14 - 82.2	46/46	11
Beryllium	0.114	0.228	0.187 - 0.344	12/46	4
Cadmium	0.325	0.655	0.854 - 7.44	5/46	5
Calcium	799	1,598	32.9 - 40,300	42/46	12
Chromium	2.49	4.97	2.19 - 41.4	41/46	24
Cobalt	1.728	3.455	6.46	1/46	1
Copper	7.04	14.08	4.17 - 132	15/46	4
Iron	1,583.12	3,166.24	397 - 91,600	46/46	20
Lead	18.55	37.09	2.57 - 341J	46/46	9
Magnesium	105.52	211.05	28.1 - 1,100	46/46	10
Manganese	8.42	16.84	1.67 - 6,000J	44/46	11
Mercury	0.043	0.087	0.074 - 0.768	22/46	13
Nickel	2.02	4.05	7.36 - 35.3	4/46	4
Potassium	99.26	198.52	184 - 547	14/46	11
Selenium	0.337	0.674	0.357 - 0.596	3/46	0
Silver	0.49	0.98	0.096 - 18.3J	3/46	1
Sodium	42.706	85.412	84.7 - 230	8/46	7
Vanadium	3.38	6.76	4.62 - 39.8	31/46	24
Zinc	6.676	13.353	1.09 - 1.57	46/46	0

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
ND - Not Detected
NA - Not Applicable

TABLE 1-3

ORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SUBSURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
1,4-Dichlorobenzene	49J	1/66
2-Methylnapthalene	41J - 550	4/66
4-chloro-3-methylphenol	61J	1/66
4-Methylphenol	53J	1/66
Acenaphthene	52J - 130J	3/66
Benzo(a)anthracene	71J - 160J	2/66
Benzo(b)fluoranthene	75J - 150J	2/66
Benzo(a)pyrene	74J - 4,700J	6/66
bis(2-chloroethyl)phthalate	79J - 800	3/66
bi(2-ethylhexyl)phthalate	39J - 7,200J	33/66
Butylbenzyl phthalate	88J	1/66
Carbazole	66J	1/66
Chrysene	43J - 170J	4/66
Dibenzofuran	48J	1/66
Diethylphthalate	110J	1/66
di-n-Butylphthalate	40J - 230J	26/66
di-n-Octylphthalate	40J - 1,600	9/66
Fluoranthene	46J - 260J	5/66
Fluorene	44J - 120J	4/66
Indeno(1,2,3-cd)pyrene	105J	1/66
Naphthalene	45J - 130J	5/66
N-nitrosodiphenylamine	240J	1/66
Phenanthrene	39J - 260J	5/66
Pyrene	52J - 290J	6/66
Benzo(g,h,i)perylene	41J - 4,600J	5/66
Benzo(k)fluoranthene	80J - 109J	2/66

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-3 (Continued)

ORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SUBSURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Chloromethane	2J - 3J	2/66
Acetone	4J - 6,000J	34/66
2-Butanone	1J - 15J	8/66
Trichloroethene	1J	1/66
Benzene	1J	2/66
Chlorobenzene	4J - 100	5/66
Ethylbenzene	7J - 58	2/66
delta-BHC	0.91J	2/66
Lindane (gamma-BHC)	11.9J	1/66
Heptachlor	0.68J - 18	9/66
Aldrin	0.7J - 12.8J	5/66
Heptachlor epoxide	0.4J - 11.5J	5/66
Endosulfan I	0.78NJ - 2.92NJ	5/66
4,4-DDE	0.32NJ - 39.6J	27/66
Endrin	0.35J - 28.3J	11/66
Endosulfan II	0.5NJ - 25.2NJ	24/66
4,4-DDD	0.34NJ - 1,060J	26/66
4,4-DDT	0.68NJ - 302J	10/66
Methoxychlor	5.47NJ	1/66
Endrin ketone	0.86J	1/66
Endrin aldehyde	0.85NJ - 4.38J	9/66
alpha-Chlordane	0.28NJ - 160J	17/66
gamma-Chlordane	0.31J - 170J	13/66
Aroclor 1254	36.7J - 214J	5/66
Aroclor 1260	34.6J - 317J	5/66
Acetophenone	120J	1/66
Dieldrin	0.32J - 60NJ	17/66

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-4

INORGANIC DATA SUMMARY
DOWNSLOPE AND ON-SITE SUBSURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil				
	Average Base-Specific Background[1] Concentration Range	Twice the Average Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	672 - 10,200	8,946.3	486 - 13,500J	66/66	6
Arsenic	0.03 - 0.47	0.6	0.518 - 3.02	33/66	29
Barium	2 - 11	11.9	3.15 - 186	63/66	37
Beryllium	0.03 - 0.23	0.2	0.187 - 0.31	10/66	8
Cadmium	0.17 - 1.2	1.0	1.32 - 4.73	3/66	3
Calcium	5 - 4,410	1,508.3	37.3 - 18,900	60/66	13
Chromium	2 - 9	8.7	2.1 - 40.5J	64/66	18
Cobalt	0.175 - 2	1.6	4.53	1/66	1
Copper	0.47 - 2	1.6	3.77 - 39.8	15/66	15
Iron	126 - 2,840	1,778.0	115J - 41,100	66/66	21
Lead	1 - 12	9.1	0.894J - 829	66/66	27
Magnesium	13 - 260	231.2	18.4 - 567	65/6	14
Manganese	0.40 - 8	6.2	1.63 - 244	60/66	30
Mercury	0.01 - 0.11	0.1	0.057-0.312	17/66	11
Nickel	0.70 - 5	4.0	7.56 - 12.9	2/66	2
Potassium	41 - 187	228.8	123 - 562	26/66	16
Selenium	0.12 - 0.55	0.8	0.373J - 0.948	11/66	3
Silver	0.18 - 1	1.1	0.202 - 9.71J	4/66	1
Sodium	7 - 45	40.6	59.3 - 486	10/66	10
Vanadium	0.75 - 13	10.1	4.79 - 25.7	44/66	20
Zinc	0.40 - 12	5.6	2.8J - 407	57/66	44

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
ND - Not Detected
NA - Not Applicable

TABLE 1-5

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range[4]		Comparison to Criteria			
			Federal Health Advisories[3]						No. of Detects Above Health Advisories	
Contaminant	NCWQS[1]	MCL[2]	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
Acetone	NE	NE	NE	NE	3-18	4J - 12J	NA	NA	NA	NA
Benzene	1.0	5	NE	NC	1/18	2J	1	0	NA	NA
Bromoform	0.19	100	2,000	6,000	1/18	2J	3	0	0	0
Chlorobenzene	50	NE	NE	NE	1/18	1.4J	0	0	NA	NA
Arsenic	50	50	NE	NE	13/18	2.1 - 53.5	1	1	NA	NA
Barium	2,000	2,000	NE	NE	18/18	18.2 - 836	0	0	NA	NA
Beryllium	NE	4	30,000	20,000	11/18	0.954 - 37.4	NA	5	0	0
Cadmium	5	5	40	20	11/18	2.58 - 37.5	7	7	0	0
Chromium	50	100	1,000	800	12/18	12.1 - 166	8	4	0	0
Cobalt	NE	NE	NE	NE	6/18	15.6 - 106	NA	NA	NA	NA
Lead	15	15	NE	NE	13/18	2.3 - 145	10	10	NA	NA
Manganese	50	50	NE	NE	18/18	24.5 - 766	15	15	NA	NA
Mercury	1.1	2	NE	NE	2/18	0.264 - 0.33	0	0	NA	NA
Nickel	100	100	1,000	50	9/18	22.8 - 177	1	1	0	3
Selenium	50	50	NE	NE	1/18	10.3J	0	0	NA	NA
Vanadium	NE	NE	NE	NE	14/18	10.6 - 179	NA	NA	NA	NA
Zinc	2,100	5,000	3,000	1,200	13/18	17.8 41.6 - 675	1	1	1	1

Notes: Concentrations expressed in microgram per liter (µg/L).

(1) NCWQS = North Carolina Water Quality Standard for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
(4) Data shown reflect a replacement of Round 2 sampling results with low-flow sampling results
(5) SMCL = Secondary Maximum Contaminant Level

NE - Not Established
NA - Not Applicable
NJ - Estimated/tentative value
J - Estimated value

TABLE 1-6

**COMPARISON OF TOTAL METALS IN GROUNDWATER
USING LOW FLOW PURGING TECHNIQUES AT SITES 41 AND 74
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA**

Constituent (µg/L)	Site 41 41-GW02			Site 41 41-GW07			Site 41 41-GW10		
	2/14/94	4/27/94	8/27/94	2/18/94	4/28/94	8/27/94	2/16/94	4/27/94	8/27/94
Aluminum	125,000	69,400	230	145,000	20,400	3,410	81,900	113,000	40.2
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	7.44	5.76	ND	13.3	5.76	2.1	36.3	31.1	ND
Barium	465	322	67.5	717	224	57.3	248	182	21.5
Beryllium	6.8	6.5	ND	5.59	0.662	1.1	7.41	10.9	ND
Cadmium	6.36	ND	ND	9.08	ND	ND	16.3	9.62	ND
Calcium	136,000	151,000	116,000	111,000	3,540	2,050	250,000	122,000	46,300
Chromium	244	151	ND	166	28	ND	176	158	ND
Cobalt	16.5	ND	ND	ND	ND	ND	37.8	62.7	ND
Copper	83.6	81.5	ND	28.5	ND	ND	26.3	38	ND
Iron	80,800	65,900	20,600	71,100	15,200	2,890	124,000	123,000	890
Lead	19.8	15.4	2.3	94.6	26.4	3.2	73.6	92.1	ND
Magnesium	31,000	26,800	20,300	5,960	3,010	1,750	15,300	8,830	1,570
Manganese	572	484	334	167	48.4	24.5	455	390	64.3
Mercury	0.922	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	41.4	22.9	ND	88.7	ND	ND	68.1	72.5	ND
Potassium	21,300	19,100	17,200	4,780	1,430	1,870	2,750	1,580	ND
Selenium	3.66	ND	ND	7.74	9.44	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	28,600	32,000	29,400	11,700	10,900	9,930	40,200	27,600	4,770
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	204	181	ND	150	24.8	ND	199	156	ND
Zinc	146	76.5	114	276	66.1	237	173	231	41.6
Cyanide	ND			ND			ND		

TABLE 1-6 (Continued)

COMPARISON OF TOTAL METALS IN GROUNDWATER
USING LOW FLOW PURGING TECHNIQUES AT SITES 41 AND 74
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent (μg/L)	Site 41 41-GW11			Site 74 74-GW03A		Site 74 74-GW07	
	2/16/94	4/28/94	8/27/94	1/7/94	8/27/94	1/7/94	8/27/94
Aluminum	75,700	49,400	83	132,000	1,600	58,200	10,400
Antimony	17.9	73.2	ND	ND	ND	ND	ND
Arsenic	24.2	26.9	ND	26.1	3.5	31.6	3.2
Barium	999	969	358	336	28.2	195	80.1
Beryllium	ND	1.58	ND	2.23	ND	1.37	ND
Cadmium	110	73.1	ND	ND	ND	ND	ND
Calcium	130,000	123,000	82,900	8,340	554	7,050	686
Chromium	149	102	ND	144	ND	58.2	ND
Cobalt	ND	16.4	ND	36.7	ND	32.8	ND
Copper	1,030	698	ND	43.6	ND	ND	ND
Iron	155,000	144,000	26,200	38,500	821	29,300	5,110
Lead	9,340	12,600	26.3	64.2	ND	43.1	5.3
Magnesium	22,700	21,800	14,200	4,970	480	3,800	1,900
Manganese	2,110	1,740	186	347	17.2	122	18
Mercury	ND	ND	0.33	ND	ND	ND	ND
Nickel	137	108	ND	69.4	ND	41.7	ND
Potassium	26,800	24,000	22,400	5,680	ND	2,980	1,660
Selenium	ND	ND	ND	ND	ND	ND	ND
Silver	8.52	4.31	ND	ND	ND	ND	ND
Sodium	27,900	31,800	27,300	26,200	3,560	5,800	5,520
Thallium	ND	ND	ND	ND	ND	ND	ND
Vanadium	244	201	ND	146	ND	82.1	14.3
Zinc	5,180	4,700	118	311	94.9	93.2	154
Cyanide	ND			ND		ND	

TABLE 1-7

SURFACE WATER DATA SUMMARY
UNNAMED TRIBUTARY AND TANK CREEK
OPERABLE UNIT NO. 4 (SITE 41)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
	NCWQs[1]	Federal Health AWQCs[2]				Positive Detects Above NCWQS	Positive Detects Above AWQC	
		Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Chlorobenzene	488	680	NE	2/14	1J - 4J	0	0	NA
Lindane (gamma-BHC)	NE	0.0186	0.0625	1/28	0.02J	NA	1	0
4,4-DDT	0.000588	0.00059	0.000024	1/28	0.03J	NA	1	1
Barium	1,000	2,000	NE	28/28	17.9 - 442	0	0	0
Chromium	NE	50	NE	1/28	8.52	NA	0	NA
Lead	NE	50	NE	19/28	1.13J - 36.8	0	0	0
Manganese	50	50	100	28/28	12.3 - 1700	1	1	1
Mercury	NE	0.144	0.146	9/28	0.101 - 0.56	0	0	0
Zinc	NE	NE	NE	23/28	16.3 - 235	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (μg/L).
(1) NCWQS = North Carolina Water Quality Standards for Surface Water
(2) AWQC = Ambient Water Quality Criteria
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 1-8

COMPARISON OF TAL METALS IN SEEPS AND THE UNNAMED TRIBUTARY AT SITE 41
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (µg/L)	NORTHERN SEEP						UNNAMED TRIBUTARY	
	41-UN-SW11 2/4/94	41-UN-SW12 2/4/94	41-UN-SW15 8/23/94	41-UN-SW16 8/23/94	41-UN-SW17 8/23/94	41-UN-SW18 8/23/94	UPSTREAM (AVE.)	DOWNSTREAM (AVE.)
Aluminum	ND	ND	260	183	988	356	332	366
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	11.8	2.7	2.2	ND	2.5	2.8
Barium	24.4	37.5	26.3	85.4	53.8	39.4	21.2	23.4
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	20,200	39,800	43,200	62,200	20,100	34,600	43,300	39,867
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND
Iron	2,690	6,260	39,600	33,400	17,600	10,600	903	1,638
Lead	8.1	ND	3.1	7.7	3.6	4.3	1.3	7.6
Magnesium	2,160	4,220	2,790	10,500	3,340	2,960	1,873	2,137
Manganese	12.3	47.7	76.5	106	52.4	130	18	51.9
Mercury	ND	ND	0.28	ND	0.36	0.28	0.19	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	923	3,370	2,220	13,400	2,920	2,080	2,163	1,760
Selenium	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	4,760	7,490	573	19,300	9,680	11,300	21,400	14,933
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	25	27.2	59.2	68.7	80.7	43	27.5	39.6

TABLE 1-8 (Continued)

COMPARISON OF TAL METALS IN SEEPS AND THE UNNAMED TRIBUTARY AT SITE 41
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (µg/L)	EASTERN SEEP						UNNAMED TRIBUTARY	
	41-UN-SW13 2/3/94	41-UN-SW14 2/3/94	41-UN-SW22 8/23/94	41-UN-SW23 8/23/94	41-UN-SW24 8/23/94	41-UN-SW25 8/23/94	UPSTREAM (AVE.)	DOWNSTREAM (AVE.)
Aluminum	3,390	ND	ND	11,000	17,800	7,060	332	366
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	4.8	22.1	30.2	11.7	2.5	2.8
Barium	113	54.5	89.9	360	442	327	21.2	23.4
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	6.2	ND	ND	ND
Calcium	75,800	84,200	104,000	165,000	158,000	121,000	43,300	39,867
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	19.6	43.9	20.5	ND	ND
Copper	ND	ND	ND	34.1	41.2	20.1	ND	ND
Iron	14,100	2,810	15,700	245,000	278,000	238,000	903	1,638
Lead	12.1	1.52	ND	36.2	36	36.8	1.3	7.6
Magnesium	12,700	11,000	13,500	12,800	11,400	10,000	1,873	2,137
Manganese	34.1	209	1,380	1,590	1,700	1,200	18	51.9
Mercury	0.101	ND	ND	0.56	0.46	0.26	0.19	ND
Nickel	ND	ND	ND	ND	20	ND	ND	ND
Potassium	10,200	6,760	8,740	5,870	4,920	4,450	2,163	1,760
Selenium	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	14,800	23,600	38,300	60,700	67,600	52,600	21,400	14,933
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	40.4	51.5	35.4	ND	ND
Zinc	ND	ND	29.8	231	235	133	27.5	39.6

TABLE 1-8 (Continued)

COMPARISON OF TAL METALS IN SURFACE WATER - UNNAMED TRIBUTARY
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (µg/L)	UNNAMED TRIBUTARY (UPSTREAM)				UNNAMED TRIBUTARY (DOWNSTREAM)				UNNAMED TRIBUTARY	
	41-UN-SW02 2/3/94	41-UN-SW19 8/23/94	41-UN-SW20 8/23/94	41-UN-SW21 8/23/94	41-UN-SW26 8/23/94	41-UN-SW27 8/23/94	41-UN-SW28 8/23/94	41-UN-SW03 2/1/94	UP-STREAM (AVE.)	DOWN-STREAM (AVE.)
Aluminum	303	245	110	ND	102	76.6	585	437	332	366
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	2.4	ND	ND	ND	ND	2.6	ND	2.5	2.8
Barium	21.2	19.2	18.4	18.6	21.8	23.6	26.5	20	21.2	23.4
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	41,400	46,900	46,700	50,100	42,500	44,000	45,600	30,000	43,300	39,867
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	13.3	ND	ND	ND	ND	ND
Iron	662	747	683	649	936	1,340	2,940	633	903	1,638
Lead	ND	ND	ND	ND	7.2	17	4.8	ND	1.3	7.6
Magnesium	1,940	1,910	1,850	1,990	1,940	2,140	2,410	1,860	1,873	2,137
Manganese	16.6	19.9	17.5	17.7	20.4	44.9	85.6	25.2	18	51.9
Mercury	ND	0.21	ND	ND	0.23	ND	ND	ND	0.19	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	2,090	2,540	2,180	2,650	2,290	1,960	1,620	1,700	2,163	1,760
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	20,900	21,200	20,800	21,800	14,100	15,300	16,300	13,200	21,400	14,933
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	30.4	27.2	31.9	28.1	21.4	30.8	47.8	ND	27.5	39.6

(1) Upstream (Ave.) includes 41-UN-SW01, 41-UN-SW02, and 41-UN-SW19. Downstream (Ave.) includes 41-UN-SW27, 41-UN-SW28, and 41-UN-SW03.

TABLE 1-9

COMPARISON OF TAL TOTAL AND DISSOLVED METALS IN SITE 41 SURFACE WATER
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (μg/L)	NORTHERN SEEP							
	41-UN-SW15		41-UN-SW16		41-UN-SW17		41-UN-SW18	
	8/23/94		8/23/94		8/23/94		8/23/94	
	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED
Aluminum	260	ND	183	ND	988	ND	356	ND
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	11.8	2	2.7	ND	2.2	ND	ND	ND
Barium	26.3	24.6	85.4	82.4	53.8	47.2	39.4	34.1
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	43,200	53,000	62,200	74,000	20,100	23,700	34,600	39,200
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	18.2	ND	ND	ND	15.1	ND	21.5
Iron	39,600	118	33,400	6,000	17,600	1,060	10,600	2,390
Lead	3.1	ND	7.7	ND	3.6	ND	4.3	ND
Magnesium	2,790	3,570	10,500	12,700	3,340	4,000	2,960	3,380
Manganese	76.5	83.8	106	121	52.4	50.7	130	152
Mercury	0.28	ND	ND	ND	0.36	ND	0.28	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	2,220	2,520	13,400	15,600	2,920	3,120	2,080	2,380
Selenium	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	573	6,860	19,300	22,700	9,680	11,400	11,300	12,300
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	59.2	7.8	68.7	5.4	80.7	11.1	43	11.4

TABLE 1-9 (Continued)

COMPARISON OF TAL TOTAL AND DISSOLVED METALS IN SITE 41 SURFACE WATER
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (ug/L)	EASTERN SEEP							
	41-UN-SW22		41-UN-SW23		41-UN-SW24		41-UN-SW25	
	8/23/94		8/23/94		8/23/94		8/23/94	
	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED
Aluminum	ND	ND	11,000	ND	17,800	ND	7,060	ND
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	4.8	2.6	22.1	ND	30.2	2.8	11.7	ND
Barium	89.9	79.5	360	73	442	75.1	327	80.5
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	6.2	ND	ND	ND
Calcium	104,000	106,000	165,000	154,000	158,000	144,000	121,000	115,000
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	19.6	ND	43.9	15.7	20.5	ND
Copper	ND	ND	34.1	11.2	41.2	17.8	20.1	18.9
Iron	15,700	6,110	245,000	8,170	278,000	12,800	238,000	11,300
Lead	ND	ND	36.2	ND	36	ND	36.8	ND
Magnesium	13,500	14,200	12,800	13,400	11,400	12,200	10,000	11,200
Manganese	1,380	1,360	1,590	1,170	1,700	1,230	1,200	972
Mercury	ND	ND	0.56	ND	0.46	ND	0.26	ND
Nickel	ND	ND	ND	ND	20	ND	ND	ND
Potassium	8,740	9,670	5,870	6,020	4,920	4,820	4,450	3,670
Selenium	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	38,300	38,100	60,700	65,900	67,600	76,800	52,600	58,800
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	40.4	ND	51.5	ND	35.4	ND
Zinc	29.8	8.9	231	6.4	235	9.5	133	10.2

TABLE 1-9 (Continued)

**COMPARISON OF TAL TOTAL AND DISSOLVED METALS IN SITE 41 SURFACE WATER
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA**

CONSTITUENT (µg/L)	UNNAMED TRIBUTARY (UPSTREAM)					
	41-UN-SW19		41-UN-SW20		41-UN-SW21	
	8/23/94		8/23/94		8/23/94	
	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED
Aluminum	245	ND	110	ND	ND	ND
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	2.4	ND	ND	ND	ND	ND
Barium	19.2	19.1	18.4	18.8	18.6	18.2
Beryllium	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND
Calcium	46,900	54,400	46,700	55,400	50,100	56,500
Chromium	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	20.8	ND	19	ND	ND
Iron	747	161	683	146	649	148
Lead	ND	ND	ND	ND	ND	ND
Magnesium	1,910	2,200	1,850	2,230	1,990	2,220
Manganese	19.9	18.5	17.5	18.1	17.7	20.6
Mercury	0.21	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND
Potassium	2,540	2,670	2,180	2,500	2,650	2,780
Selenium	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND
Sodium	21,200	24,500	20,800	24,700	21,800	24,300
Thallium	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	27.2	8.1	31.9	8.1	28.1	6

TABLE 1-9 (Continued)

COMPARISON OF TAL TOTAL AND DISSOLVED METALS IN SITE 41 SURFACE WATER
OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

CONSTITUENT (µg/L)	UNNAMED TRIBUTARY (DOWNSTREAM)					
	41-UN-SW26		41-UN-SW27		41-UN-SW28	
	8/23/94		8/23/94		8/23/94	
	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED
Aluminum	102	ND	76.6	ND	585	ND
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	2.6	2.9
Barium	21.8	21	23.6	25.1	26.5	22.3
Beryllium	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND
Calcium	42,500	44,400	44,000	49,200	45,600	47,000
Chromium	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND
Copper	13.3	23.8	ND	18.7	ND	17.7
Iron	936	498	1,340	1,210	2,940	783
Lead	7.2	ND	17	ND	4.8	2.4
Magnesium	1,940	2,020	2,140	2,630	2,410	2,290
Manganese	20.4	21.2	44.9	88.8	85.6	47.4
Mercury	0.23	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND
Potassium	2,290	2,150	1,960	1,770	1,620	1,840
Selenium	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND
Sodium	14,100	14,900	15,300	17,700	16,300	16,000
Thallium	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	21.4	13	30.8	14.1	47.8	11.2

TABLE 1-10

SEDIMENT DATA SUMMARY
UNNAMED TRIBUTARY AND TANK CREEK
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L(1) Concentration	NOAA ER-M(2) Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Benzo(a)pyrene	430	1600	57J	1/28	NA	NA
Benzo(b)fluoranthene	NE	NE	69J	1/28	NA	NA
Benzo(k)fluoranthene	NE	NE	58J	1/28	NA	NA
di-n-Octylphthalate	NE	NE	49J - 310J	3/28	NA	NA
di-n-Butylphthalate	NE	NE	48J-370J	6/28	NA	NA
Methylene Chloride	NE	NE	2J-7J	8/28	NA	NA
Acetone	NE	NE	4J-190	11/28	NA	NA
Trichloroethene	NE	NE	2J	1/28	NA	NA
Toluene	NE	NE	2J	2/28	NA	NA
Dieldrin	0.02	8	0.46NJ - 6.39	10/41	10	0
4,4-DDE	2	15	0.53J - 31.3J	9/41	11	2
Endosulfan II	NE	NE	0.64NJ - 8.22	9/41	NA	NA
4,4-DDD	2	20	0.38NJ - 73.9J	22/41	13	3
4,4-DDT	1	7	0.36NJ - 34.8J	17/41	11	2
Methoxychlor	NE	NE	0.91J - 3.2	6/41	NA	NA
Endrin ketone	NE	NE	0.66NJ	1/41	NA	NA
alpha-Chlordane	NE	NE	0.34J - 3.72	13/41	NA	NA
gamma-Chlordane	NE	NE	0.4J - 6.35J	11/41	NA	NA
Aroclor 1242	22.7	80(3)	63J - 140J	2/41	3	0
Aroclor 1254	22.7	80(3)	68J	1/41	1	0
1,3,5-Trinitrobenzene	NE	NE	1,390	1/28	NA	NA

TABLE 1-10 (Continued)

SEDIMENT DATA SUMMARY
UNNAMED TRIBUTARY AND TANK CREEK
OPERABLE UNIT NO. 4 (SITE 41)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Arsenic	8.2	70	0.617 - 9.3	13/42	0	0
Barium	NE	NE	1.4 - 161	36/42	NA	NA
Beryllium	NE	NE	0.235 - 1.02	5/42	NA	NA
Chromium	81	370	2.32J - 16.5J	16/42	0	0
Copper	34	270	6.13 - 19.9	4/42	0	0
Lead	46.7	218	1.1 - 59.4J	42/42	2	0
Manganese	NE	NE	1.3 - 3.6	37/42	NA	NA
Mercury	0.15	0.71	0.46-0.63	2/40	2	0
Nickel	20.9	51.6	3.79 - 6.12	6/42	0	0
Selenium	NE	NE	0.629J - 0.862J	4/42	NA	NA
Thallium	NE	NE	1.19J	1/42	NA	NA
Vanadium	NE	NE	3.5 - 30	12/42	NA	NA
Zinc	150	410	5.5 - 155	25/42	0	0

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
[1] ER-L - Effective Range-Lower
[2] ER-M - Effective Range-Medium
[3] Total PCBs.
NE - Not Established
NA - Not Applicable
J - Estimated Value
NJ - Estimated/tentative value

TABLE 1-11

ORGANIC DATA SUMMARY
PESTICIDE DISPOSAL AREA SURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 74)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
4-chloro-3-methylphenol	54J - 240J	2/60
Acenaphthene	39J	1/60
Benzo(a)pyrene	130J	1/60
Benzo(g,h,i)pyrene	61J - 160J	2/60
bis(2-chloroethyl)ether	12J - 180J	5/60
Diethylphthalate	86J - 866	2/60
di-n-Butylphthalate	39J - 126J	13/60
Pyrene	38J	1/60
Methylene chloride	4J - 23J	20/60
Acetone	4J - 210J	22/60
Trichloroethene	2J - 8J	5/60
Toluene	1J - 3J	3/60
Styrene	1J	1/60
Xylenes (total)	3J - 6J	2/60
alpha-BHC	0.45	1/60
Heptachlor	0.2 NJ - 298J	8/60
Aldrin	0.41NJ	1/60
Heptachlor epoxide	0.21NJ - 1.43J	4/60
Dieldrin	0.32J - 706NJ	5/60
4,4-DDE	0.31J - 1,730J	31/60
Endrin	0.42J - 1.06J	3/60
Endosulfan II	0.44NJ - 1.31NJ	3/60
4,4-DDT	0.81J - 3,840J	22/60
Methoxychlor	166J	1/60
Endrin aldehyde	0.5NJ - 2.29NJ	5/60
alpha-chlordane	0.39J - 1,160J	8/60
gamma-chlordane	0.45J - 1,680J	8/60
Hydroxyacetophenone	190J	1/37
4,4'-DDD	0.37 - 3,700J	17/60

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-12

INORGANIC DATA SUMMARY
PESTICIDE DISPOSAL AREA SURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 74)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil				
	Average Base-Specific Background[1] Concentration Range	Twice the Average Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	2,435.66	4,871.32	36.3 - 10,900	60/60	20
Arsenic	0.38	0.76	0.62J - 1.16	9/60	9
Barium	8.79	17.58	2.89 - 54.7	54/60	1
Beryllium	0.114	0.228	ND	0/60	NA
Cadmium	0.325	0.655	0.543 - 0.686	4/60	1
Calcium	799	1,598	34. 9 - 175,000	53/60	7
Chromium	2.49	4.97	1.89 - 10.6	50/60	17
Cobalt	1.728	3.455	ND	0/60	NA
Copper	7.04	14.08	5.07 - 22	4/60	1
Iron	1,583.12	3,166.24	31.21J - 34,200	60/60	6
Lead	18.55	37.09	0.878J - 15.4	60/60	0
Magnesium	105.52	211.05	16.3 - 2,790	52/60	5
Manganese	8.42	16.84	1.44 - 96.2	58/60	4
Mercury	0.043	0.087	0.015 - 0.092	8/60	2
Nickel	2.02	4.05	3.15 - 4.78	6/60	2
Potassium	99.26	198.52	80.7 - 351	16/60	3
Selenium	0.337	0.674	0.609 - 1.2	14/60	12
Silver	0.49	0.98	0.116J	1/60	1
Sodium	42.706	85.412	105J - 860	10/60	10
Vanadium	3.38	6.76	4.03 - 15.1	34/60	0
Zinc	6.676	13.353	2.27 - 33.9	33/60	2

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
[1] Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
ND - Not Detected
NA - Not Applicable

TABLE 1-13

ORGANIC DATA SUMMARY
PESTICIDE DISPOSAL AREA SUBSURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 74)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
bis(2-ethylhexyl)phthalate	37J - 240J	8/47
Diethylphthalate	874	1/47
di-n-Butylphthalate	43J - 155J	10/47
Methylene chloride	190	1/47
Acetone	6J - 820	32/47
Heptachlor	0.24J - 1.59J	3/47
Aldrin	0.4J	1/47
Heptachlor epoxide	0.33J	1/47
4,4-DDE	1.05NJ - 21.3J	5/47
4,4-DDD	0.59J - 3.61J	5/47
4,4-DDT	0.34NJ - 21.37J	9/47
Methoxychlor	7.06J	1/47
Endrin aldehyde	0.48NJ - 0.77NJ	2/47

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value
NJ - Estimated/tentative value

TABLE 1-14

INORGANIC DATA SUMMARY
PESTICIDE DISPOSAL AREA SUBSURFACE SOIL
OPERABLE UNIT NO. 4 (SITE 74)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil				
	Average Base-Specific Background[1] Concentration Range	Twice the Average Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	672 - 10,200	8,946.3	349 - 9,380	47/47	1
Arsenic	0.03 - 0.47	0.6	0.538J - 2.76	10/47	8
Barium	2 - 11	11.9	2.77 - 17.5	29/47	3
Beryllium	0.03 - 0.23	0.2	ND	0/47	NA
Cadmium	0.17 - 1.2	1.0	ND	0/47	NA
Calcium	5 - 4,410	1,508.3	34 - 2,250	23/47	1
Chromium	2 - 9	8.7	1.92 - 9.91	41/47	2
Cobalt	0.175 - 2	1.6	ND	0/47	NA
Copper	0.47 - 2	1.6	ND	0/47	NA
Iron	126 - 2,840	1,778.0	123 - 4,940	47/47	6
Lead	1 - 12	9.1	0.751 - 7.42	47/47	0
Magnesium	13 - 260	231.2	15.4 - 250	45/47	1
Manganese	0.40 - 8	6.2	1.55 - 21.7	32/47	2
Mercury	0.01 - 0.11	0.1	0.056	1/47	0
Nickel	0.70 - 5	4.0	ND	0/47	NA
Potassium	41 - 187	228.8	191 - 302	4/47	1
Selenium	0.12 - 0.55	0.8	0.818	1/47	1
Silver	0.18 - 1	1.1	ND	0/47	NA
Sodium	7 - 45	40	ND	0/47	NA
Vanadium	0.75 - 13	10.1	3.93 - 14.2	16/47	3
Zinc	0.40 - 12	5.6	2.51 - 11.9	18/47	2

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
[1] Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
ND - Not Detected
NA - Not Applicable
J - Estimated value

TABLE 1-15

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 4 (SITE 74)
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	NCWQS[(1)]	MCL[(2)]	Federal Health Advisories[(3)]		No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above Health Advisories	
			10 kg Child	70 kg Adult					10 kg Child	70 kg Adult
di-n-butylphthalate	700	NE	NE	NE	1/8	2J	0	NA	NA	NA
Acetone	700	NE	NE	NE	2/8	2J - 2.04J	0	NA	NA	NA
Lindane (gamma-BHC)	0.2	0.2	30	100	1/7	0.04J	0	0	0	0
Heptachlor	0.008	0.4	5	5	1/7	0.01NJ	1	0	0	0
Endosulfan II	NE	NE	NE	NE	1/7	0.02J	NA	NA	NA	NA
alpha-Chlordane	0.027	2	NE	NE	1/7	0.02NJ	0	0	NA	NA
Arsenic	50	50	NE	NE	5/8	2.86J - 18.1	0	0	NA	NA
Barium	2,000	2,000	NE	NE	8/8	28.2-117	0	0	NA	NA
Beryllium	NE	4	4,000	20,000	3/8	0.842 - 2.25	NA	0	0	0
Chromium	50	100	200	800	5/8	15.9-56.6	1	1	0	0
Lead	15	15	NE	NE	7/8	3.1J - 15.3	1	1	NA	NA
Manganese	50	50[(5)]	NE	NE	8/8	8.47 - 115	1	1	NA	NA
Mercury	1.1	2	NE	2	1/8	0.244	0	0	NA	0
Selenium	50	50	NE	NE	1/8	1.8J	0	0	NA	NA
Vanadium	NE	NE	NE	NE	4/8	4.3 - 301	NA	NA	NA	NA
Zinc	2,100	5,000[(5)]	3,000	12,000	5/5	19.1 - 417J	0	0	0	0

Notes: Concentrations expressed in microgram per liter (µg/L).

(1) NCWQS = North Carolina Water Quality Standards for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
(4) Data shown reflect a replacement of Round 2 sampling results with low-flow sampling results.
(5) SMCL = Secondary Maximum Contaminant Level

NE - Not Established
NA - Not Applicable
NJ - Estimated/tentative value
J - Estimated value

SECTION 1.0 FIGURES

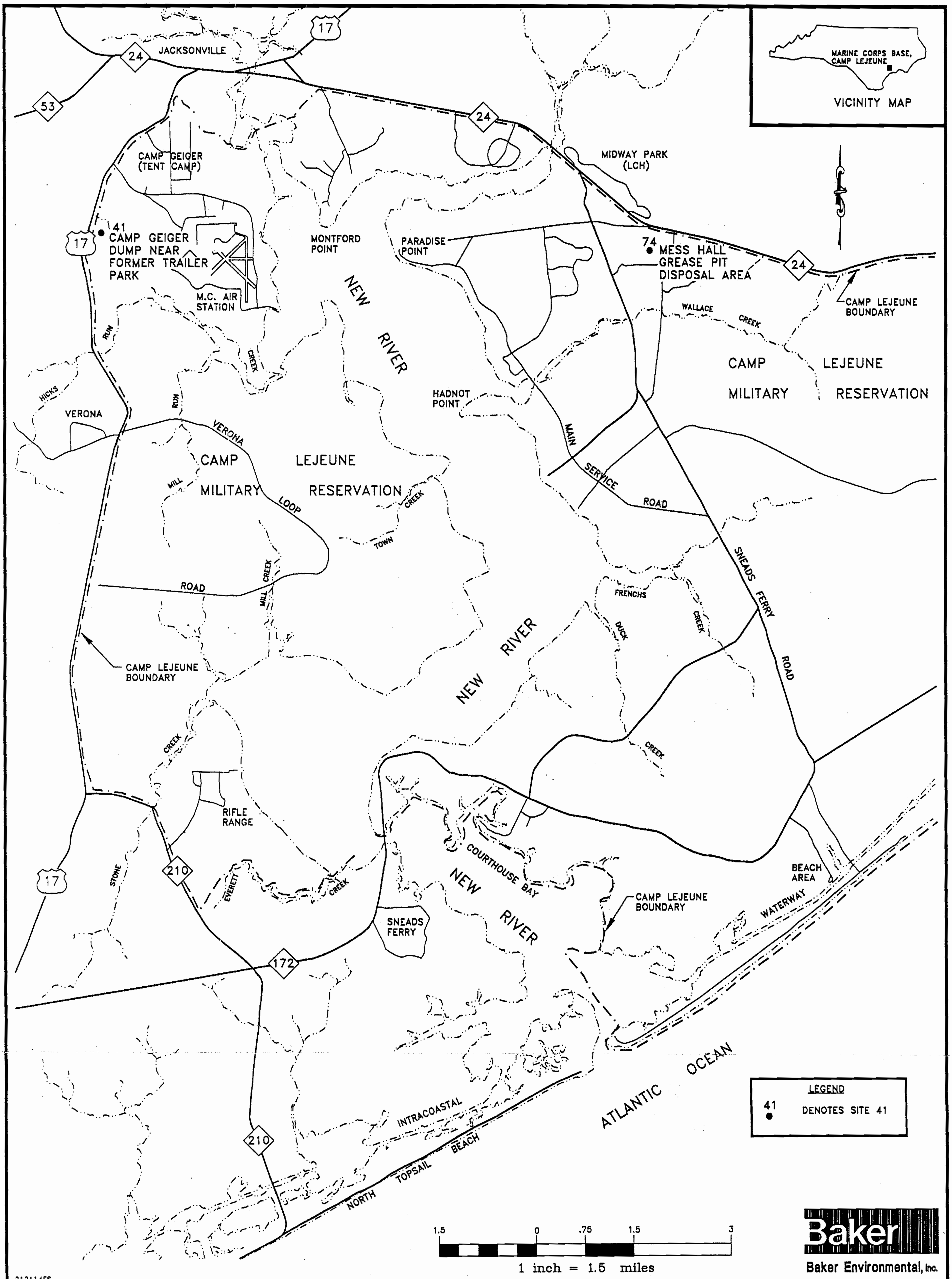
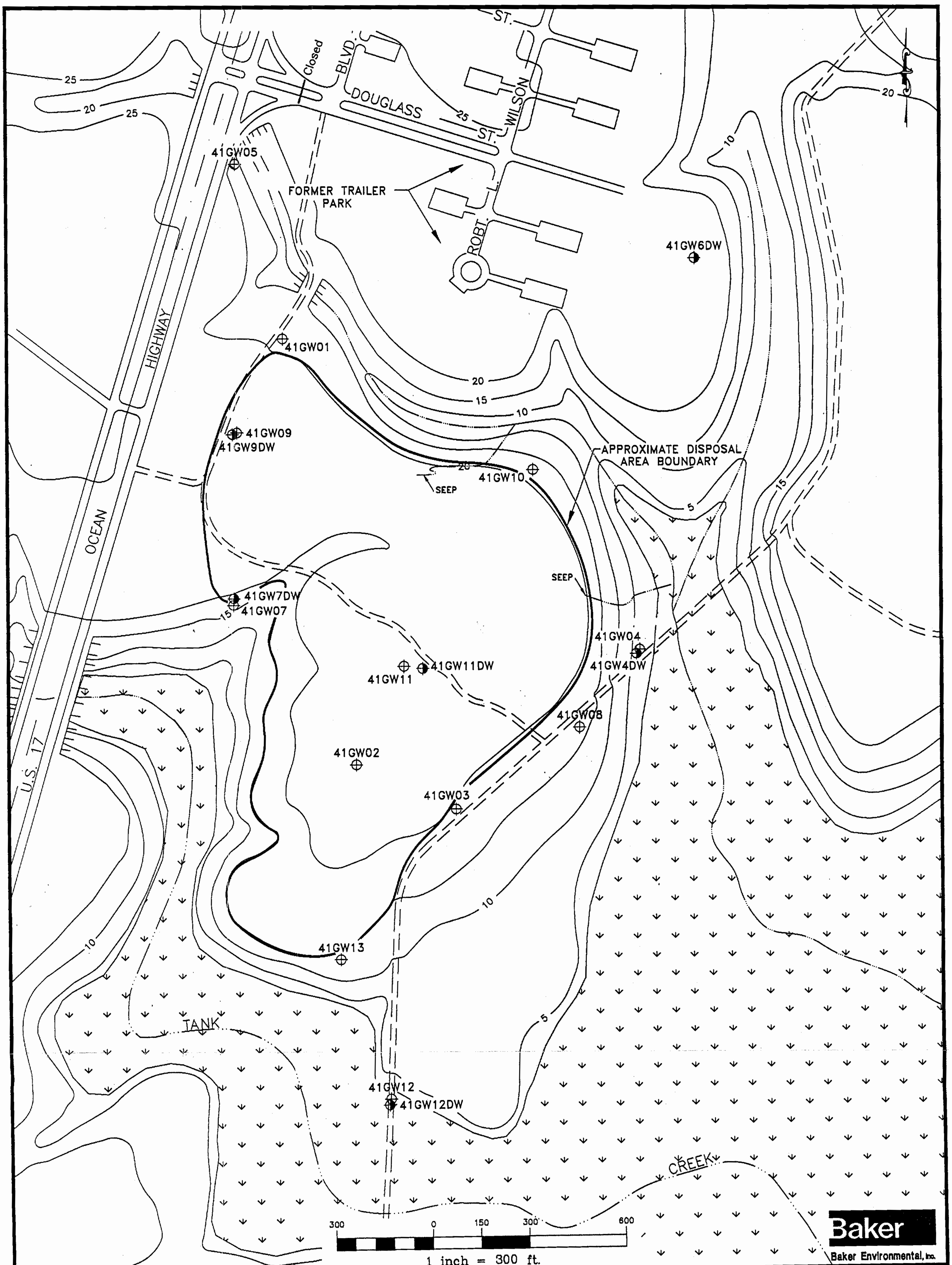


FIGURE 1-1
LOCATION MAP, OPERABLE UNIT No. 4
SITES 41 AND 74
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01568 CCB12

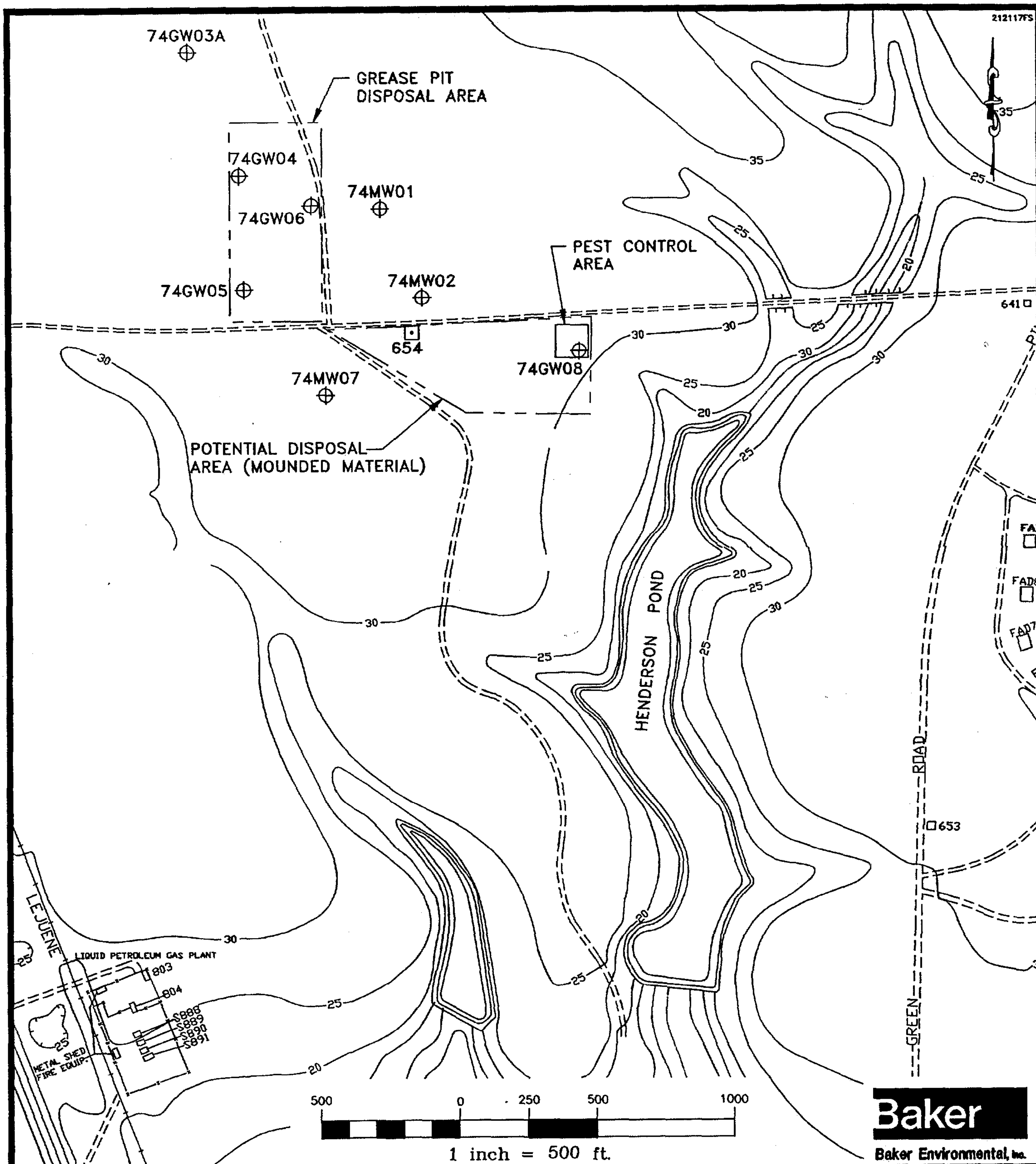


LEGEND

41GW01 – SHALLOW MONITORING WELL
41GW4DW – DEEP MONITORING WELL
– MARSH
5 – TOPOGRAPHIC ELEVATION LINES
– ROAD (IMPROVED)
– ROAD (UNIMPROVED)
– INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-2
GENERAL ARRANGEMENT MAP
SITE 41 – CAMP GEIGER DUMP
NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

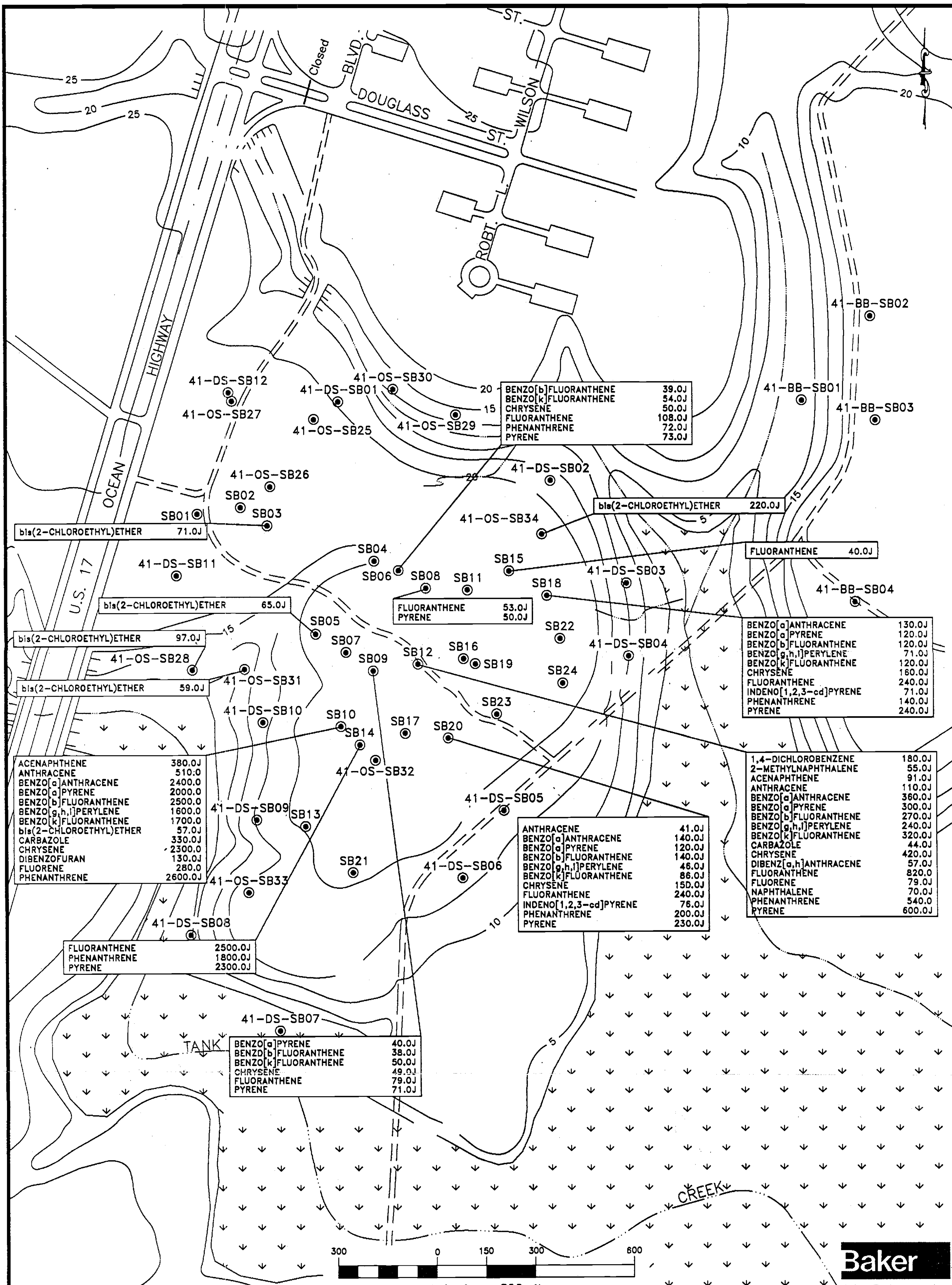
74MW01 SHALLOW MONITORING WELL

654 WATER SUPPLY WELL

UNPAVED ROAD

SOURCE: LANTDIV, FEB. 1994

FIGURE 1-3
GENERAL ARRANGEMENT MAP
SITE 74 - MESS HALL
GREASE PIT DISPOSAL AREA
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



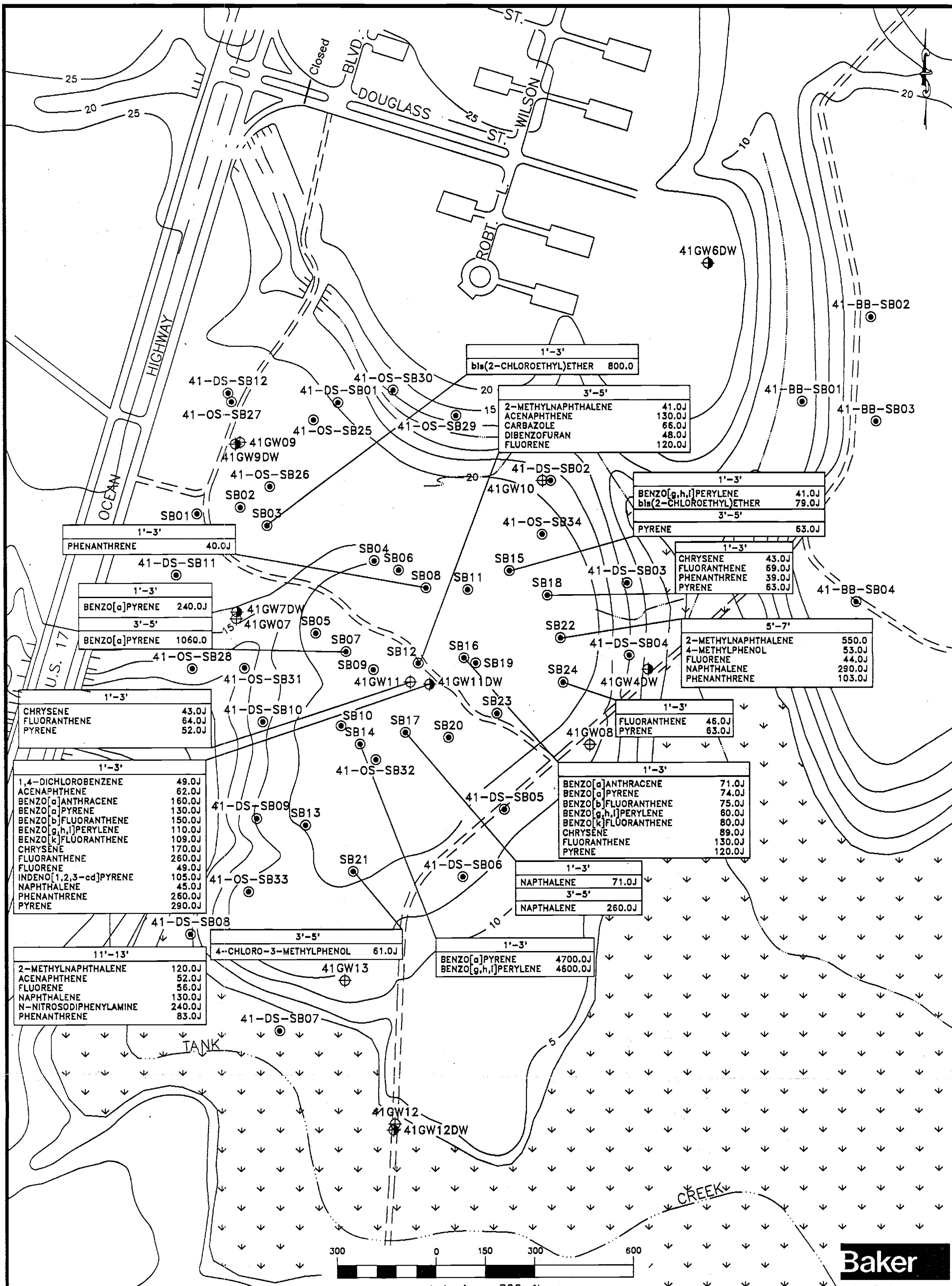
LEGEND

- SB01 – SOIL BORING LOCATION
- MARSH
- 5 – TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: LANTDIV, OCT. 1991

FIGURE 1-4
POSITIVE DETECTIONS OF SEMIVOLATILES IN SURFACE SOILS – SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01568 CC B22



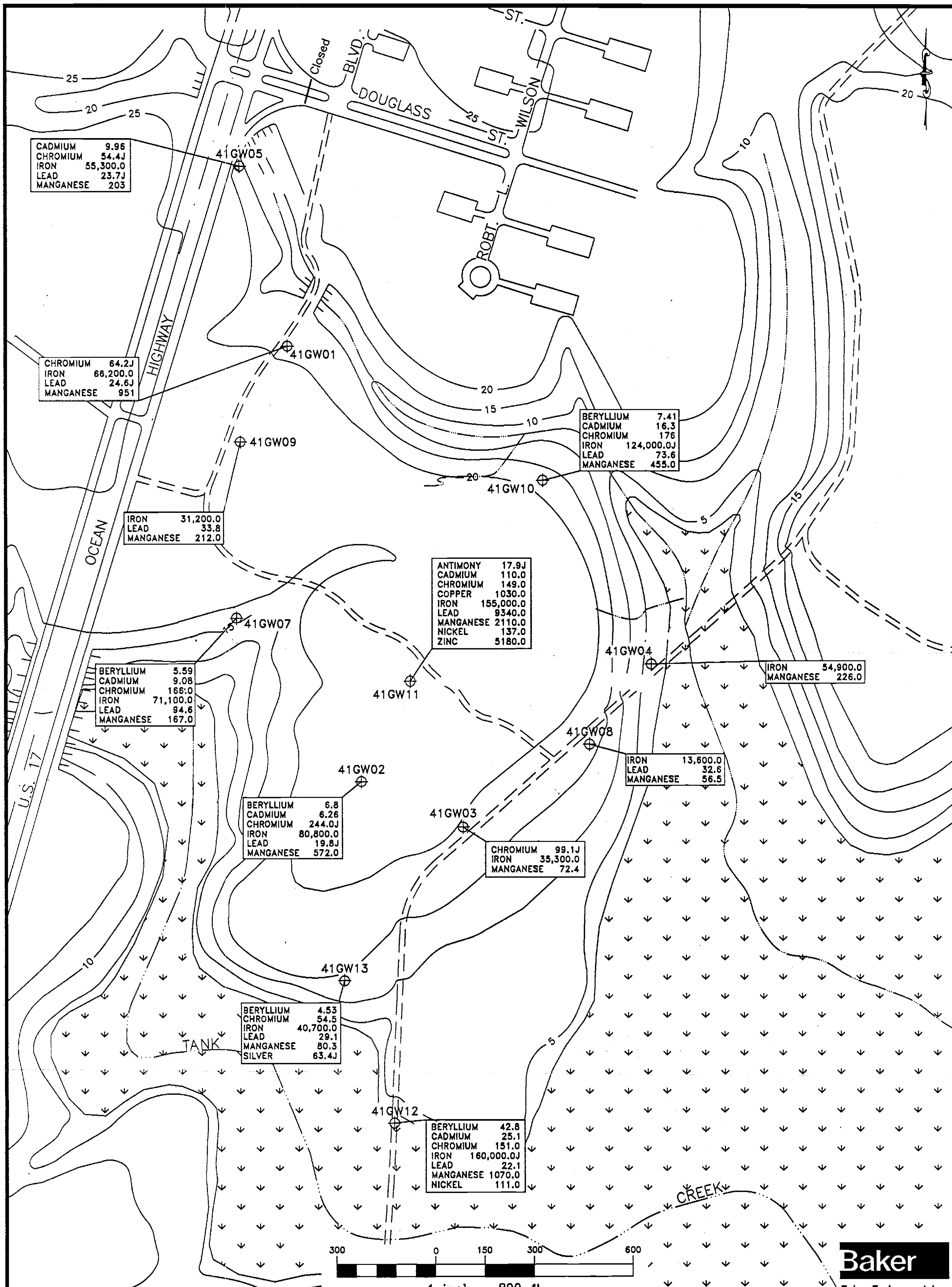
LEGEND

41GW07 - SHALLOW MONITORING WELL LOCATION
41GW4D - DEEP MONITORING WELL LOCATION
SB01 - SOIL BORING LOCATION
- MARSH
5 - TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-5
POSITIVE DETECTION OF SEMIVOLATILES IN SUBSURFACE SOILS - SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

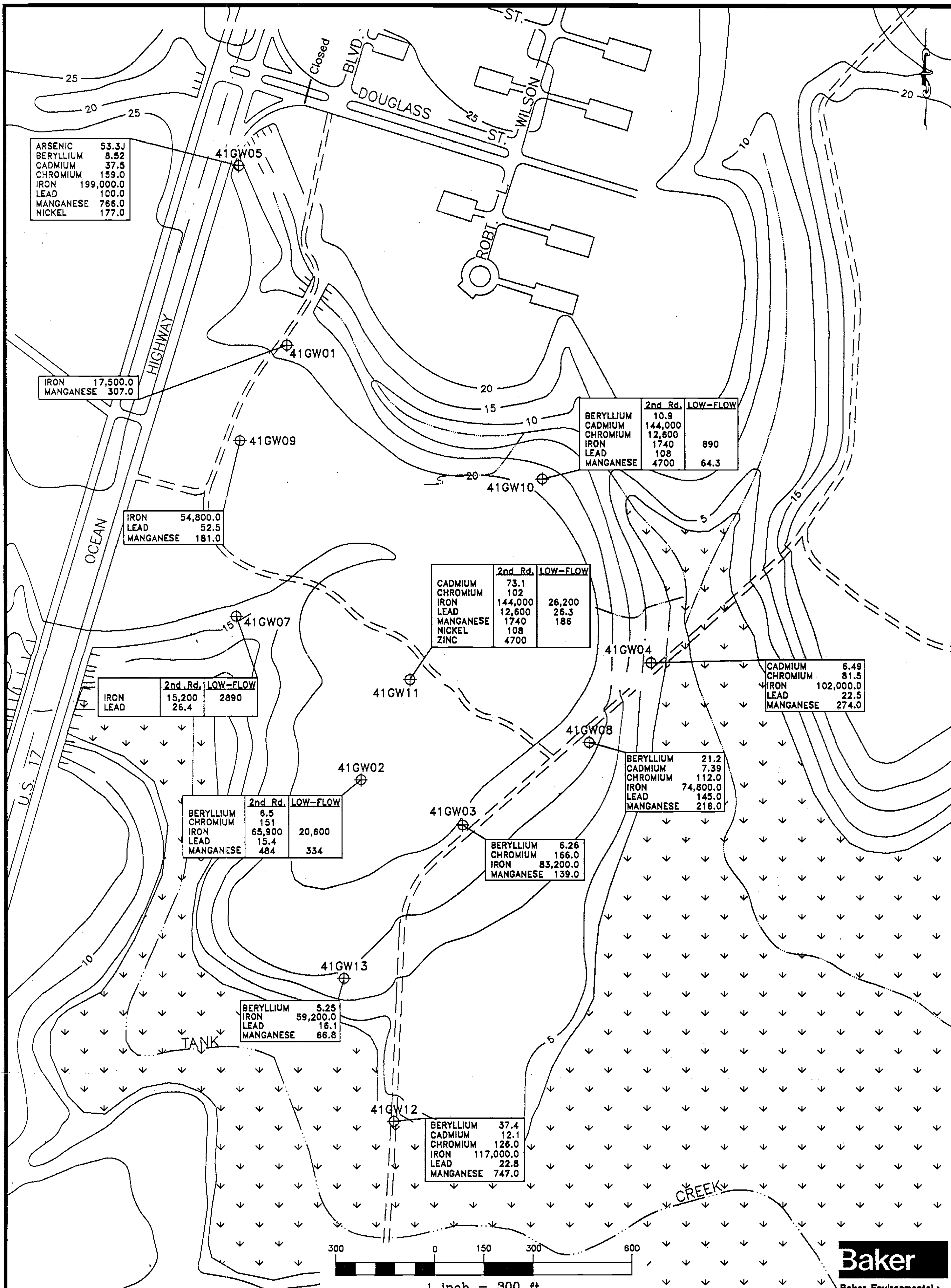


LEGEND

- 41GW01 – SHALLOW MONITORING WELL
- MARSH
- 5 – TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
SOURCE: LANTDIV, OCT. 1991

FIGURE 1-6
POSITIVE DETECTIONS OF TAL METALS FOR ROUND 1 ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS – SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

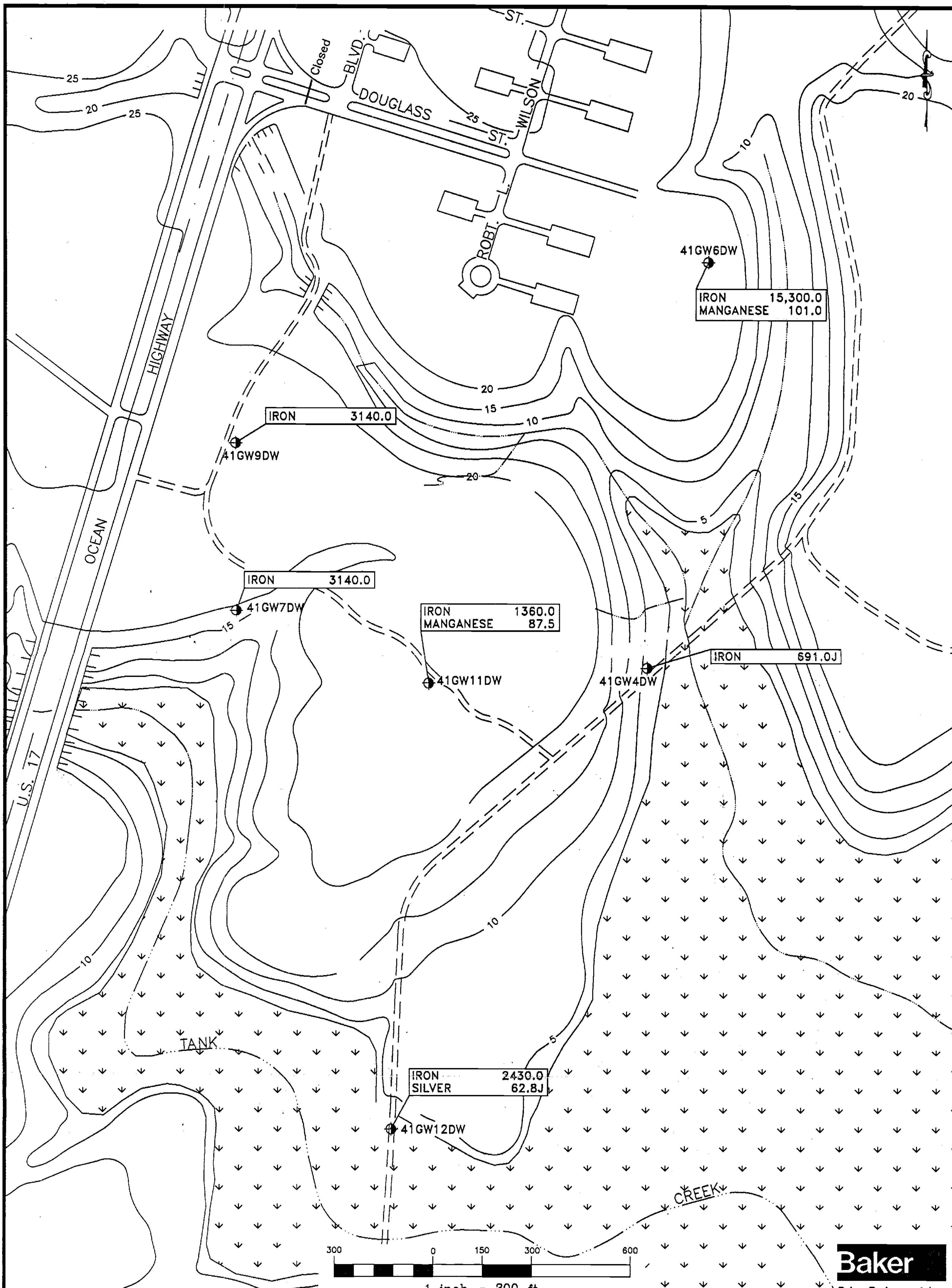


LEGEND

- 41GW01 – SHALLOW MONITORING WELL
- – MARSH
- 5 – TOPOGRAPHIC ELEVATION LINES
- – ROAD (IMPROVED)
- – ROAD (UNIMPROVED)
- – INTERMITTENT STREAM

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
SOURCE: LANTDIV, OCT. 1991

FIGURE 1-7
POSITIVE DETECTIONS OF TOTAL METALS FOR ROUND 2 AND LOW-FLOW SAMPLING ROUND ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 41 – CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

41GW4D – DEEP MONITORING WELL

– MARSH

5 – TOPOGRAPHIC ELEVATION LINES

– ROAD (IMPROVED)

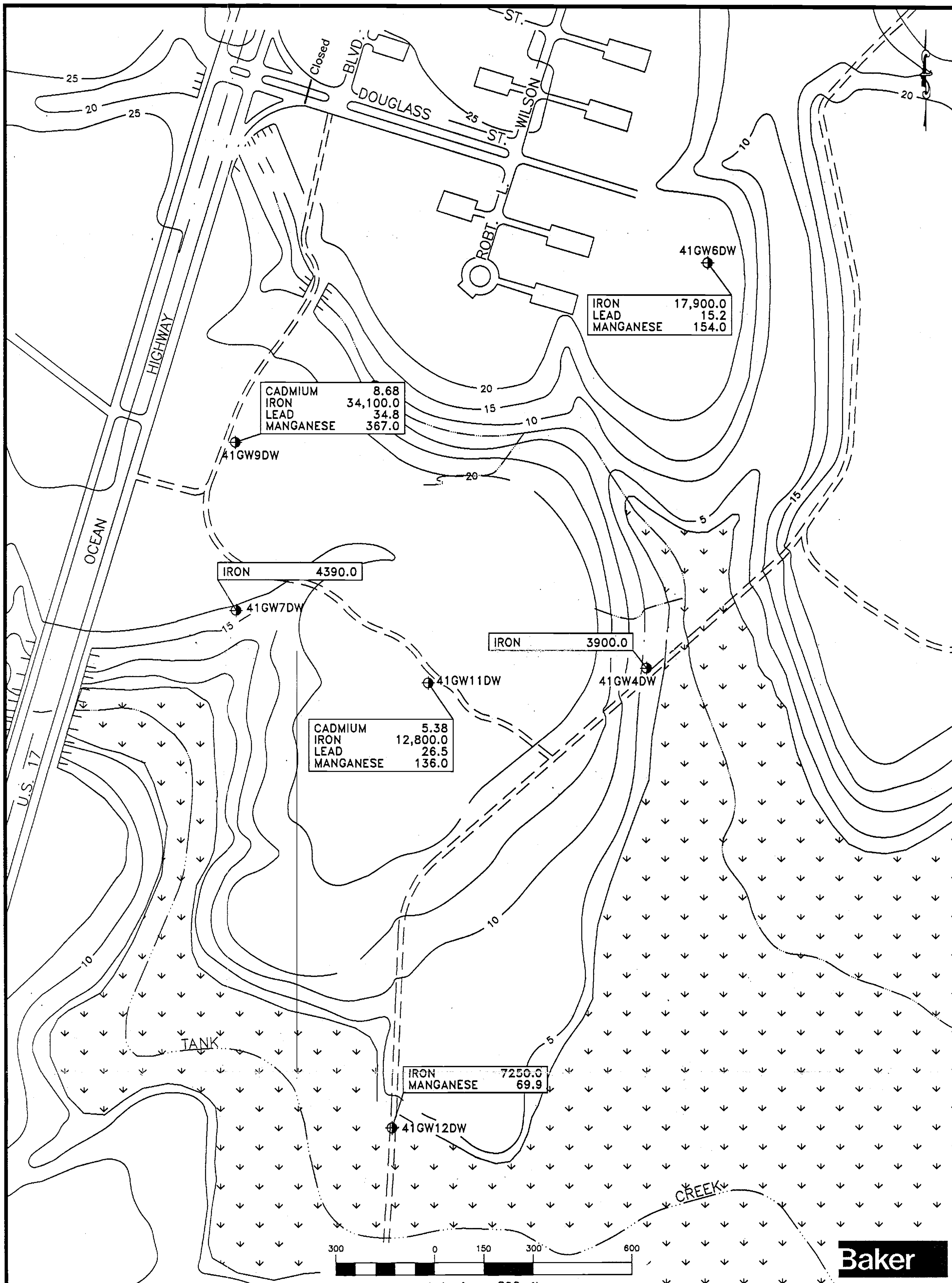
– ROAD (UNIMPROVED)

– INTERMITTENT STREAM

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: LANTDIV, OCT. 1991

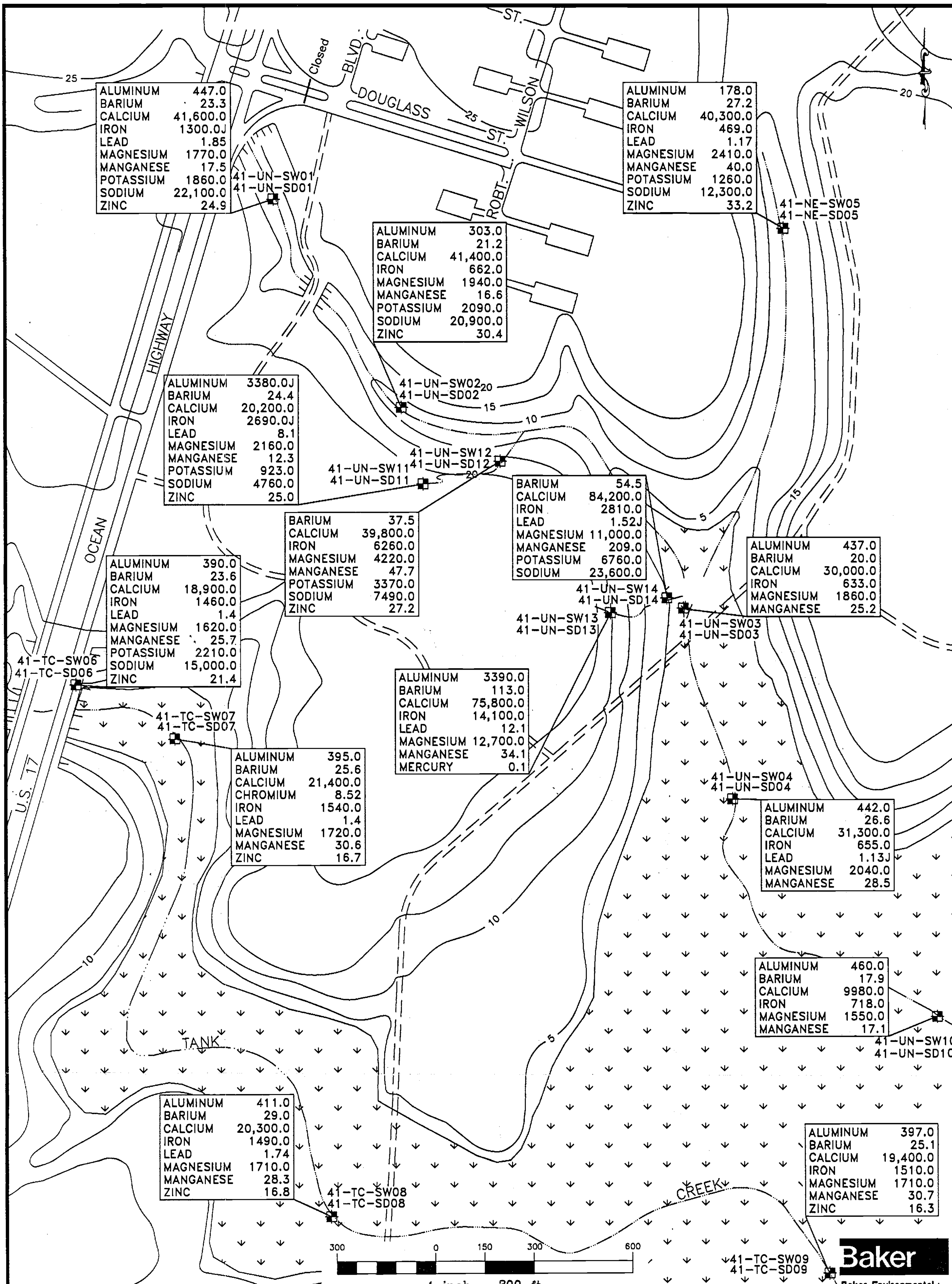
FIGURE 1–8
POSITIVE DETECTIONS OF TAL METALS FOR ROUND 1 ABOVE FEDERAL MCLs AND/OR NCWQS IN DEEP WELLS – SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO–0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
Baker Environmental, Inc.

LEGEND
41GW4D - EXISTING DEEP MONITORING WELL
- MARSH
5 - TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM
ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
SOURCE: LANTDIV, OCT. 1991

FIGURE 1-9
POSITIVE DETECTIONS OF TOTAL METALS FOR ROUND 2 ABOVE FEDERAL MCLs AND/OR NCWQS IN DEEP WELLS
SITE 41 - CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

41-UN-SW01
41-UN-SD01
– SURFACE WATER/SEDIMENT SAMPLING STATIONS

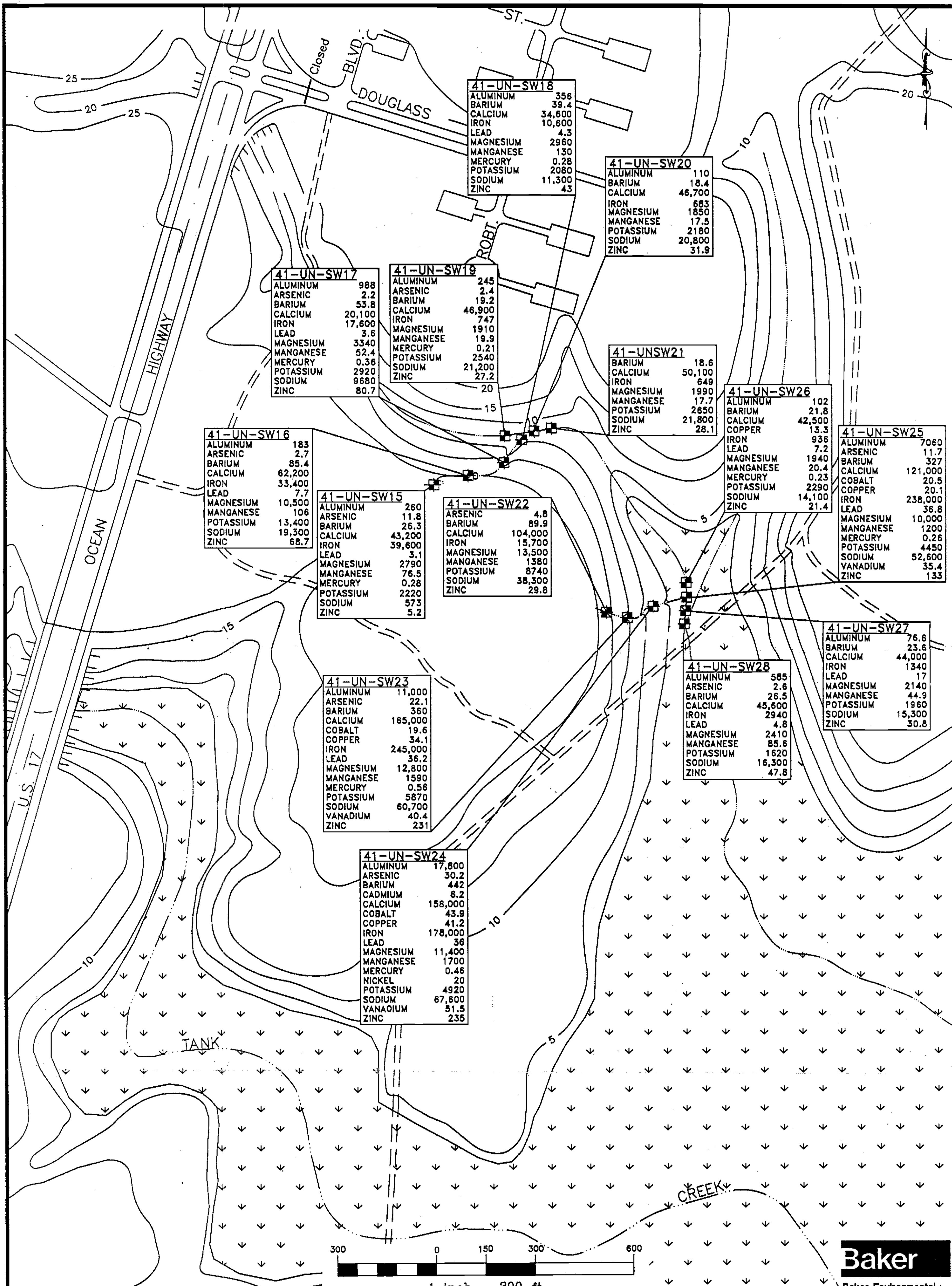
5 – TOPOGRAPHIC ELEVATION LINES

– ROAD (IMPROVED) – ROAD (UNIMPROVED)

– INTERMITTENT STREAM – MARSH

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-10
POSITIVE DETECTIONS OF TAL METALS
IN SURFACE WATER - SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

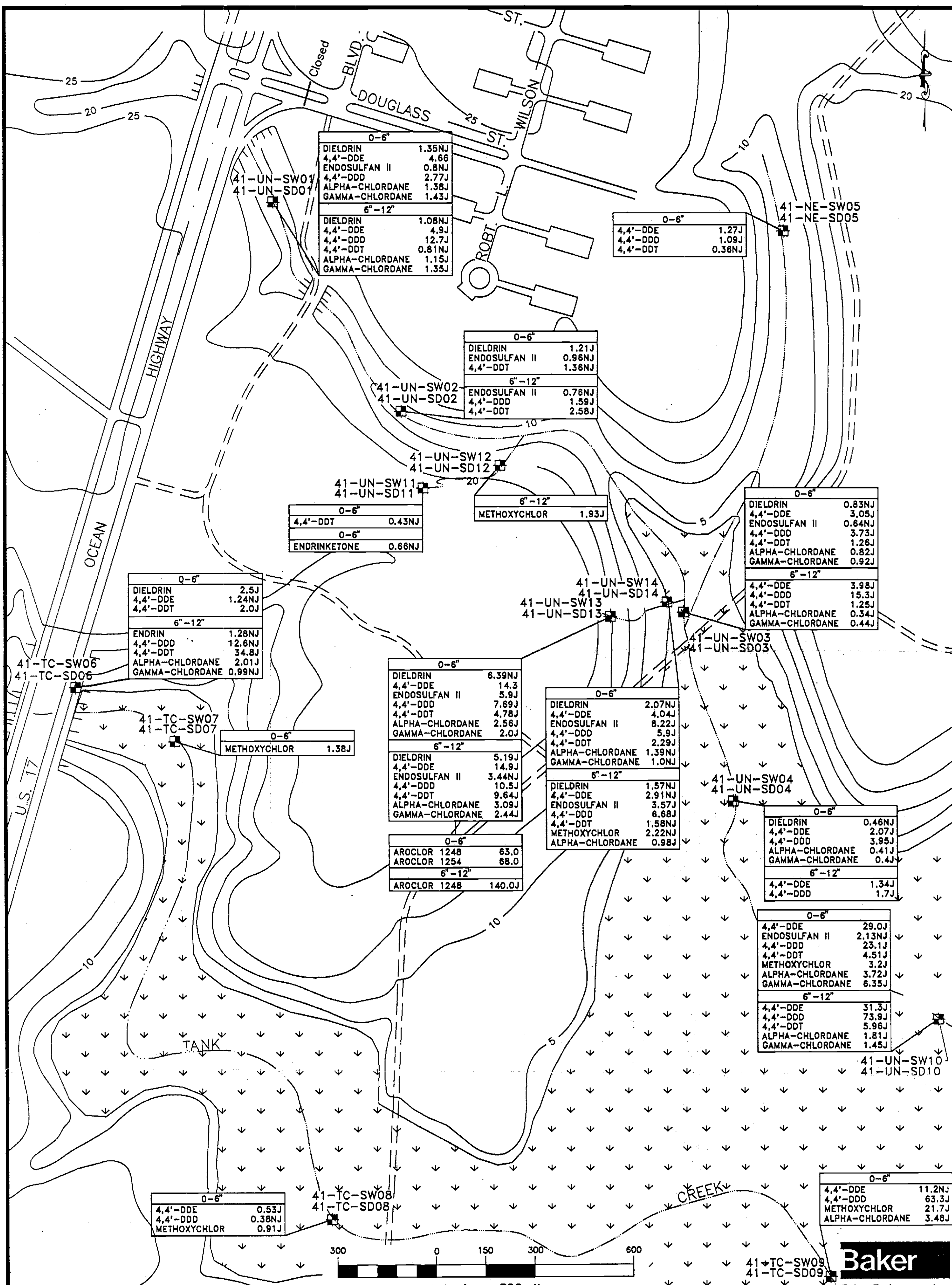


LEGEND

41-UN-SW15 – SURFACE WATER/SEDIMENT SAMPLE LOCATION
– MARSH
5 – TOPOGRAPHIC ELEVATION LINES
– ROAD (IMPROVED)
– ROAD (UNIMPROVED)
– INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-11
POSITIVE DETECTIONS OF TAL METALS FOR SECOND SAMPLING EVENT IN SURFACE WATER – SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

41-UN-SW01
41-UN-SD01 - SURFACE WATER/SEDIMENT SAMPLING STATIONS

5 - TOPOGRAPHIC ELEVATION LINES

- ROAD (IMPROVED)

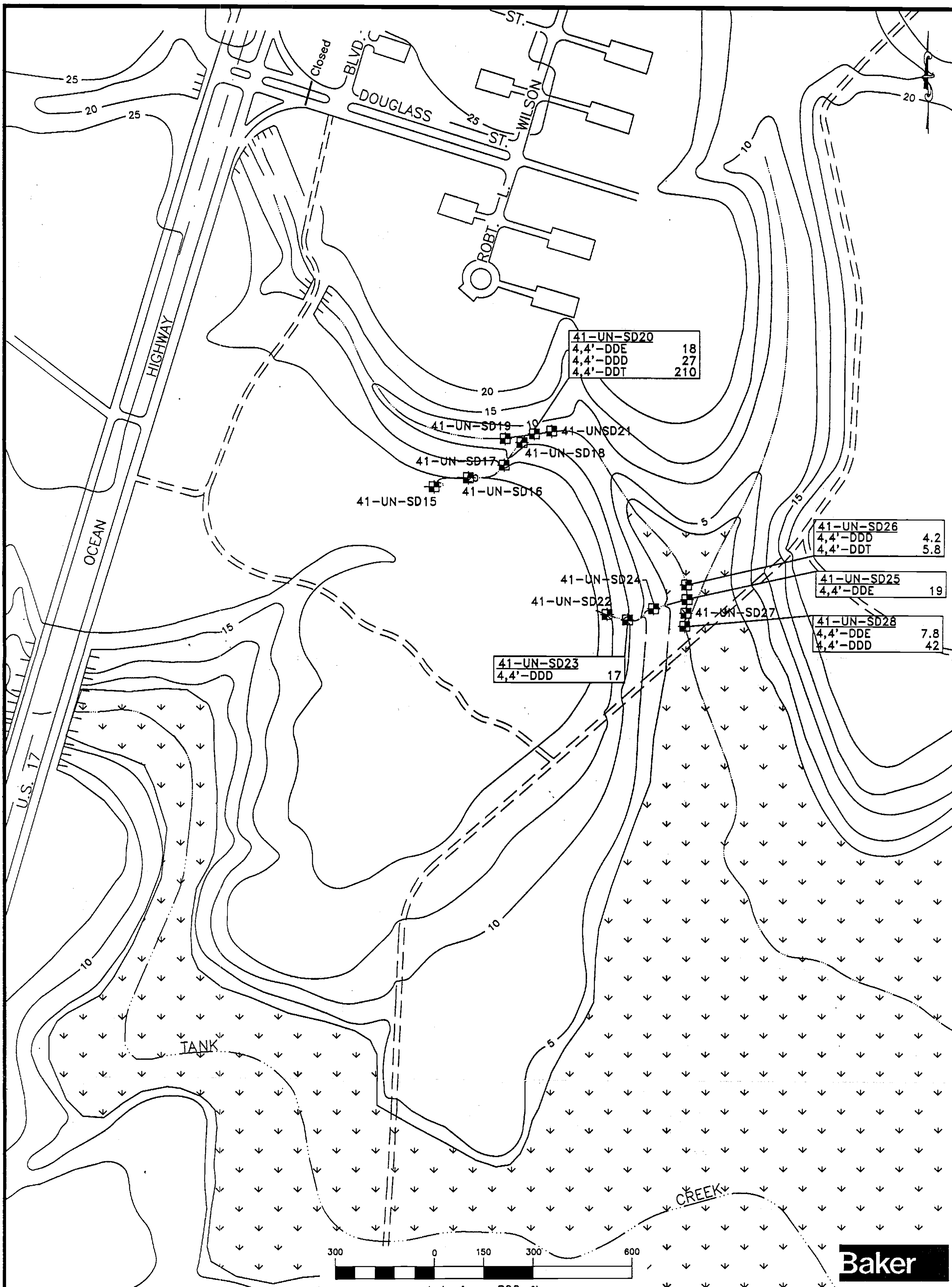
- ROAD (UNIMPROVED)

- INTERMITTENT STREAM

- MARSH

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: LANTDIV, OCT. 1991

FIGURE 1-12
POSITIVE DETECTIONS OF PESTICIDES/
PCBs IN SEDIMENT - SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

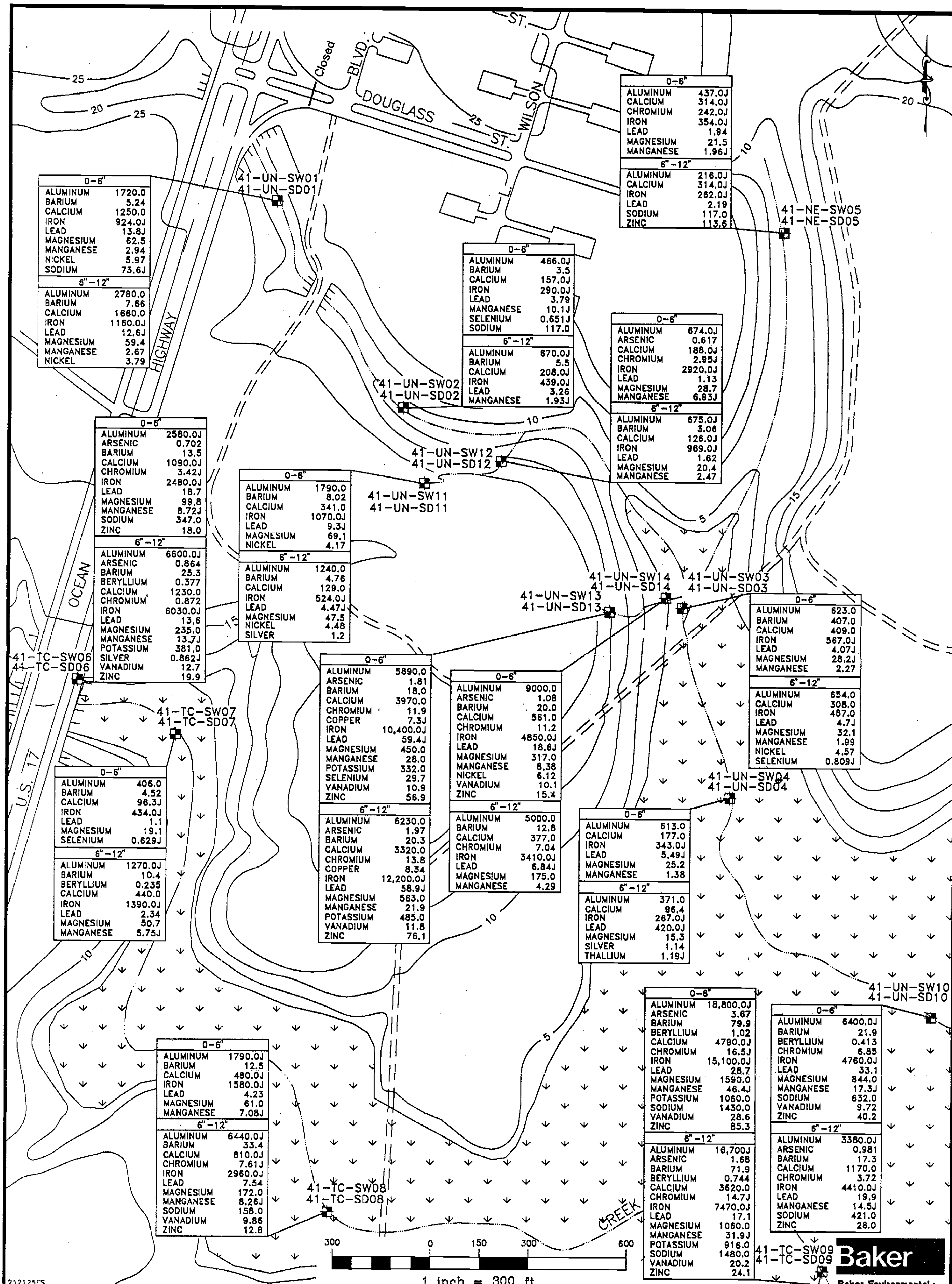


LEGEND

41-UN-SD15 - SURFACE WATER/SEDIMENT SAMPLE LOCATION
- MARSH
5 - TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-13
POSITIVE DETECTIONS OF PESTICIDES FOR SECOND SAMPLING EVENT IN SEDIMENT - SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

41-UN-SW01
41-UN-SD01 – SURFACE WATER/SEDIMENT SAMPLING STATIONS

— 5 — – TOPOGRAPHIC ELEVATION LINES

– ROAD (IMPROVED)

– ROAD (UNIMPROVED)

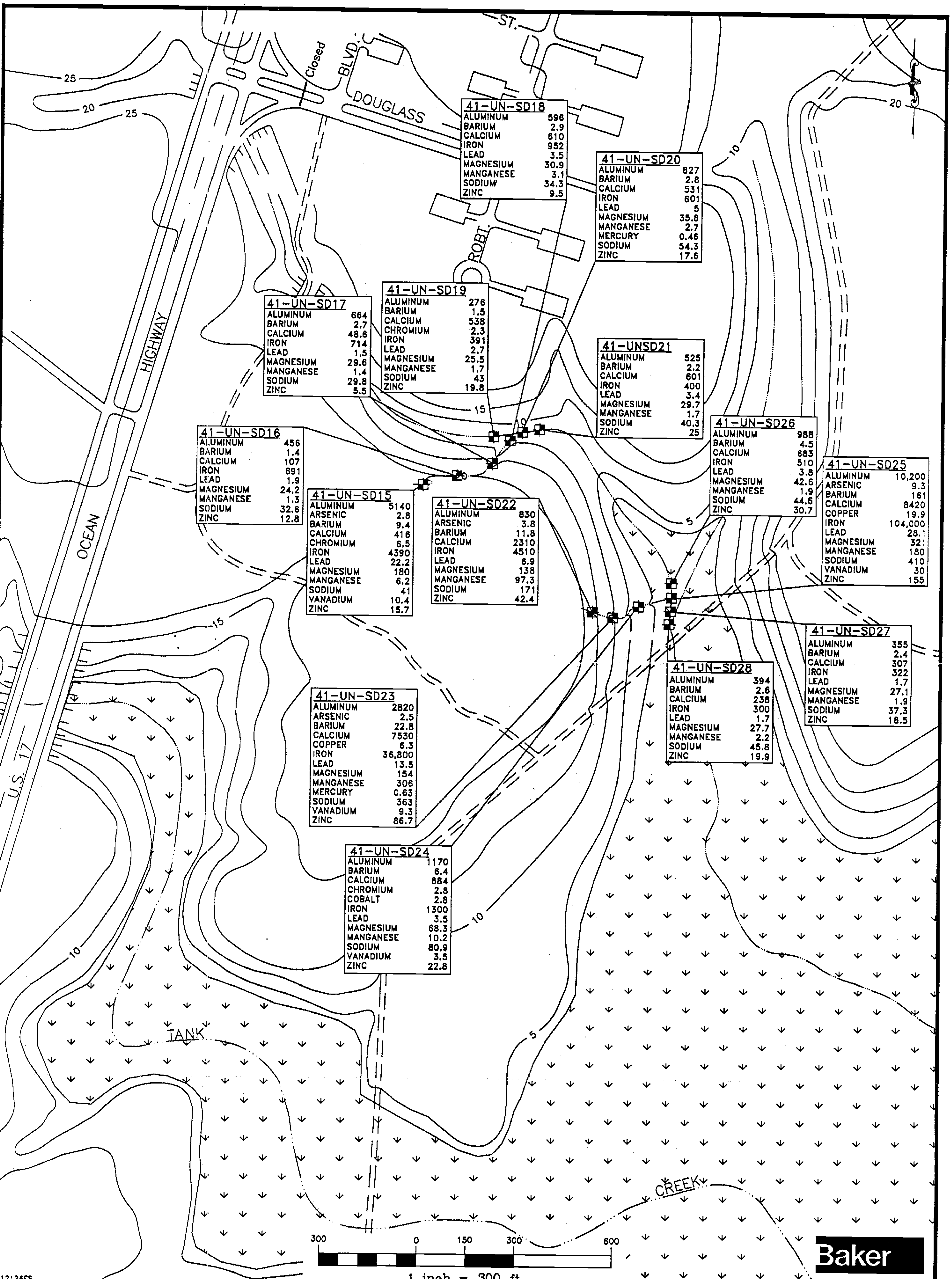
– INTERMITTENT STREAM

– MARSH

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-14
POSITIVE DETECTION OF TAL METALS
IN SEDIMENT – SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

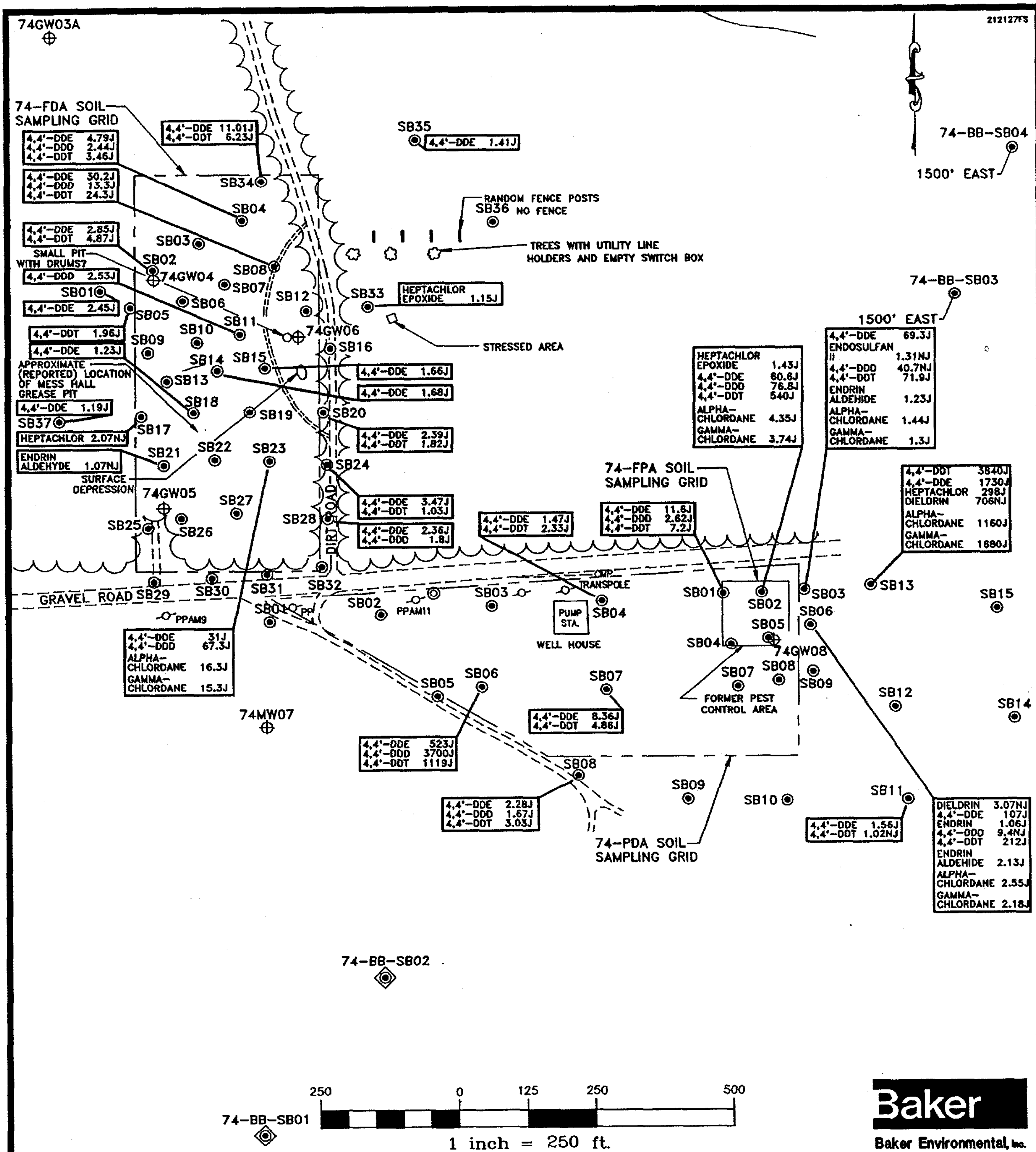


LEGEND

41-UN-SD15 - SEDIMENT SAMPLE LOCATION
- MARSH
5 - TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 1-15
POSITIVE DETECTIONS OF TAL METALS FOR SECOND SAMPLING EVENT IN SEDIMENT - SITE 41
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

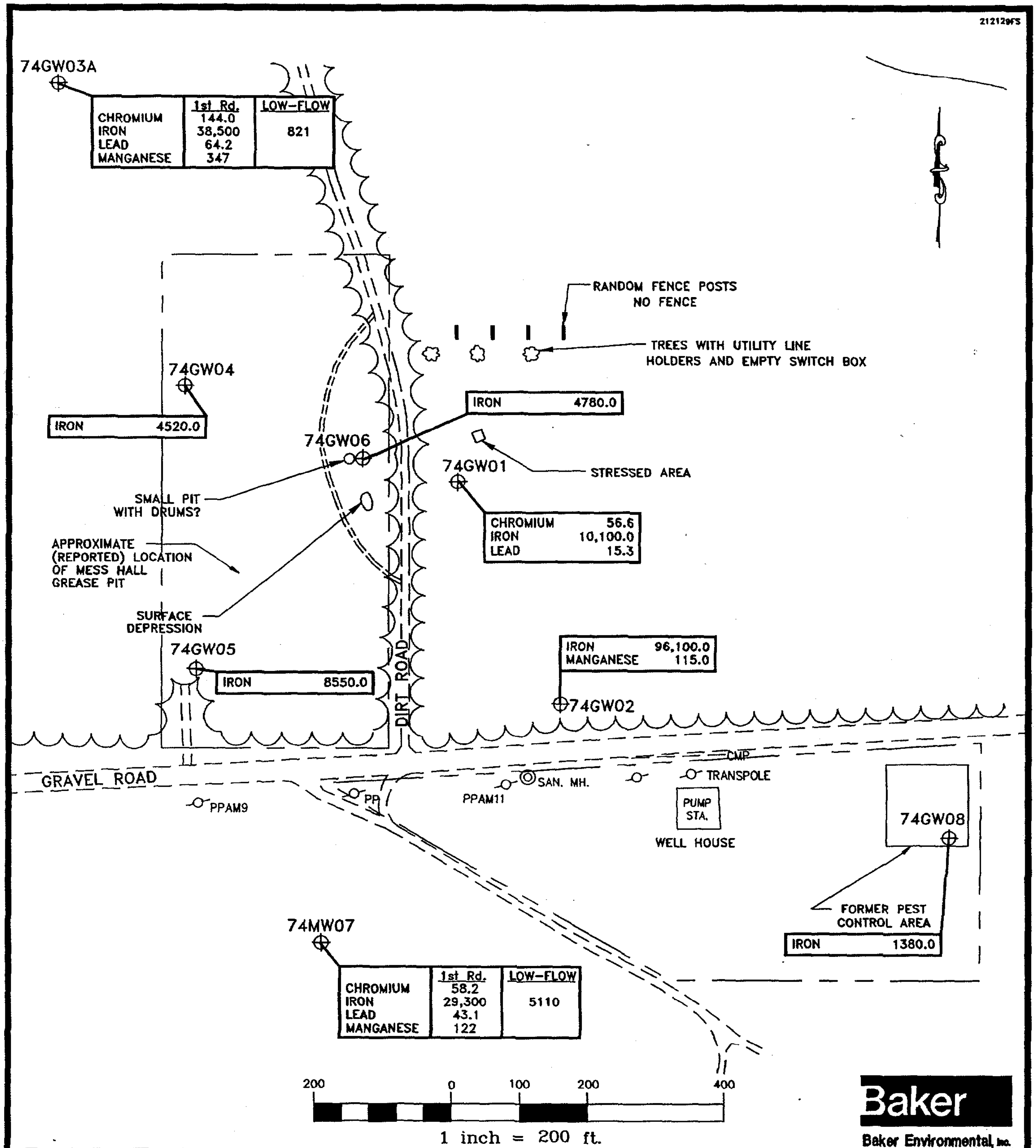


LEGEND

74GW03A ⊕	SHALLOW MONITORING WELL LOCATION
SB01 ◉	SOIL BORING LOCATION
74-BB-SB02 ◈	BACKGROUND SOIL BORING LOCATION

SOURCE: REVISED FROM LANTDIV. OCT. 1991

FIGURE 1-16
POSITIVE DETECTIONS OF PESTICIDES ABOVE 1 ug/kg IN SURFACE SOILS – SITE 74
MESS HALL GREASE PIT DISPOSAL AREA
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

74GW03A SHALLOW MONITORING WELL

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: REVISED FROM LANTDIV. OCT. 1991

FIGURE 1-17
POSITIVE DETECTIONS OF TAL METALS ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 74 - MESS HALL GREASE PIT DISPOSAL AREA
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 DEVELOPMENT OF REMEDIATION GOAL OPTIONS, REMEDIATION LEVELS, AND REMEDIAL ACTION OBJECTIVES

This section presents the development of remediation goal options (RGOs), remediation levels (RLs), and remedial action objectives (RAOs) for OU No. 4 (Sites 41 and 74). RGOs are chemical-specific concentration goals established for specific medium and land use combinations for the protection of human health and the environment. There are two general sources of chemical-specific RGOs: (1) concentrations based on applicable or relevant and appropriate requirements (ARARs) and, (2) risk-based concentrations for the protection of public health and the environment. The selection of RGOs includes: identifying the media of concern, selection of contaminants of concern (COCs), evaluation of ARARs, and identification of site-specific information for the exposure pathway information (i.e., exposure frequency, duration, or intake rate data). The development of RGOs for OU No. 4 via these criteria is detailed in Sections 2.1 through 2.5. The resulting RLs, areas that require remediation, and the remedial action objectives are presented in Sections 2.6, 2.7, and 2.8, respectively.

2.1 <u>Media of Concern Identified by the Human Health and Ecological Risk Assessment</u>

The results of the baseline human health and ecological risk assessment indicate that there would be no unacceptable risks to human health posed by exposure to soil, groundwater, surface water, or sediments at any of the sites under current land usage. Currently, the only human exposure pathway is associated with soil (e.g., military personnel who may come into contact with the soil during training exercises). From an ecological standpoint, the seep surface water at Site 41 poses a potential adverse impact to ecological receptors; however, the unnamed tributary, which receives flow from the seeps, does not pose unacceptable ecological risks.

Under future potential land use scenarios (i.e., residential), soil and groundwater are the media of concern which would result in unacceptable risks to human health. For purposes of this FS, soil includes the material within the landfill. As mentioned previously in Section 1.0, the material within the landfills could not be completely characterized since no intrusive investigations (e.g., test pitting) could be conducted because of suspected CWM. Although results of the risk assessment for the construction worker showed no adverse health effects associated with exposure to subsurface soil, both sites are suspected of receiving CWM, which may be buried within the sites. Therefore, exposure to the landfill materials for construction workers is potentially a human health concern. For these reasons, the soil/fill materials at Sites 41 and 74 have been included as a medium of concern.

In summary, the following media of concern have been identified:

<u>Site 41</u>

- Soil/landfill material
- Shallow groundwater and seep surface water

<u>Site 74</u>

- Shallow groundwater
- Soil/landfill material

2.2 Contaminants of Concern

COCs initially selected and evaluated in the baseline risk assessment (RA) were selected on the basis of frequency of detection, prevalence above background concentrations, toxicity, and comparison to established criteria or standards. The COCs identified for groundwater, soil, surface water, and sediment for both the human health and ecological RAs are listed in Table 2-1. COCs that do not exceed a regulatory or a risk-based RGO will be eliminated from further consideration as a COC. In addition, an evaluation will be conducted on the remaining set of contaminants to determine areas and media of concern for the operable unit. A final set of COCs will be identified, which then will be the basis for a set of remedial action objectives applicable to OU No. 4.

2.3 Remediation Goal Options

RGOs are based on Federal and State criteria or risk-based concentrations. Federal and State criteria will be identified and evaluated in Section 2.3.1. Site specific risk-based RGOs for the COCs at OU No. 4 will be developed in Section 2.3.2. The results from both of these sections will be used to develop the initial set of RGOs for the operable unit.

2.3.1 Applicable or Relevant and Appropriate Federal and State Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from both Federal and State laws. USEPA Interim Guidance (52 Fed. Reg. 32, 496, August 27, 1987) provides a definition of "Applicable Requirements" as follows:

> ...cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstance at a CERCLA site.

Drinking water criteria may be an applicable requirement for a site with contaminated groundwater that is used as a drinking water source. The definition of "Relevant and Appropriate Requirements" is:

> ...cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

There are three types of ARARs. The first type, chemical-specific ARARs, are requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

The second type of ARARs, location-specific, set restrictions on activities based upon the characteristics of the site and/or the nearby suburbs. Examples of this type of ARAR include Federal and State citing laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARARs, action-specific, refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly-owned treatment works (POTWs) are examples of action-specific ARARs.

Subsection 121(d) of CERCLA requires that the remedial action meet a level or standard which at least attains Federal and State substantive requirements that qualify as ARARs. Federal, State, or local permits do not need to be obtained for removal or remedial actions implemented on site, but their substantive requirement must be obtained. "On site" is interpreted by the USEPA to include the areal extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

ARARs can be identified only on a site-specific basis. They depend on the detected contaminants at a site, specific site characteristics, and particular remedial actions proposed for the site. ARARs identified for OU No. 4 are presented in the following sections.

2.3.1.1 Chemical-Specific ARARs

A summary of chemical-specific ARARs and their applicability to the areas of concern are provided in Table 2-2.

The following criteria were used in the selection of chemical-specific ARARs: the North Carolina Water Quality Standards (NCWQSs) applicable to groundwaters; the Federal MCLs and secondary MCLs, Federal risk-based Health Advisories (HAs); the PCB Spill Cleanup Policy under the Toxic Substances Control Act (TSCA); and NCWQSs applicable to surface waters and the Region IV Surface Water/Sediment Screening Values (SSVs). A brief description of each these standards/guidance is presented below.

North Carolina Water Quality Standards (Groundwater) - Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the NC DEHNR has established groundwater standards (NCWQSs) for three classifications of groundwater within the State: GA, GSA, and GC. Class GA waters are those groundwaters in the State naturally containing 250 milligram per liter (mg/L) or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the State naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The shallow and Castle Hayne Aquifers under Sites 41 and 74 are Class GA groundwaters.

The water quality standards for the groundwaters are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the State, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the practical quantitation limit, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration as determined by the State. Substances which are not naturally occurring, and for which no standard is specified, are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15A-NCAC-2L.0202).

The NCWQSs for substances in Class GA and Class GSA groundwaters are established as the lesser of:

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of 1.0E-6
- Taste threshold limit value
- Odor threshold limit value
- Federal MCL
- National Secondary Drinking Water Standard (or secondary MCL)

Note that the water quality standards for Class GA and Class GSA groundwaters are the same except for chloride and total dissolved solids concentrations (15A NCAC 2L.0202).

The NCWQSs for Site 41 groundwater COCs are presented in Table 1-5. As shown in the table, the majority of the State standards are the same or more stringent than the Federal MCLs.

Federal Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the SDWA and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. These standards are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

Secondary MCLs are nonenforceable guidelines established under the SDWA. The secondary MCLs are set to control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water. A comparison of Site 41 groundwater contaminants to MCLs is presented in Table 1-5.

USEPA Region IV Sediment Screening Values - In the absence of promulgated sediment quality criteria, USEPA Region IV uses the Sediment Screening Values (SSVs) compiled by the National Oceanic and Atmospheric Administration (NOAA) for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (USEPA, 1992b). The low ten percentile [Effects Range - Low (ER-L)] and the median percentile [Effects Range - Median (ER-M)] of biological effects have been developed for several of the chemicals identified during the sediment investigations at Site 41. If sediment contaminant concentrations are between the ER-L and ER-M, adverse effects on the biota are considered possible, and USEPA recommends conducting toxicity tests or other evaluations as a follow up. If contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (USEPA, 1992b). The SSVs (ER-L and ER-M) for the Site 41 sediment COCs are presented in Section 1.0, Table 1-10.

North Carolina Water Quality Standards (NCWQS) - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair the waters for any designated use. The NCWQSs for the surface water COCs for Site 41 are provided in Section 1.0, Table 1-7.

Ambient Water Quality Criteria (AWQC) - AWQC are nonenforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The AWQCs for the protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e. the 10E-7 to 10E-5 range). The AWQCs for the Site 41 surface water COCs are provided in Section 1.0, Table 1-7.

2.3.1.2 Location-Specific ARARs

Potential location-specific ARARs identified for OU No. 4 are listed in Table 2-3. An evaluation determining the applicability of these location-specific ARARs with respect to OU No. 4 is also presented and summarized in Table 2-3. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to OU No. 4:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Please note that the citations listed in Table 2-3 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

2.3.1.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for OU No. 4. A set of potential action-specific ARARs are listed in Table 2-4. These ARARs are based on RCRA, CWA, SDWA, and Department of Transportation (DOT) requirements. Note that the citations listed in Table 2-4 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

These ARARs will be evaluated after the remedial action alternatives have been identified for OU No. 4. Additional action-specific ARARs may also be identified and evaluated at that time.

2.3.2 Risk-Based Remediation Goal Options

In conjunction with the RGOs based on Federal and State criteria (Section 2.3.1), risk-based RGOs were developed for the groundwater COCs. The methodology used for the derived RGOs was in accordance with USEPA risk assessment guidance (USEPA, 1989a) (USEPA, 1991a). For noncarcinogenic effects, an action level was calculated that corresponds to a HI of 1.0, or unity, which is the level of exposure to a contaminant from all significant exposure pathways in a given medium below which it is unlikely for even sensitive populations to experience health effects. For carcinogenic effects, an action level was calculated that corresponds to 1.0E-04 (one in ten thousand) ICR over a lifetime as a result of exposure to the potential carcinogen from all significant exposure pathways for a given medium. A 1.0E-04 risk level was used as an end point for determining action levels for remediation. Based on the NCP (40 CFR 300.430), for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an ICR between 1.0E-04 and 1.0E-06. The action levels for OU No. 4 are representative of acceptable incremental risks based on current and probable future use of the area.

Three steps were involved in estimating the risk-based RGOs for OU No. 4 COCs. These steps are generally conducted for a medium and land-use combination and involved identifying: (1) the most significant exposure pathways and routes, (2) the most significant exposure parameters, and (3) equations. The equations included calculations of total intake from a given medium and were based on identified exposure pathways and associated parameters.

2.3.2.1 Derivation of Risk Equations

The determination of chemical-specific RGOs was performed in accordance with USEPA guidance (USEPA, 1989a). Reference doses (RfDs) were used to evaluate noncarcinogenic contaminants, while cancer slope factors (CSFs) were used to evaluate carcinogenic contaminants.

Potential exposure pathways and receptors used to determine RGOs are site-specific and consider the current and future land use of a site. The following exposure scenario was used in the determination of RGOs for OU No. 4:

- Ingestion of groundwater (future resident)

The potential risk estimated in the human health risk assessment indicated that the majority of the site-specific risk at Site 41 is likely to occur from future potential exposure to groundwater. Currently, soil does not appear to pose an appreciable risk with respect to both dermal contact and incidental ingestion at any of the sites. For this FS, the most conservative exposure pathway (i.e., groundwater ingestion) was used in the development of RGOs. The RGOs were calculated for future (adult and children) receptors in order to provide site-specific RGOs from which remedial alternatives could be generated.

Consistent with USEPA guidance, noncarcinogenic health effects were estimated using the concept of an average annual exposure. The action level incorporated the exposure time and/or frequency that represented the number of days per year and number of years that exposure occurs. This is used with a term known as the averaging time, which converts the daily exposure to an annual exposure. Carcinogenic health effects were calculated as an incremental lifetime cancer risk, and therefore represented the exposure duration (years) over the course of a potentially exposed individual's lifetime (70 years).

The estimation methods and models used in this section were consistent with current USEPA risk assessment guidance (USEPA, 1989a, 1991a). Exposure estimates associated with groundwater ingestion are presented below. RGOs were developed, with site-specific inputs, for groundwater COCs presented in the human health risk assessment. However, in order to determine if a medium at a site requires remediation, estimated RGOs were compared to site-specific contaminant levels. This assessment was conducted to assure that media and contamination at each site would be addressed on a site-specific basis. The following sections present the equations and inputs used in the estimation of groundwater RGOs developed for OU No. 4.

Ingestion of Groundwater

Currently there are no receptors who are exposed to potential groundwater contamination at Sites 41 and 74 since groundwater is obtained from "noncontaminated" supply wells, pumped to water treatment plants, and distributed via a potable water system. However, it is assumed for the purposes of calculating remediation goals, that potable wells would pump groundwater from the site area for public consumption. Groundwater ingestion RGOs are characterized using the following equation:

$$Cw = \frac{TR \ or \ THI*BW*AT_C \ or \ AT_{nc}*DY}{CSF \ or \ 1/RfD*EF*ED*IR}$$

Where:

Cw	=	contaminant concentration in groundwater (mg/L)
TR	=	total lifetime risk
THI	=	total hazard index
BW	=	body weight (kg)
AT_c	=	averaging time carcinogens (yr)
AT_{nc}	=	averaging time noncarcinogens (yr)
DY	=	days per year (day/year)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	reference dose (mg/kg-day)
EF	=	exposure frequency (day/year)
ED	=	exposure duration (yr)
IR	=	ingestion rate (L/day)

Future On-Site Residents

Exposure to COCs via ingestion of groundwater was retained as a potential future exposure pathway for both children and adults.

An ingestion rate (IR) of 1.0 liter/day was used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)]. An averaging time (AT) of 2,190 days (6 years x 265 days/year) is used for noncarcinogenic compound exposure.

The IR for adults was 2 liters/day (USEPA, 1989a). The exposure duration (ED) used for the estimation of adult CDIs was 30 years (USEPA, 1989a), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens was 10,950 days. An AT of 25,550 days (70 years x 365 days/year) was used to evaluate exposure for both children and adults to potential carcinogenic compounds.

Table 2-5 presents a summary of the input parameters for the ingestion of groundwater scenarios.

2.3.2.2 <u>Summary of Site-Specific Risk-Based Remediation Goal Options</u>

The risk-based RGOs for the cleanup of a specific medium are used in the FS to identify areas of concern. COCs were chosen based on available toxicity data and frequency of detection and available ARARs. RGOs were generated for contaminants with available toxicity data. Separate RGOs for future adult residents and children have been calculated. In addition, both carcinogenic and noncarcinogenic RGOs have been calculated. Calculations are provided in Appendix A of this report.

Ingestion of Groundwater

The groundwater ingestion RGOs were estimated for the groundwater at Site 41. Currently, there are no known receptors who are exposed to contaminated groundwater. Base personnel receive potable water via a base water distribution. However, a hypothetical future ingestion RGO was estimated for the COCs. In order to estimate conservative RGOs for subpopulations (i.e., adult resident and child resident), specific input variables were developed for each subpopulation. Tables 2-6 and 2-7 present the RGOs calculated for the carcinogenic and noncarcinogenic COCs in the groundwater, respectively.

2.4 Comparison of Remediation Goal Options to Maximum Contaminant Concentrations in Groundwater

Generally, RGOs are not required for a contaminant in a medium with a cumulative cancer risk of less than 1.0E-04, where a HI is less than or equal to 1.0, or where the RGOs are clearly defined by ARARs. In order to decrease uncertainties in the estimation of the reasonable maximum exposure (RME), which is the maximum exposure that is reasonably expected to occur at the site, the maximum concentration of a contaminant in a media can be compared to the estimated risk-based RGO if chemical-specific criteria are not available.

The carcinogenic and noncarcinogenic risk-based RGOs for groundwater ingestion with respect to future residential receptors (adult and children) are compared to the maximum groundwater contaminant concentrations detected at Site 41 from groundwater samples collected during the RI in Table 2-8. Additionally, the NCWQSs and MCLs are presented in this table.

2.4.1 Site 41

The maximum concentration of arsenic (53.5 µg/L), beryllium (37.4 µg/L), cadmium (37.5 µg/L), chromium (166 µg/L), and nickel (177 µg/L) exceeded the NCWQS, Federal MCL and the risk-based RGO estimated for these inorganics. Additionally, the maximum concentration of manganese (766 µg/L), lead (145 µg/L), and zinc (675 µg/L) exceed the NCWQS and Federal MCL established for each inorganic. These maximum concentrations are based on a data set in which the Round 2 sampling results were replaced with the low-flow sampling results for the wells that were sampled.

2.5 Uncertainty Associated with Risk-Based RGOs

The uncertainties associated with calculating risk-based RGOs are summarized below. The RGO estimations presented in this section are quantitative in nature, and their results are highly dependent upon the accuracy of the input. The accuracy with which input values can be quantified is critical to the degree of confidence that the decision maker has in the action levels.

Most scientific computation involves a limited number of input variables, which are tied together by a scenario to provide a desired output. Some RGO inputs are based on literature values rather than measured values. In such cases the degree of certainty may be expressed as whether the estimate was based on literature values or measured values, not on how well defined the distribution of the input was. Some RGOs are based on estimated parameters.

The toxicity factors, CSFs and RfDs, have uncertainties built into the assumptions used to calculate these values. Because the toxicity factors are determined from high doses administered to experimental animals and extrapolated to low doses to which humans may be exposed, uncertainties exist. Thus, toxicity factors could either overestimate or underestimate the potential effects on humans. However, because human data exists for very few chemicals, risks are based on these values. In addition, the exposure assumption (e.g., 10 events per year, etc.) also have uncertainties associated with them.

Although RGOs are believed to be fully protective for the RME individual(s), the existence of the same contaminants in multiple media or of multiple chemicals affecting the same population(s), may lead to a situation where, even after attainment of all RGOs, protectiveness is not fully achieved (i.e., cumulative risk may fall outside the risk range).

2.6 Remediation Levels

This section presents the remediation levels (RLs) chosen for Site 41 groundwater. RLs are chosen by the risk manager for the COCs and are addressed in the FS and the ROD. These numbers derived from the RGOs are no longer goals and should be considered required levels for the remedial actions to achieve, if possible.

The RLs associated with Site 41 are presented in Table 2-9. This list was based on a comparison of contaminant-specific ARARs (or ARAR-based RGOs) and the site-specific risk-based RGOs. If a COC had an ARAR, the most limiting (or conservative) ARAR was selected as the RL for that contaminant. If a COC did not have an ARAR, the most conservative risk-based RGO was selected for the RL.

In order to determine the final COCs for groundwater at Site 41, the maximum contaminant concentrations detected at each site (Table 2-8) were compared to the RLs presented in Table 2-9. The contaminants which exceeded at least one of the RLs have been retained as final COCs. The contaminants that did not exceed any of the RLs are no longer considered as COCs with respect to this FS. The final COCs for Site 41 and their associated RLs are presented in Table 2-10.

2.7 Areas of Concern Requiring Remediation and/or Institutional Controls

The results of the baseline human health RA and the ecological risk assessment were evaluated to determine the areas of concern (AOC) within OU No. 4 that may warrant remediation or institutional controls to protect the public health and the environment. This determination is presented below for each site.

2.7.1 Site 41 Areas of Concern

Shallow groundwater, seep surface water, and buried soil (including the landfill material and potential CWM) are media at Site 41 which could potentially pose unacceptable future human health or ecological risks. As mentioned previously, these media do not present unacceptable risks to human health or the environment, at present.

Shallow groundwater and seep surface water have been combined as one area of concern because of their hydraulic connection to one another (the seeps are believed to be groundwater discharge from the site). Shallow groundwater within the central portion of the former disposal area has exhibited elevated total metals (mainly lead, iron, and manganese) and to a limited degree, dissolved metals (primarily iron). Although there is no current human receptor associated with shallow groundwater, future potential exposure to groundwater could occur, albeit unlikely, under a residential land use scenario.

With respect to the seeps, ecological receptors that could be exposed to the seep discharges may be at risk. Seep surface water has exhibited total metals which exceed ambient water quality criteria for the protection of aquatic organism. However, due to the nature of the seeps, the seeps do not serve the purpose of providing an ecological habitat.

The impact of these seeps to the receiving stream, the unnamed tributary, does not appear to be problematic. The unnamed tributary provides a habitat for aquatic organisms, mammals, and reptiles. Surface water and sediment samples collected upstream and downstream of the seep discharges are similar to each other and to other streams throughout MCB Camp Lejeune. Although the unnamed tributary is not included as an area of concern, monitoring of this surface water should be considered as a part of the overall remedy at this site.

The following objectives have been identified for shallow groundwater and seep surface water at Site 41:

- Prevent future potential exposure to contaminated groundwater.
- Protect uncontaminated groundwater for future potential beneficial use.
- Restore contaminated groundwater for future potential beneficial use.
- Protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge.

For purposes of the FS, buried soil and the landfill material have been combined together to form a second AOC. These media do not currently pose an unacceptable risk to human health based on current land use, but may pose an unacceptable risk under a future potential scenario involving residential land use or construction. The baseline risk assessment did not result in any unacceptable risks to human health from exposure to soils since CWM or significant contaminant levels were not detected in soils at the site. However, the fact that the site may still contain CWM, not identified during the RI, results in a risk from a safety as well as a health standpoint.

The following remedial action objective has been identified for soil at Site 41:

- Prevent future potential exposure to buried contaminated soil and waste.

2.7.2 Site 74 Areas of Concern

Shallow groundwater and soil (including the landfill material and potential CWM) are media at Site 74 which could potentially pose unacceptable future human health risks. As mentioned previously, these media do not present unacceptable risks to human health or the environment, at present.

Shallow groundwater has exhibited elevated total metals (mainly lead, iron, and manganese) and to a limited degree, pesticides. Although there is no current human receptor associated with shallow groundwater, future potential exposure to groundwater could occur, albeit unlikely, under a residential land use scenario.

The following objective has been identified for shallow groundwater at Site 74:

- Prevent future potential use of the shallow groundwater.

Soil, including the landfill material, has also been identified as an AOC. Exposure to soil does not currently result in unacceptable human health risks, but may result in unacceptable risks under a future potential scenario involving residential land use or construction. The baseline risk assessment did not result in any unacceptable risks to human health from exposure to soils since CWM or significant contaminant levels were not detected in soils at the site. However, the fact that the site may still contain CWM, not identified during the RI, results in a risk from a safety as well as a health standpoint.

The following remedial action objective has been identified for soil at Site 74:

- Prevent future potential exposure to buried contaminated soil and waste.

A summary of the AOCs for Sites 41 and 74 to be addressed in this FS is provided in Table 2-11.

SECTION 2.0 TABLES

TABLE 2-1

CONTAMINANTS OF CONCERN
OPERABLE UNIT NO. 4
SITES 41 AND 74
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment	
	41	74	41	74	41	74	41	74	41	74
Volatile Organic Compounds										
Trichloroethene		X							X	X
Toluene									X	
Chlorobenzene					X		X			
Total 1,2-Dichloroethene					X					
Acetone									X	
Methylene Chloride									X	
Semivolatile Organic Compounds										
Bis(2-chloroethyl)ether	X									
Di-n-Octylphthalate									X	
Di-n-Butylphthalate									X	
3,3-Dichlorobenzidine										X
Ordnance										
1,3,5-Trinitrobenzene									X	
Polycyclic Aromatic Hydrocarbons										
Anthracene	X									
Benzo(a)anthracene	X									
Benzo(a)pyrene	X		X						X	
Benzo(b)fluoranthene	X								X	
Benzo(g,h,i)perylene	X		X							
Benzo(k)fluoranthene	X								X	
Chrysene	X									
Fluoranthene	X		X						X	
Phenanthrene	X		X							
Pyrene	X		X						X	
Naphthalene			X							
2-Methylnaphthalene			X							

TABLE 2-1 (Continued)

CONTAMINANTS OF CONCERN
OPERABLE UNIT NO. 4
SITES 41 AND 74
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment	
	41	74	41	74	41	74	41	74	41	74
Pesticides/PCBs										
Heptachlor	X	X	X	X		X				
Heptachlor Epoxide	X	X	X							
Dieldrin	X	X	X						X	
4,4'-DDE	X	X	X	X					X	X
4,4'-DDT	X	X	X	X			X		X	X
4,4'-DDD	X	X	X	X					X	
Endrin Aldehyde	X	X	X							X
alpha-Chlordane	X	X	X			X			X	
gamma-Chlordane	X	X	X						X	
gamma-BHC							X			
Endosulfan II	X		X			X			X	X
Aldrin			X							
Endrin			X							
Endosulfan I			X							
PCB-1254			X						X	
PCB-1260			X							
PCB-1242									X	
alpha-BHC					X					
Methoxychlor									X	X
Endrin Ketone									X	
Inorganics										
Arsenic	X	X	X	X	X	X			X	
Barium	X	X	X	X	X	X	X		X	X
Beryllium	X		X		X	X			X	
Cadmium	X				X					
Cobalt					X					
Chromium	X	X	X	X	X	X	X		X	X
Copper	X		X						X	
Lead	X		X		X	X	X	X	X	X
Nickel	X	X			X				X	
Manganese	X	X	X	X	X	X	X		X	X

TABLE 2-1 (Continued)

CONTAMINANTS OF CONCERN
OPERABLE UNIT NO. 4
SITES 41 AND 74
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment	
	41	74	41	74	41	74	41	74	41	74
Inorganics (continued)										
Mercury	X		X				X		X	
Selenium		X			X				X	
Thallium									X	
Vanadium	X	X	X	X	X	X			X	X
Zinc	X	X	X	X	X	X	X		X	X
Cyanide		X	X	X						

X - Selected as risk-based and/or criteria-based COC

TABLE 2-2

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 4 MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL/CONTAMINANT-SPECIFIC		
Safe Drinking Water Act a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing remediation levels for contaminated groundwater used as a potable water supply.
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, trichloroethylene, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.

TABLE 2-2 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA
OPERABLE UNIT NO. 4
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
National Ambient Air Quality Standards (40 CFR 50)	Standards for the following six criteria pollutants: particulate matter; sulfur dioxide; carbon monoxide; ozone; nitrogen dioxide; and lead. The attainment and maintenance of these standards are required to protect the public health and welfare.	Not enforceable and therefore not an ARAR. May be a TBC for excavation activities.
EPA Ambient Water Quality Criteria (Section 304(a)(1) of CWA)	Non-enforceable criterion for water quality for the protection of human health from exposure to contaminants in drinking water and from ingestion of aquatic biota and for the protection of fresh-water and salt-water aquatic life.	Potentially relevant and appropriate for discharge of treated groundwater to a surface water.
STATE/CONTAMINANT-SPECIFIC		
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2B.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina	Surface water quality standards based on water use and criteria class of surface water.	Relevant and appropriate for remedial actions requiring discharge to surface water.
North Carolina Anti-Degradation Policy for Surface Water (Water Quality Standards Title 15A, Chapter 2, Subchapter 2B)	Provides for an anti-degradation policy for surface water quality. Pursuant to this policy, the requirements of 40 CFR 131.12 are adopted by reference in accordance with General Statute 150B-14(b).	This policy is a TBC requirement for remedial actions requiring discharge to surface water.
State of North Carolina Department of Environment, Health and Natural Resources Division of Environmental Management 15A NCAC 2L.0200 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina	Establishes groundwater classifications and maximum contaminant concentrations to protect groundwater. These standards are mandatory.	Potentially relevant and appropriate for remedial actions requiring discharge to groundwater.

TABLE 2-2 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA
OPERABLE UNIT NO. 4
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina DEHNR Toxic Air Pollutant Rule Statutory Authority G.S. 143-215.107(a)(1),(3),(4),(5); 143-B-282	A facility shall not emit any toxic air pollutants (as listed in Rule .1104) that may cause or contribute beyond the premises (contiguous property boundary) to any significant ambient air concentration that may adversely affect human health.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.

TABLE 2-3

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Historic Preservation Act of 1966 - requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	No known historic properties are within or near OU No. 4, therefore, this act will not be considered as an ARAR.
Archeological and Historic Preservation Act - establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	16 USC 469 and 40 CFR 6.301(c)	No known historical or archeological data is known to be present at the sites, therefore, this act will not be considered as an ARAR.
Historic Sites, Buildings and Antiquities Act - requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	16 USC 461467 and 40 CFR 6.301(a)	No known historic sites, buildings or antiquities are within or near OU No. 4, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act - requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	16 USC 661-666	Tank Creek and the Unnamed Tributory to Tank Creek are located near and/or within the Site 41 boundaries. If remedial actions are implemented that modify these creeks, this will be an applicable ARAR.
Federal Endangered Species Act - requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	16 USC 1531, 50 CFR 200, and 50 CFR 402	Many protected species have been cited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991),(Fussell, 1991),(Walters, 1991). In addition, the alligator has been sighted on Base. Therefore, this will be considered as an ARAR.

TABLE 2-3 (Continued)

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
North Carolina Endangered Species Act - per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rate species, and the State watch list.	GS 113-331 to 113-337	Since the American alligator has been sighted within MCB Camp Lejeune, this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) - requires permit for structures or work in or affecting navigable waters.	33 USC 403	There are no navigable waters in the vicinity of Sites 41 and 74. Therefore, this act will not be considered as an ARAR.
Executive Order 11990 on Protection of Wetlands - establishes special requirements for Federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Executive Order Number 11990, and 40 CFR 6	Based on a review of Wetland Inventory Maps, Site 41 is surrounded by wetlands. Therefore, this will be an applicable ARAR.
Executive Order 11988 on Floodplain Management - establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Executive Order Number 11988, and 40 CFR 6	Based on the Federal Emergency Management Agency's Flood Insurance Rate Map for Onslow County, OU No. 4 is primarily within a minimal flooding zone (outside the 500-year floodplain). The immediate areas around Tank Creek and the Unnamed Tributary to Tank Creek are within the 100-year floodplain (FEMA, 1987). Therefore, this may be an ARAR for Site 41.

TABLE 2-3 (Continued)

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
Wilderness Act - requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	16 USC 1131 and 50 CFR 35.1	No known federally owned wilderness areas near the operable unit, therefore, this act will not be considered as an ARAR.
National Wildlife Refuge System - restricts activities within a National Wildlife Refuge.	16 USC 668 and 50 CFR 27	No known National Wildlife Refuge areas near the operable unit, therefore, this will not be considered as an ARAR.
Scenic Rivers Act - requires action to avoid adverse effects on designated wild or scenic rivers.	16 USC 1271 and 40 CFR 6.302(e)	No known wild or scenic rivers near the operable unit, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act - requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	16 USC 1451	No activities will affect land or water uses in a coastal zone, therefore, this act will not be considered as an ARAR.
Clean Water Act (Section 404) - prohibits discharge of dredged or fill material into wetland without a permit.	33 USC 404	No actions to discharge dredged or fill material into wetlands will be considered for the operable unit, therefore, this act will not be considered as an ARAR.
RCRA Location Requirements - limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	40 CFR 264.18	These requirements may be relevant and appropriate if the remedial actions for the operable unit include the on-site storage, treatment, or disposal of RCRA hazardous waste for more than a 90-day period. On-site storage treatment or disposal of RCRA hazardous waste is not anticipated. Therefore, these requirements will not be considered an ARAR.

TABLE 2-4

POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OPERABLE UNIT NO. 4
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ACTION-SPECIFIC		
DOT Rules for Hazardous Materials Transportation (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Remedial actions may include off-site treatment and disposal of contaminated soil or waste. Applicable for any action requiring off-site transportation of hazardous materials.
Resource Conservation and Recovery Act (RCRA) Subtitle C		
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Primary site contaminants are not considered to be listed wastes. However, contaminated media may be considered hazardous by characteristic.
Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262-265, and 266)	Regulates the treatment, storage, and disposal of hazardous waste.	During remediation, treatment, storage, and disposal activities may occur. Materials may be classified as hazardous wastes.
RCRA Subtitle D	Regulates the treatment, storage, and disposal of solid waste and materials designated by the State as special waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid and/or special waste.
RCRA Land Disposal Restrictions (LDRs) Requirements (40 CFR Part 268)	Restricts certain listed or characteristic hazardous waste from placement or disposal on land (includes injection wells) without treatment. Provides treatment standards and Best Demonstrated Available Technology (BAT).	LDRs may prohibit or govern the implementation of certain remedial alternatives. Excavation and treatment, disposal, or movement of RCRA hazardous waste out of the area of contamination may trigger LDR requirements for the waste.
Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0-28)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	Remedial actions involving air stripping are not anticipated. Therefore this guidance will not be considered.

TABLE 2-4 (Continued)

POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OPERABLE UNIT NO. 4
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section .0100)	Regulates point-source discharges through the North Carolina permitting program. Substantive requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	May be applicable for actions requiring discharge of treated groundwater to surface water.
Protection of Archaeological Resources (32 CFR Parts 229 and 229.4; 43 CFR Parts 107 and 171.1-5)	Develops procedures for the protection of archaeological resources.	Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and State archaeologists.
North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A)	Regulates stormwater management and erosion/sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities (i.e., excavation of soil and waste).
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2L.0106 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina, Corrective Action	Regulates corrective actions taken to restore contaminated groundwater or terminate and control the discharge of a waste, hazardous substance, or oil to groundwaters of the state.	May be applicable to groundwater remedial actions and institutional controls.

TABLE 2-5

INGESTION OF GROUNDWATER
RGO PARAMETERS
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Ingestion of Groundwater Input Parameters			
Input Parameter	Description	Value	Rationale
C_w	Exposure Concentration	Calculated	USEPA, 1989a
TR	Total Lifetime Risk	1.0E-04	USEPA, 1991a
THI	Total Hazard Index	1.0	USEPA, 1991a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 70 yr	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 6 yr Adult 30 yr	USEPA, 1989a
DY	Days Per Year	365 days/yr	USEPA, 1989a
CSF	Carcinogenic Slope Factor	Chemical Specific	IRIS, HEAST, USEPA
RfD	Reference Dose	Chemical Specific	IRIS, HEAST, USEPA
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child 6 yr Adult 30 yr	USEPA, 1991b
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, 1989a

TABLE 2-6

INGESTION OF GROUNDWATER CARCINOGENIC RGOs
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Carcinogenic RGO	
	Adult Resident	Child Resident
Trichloroethene	774	1,659
1,1,2,2-Tetrachloroethane	43	91
4,4'-DDD	35	76
Arsenic	5	11
Beryllium	2	4

Notes: RGO = Remedial Goal Options
Remediation Goal Options concentrations expressed in μg/L (ppb).
Remediation Goal Options based on a risk of 1.0E-04.

TABLE 2-7

INGESTION OF GROUNDWATER NONCARCINOGENIC RGOs OPERABLE UNIT NO. 4 FEASIBILITY STUDY CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic RGO	
	Adult Resident	Child Resident
Arsenic	11	5
Barium	2,555	1,095
Beryllium	183	78
Cadmium	18	8
Chromium	183	78
Copper	1,354	580
Nickel	730	313
Manganese	183	78
Mercury	11	5
Selenium	183	78
Vanadium	256	110
Zinc	10,950	4,693

Notes: RGO = Remedial Goal Options
Remediation Goal Options concentrations expressed in µg/L (ppb).
Remediation Goal Options based on a risk of 1.0E-04.

TABLE 2-8

COMPARISON OF GROUNDWATER INGESTION RISK-BASED RGOs AND GROUNDWATER CRITERIA TO MAXIMUM GROUNDWATER CONTAMINANT LEVELS AT SITE 41
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	NCWQS(1)	Federal MCL(2)	RGO(3)		Maximum Groundwater Concentration (4)
			Adult	Child	Site 41
Arsenic	50	50	5	11	53.5
Barium	2,000	2,000	2,555	1,095	836
Beryllium	NE	4	2	4	37.4
Cadmium	5	5	18	8	37.5
Chromium	50	100	183	78	166
Lead	15	15(5)	NE	NE	145
Manganese	50	50(4)	5,110	2,190	766
Nickel	100	100	11	5	177
Selenium	50	50	183	78	10.3
Vanadium	NE	NE	256	110	179
Zinc	2,100	5,000(4)	10,950	4,693	675

Notes: Concentrations expressed in microgram per liter (μg/L).
(1) NCWQS = North Carolina Water Quality Standards for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) RGO = Risk-based Remediation Goal Options
(4) Data shown reflect a replacement of Round 2 sampling results with low-flow sampling results.
(5) SMCL = Secondary Maximum Contaminant Level
(6) Action Level
NE = No Criteria Established
ND = Not Detected

TABLE 2-9

GROUNDWATER REMEDIATION LEVELS FOR COCs
SITE 41
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL[1]	Basis of Goal	Corresponding Risk
Arsenic	50	NCWQS[2]	
Barium	2,000	NCWQS	
Beryllium	4	MCL[3]	
Cadmium	5	NCWQS	
Chromium	50	NCWQS	
Lead	15	NCWQS	
Manganese	50	NCWQS	
Nickel	100	NCWQS	
Selenium	50	NCWQS	
Vanadium	110	ICR-Ingestion	HI[5] = 1.0
Zinc	2,100	NCWQS	

Notes: [1] RL = Remediation Level
Groundwater/expressed as μg/L (ppb).
[2] NCWQS = North Carolina Water Quality Standard
[3] MCL = Maximum Contaminant Level
[4] ICR = Incremental Cancer Risk
[5] HI = Hazard Index

TABLE 2-10

GROUNDWATER COCs THAT EXCEEDED REMEDIATION LEVEL AT SITE 41 FEASIBILITY STUDY CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL[1]
Arsenic	50
Beryllium	4
Cadmium	5
Chromium	50
Lead	15
Nickel	100

Notes: [1] RL = Remediation Level
Groundwater RLs expressed as μg/L (ppb).

TABLE 2-11

REMEDIAL ACTION OBJECTIVES FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Site	Media	Remedial Action Objective
Site 41	Shallow Groundwater and Seep Surface Water	• Prevent future potential exposure to contaminated groundwater. • Protect uncontaminated groundwater for future potential beneficial use. • Restore contaminated groundwater for future potential beneficial use. • Protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge.
	Soil and Waste (Landfilled Material)	• Prevent future potential exposure to buried contaminated soil and waste.
Site 74	Shallow Groundwater	• Prevent future potential exposure to contaminated groundwater.
	Soil and Waste (Landfilled Material)	• Prevent future potential exposure to buried contaminated soil and waste.

3.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES

This section includes the identification and preliminary screening of remedial action technologies that may be applicable for the remediation of the groundwater and soils at OU No. 4. Section 3.1 identifies a set of general response actions which correspond to the remedial action objectives. Section 3.2 identifies a set of remedial technologies and process options applicable to groundwater and soil. Section 3.3 presents the preliminary screening of the remedial technologies and process options. Section 3.4 presents a summary of the preliminary screening, and Section 3.5 presents the process option evaluation.

3.1 <u>General Response Actions</u>

General response actions are broad-based medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. The general response actions that will satisfy the remedial action objectives identified for OU No. 4 are listed in Table 3-1. As shown on the table, six general response actions have been identified for the groundwater objectives: no action, institutional controls, containment actions, collection/discharge, in situ treatment, and physical/chemical treatment actions. Five general response actions have also been identified for the soil objectives: no action, institutional controls, in situ treatment, removal, and containment.

A brief description of each of the above-mentioned general response actions follows.

3.1.1 No Action

The NCP requires the evaluation of the no action response action as part of the FS process. A no action response provides the baseline assessment for the comparison with other remedial alternatives that have a greater level of response. A no action alternative may be considered appropriate when there is no adverse or unacceptable risks to human health or the environment, or when the response action may cause a greater environmental or health danger than the no action alternative itself.

3.1.2 Institutional Controls

Institutional controls are actions that can be implemented at a site as part of a complete remedial alternative to minimize exposure to potential hazards. With respect to groundwater, institutional controls may include monitoring programs or ordinances which restrict placement of supply wells. With respect to soil, institutional controls may include monitoring, access restrictions, and deed restrictions.

3.1.3 Containment Actions

Containment measures include various technologies which contain and/or isolate the contaminants at a site. Containment measures are designed to isolate so as to prevent direct exposure with or migration of the contaminated media without disturbing or removing the waste from the site. Containment actions generally serve to cover, seal, chemically stabilize, or provide an effective barrier against specific areas of contamination. Although these actions may be considered applicable to both media of concern (soil and groundwater) at OU No. 4, they have been included under the groundwater category for technology evaluation purposes.

3.1.4 Collection/Discharge Actions

Collection/discharge actions are typically associated with groundwater or surface water. For this FS, groundwater collection/discharge actions at Site 41 will be addressed. For groundwater, collection actions may include extraction wells or subsurface drains. Discharge actions are those means for discharging groundwater that has been treated.

3.1.5 Removal Actions

Removal actions involve the excavation of soil or drums using mechanical equipment for subsequent treatment and/or disposal. For this FS, removal actions are limited due to the suspected CWM at each site.

3.1.6 Treatment Actions

3.1.6.1 Ex Situ Treatment

Ex situ treatment actions would involve physical and/or chemical means of reducing the toxicity or destroying contaminants that are present in soil or groundwater. Treatment actions at OU No. 4 would only be applicable to the groundwater once it has been collected via either extraction wells or subsurface drains. Treatment actions that involve extensive excavation cannot be implemented for soil at the former disposal areas due to the presence of suspected CWM. Treatment actions for groundwater are normally conducted on site, but off-site treatment actions are also considered.

3.1.6.2 In Situ Treatment

In situ treatment takes place without excavation (applicable to soil) or extraction (applicable to groundwater). In situ treatment could be performed chemically, biologically, or physically. For this FS, soil treatment actions are limited to in situ actions due to the suspected CWM within the site dumps. The U.S. Army has advised the base that CWM, which is buried but does not pose a human health or ecological risk if not disturbed, not be removed because of the high risks to human health involved.

3.2 Identification of Remedial Action Technologies and Process Options

In this step, an extensive set of potentially applicable technology types and process options will be identified for each of the general response actions identified for the media of concern at OU No. 4. The term "technology type" refers to general categories of technologies such as chemical treatment, thermal treatment, biological treatment, and in situ treatment. The term "technology process option" refers to specific processes within each technology type, for example, rotary kiln, fluidized bed, and multiple hearth incineration are process options of thermal treatment. Several technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Remedial action technologies potentially applicable to OU No. 4 are listed in Table 3-2 with respect to their corresponding general response action. The applicable process options associated with each of the listed technologies are also listed on the table.

3.3 Preliminary Screening of Remedial Action Technologies and Process Options

In this step, the set of remedial action technologies and process options identified in the previous section will be reduced (or screened) by evaluating the technologies with respect to technical implementability and site-specific factors. This screening step is site-specific and will be accomplished by using readily available information from the RI with respect to contaminant types, contaminant concentrations and on-site characteristics to screen out technologies and process options that cannot be effectively implemented at the site (USEPA, 1988a). In general, all technologies/options which appear to be applicable to the site contaminants and to the site conditions will be retained for further evaluation. The preliminary screening is presented in Tables 3-3 and 3-4 for groundwater and soil, respectively. Each of the process options remaining following the preliminary screening will be evaluated in Section 3.4.

As shown in Tables 3-3 and 3-4, several technologies and/or process options were eliminated from further evaluation since they were determined to be inappropriate for the site-specific characteristics and/or contaminant-specific characteristics of OU No. 4. The groundwater technologies/options that were eliminated include:

- Deed Restrictions
- Capping
- Vertical Barriers
- Horizontal Barriers
- Reverse Osmosis
- Oil/Water Separation
- Air Stripping
- Steam Stripping
- Carbon Adsorption
- Biological Treatment
- Chemical Dechlorination
- Thermal Treatment
- Off-Site Treatment (Base STP)
- Off-Site Treatment (RCRA Facility)
- Off-Site Treatment (POTW)
- In Situ Treatment
- Off-Site Discharge (POTW)
- Off-Site Discharge (Base STP)

Although a capping is often considered for former landfill sites, a capping technology was not retained because of implementability and effectiveness concerns. Results of the human health risk assessment indicate that the surface soils currently do not pose an unacceptable risk to base personnel. Therefore, a cap is not necessary to eliminate contact with the surface soil. Installation of a low-permeability cap would require extensive clearing, grubbing, and regrading activities that would disturb the landfill contents. Since the landfill may contain CWM and other hazardous wastes, implementation of a cap would pose a significant risk to human health and the environment during construction. Furthermore, because the sites are heavily vegetated and tree-covered, regrowth of vegetation following cap installation could puncture the cap causing a long-term operational concern. Control of vegetation regrowth could require the application of an herbicide, which could pose additional environmental and human health risks. Finally, the waste materials are not underlain by a continuous low-permeability liner, and the water table is very close to the ground surface. These conditions would limit the ability of cap to protect groundwater. Any contaminants present in the landfills could continue to leach to groundwater even after the cap is installed. For these reasons, capping technologies were eliminated from further consideration.

The only soil technology/option that was eliminated is deed restrictions.

The technologies and process options that passed this preliminary screening are listed in Table 3-5.

3.4 Process Options Evaluation

The objective of the process option evaluation is to select only one process option for each applicable remedial technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. More than one process option may be selected for a technology type if the processes are sufficiently different in their performance that one would not adequately represent the other. The representative process provides a basis for developing performance specifications during preliminary design; however the specific process option used to implement the remedial action may not be selected until the remedial design phase.

The process options listed in Table 3-5 were evaluated based on effectiveness, implementability, and relative cost. The effectiveness evaluation focussed on: the potential effectiveness of process options in meeting the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phase; and how reliable the process is with respect to the contaminants of concern. The implementability evaluation focussed on the administrative feasibility of implementing a technology as well as the technical implementability. The cost evaluation played a limited role in this screening. Only relative capital and operating and maintenance (O&M) costs were used instead of detailed estimates. Per the USEPA FS guidance, the cost analysis was made on the basis of engineering judgment.

A summary of the process option evaluation is presented in Tables 3-6 and 3-7 for groundwater and soil, respectively. It is important to note that the elimination of process option does not mean that the process option/technology can never be reconsidered for the site. As previously stated, the purpose of this part of the FS process is to simplify the development and evaluation of potential alternatives.

Table 3-8 identifies the final set of feasible technologies/process options that will be used to develop potential remedial alternatives in Section 4.0.

SECTION 3.0 TABLES

TABLE 3-1

GENERAL RESPONSE ACTIONS FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Area of Concern	Remedial Action Objective	General Response Action
Groundwater	Site 41 - Shallow Groundwater and Seep Surface Water (Site 41, AOC No. 1)	1. Prevent future potential exposure to contaminated groundwater. 2. Protect uncontaminated groundwater for future potential beneficial use. 3. Restore contaminated groundwater for future potential beneficial use. 4. Protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge.	• No Action • Institutional Controls • Containment Actions • Collection/Discharge • Physical/Chemical Treatment
	Site 74 - Shallow Groundwater (Site 74, AOC No. 1)	1. Prevent future potential exposure to contaminated groundwater.	• No Action • Institutional Controls
Soil	Site 41 - Soil and Landfill Material (Site 41, AOC No. 2)	1. Prevent future potential exposure to buried contaminated soil and waste.	• No Action • Institutional Controls
	Site 74 - Soil and Landfill Material	1. Prevent future potential exposure to buried contaminated soil and waste.	• No Action • Institutional Controls

TABLE 3-2

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 4
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring
		Aquifer-Use	Restrictions in Base Master Plan
			Deed Restrictions
	Containment Actions	Capping	Clay/Soil Cap
			Asphalt/Concrete Cap
			Soil Cover
			Multilayered Cap
		Vertical Barriers	Grout Curtain
			Slurry Wall
			Sheet Piling
			Rock Grouting
		Horizontal Barriers	Grout Injection
			Block Displacement
		Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Collection/Discharge Actions	Extraction	Extraction Wells
			Extraction/Injection Wells
		Subsurface Drains	Interceptor Trenches
		On-Site Discharge	Reinjection
			Infiltration Galleries
			Surface Water
		Off-Site Discharge	POTW
			Base STP
			Surface Water
	Treatment Actions	Biological Treatment	Aerobic
			Anaerobic
		Physical/Chemical Treatment	Air Stripping
			Steam Stripping
			Carbon Adsorption
			Reverse Osmosis
			Ion Exchange
			Chemical Reduction
			Chemical Oxidation
			Electrochemical Iron Generation

TABLE 3-2 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 4 FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater (Cont.)	Treatment Actions (Cont.)	Physical/Chemical Treatment (Cont.)	Neutralization
			Precipitation
			Oil/Water Separator
			Filtration
			Flocculation
			Sedimentation
			Chemical Dechlorination
		Engineered Wetland Treatment	Constructed Wetlands
		Off-Site Treatment	POTW
			RCRA Facility
			Sewage Treatment Plant
		In-Situ Treatment	Biodegradation
			Air Sparging
			In-Well Aeration
Soil	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Monitoring
		Access Restrictions	Restrictions in Base Master Plan
			Deed Restrictions
			Fencing

TABLE 3-3

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No action - contaminated groundwater remains as is.	Potentially applicable to any site; required by the NCP.	Retained
Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring	Ongoing monitoring of groundwater or surface water.	Potentially applicable.	Retained
	Aquifer-Use Restrictions	Restrictions in Base Master Plan	Prohibit the use of the contaminated aquifer as a drinking water source.	Potentially applicable.	Retained
		Deed Restrictions	Limit the future use of land including placement of wells.	Not applicable to a military installation not on closure list.	Eliminated
Containment Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Soil Cover Multilayered Cap	Capping material placed over areas of contamination. Would be used in conjunction with vertical barriers.	Not implementable since regrading and construction activities may result in exposure to CWM. Not applicable for contaminated groundwater based on depth of the contamination, site hydrology, and lack of impermeable liner.	Eliminated
	Vertical Barriers	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to contain contamination.	The heterogeneity of the fill material at the sites may prevent a "gap-free" curtain. No continuous confining layer under the sites to which the wall should adjoin.	Eliminated
		Slurry Wall	Trench around areas of contamination. The trench is filled with a soil bentonite slurry to limit migration of contaminants.	The heterogeneity of the fill material at the sites may prevent a "gap-free" curtain. No continuous confining layer under the sites to which the wall should adjoin.	Eliminated
		Sheet Piling	Interlocking sheet pilings installed via drop hammer around areas of contamination.	No continuous confining layer under the sites to which the wall should adjoin.	Eliminated
		Rock Grouting	Specialty operation for sealing fractures, fissures, solution cavities, or other voids in rock to control flow of groundwater.	No rock at the sites.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Containment Actions (Continued)	Horizontal Barriers	Grout Injection	Pressure injection of grout to form a bottom seal across a site at a specific depth.	Technique is in the experimental stage. Depth of the contaminated groundwater at the sites would limit its use.	Eliminated
		Block Displacement	Continued pumping of grout into specially notched holes causing displacement of a block of contaminated earth.	Depth of contaminated groundwater would limit its use. Technique is in the experimental stage.	Eliminated
	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater.	Depth of the contaminated groundwater will limit its use. Applicable to only the shallow groundwater. May not be effective in containing existing vertical migration in the Castle Hayne.	Retained
Collection Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater at a pumping rate which would create a cone of influence sufficient to contain contaminant migration.	Potentially applicable	Retained
		Extraction/Injection Wells	Injection wells inject uncontaminated groundwater to enhance collection of contaminated groundwater via the extraction wells. Or the injection wells can also inject material into an aquifer to remediate groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater.	Depth of the contaminated groundwater will limit its use. Applicable to only the shallow groundwater. May not be effective in containing existing vertical migration in the Castle Hayne.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions	Biological Treatment	Aerobic	Degradation of organics using microorganisms in an aerobic environment.	Not applicable to inorganic contaminants of concern.	Eliminated
		Anaerobic	Degradation of organics using microorganisms in an anaerobic environment.	Not applicable to inorganic contaminants of concern.	Eliminated
	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air. Applicable to volatile organics.	Not applicable to inorganic contaminants of concern.	Eliminated
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air. Applicable to a wide range of organics.	Not applicable to inorganic contaminants of concern.	Eliminated
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to wide range of organics.	Not applicable to inorganic contaminants of concern.	Eliminated
		Reverse Osmosis	Using high pressure to force water through a membrane leaving contaminants behind. Applicable to dissolved solids (organic and inorganic).	Not applicable for most of the constituents of concern.	Eliminated
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Applicable for inorganics, not organics.	Potentially applicable	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility.	Not applicable to metals of concern.	Eliminated
		Chemical Oxidation	Addition of an oxidizing agent to raise the oxidation state of a substance. Applicable to some metals, primarily iron and manganese.	Potentially applicable	Retained
		Electrochemical Iron Generation	Electrical currents are used to put ferrous and hydroxyl ions into solution for subsequent removal via precipitation. Applicable to metals removal.	Potentially applicable	Retained
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. Applicable to acidic or basic waste streams.	Although pH is not a concern at the operable unit, neutralization may be applicable in a treatment train with precipitation.	Retained
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Potentially applicable.	Retained
		Oil/Water Separation	Materials in solution are transferred into a separate phase for removal. Applicable to petroleum hydrocarbons.	Not necessary for the contaminants of concern. No free phase product detected at the sites.	Eliminated
		Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Potentially applicable.	Retained
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. applicable to suspended solids.	Potentially applicable	Retained
		Chemical Dechlorination (KPEG)	Process which uses specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to toxify them to form other less harmful compounds. Applicable to PCBs, chlorinated hydrocarbons and dioxins.	Not applicable to the groundwater contaminants of concern.	Eliminated
	Thermal Treatment	Incineration • Rotary Kiln • Fluidized Bed	Combustion of waste at high temperatures. Different incinerator types can be applicable to pumpable organic wastes, combustible liquids, soils, slurries, or sludges.	Not implementable on groundwater waste streams due to volume of groundwater.	Eliminated
	Engineered Wetland Treatment	Constructed Wetlands	An engineered complex of plants, substrates, water, and microbial populations. Contaminants are removed via plant uptake, biodegradation (organics only), precipitation, and sorption processes.	Potentially applicable at Site 41.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Off-site Treatment	POTW	Extracted groundwater discharged to Jacksonville POTW for treatment.	Not implementable since this POTW will not accept contaminated groundwater.	Eliminated
		RCRA Facility	Extracted groundwater discharged to licensed RCRA facility for treatment and/or disposal.	Not implementable due to large volume of groundwater.	Eliminated
		Sewage Treatment Plant	Extracted groundwater discharged to Base STP for treatment.	Not implementable since Base STP cannot effectively treat contaminants of concern.	Eliminated
	In Situ Treatment	Biodegradation	System of introducing nutrients and oxygen to waste for the stimulation or augmentation of microbial activity to degrade contamination. Applicable to a wide range of organic compounds.	Not applicable to contaminants of concern.	Eliminated
		Air Sparging	The injection of air under pressure in groundwater to remove VOCs via volatilization. Air bubbles migrate into the vadose zone where they can be extracted or treated by other methods. Introduction of air also may promote degradation of contaminants through biological transformation.	Not applicable to contaminants of concern.	Eliminated
		Dual-Phase Vacuum Extraction	Extraction of a two-phase air-water stream under high vacuum using wells screened above and below the water table. Developed for low-permeability soils and low-conductivity aquifers, where submersible pumps yield little or no water and simultaneous treatment of soil and groundwater is desired.	Not applicable to contaminants of concern.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	In Situ Treatment (Continued)	In-Well Aeration (a.k.a. vacuum vaporizer well, in-situ air stripping)	Process of inducing air into a well by applying a vacuum. Results in an in-well airlift pump effect that serves to strip volatiles from groundwater inside the well. Can be considered a type of air sparging. Can also be used to remediate soil.	Not applicable to contaminants of concern.	Eliminated
Discharge Actions	On-Site Discharge	Reinjection • Injection Wells • Infiltration Galleries	Treated water reinjection into the site aquifer via use of shallow infiltration galleries (trenches) or via deep injection wells.	Deep injection wells potentially applicable. Site geology and low water table may prohibit the use of infiltration galleries.	Retained
		Surface Water	Treated water discharged to the unnamed tributary or Tank Creek.	Potentially applicable at Site 41.	Retained
	Off-Site Discharge	POTW	Treated water discharged to Jacksonville POTW.	Not implementable due to distance	Eliminated
		Base STP	Treated water discharged to closest Base STP.	Not implementable due to distance.	Eliminated

TABLE 3-4

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No Action - contaminated soil remains untreated.	Potentially applicable to any site; required by NCP.	Retained
Institutional Controls	Monitoring	Monitoring	Periodic sampling and analyses.	Potentially applicable	Retained
	Access Restrictions	Restrictions in Base Master Plan	Limit future land use in areas with potential soil contamination.	Potentially appplicable	Retained
		Deed Restrictions	Limit future land use in areas with potential soil contamination.	Not applicable to a military installation not on base closure list.	Eliminated
		Fencing	Limit access by installing fencing around contaminated areas.	Potentially applicable.	Retained

TABLE 3-5

POTENTIAL SET OF POTENTIAL TECHNOLOGIES/PROCESS OPTIONS
THAT PASSED THE PRELIMINARY SCREENING
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring
		Aquifer-Use Restrictions	Restrictions in Base Master Plan
	Containment/Collection Actions	Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Treatment Actions	Physical/Chemical Treatment	Ion Exchange
			Chemical Oxidation
			Electrochemical Iron Generation
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
		Engineered Wetland Treatment	Constructed Wetlands
	Discharge Actions	On-Site Discharge	Injection Wells
			Pipeline to Tank Creek
Soils	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Monitoring
		Access Restrictions	Restrictions in Base Master Plan
			Fencing

TABLE 3-6

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
No Action	No Action	Not Applicable	• Evaluation not necessary since only one process option	• Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Retained
Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring	• Effective in evaluating groundwater conditions due to treatment or to monitor migration over time	• Easily implemented	Low O&M; no capital	Retained
	Aquifer-Use Restrictions	Restrictions in Base Master Plan	• Effective in preventing future potential exposure to contaminated groundwater	• Easily implemented	Negligible Cost	Retained
Collection/ Containment Actions	Extraction	Extraction Wells	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation	• Easily implemented • Equipment readily available • No permits requires	Low to moderate capital; low O&M	Retained
	Subsurface Drains	Interceptor Trenches	• Effective for collecting a contaminated groundwater plume • Potential exposures to unknown buried wastes during implementation • Applicable for only shallow groundwater plumes • Slower recovery than extraction wells • More effective for low permeability soils than extraction wells	• Equipment readily available • Requires extensive excavation/ trenching • Requires more area than extraction wells • May require handling and treatment of contaminated soil and/or waste material.	Moderate capital; low O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Cost	Evaluation Results
Treatment Actions	Physical/ Chemical Treatment	Carbon Adsorption	• Can potentially meet effluent goals • Applicable to a wide variety of organics and inorganics • Can be used as a polishing step following air stripping • Proven and widely used technology	• Equipment readily available • Many fabricated mobile units available • May require bench-scale testing • Spent carbon must be properly handled	Moderate capital; low to high O&M (depending on contaminant loading requirements)	Retained
		Ion Exchange	• Effective and reliable; proper pretreatment required • Typically used as a polishing step for removal of selected dissolved metals • Insensitive to variations in flow rates • Pretreatment for oil and grease required	• Full-scale industrial use for recovery of valuable metals • Equipment is widely available • Regeneration solutions are generally readily available • Bench-testing required	Moderate to high capital; low to high O&M (depending on contaminant loading)	Retained
		Chemical Oxidation	• Reliable and proven on industrial wastewaters for metals (manganese, iron) treatment. Can be used alone or in conjunction with precipitation	• Well-demonstrated at hazardous waste sites in pilot- and full-scale • Readily available, conventional equipment required • Bench-scale testing may be required	Low to moderate capital; moderate O&M	Retained
		Electrochemical Iron Generation	• Not significantly impacted by varying concentrations • Less sludge may be produced	• Emerging technology - bench or pilot testing required • Used in combination with precipitation	Low to moderate capital; moderate O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Cost	Evaluation Results
Treatment Actions (Continued)	Physical/ Chemical Treatment (Continued)	Neutralization	• Can be used in a treatment train for pH adjustment	• Widely used and well demonstrated • Simple and readily available equipment/materials • Bench-scale studies may be required	Low capital; low to moderate O&M	Retained
		Precipitation	• Effective, reliable, permanent, and conventional technology • Typically used for removal of heavy metals • Followed by solids-separation method • Generates sludge which can be voluminous, difficult to dewater, and may require treatment	• Widely used and well demonstrated • Equipment is basic and easily designed • Compact, single units that are deliverable to the site • May require bench- or pilot-scale tests	Low capital; moderate O&M	Retained
		Filtration	• Conventional, proven method of removing suspended solids from wastewater • Does not remove other contaminants • Pretreatment for oil and grease required • Generates a sludge which requires proper handling	• Equipment is relatively simple to install and no chemicals are required • Package units available	Low capital; low O&M	Retained
		Flocculation	• Well established technology • Applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to other types of treatment • Performance depends on the variability of the composition of the waste being treated.	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	Low capital; moderate O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions (Continued)	Physical/ Chemical Treatment (Continued)	Sedimentation	• Effective for removing suspended solids and precipitated materials from wastewater • Performance depends on density and particle size of the solids; effective charge on the suspended particles; types of chemicals used in pretreatment; surface loading; upflow rate; and reinjection time • Feasible for large volumes of water to be treated	• Sedimentation tanks demonstrated and proven successful at hazardous waste sites • Effluent streams include the effluent water, scum, and settled solids	Moderate capital; moderate O&M	Retained
	Engineered Wetland Treatment	Constructed Wetlands	• Inorganic removal demonstrated in case studies • Pilot tests required	• Area surrounding Site 41 is primarily wetlands; adaptation of manmade wetlands should not be difficult • Easy to maintain once constructed	Moderate capital; low O&M	Retained (Site 41 only)
Discharge Actions	On-Site Discharge	Reinjection - Injection Wells	• Injection wells effectiveness is highly dependent on site geology • Wells may clog in time • Potential exposures during implementation	• Easily installed • Equipment readily available • No permits required • Recapture of water required if installed upgradient of extraction wells. • Significant maintenance	Moderate capital; moderate O&M	Eliminated
		Surface Water	• Effective and reliable discharge method	• Easily implementable at Site 41; two surface water bodies are available	Low capital; low O&M	Retained

TABLE 3-7

SUMMARY OF SOIL PROCESS OPTION EVALUATIONS
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation: Effectiveness	Evaluation: Implementability	Evaluation: Cost	Evaluation Results
No Action	No Action	Not Applicable	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	No capital; low O&M	Retained
Institutional Controls	Monitoring	Monitoring	Useful to evaluate site conditions over time	Regulatory agencies should receive annual sampling reports	No capital; low O&M	Retained
	Access Restrictions	Restrictions in Base Master Plan	• Does not provide treatment of soil • No exposures during implementation • Effectiveness dependent on continued future implementation	• Easily implemented • Administrative requirements	Negligible cost	Retained
		Fencing	• Does not meet remediation goals alone • Minimal to low exposures during implementation • Based on past experience at other fenced sites, would not effectively keep out base personnel	• Would require encompassment of very large areas • No legal requirements • Some clearing required	Low capital, Low O&M	Eliminated based on limited effectiveness

TABLE 3-8

FINAL SET OF POTENTIAL REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option	Site Applicability	
				41	74
Groundwater	No Action	No Action	Not Applicable	Y	Y
	Institutional Controls	Monitoring	Groundwater	Y	Y
			Surface Water/Sediment Monitoring	Y	N
		Aquifer-Use Restrictions	Restrictions in Base Master Plan	Y	Y
	Collection Actions	Extraction	Extraction Wells	Y	Y
	Discharge Actions	On-Site Discharge	Unnamed Tributary and Tank Creek	Y	N
	Treatment Actions	Physical/Chemical Treatment	Ion Exchange	Y	N
			Chemical Oxidation	Y	N
			Electrochemical Iron Generation	Y	N
			Neutralization	Y	N
			Precipitation	Y	N
			Filtration	Y	N
			Flocculation	Y	N
		Engineered Wetland Treatment	Constructed Wetland	Y	N
Soil	No Action	No Action	Not Applicable	Y	Y
	Institutional Controls	Monitoring	Monitoring	Y	Y
		Access Restrictions	Restrictions in Base Master Plan	Y	Y

Y = Yes
N = No

4.0 DETAILED ANALYSIS OF SITE 41 REMEDIAL ALTERNATIVES

In this section, detailed analyses and comparisons of alternatives developed for Site 41 are presented in Sections 4.1 and 4.2 for soil (including sediments within the two seeps and landfilled waste materials) and groundwater (including associated seep surface water), respectively.

Typically in a feasibility study, an initial group of potential remedial alternatives is developed that undergoes a screening based on effectiveness, implementability, and cost. The purpose of this screening is to reduce the number of alternatives that are subsequently evaluated as part of the detailed analysis. However, since only a limited number of alternatives have been developed for each medium at Site 41, the preliminary screening tier was not performed.

The detailed analysis of alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988b) and the NCP, including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were used for the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance will be evaluated in the Record of Decision (ROD) by addressing comments received after the FS and Proposed Remedial Action Plan (PRAP) have been reviewed by the Technical Review Committee (TRC), which includes participants from the NC DEHNR, USEPA Region IV, and the public.

These criteria are described below.

Overall Protection of Human Health and the Environment: The primary requirement is that remedial actions are protective of human health and the environment. A remedy is protective if it adequately eliminates, reduces, or controls all current and potential site risks posed through each exposure pathway at the site. A site where, after the remedy is implemented, hazardous substances remain without engineering or institutional controls, must allow for unrestricted use and unlimited exposure for human and environmental receptors. Alternatively, adequate engineering controls, institutional controls, or some combination of the two must be implemented to control exposure and thereby ensure reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks or cross-media impacts on human health and the environment.

Compliance with ARARs: Compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FS process to ensure that they will meet all of the respective ARARs or that there is a good rationale for waiving an ARAR. During the detailed analysis, information on federal and state action-specific ARARs will be assembled along with previously identified contaminant-specific and location-specific ARARs. Alternatives will be refined to ensure compliance with these requirements.

Long-term Effectiveness and Permanence: This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the future, as well as in the near term. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis will focus on the residual risks present at the site after the completion of the remedial action. The analysis will include consideration of the following:

- Degree of threat posed by the hazardous substances remaining at the site.
- Adequacy of any controls (e.g., engineering and institutional controls) used to manage the hazardous substances remaining at the site.
- Reliability of those controls.
- Potential impacts on human health and the environment, should the remedy fail, based on assumptions included in the reasonable maximum exposure scenario.

Reduction of Toxicity, Mobility, or Volume through Treatment: This criterion addresses the statutory preference for remedies that employ treatment as a principal element by ensuring that the relative performance of the various treatment alternatives in reducing the toxicity, mobility, or volume will be assessed. Specifically, the analysis will examine the magnitude, significance, and irreversibility of reductions.

Short-term Effectiveness: This criterion examines the short-term impacts of the alternative (i.e., impacts of the implementation) on the neighboring community, workers, or surrounding environment. This includes potential threats to human health and the environment associated with the excavation, treatment, and transportation of hazardous substances. The potential cross-media impacts of the remedy and the time to achieve protection of human health and the environment will also be analyzed.

Implementability: Implementability considerations include the technical and administrative feasibility of the alternatives, as well as the availability of goods and services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementability considerations often affect the timing of various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps, and the need to secure technical services). On-site activities must comply with the substantive portions of applicable permitting regulations.

Cost: Cost includes all capital costs and annual operation and maintenance costs incurred over the life of the project. The focus during the detailed analysis is on the present worth of these costs. Costs are used to select the most cost-effective alternative that will achieve the remedial action objectives.

State Acceptance: This criterion, which is an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. State comments will be addressed during the development of the FS, PRAP, and ROD, as appropriate.

Community Acceptance: This criterion refers to the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include all interested parties. These comments are taken into account throughout the FS process. However, only preliminary assessment of community acceptance can be conducted during the development of the FS, since formal public comment will not be received until after the public comment period for the PRAP is held.

4.1 Site 41 Soil (SO) Alternatives

Site 41 soil (SO) (including buried waste) alternatives were developed based on the remedial action objectives (RAOs) and general response actions identified in Section 2.0, as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-1, the RAO for the soil and waste (landfilled material) at this site is as follows:

- Prevent future potential exposure to buried contaminated soil and waste.

The soil remedial alternatives developed for Site 41 and evaluated in Sections 4.1.1 and 4.1.2 are listed below:

- Alternative 41SO-1 - No Action
- Alternative 41SO-2 - Institutional Controls

A comparison of these soil alternatives is presented in Section 4.1.3.

Although a capping alternative is often considered for former landfill sites, a capping alternative was not developed for this site because of implementability and effectiveness concerns. Results of the human health risk assessment indicate that the surface soils currently do not pose an unacceptable risk to base personnel. Therefore, a cap is not necessary to eliminate contact with the surface soil. As indicated in Table 3-3 in Section 3.3, installation of a low-permeability cap would require extensive clearing, grubbing, and regrading activities that would disturb the landfill contents. Since the landfill may contain Chemical Warfare Materiel (CWM) and other hazardous wastes, implementation of a cap would pose a significant risk to human health and the environment during construction. Furthermore, because the site is heavily vegetated, regrowth of vegetation following cap installation could puncture the cap causing a long-term operational concern. Control of vegetation regrowth could require the application of an herbicide, which could pose additional environmental and human health risks. Finally, the waste materials are not underlain by a continuous low-permeability liner, and the water table is very close to the ground surface. These conditions would limit the ability of cap to protect groundwater. Any contaminants present in the landfill could continue to leach to groundwater even after the cap is installed. For these reasons, capping technologies were eliminated from further consideration in Section 3.3.

4.1.1 Alternative 41SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 41, which was used as an open burn dump from 1946 to 1970.

Overall Protection: Since no actions would be taken, exposure pathways would be unaffected by this alternative. During its operation, the site received a variety of waste materials including POLs, solvents, drums of unknown wastes, chemical training agents, and unexploded ordnance (UXO). Based on the results of the soil and groundwater investigations, it appears that these materials were most likely burned on site since only residual levels of contamination were detected in the surface and subsurface soils. However, the potential still exists for waste materials, chemical training agents, and UXO to be present within the landfill. It should be noted that intrusive investigations (e.g., test pitting) were not conducted to completely characterize subsurface conditions at the site.

The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan. The site is indicated as a contaminated site in the Planning Factors Diagram referenced in the Master Plan.

There are no construction activities planned for this area. However, there are also currently no official institutional controls in place to prohibit potential construction activities from occurring at the site in the future. Thus, under this alternative, the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents) would not be reduced, therefore, the RAO for this site would not be achieved.

As discussed in Section 1.0, the groundwater, surface water, and sediments associated with the site have been marginally impacted by the landfill. Since a source of metals contamination was not identified within the landfill, elevated metals concentrations detected in unfiltered samples from shallow monitoring wells are most likely the result of turbidity (i.e., suspended solids) in the wells rather than from actual leaching of contaminants from the soils to groundwater. The landfill has been closed since 1970. After 20 years, any drums present in the landfill would most likely have leaked their contents into the surrounding soil and groundwater. The results of the soil and groundwater investigation, however, do not suggest a source of contamination at the site.

Although unlikely, potential contamination present in the landfill could, in the future, act as a significant source of groundwater, surface water, and sediment contamination. Contaminant trends could be analyzed using analytical results from groundwater and surface water/sediment monitoring programs (included under Alternative 41GW-2 in Section 4.2.2) to assess whether any portion of the landfill is acting as a source of groundwater contamination over the long term.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface and subsurface soils at Site 41, at present. Future residential and future construction use scenarios do result in unacceptable risks. In addition, the potential still exists for waste materials, chemical training agents, and UXO to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. Hence, this alternative would not provide a permanent, long-term remedy with respect to attainment of the RAO.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any residual contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as biodegradation, volatilization, and dispersion (i.e., leaching).

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

4.1.2 Alternative 41SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site, which was used as an open burn dump from 1946 to 1970. These institutional controls would consist of designation of the area as a restricted, or limited-use area. No remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at the site.

The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan. The site is indicated as a contaminated site in the Planning Factors Diagram referenced in the Master Plan. Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area as well as invasive construction activities. If needed, warning signs could be posted around the site to indicate that wastes are buried at the site and that construction activities are prohibited in the area.

Under this alternative, institutional controls would be implemented, which would restrict the site to nonresidential uses and would significantly reduce the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents). Thus, this alternative would achieve the RAO for soil and waste at this site.

Potential contamination present in the landfill could act as a significant source of groundwater, surface water, and sediment contamination. Contaminant trends could be analyzed using analytical results from groundwater and surface water/sediment monitoring programs (included under Alternative 41GW-2 in Section 4.2.2) to assess whether any portion of the landfill is acting as a source of groundwater contamination over the long term.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface soil at Site 41, at present. Future residential and future construction use scenarios do result in unacceptable risk. In addition, the potential still exists for waste materials, chemical training agents, and UXO to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. With respect to attainment of the RAO, this alternative would provide strict enforcement of the revised Base Master Plan to restrict site access, prohibit future invasive construction activities, and prohibit future residential use of the land.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any residual contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as biodegradation, volatilization, and dispersion (i.e., leaching).

Short-term Effectiveness: This alternative would not involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: This alternative should be administratively straightforward to implement. Appropriate access restrictions and land use designations could be readily incorporated into the Base Master Plan.

Cost: There are no estimated costs for this alternative. Labor costs associated with revision of the Base Master Plan have not been estimated.

4.1.3 Comparison of Site 41 Soil Alternatives

The soil alternative comparison for Site 41, based on the seven criteria, is provided in the following sections.

Overall Protection: The potential still exists for waste materials, chemical training agents, and UXO to be present within the landfill. Alternative 41SO-1 would not reduce the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents), whereas Alternative 41SO-2 would reduce this risk through the use of institutional controls. Thus, only Alternative 41SO-2 would achieve the RAO for soil and waste at this site.

Potential impacts of the soils and wastes on surface water and groundwater are discussed as part of the Site 41 groundwater alternatives in Section 4.2.

Compliance with ARARs: There are no State or federal contaminant-, location-, or action-specific ARARs associated with Alternatives 41SO-1 and 41SO-2 since no remedial actions would be taken under either alternative.

Long-term Effectiveness and Permanence: With respect to attainment of the RAO, only Alternative 41SO-2 would provide a permanent, long-term solution through revisions to the Base Master Plan to restrict site access, prohibit future invasive construction activities, and limit the area to non-residential uses.

Reduction of Toxicity, Mobility, or Volume: Neither Alternative 41SO-1 nor 41SO-2 would reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment.

Short-term Effectiveness: Neither Alternative 41SO-1 nor 41SO-2 would involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with Alternative 41SO-1, since no actions would be taken. Alternative 41SO-2 should be administratively straightforward to implement.

Cost: There are no costs associated with Alternatives 41SO-1 or 41SO-2.

4.2 Site 41 Groundwater (GW) Alternatives

Groundwater (GW) (including associated surface water in the seeps) alternatives were developed based on the RAOs and general response actions identified in Section 2.0 as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-11, the RAOs for the groundwater and associated surface water in the seeps at this site are as follows:

1. Prevent future potential exposure to contaminated groundwater.

2. Protect uncontaminated groundwater for future potential beneficial use.

3. Restore contaminated groundwater for future potential beneficial use.

4. Protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge.

The groundwater remedial alternatives developed for Site 41 and evaluated in Sections 4.2.1 and 4.2.2 are listed below:

- Alternative 41GW-1 - No Action
- Alternative 41GW-2 - Institutional Controls and Monitoring
- Alternative 41GW-3 - Seep Collection and Treatment with Institutional Controls and Monitoring
- Alternative 41GW-4 - Groundwater Extraction and Treatment with Institutional Controls and Monitoring

With respect to treatment of the collected water, two subalternatives were developed under Alternatives 41GW-3 and 41GW-4 as follows:

- Subalternatives 41GW-3a and 41GW-4a - Physical/Chemical Treatment
- Subalternatives 41GW-3b and 41GW-4b - Constructed Wetlands Treatment

A comparison of the groundwater alternatives is presented in Section 4.2.5.

4.2.1 Alternative 41GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat potentially contaminated groundwater and associated surface water at Site 41.

With respect to groundwater, the key risk contributor at Site 41 consists of the total (unfiltered) metal concentration of lead (26 µg/L) detected in an unfiltered sample from shallow well 41GW11 during the August 1994 low-flow sampling round. Since no dissolved lead was detected in the well from filtered samples, the total lead may or may not be due to leaching of contaminants from the soils to groundwater. Both total (filtered) and dissolved (unfiltered) iron and manganese concentrations in most of the monitoring wells exceeded their respective MCL and NCWQS standards. However, high levels of these metals have been detected in groundwater wells throughout the Base (Greenhorne & O'Mara, 1992).

Shallow groundwater generally flows radially from the center of the site, whereas deeper groundwater in the Castle Hayne Aquifer flows in a southeasterly direction. Groundwater on site currently is not used for any purpose. Potable water throughout the Base is supplied by wells located in the mid and lower regions of the Castle Hayne Aquifer. The shallow aquifer is not used as a potable water supply on Base. However, both the shallow and upper Castle Hayne Aquifers are classified as GA waters under the North Carolina Water Quality Standards (NCWQS), which are current or potential sources of drinking water. There are no groundwater production wells located immediately downgradient of the site. The nearest downgradient supply wells (wells MCAS-4150 and MCAS-500 are located approximately 1.1 miles southeast of the site (Baker, 1994).

As discussed in Section 1.0 and shown in Figure 1-2, two shallow seeps are present at the site, which originate along the northern and eastern edges of the site (near the top of the landfill). Both seeps discharge into the unnamed tributary.

Overall Protection: Exposure pathways would be unaffected by the implementation of this alternative. With respect to achievement of RAOs, this alternative would not prevent future potential exposure to contaminated groundwater (RAO Number 1). This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment (RAO Number 3). Any future contaminated groundwater could migrate from the site (RAO Number 2). Under this scenario, contaminant concentrations in the groundwater could eventually decrease below the NCWQS through natural dilution and dispersion.

This alternative would not protect ecological receptors from future potential exposure to contaminated surface water resulting from discharge of contaminated groundwater. However, the ecological risk assessment did not indicate significant site-related ecological risks to aquatic receptors in the unnamed tributary and Tank Creek. The seeps are ephemeral in nature and do not represent a significant habitat for aquatic receptors.

Compliance with ARARs: There are no location-specific ARARs associated with this alternative.

The only action-specific ARAR associated with this alternative are the Corrective Action Requirements of the North Carolina Administrative Code, Chapter 2L, Section .0106. Since this alternative would not provide the best available technology for restoration of groundwater to the NCWQSs, a demonstration would need to be made in accordance with the Corrective Action requirements. The demonstration would involve the use of existing groundwater data to show that groundwater treatment is not required to provide adequate protection of human health and the environment.

Compliance with contaminant-specific ARARs is discussed in the following sections.

Groundwater

As discussed in Section 1.0, four wells (41GW2, 41GW7, 41GW10, and 41GW11) were resampled in August 1994 using low-flow purging/sampling techniques.

For total metals, iron exceeded the NCWQS of 300 μg/L in all four wells with concentrations ranging from 890 - 26,200 μg/L. Manganese exceeded the MCL and NCWQS of 50 μg/L in three of the four wells with concentrations ranging from 24.5 - 334 μg/L. Lead exceeded the MCL and NCWQS of 15 μg/L in only one well (26 μg/L). As previously stated, this lead concentration may or may not be due to actual leaching from the soils to groundwater since soil results did not exhibit a significant lead problem.

For dissolved metals, iron ranged from 298 - 24,900 μg/L ,and manganese ranged from 25.3 - 352 μg/L. Dissolved lead was not detected in any of the four wells.

Surface Water

Based on the most recent sampling results (August 1994), total and dissolved iron concentrations exceeded the NCWQS of 1,000 μg/L in all samples collected from the seeps. Total iron concentrations in the seeps (2,690 - 39,600 μg/L in the northern seep and 2,810 - 278,000 in the eastern seep) were an order of magnitude higher than upstream (662 - 747 μg/L) or downstream concentrations (633 - 2,940 μg/L) in the unnamed tributary. No dissolved iron was detected above the NCWQS in upstream samples collected from the unnamed tributary. Downstream samples in the unnamed tributary exhibited slightly elevated iron levels ranging from 498 - 1210 μg/L.

Manganese exceeded the NCWQS and AWQC standard of 50 μg/L in the northern seep (52.4 - 130 μg/L) and eastern seep (1,200 - 1,700 μg/L). However, only one sample in the unnamed tributary downstream of the seep discharge area exceeded the 50 μg/L value (85.6 μg/L). In general, dissolved manganese concentrations were similar to total manganese.

Mercury exceeded the AWQC of 0.144 μg/L in the northern seep (0.28 - 0.36), eastern seep (0.26 - 0.56), upstream unnamed tributary (one sample at 0.21 μg/L), and downstream unnamed tributary (one sample at 0.23 μg/L). No dissolved mercury was detected.

Sediments

Based on the most recent sampling results (August 1994), no pesticides were detected above the EPA Region IV sediment screening values [Effects Range Low (ER-L)] in the northern seep; however, dieldrin, 4,4-DDE, endosulfan II, and 4,4-DDD were detected above the ER-L in the eastern seep.

Upstream sediment samples collected from the unnamed tributary exhibited 4,4-DDT above the ER-L in one sample. Downstream sediment samples collected from the unnamed tributary exhibited dieldrin, 4,4-DDE, 4,4-DDD, and 4,4-DDT in one sample collected just downstream from the seep discharge.

Lead exceeded the ER-L in one sediment sample from the eastern seep. Mercury also exceeded the ER-L in one sediment sample from the eastern seep, and in one sample collected from an upstream location within the unnamed tributary.

Long-term Effectiveness and Permanence: This alternative would not attain the RAOs and would not provide a permanent, long-term solution for the site. If the groundwater in the shallow or deep aquifers at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would slightly exceed 1 x 10^{-4}, and the hazard index would exceed 1 by about an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the total metals concentrations detected in the aquifers. (Note that these risk values are based on Round 1 groundwater data, which are likely "biased high" due to suspended solids in the sample).

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant sources, which appear to be minimal based on the subsurface soil investigation.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

4.2.2 Alternative 41GW-2 - Institutional Controls and Monitoring

Under this alternative, a groundwater, surface water, and sediment sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that, on average, seven monitoring wells would be periodically sampled. The surface water and sediment sampling program would involve periodic collection of samples in the two seeps and at upgradient and downgradient locations in the unnamed tributary. For costing purposes, it was assumed that, on average, seven surface water and sediment samples would be periodically sampled.

Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period for surface water and groundwater. For sediments, which require a lower sampling frequency, it was assumed that a round of sediment samples would be collected once every three years.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans for installing any supply wells in the area. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius from the site boundary. Under the Corrective Action section of the NC DEHNR Drinking Water and Groundwater Standards (15A NCAC 2L.0107(a)), the compliance boundary for disposal systems permitted prior to December 30, 1993 is 500 feet from the waste boundary or at the property boundary, whichever is closer to the source. In addition, under the Siting and Design Requirements section of North Carolina Solid Waste Rules (15A NCAC 13B.0503(f)), a 500-foot minimum buffer between disposal areas and private dwellings/wells must be maintained for new sanitary landfills. Thus, the 500-foot radius is consistent with these regulations.

Overall Protection: With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater (RAO Number 1) through institutional controls and monitoring. This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment (RAO Number 3). Any future contaminated groundwater could migrate from the site (RAO Number 2). Under this scenario, contaminant concentrations in the groundwater could eventually decrease below the NCWQS through natural dilution and dispersion. The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

The ecological risk assessment did not indicate significant site-related ecological risks to aquatic receptors in the unnamed tributary and Tank Creek. The seeps are ephemeral in nature and do not represent a significant habitat for aquatic receptors.

This alternative would protect ecological receptors from future potential exposure to contaminated surface water (RAO Number 4) in the sense that the surface water and sediment monitoring program would facilitate ongoing assessment of contaminant concentrations and their potential impacts on ecological receptors. Thus, remedial actions could be conducted in the future, if necessary, based on the monitoring results.

Compliance with ARARs: There are no location- specific ARARs associated with this alternative. Compliance with contaminant- and action-specific ARARs would be the same as with Alternative 41GW-1 (see Section 4.2.1, "Compliance with ARARs").

Long-term Effectiveness and Permanence: If the groundwater in the shallow or upper Castle Hayne Aquifers at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would slightly exceed 1×10^{-4} and the hazard index would exceed 1 by an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the total metals concentrations detected in the aquifers.

This alternative would attain the RAOs and would provide a permanent, long-term solution for the site since contaminant levels are marginal and periodic environmental sampling is a reliable means of tracking contaminant migration. Potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and strict enforcement of institutional controls.

A 5-year site review would be required under CERCLA to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant sources, which appear to be minimal based on the subsurface soil investigation.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: An environmental monitoring program could be readily implemented at the site. Appropriate groundwater use designations could also be readily incorporated into the Base Master Plan.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $38,500
- Net present worth (30-year): $592,000

4.2.3 Alternative 41GW-3 - Seep Collection and Treatment with Institutional Controls and Monitoring

The main intent of this alternative is to provide protection of ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge (RAO Number 4) through collection and treatment of the seep water.

As discussed in Section 1.0 and shown in Figure 1-2, two shallow seeps are present at the site, which originate along the northern and eastern edges of the site near the top of the landfill and discharge into the unnamed tributary.

This alternative includes collection of the seeps in subsurface drains and routing by gravity flow to a treatment system prior to discharge to an existing waterway (unnamed tributary). This alternative includes two subalternatives for treatment of the seep water as follows:

- Subalternative 41GW-3a - Physical/Chemical Treatment
- Subalternative 41GW-3b - Constructed Wetlands Treatment

The conceptual design developed for this alternative includes the following:

- Installation of a total of approximately 400 linear feet of seep collection trenches along the north and east seeps.

- Installation of approximately 900 linear feet of gravity flow subsurface conduit.

- Construction of a physical chemical/treatment plant (Subalternative 41GW-3a) or a constructed wetlands treatment system (Subalternative 41GW-3b).

- Access road upgrade into the site.

- Extension of electrical service to the physical/chemical treatment plant (Subalternative 41GW-3a).

Seep Collection

Seep collection trenches would be installed parallel to the observed line of seep discharge. Collection trenches consist of a coarse aggregate filled trench containing perforated piping at the base to concentrate the flow collected in the aggregate. Geotextile is used to wrap the aggregate to minimize infiltration of fine soil particles into the aggregate and avoid clogging of the trench. The perforated piping is connected to solid wall pipe for subsurface gravity flow away from the seep collection area to the treatment system. Figure 4-1 provides plan and cross section schematics of a typical seep collection trench.

The actual location and length of the seep collection trenches would be based upon the observed seep locations/dimensions at the time of construction. Approximate trench locations and orientations, based upon previously observed field conditions and available topographic mapping, are shown in Figure 4-2 for Subalternative 41GW-3a.

The conduit routing from the collection trench to the treatment system would also be established at construction. To facilitate gravity flow and minimize the potential for sediment buildup in the conduit, a minimum two percent slope is recommended. Manholes would be installed as necessary to facilitate construction and minimize trench excavation depths (i.e., at grade changes, or directional changes in the pipe routing). Figure 4-2 shows an approximate conduit routing and manhole locations used for alternative costing purposes.

The water would be treated and discharged via gravity flow to the adjacent unnamed tributary. Monthly effluent sampling and analyses also would be conducted to monitor the treated effluent quality. The treatment systems would facilitate metals removal from the seep water (primarily iron, manganese, and lead). Hence, the effluent monthly monitoring parameters would most likely be selected toxic metals and miscellaneous water quality parameters, such as pH, total suspended solids (TSS), and biochemical oxygen demand (BOD).

Physical/Chemical Treatment (Subalternative 41GW-3a)

Physical/chemical treatment of the collected seep water is anticipated to consist primarily of chemical precipitation and clarification, as shown in Figure 4-3. Because of the very low flow rate (i.e., approximately 2 gpm), the system would be operated in a batch mode. However, a treatment system capable of handling a 15 gpm continuous flowrate was used for costing purposes. The metals treatment system would most likely be designed and built as a packaged system.

The bulk of the metals that would be removed from the seep water would consist of iron and manganese along with inert suspended solids. Any heavy metals present in the water would most likely coprecipitate with the iron and manganese. If most of the dissolved iron and manganese in the water is present in their oxidized states, then precipitation would occur in the neutral pH range (i.e., 7-8). Thus, only a slight adjustment in pH may be needed to promote precipitation. If oxidation is necessary, then an oxidizing agent, such as oxygen or potassium permanganate, could be added to the process.

The settled solids would be concentrated in a sludge holding tank and eventually pumped to a filter press for dewatering. The dewatered sludge would most likely be nonhazardous and could probably be disposed in a local municipal (i.e., sanitary) landfill. However, bench-scale testing may need to be conducted to determine the nature of dewatered sludge.

The treatment system would be housed in a prefabricated metal building located adjacent to the existing access road entering the eastern portion of the site (Figure 4-2). This location would facilitate extension of electrical service into the site and also allow gravity flow of the collected seep discharge water to the collection manhole from where the water would be pumped into the treatment building.

Constructed Wetlands Treatment (Subalternative 41GW-3b)

Constructed wetlands treatment consists of construction of a specifically designed wetlands for passive treatment of wastewater. Wetlands provide treatment by several processes including the following:

- Bacteria attached to the roots and stems of aquatic plants provide adsorption and filtration.
- Sedimentation.
- Substrate ion exchange/adsorption capabilities.

Although all of the processes contributing to water quality improvement within the wetlands system are not well-understood, constructed wetlands are capable of moderating, removing, or transforming a variety of water pollutants while also providing wildlife and recreation benefits commonly associated with natural wetlands systems. Constructed wetlands have been used successfully in treating acid mine drainage, whose contaminants of concern generally include elevated metals (especially iron and manganese) and low pH. Case studies documenting applications of wetlands treatment technology to mine drainage sites have resulted in the development of empirical relationships for design/sizing of constructed wetlands for iron removal.

The lack of detailed/complex scientific principles forming the basis for constructed wetlands design, and the lack of long-term performance records results in the scientific community view that the wetlands should be designed according to "worst case" flow/quality data rather than on "typical site data". Figure 4-4 shows a schematic of a typical constructed wetlands treatment system. The approximate size and location of the constructed wetlands used for cost estimating purposes is shown in Figure 4-5. The actual wetlands location and specifications, such as size, dimensions, inlet and outlet structures, and vegetation requirements would be established in the design.

It should be noted that both seeps currently traverse through an area that may be classified as a wetland.

Groundwater Monitoring

As with Alternative 41GW-2, a groundwater, surface water, and sediment sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that, on average, seven monitoring wells would be periodically sampled. The surface water and sediment sampling program would involve periodic collection of samples in the two seeps and at upgradient and downgradient locations in the unnamed tributary. For costing purposes, it was assumed that, on average, seven surface water and sediment samples would be periodically sampled.

Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period for surface water and groundwater. For sediments, which require a lower sampling frequency, it was assumed that a round of sediment samples would be collected once every three years.

Institutional Controls

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius from the site, as described under Alternative 41GW-2.

Overall Protection: With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater (RAO Number 1) through institutional controls and monitoring. This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment (RAO Number 3). Any future contaminated groundwater could migrate from the site (RAO Number 2). Under this scenario, contaminant concentrations in the groundwater could eventually decrease below the NCWQS through natural dilution and dispersion. The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

The ecological risk assessment did not indicate significant site-related ecological risks to aquatic receptors in the unnamed tributary and Tank Creek. The seeps are ephemeral in nature and do not represent a significant habitat for aquatic receptors.

This alternative would protect ecological receptors from future potential exposure to contaminated surface water (RAO Number 4) through installation of the seep collection system and treatment of the seep water using either a physical/chemical treatment plant or a constructed wetlands system. The surface water and sediment monitoring program would facilitate ongoing assessment of contaminant concentrations to determine the effectiveness of the collection and treatment system. Thus, modifications to either system could be made in the future if necessary based on the monitoring results.

Compliance with ARARs:

Construction activities and discharge of treated water would need to comply with the following location-specific ARARs:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Treated water would comply with all pertinent local, state, and federal location- and action-specific ARARs before being discharged to the environment. Specifically, discharge of treated water to the unnamed tributary would require compliance with the substantive requirements of the North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section 0100). Excavation activities would require compliance with the North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A), which regulates stormwater management and erosion/sedimentation control practices.

This alternative would need to comply with the Corrective Action requirements of the North Carolina Administrative Code, Chapter 2L, Section .0106. Since this alternative would not provide the best available technology for restoration of groundwater to the NCWQASs, a demonstration would need to be made in accordance with Corrective Action requirements. The demonstration would involve the use of existing groundwater data to show that groundwater treatment is not required to provide adequate protection of human health and environment.

Compliance with contaminant-specific ARARs is discussed in the following sections.

Groundwater

Under this alternative, NCWQS and Federal MCLs for lead, iron, and manganese would be exceeded.

Surface Water

The intent of this alternative is to collect and treat the seep water so that it would comply with all NCWQS and AWQC surface water standards before it is discharged to the unnamed tributary.

Sediments

Based on the most recent sampling results (August 1994), no pesticides were detected above the EPA Region IV sediment screening values [Effects Range Low (ER-L)] in the northern seep; however, dieldrin, 4,4-DDE, endosulfan II, and 4,4-DDD were detected above the ER-L in the eastern seep.

Upstream sediment samples collected from the unnamed tributary exhibited 4,4-DDT above the ER-L in one sample. Downstream sediment samples collected from the unnamed tributary exhibited dieldrin, 4,4-DDE, 4,4-DDD, and 4,4-DDT in one sample collected just downstream from the seep discharge.

Lead exceeded the ER-L in one sediment sample from the eastern seep. Mercury also exceeded the ER-L in one sediment sample from the eastern seep, and in one sample collected from an upstream location within the unnamed tributary.

Long-term Effectiveness and Permanence: If the groundwater in the shallow or upper Castle Hayne Aquifers at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would slightly exceed 1×10^{-4} and the hazard index would exceed 1 by an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the total metals concentrations detected in the aquifers.

This alternative would attain the RAOs and would provide a permanent, long-term solution for the groundwater since contaminant levels are marginal, and periodic environmental sampling is a reliable means of tracking contaminant migration. Potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and strict enforcement of institutional controls.

Installation of the seep collection system and treatment of the seep water using either a physical/chemical treatment plant or a constructed wetlands system would provide long-term protection of ecological receptors in the unnamed tributary by significantly reducing metals concentrations in the seep waters before they discharge to the tributary.

A 5-year site review would be required under CERCLA to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume of groundwater contamination would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant sources, which appear to be minimal based on the subsurface soil investigation.

Treatment of the seep water using either a physical/chemical treatment plant or a constructed wetlands system would permanently reduce the volume and toxicity of contaminated water prior to discharge to the unnamed tributary.

Short-term Effectiveness: This alternative would involve disturbance of the seep sediment and landfill material that may pose a potential risk to aquatic receptors in the unnamed tributary during implementation. However, these risks would be minimized through engineering controls (i.e., erosion and sedimentation controls) such as silt fencing and straw bales.

During installation of the underground piping, there would be a potential risk to workers associated with digging through waste materials, contaminated soil, or contaminated sediment. However, these risks would be minimized through environmental monitoring and health and safety procedures.

Implementability: An environmental monitoring program could be readily implemented at the site. Appropriate groundwater use designations could also be readily incorporated into the Base Master Plan.

Long-term operation and maintenance considerations include quarterly groundwater monitoring and monthly effluent monitoring for both treatment options.

The operation and maintenance for the physical/chemical treatment plant (Subalternative 41GW-3a) includes labor for routine operations, water treatment sludge processing, transportation and off-site disposal of sludge, and general equipment maintenance and administrative operations.

Operation and maintenance activities specific to the constructed wetlands treatment system (Subalternative 41GW-3b) are not specifically quantifiable, because, in theory, wetlands are naturally self-maintaining/operating. Practically, in order to maintain the treatment efficiency of the wetlands system, there may be iron deposits that require removal or regrading of the system to maintain the desired flow patterns. To account for this type of maintenance, a complete replacement cost distributed over the 30-year period has been incorporated into the operation and maintenance cost for this treatment option.

Cost: The estimated costs of the two subalternatives included under this alternative are as follows:

Subalternative 41GW-3a

- Capital: $618,000
- Annual operation and maintenance: $82,000
- Net present worth (30-year): $1,878,000

Subalternative 41GW-3b

- Capital: $264,000
- Annual operation and maintenance: $49,800
- Net present worth (30-year): $1,029,000

4.2.4 Alternative 41GW-4 - Groundwater Extraction and Treatment with Institutional Controls and Monitoring

This alternative is intended to provide collection and treatment of shallow groundwater in order to: protect uncontaminated groundwater for future potential beneficial use (RAO Number 2); restore contaminated groundwater for future potential beneficial use (RAO Number 3); and protect ecological receptors from future potential exposure to contaminated surface water resulting from groundwater discharge (RAO Number 4).

This alternative includes collection of the shallow groundwater using pumping wells and discharge of the treated water to an existing waterway (unnamed tributary). Similarly to Alternative 41GW-3, this alternative includes two subalternatives for treatment of the extracted water as follows:

- Subalternative 41GW-4a - Physical/Chemical Treatment
- Subalternative 41GW-4b - Constructed Wetlands Treatment

The conceptual design developed for this alternative includes the following:

- Installation of a total of three shallow groundwater extraction wells along the eastern edge of the landfill between the north and east seeps.

- Installation of approximately 1,200 linear feet of influent and effluent subsurface piping.

- Construction of a physical chemical/treatment plant (Subalternative 41GW-4a) or a constructed wetlands treatment system (Subalternative 41GW-4b).

- Access road upgrade into the site.

- Extension of electrical service to the physical/chemical treatment plant (Subalternative 41GW-4a).

Groundwater Extraction

The groundwater extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the shallow aquifer (i.e., NCWQS) in Section 2.0. If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time. The re-evaluation would be conducted according to the Correction Action requirements of the NC DEHNR Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina (15A NCAC 2L.0106). Under this regulation, the NC DEHNR Director may authorize termination of the corrective action if the following can be demonstrated:

- Continuation of corrective action would not result in a significant reduction in the concentrations of contaminants
- Contaminants have not and will not migrate onto adjacent properties
- If the contaminant plume is expected to intercept surface waters, the groundwater discharge will not possess contaminant concentrations that would result in violations of standards for surface waters contained in 15A NCAC 2B.0200
- Public notice of the request has been provided in accordance with Rule .0114(b) of Section 2L.0106
- The proposed termination would be consistent with all other environmental laws

Under 15A NCAC 2L.0106, the Director may also reclassify the groundwater to a GC classification (water supply for purposes other than drinking) if it can be demonstrated that continued corrective action would result in no significant reduction in contaminant concentrations, and the contaminated groundwaters cannot be rendered potable by treatment using readily available and economically reasonable technologies.

Groundwater would be pumped using a series of three downgradient wells (approximately 25 feet deep) located near the downgradient edge of the contaminant plume as shown in Figure 4-4. All pumping wells would be connected to a common header pipe that discharges to a common treatment system.

The downgradient set of extraction wells was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The design of this portion of the extraction system is basically a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portion of the shallow and upper Castle Hayne Aquifers. It has been estimated that a flow rate of only 3 gpm (1 gpm per well) would be required to contain the current extent of contamination in the shallow aquifer (capture length of 900 feet).

The water would be treated and discharged via gravity flow to the adjacent unnamed tributary. Monthly effluent sampling and analyses also would be conducted to monitor the treated effluent quality. The treatment systems would facilitate metals removal from the groundwater (primarily iron, manganese, and lead). Hence, the effluent monthly monitoring parameters would most likely be selected toxic metals and miscellaneous water quality parameters, such as pH, total suspended solids (TSS), and biochemical oxygen demand (BOD).

Physical/Chemical Treatment (Subalternative 41GW-4a)

Physical/chemical treatment of the collected groundwater is anticipated to consist primarily of chemical precipitation and clarification, as shown in Figure 4-3. Because of the very low flow rate (i.e., approximately 3 gpm), the system would be operated in a batch mode. However, a treatment system capable of handling a 15 gpm continuous flowrate was used for costing purposes. The metals treatment system would most likely be designed and built as a packaged system.

The bulk of the metals that would be removed from the groundwater would consist of iron and manganese along with inert suspended solids. Any heavy metals present in the water would most likely coprecipitate with the iron and manganese. If most of the dissolved iron and manganese in the water is present in their oxidized states, then precipitation would occur in the neutral pH range (i.e., 7-8). Thus, only a slight adjustment in pH may be needed to promote precipitation. If oxidation is necessary, then an oxidizing agent, such as oxygen or potassium permanganate, could be added to the process.

The settled solids would be concentrated in a sludge holding tank and eventually pumped to a filter press for dewatering. The dewatered sludge would most likely be nonhazardous and could probably be disposed in a local municipal (i.e., sanitary) landfill. However, bench-scale testing is recommended to better assess the nature of the sludge.

The treatment system would be housed in a prefabricated metal building located adjacent to the existing access road entering the eastern portion of the site (Figure 4-6). This location would facilitate extension of electrical service into the site and also allow gravity flow of the collected seep discharge water to the collection manhole from where the water would be pumped into the treatment building.

Constructed Wetlands Treatment (Subalternative 41GW-4b)

Constructed wetlands treatment consists of construction of a specifically designed wetlands for passive treatment of wastewater. Wetlands provide treatment by several processes including the following:

- Bacteria attached to the roots and stems of aquatic plants provide adsorption and filtration
- Sedimentation
- Substrate ion exchange/adsorption capabilities

Although all of the processes contributing to water quality improvement within the wetlands system are not well-understood, constructed wetlands are capable of moderating, removing, or transforming a variety of water pollutants while also providing wildlife and recreation benefits commonly associated with natural wetlands systems. Constructed wetlands have been used successfully in treating acid mine drainage, whose contaminants of concern generally include elevated metals (especially iron and manganese) and low pH. Case studies documenting applications of wetlands treatment technology to mine drainage sites have resulted in the development of empirical relationships for design/sizing of constructed wetlands for iron removal.

The lack of detailed/complex scientific principles forming the basis for constructed wetlands design, and the lack of long-term performance records results in the scientific community view that the wetlands should be designed according to "worst case" flow/quality data rather than on "typical site data". Figure 4-4 shows a schematic of a typical constructed wetlands treatment system. The approximate size and location of the constructed wetlands used for cost estimating purposes is shown in Figure 4-7. The actual wetlands location and specifications, such as size, dimensions, inlet and outlet structures, and vegetation requirements would be established in the design.

Groundwater Monitoring

As with Alternatives 41GW-2 and 41GW-3, a groundwater, surface water, and sediment sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that, on average, seven monitoring wells would be periodically sampled. The surface water and sediment sampling program would involve periodic collection of samples in the two seeps and at upgradient and downgradient locations in the unnamed tributary. For costing purposes, it was assumed that, on average, seven surface water and sediment samples would be periodically sampled.

Initially, surface water and groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period for surface water and groundwater. For sediments, which require a lower sampling frequency, it was assumed that a round of sediment samples would be collected once every three years.

Institutional Controls

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells within a 500-foot radius from the site, as described under Alternative 41GW-2.

Overall Protection: With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater (RAO Number 1) through institutional controls and monitoring. This alternative is intended to eventually restore contaminated groundwater to drinking water standards through extraction and treatment (RAO Number 3) and to prevent contaminated groundwater from migrating off site (RAO Number 2). The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

The ecological risk assessment did not indicate significant site-related ecological risks to aquatic receptors in the unnamed tributary and Tank Creek. The seeps are ephemeral in nature and do not represent a significant habitat for aquatic receptors.

This alternative would protect ecological receptors from future potential exposure to contaminated surface water (RAO Number 4) through installation of the shallow groundwater collection and treatment system. The groundwater extraction system may eliminate or significantly reduce the volume of water discharging to the seeps. The surface water and sediment monitoring program would facilitate ongoing assessment of contaminant concentrations to determine the effectiveness of the collection and treatment system. Thus, modifications to either system could be made in the future if necessary based on the monitoring results.

Compliance with ARARs: Compliance with contaminant-specific ARARs is discussed in the following sections.

Groundwater

The intent of this alternative is to collect and treat the groundwater so that it would comply with all MCL and NCWQS drinking water standards. The groundwater extraction and treatment system may reduce the lead concentrations below the MCL and NCWQS level; however, the MCL and NCWQS standards for iron and manganese may never be achieved since these metals are elevated throughout the Base. In addition, given that the landfill material will remain, attainment of the remediation goals may not be achieved.

Surface Water

The intent of this alternative is to eliminate or significantly reduce the seep discharges so that the surface water in the unnamed tributary would comply with all NCWQS and AWQC surface water standards.

Sediments

Based on the most recent sampling results (August 1994), no pesticides were detected above the EPA Region IV sediment screening values [Effects Range Low (ER-L)] in the northern seep; however, dieldrin, 4,4-DDE, endosulfan II, and 4,4-DDD were detected above the ER-L in the eastern seep.

Upstream sediment samples collected from the unnamed tributary exhibited 4,4-DDT above the ER-L in one sample. Downstream sediment samples collected from the unnamed tributary exhibited dieldrin, 4,4-DDE, 4,4-DDD, and 4,4-DDT in one sample collected just downstream from the seep discharge.

Lead exceeded the ER-L in one sediment sample from the eastern seep. Mercury also exceeded the ER-L in one sediment sample from the eastern seep, and in one sample collected from an upstream location within the unnamed tributary.

Construction activities and discharge of treated water would need to comply with the following location-specific ARARs:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Treated water would comply with all pertinent local, state, and federal location- and action-specific ARARs before being discharged to the environment. Specifically, discharge of treated water to the unnamed tributary would require compliance with the substantive requirements of the North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section 0100). Excavation activities would require compliance with the North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A), which regulates stormwater management and erosion/sedimentation control practices.

Long-term Effectiveness and Permanence: If the groundwater in the shallow or upper Castle Hayne Aquifers at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would slightly exceed 1×10^{-4}, and the hazard index would exceed 1 by an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the total metals concentrations detected in the aquifers.

The intent of this alternative is to attain the RAOs through implementation of a permanent, long-term solution for the groundwater. As mentioned previously, this will be difficult since the landfill material will remain in place. Periodic environmental sampling is a reliable means of tracking contaminant migration. Potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and strict enforcement of institutional controls.

Installation of the shallow groundwater collection system would provide long-term protection of ecological receptors in the unnamed tributary by eliminating or significantly reducing the seep discharges to the tributary.

A 5-year site review would be required under CERCLA to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: Extraction and treatment of the groundwater using either a physical/chemical treatment plant or a constructed wetlands system would permanently reduce the volume and toxicity of contaminated groundwater.

Short-term Effectiveness: This alternative would involve disturbance of the landfill material and seep sediment that may pose a potential risk to aquatic receptors in the unnamed tributary during implementation. However, these risks would be minimized through engineering controls (i.e., erosion and sedimentation controls) such as silt fencing and straw bales.

During installation of the underground piping, there would be a potential risk to workers associated with digging through waste materials, contaminated soil, or contaminated sediment. However, these risks would be minimized through environmental monitoring and health and safety procedures.

Implementability: An environmental monitoring program could be readily implemented at the site. Appropriate groundwater use designations could also be readily incorporated into the Base Master Plan.

Long-term operation and maintenance considerations include quarterly groundwater monitoring and monthly effluent monitoring for both treatment options.

The operation and maintenance for the physical/chemical treatment plant (Subalternative 41GW-4a) includes labor for routine operations, water treatment sludge processing, transportation and off-site disposal of sludge, and general equipment maintenance and administrative operations.

Operation and maintenance activities specific to the constructed wetlands treatment system (Subalternative 41GW-4b) are not specifically quantifiable, because, in theory, wetlands are naturally self-maintaining/operating. Practically, in order to maintain the treatment efficiency of the wetlands system, there may be iron deposits that require removal or regrading of the system to maintain the desired flow patterns. To account for this type of maintenance, a complete replacement cost distributed over the 30-year period has been incorporated into the operation and maintenance cost for this treatment option.

Cost: The estimated costs of the two subalternatives included under this alternative are as follows:

Subalternative 41GW-4a

- Capital: $675,000
- Annual operation and maintenance: $83,500
- Net present worth (30-year): $1,959,000

Subalternative 41GW-4b

- Capital: $938,000
- Annual operation and maintenance: $61,800
- Net present worth (30-year): $1,887,000

4.2.5 Comparison of Site 41 Groundwater Alternatives

The groundwater alternative comparison for Site 41, based on the seven criteria, is provided in the following sections.

Overall Protection: With respect to achievement of RAO Number 1, Alternatives 41GW-2, 41GW-3, and 41GW-4 would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring.

With respect to achievement of RAO Numbers 2 and 3, only Alternative 41GW-4 may actively restore contaminated groundwater to drinking water standards through extraction and treatment. Under Alternatives 41GW-1, 41GW-2, and 41GW-3, contaminated groundwater could migrate off site in the future.

With respect to achievement of RAO Number 4, Alternative 41GW-2 would protect ecological receptors from future potential exposure to contaminated surface water and sediment in the sense that the surface water and sediment monitoring program would facilitate ongoing assessment of contaminant concentrations and their potential impacts on ecological receptors. Alternatives 41GW-3 and 41GW-4 would provide a greater level of ecological protection than Alternative 41GW-2 through seep collection/treatment and groundwater collection/treatment, respectively.

Compliance with ARARs: Under Alternatives 41GW-1, 41GW-2, and 41GW-3, contaminated groundwater would continue to exceed MCLs and NCWQS for lead, iron, and manganese. Alternative 41GW-4 may reduce lead concentrations below the MCL and NCWQS standard. The MCL and NCWQS standards for iron and manganese may never be achieved since these metals are elevated throughout the Base.

Only Alternatives 41GW-3 and 41GW-4 would implement measures to reduce surface water contaminant concentrations in the unnamed tributary to the NCWQS and AWQC surface water standards.

Long-term Effectiveness and Permanence: Alternative 41GW-1 would not achieve the RAOs and would not provide a permanent, long-term solution for the site. Alternative 41GW-2 would attain the RAOs and would provide a permanent, long-term solution for the site since contaminant levels are marginal, and periodic environmental sampling is a reliable means of tracking contaminant migration. Under Alternatives 41GW-2, 41GW-3, and 41GW-4, potential unacceptable risks associated with groundwater use would be permanently mitigated through provision of institutional controls.

Alternative 41GW-3 would provide a greater level of long-term protection of the unnamed tributary than Alternative 41GW-2, and Alternative 41GW-4 would provide the greatest degree of long-term protection by implementing measures to protect both groundwater and surface water.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by either Alternative 41GW-1 or 41GW-2. Alternatives 41GW-3 and 41GW-4 may permanently reduce the volume and toxicity of contaminated surface water. Only Alternative 41GW-4 would permanently reduce the volume and toxicity of contaminated groundwater.

Short-term Effectiveness: Neither Alternative 41GW-1 nor 41GW-2 would involve remedial actions that would pose a risk to human health or the environment during implementation.

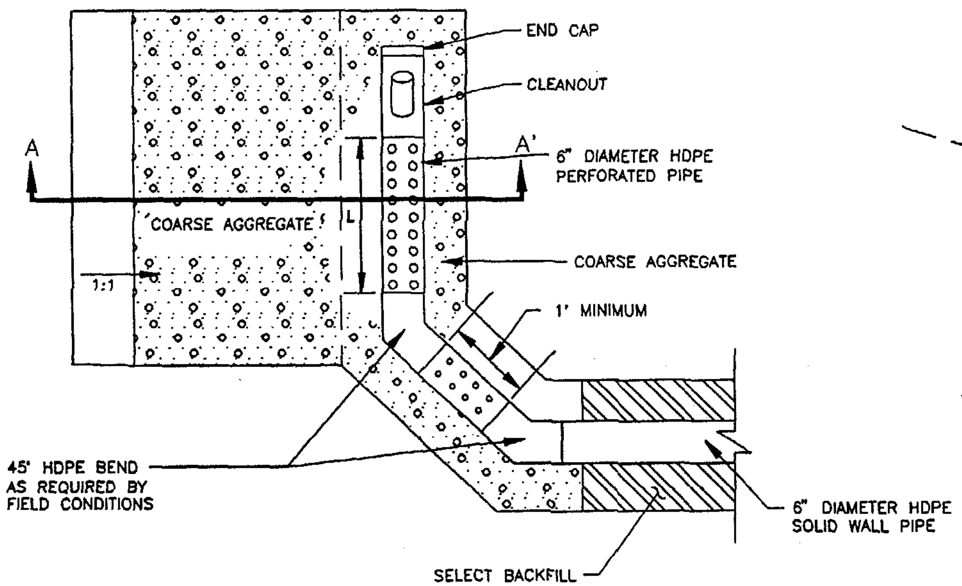
Alternatives 41GW-3 and 41GW-4 would involve disturbance of the landfill material and seep sediment that may pose a potential risk to aquatic receptors in the unnamed tributary during implementation. These alternatives would also pose a potential risk to workers associated with digging through waste materials, contaminated soil, or contaminated sediment during installation of the underground piping.

Implementability: There would be no implementability concerns associated with Alternative 41GW-1 since no actions would be taken. Under Alternative 41GW-2, the environmental monitoring program and institutional controls could be readily implemented. Alternative 41GW-3 would be significantly more difficult to implement than Alternative 41GW-2 since remedial construction activities and associated long-term maintenance activities would be required. Alternative 41GW-4 would be slightly more difficult to implement than Alternative 41GW-3 since the groundwater flowrate would be higher, and pumping wells would need to be installed and maintained.

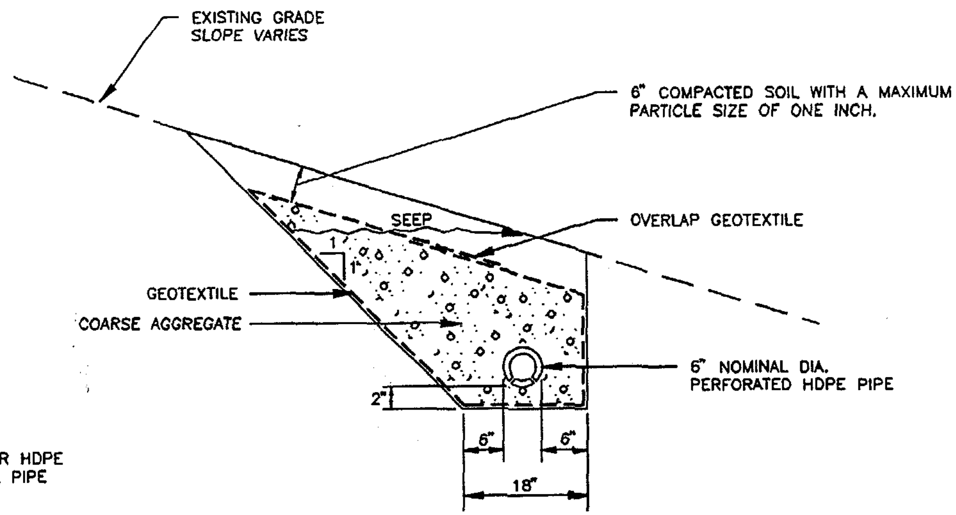
Cost: The estimated 30-year net present worth costs of the four alternatives are as follows:

• Alternative 41GW-1	$0
• Alternative 41GW-2	$592,000
• Alternative 41GW-3a/41GW-3b	$1,878,000 / $1,029,000
• Alternative 41GW-4a/41GW-4b	$1,959,000 / $1,887,000

SECTION 4.0 FIGURES



PLAN VIEW



SECTION A-A'

SEEP COLLECTION TRENCH

NOT TO SCALE

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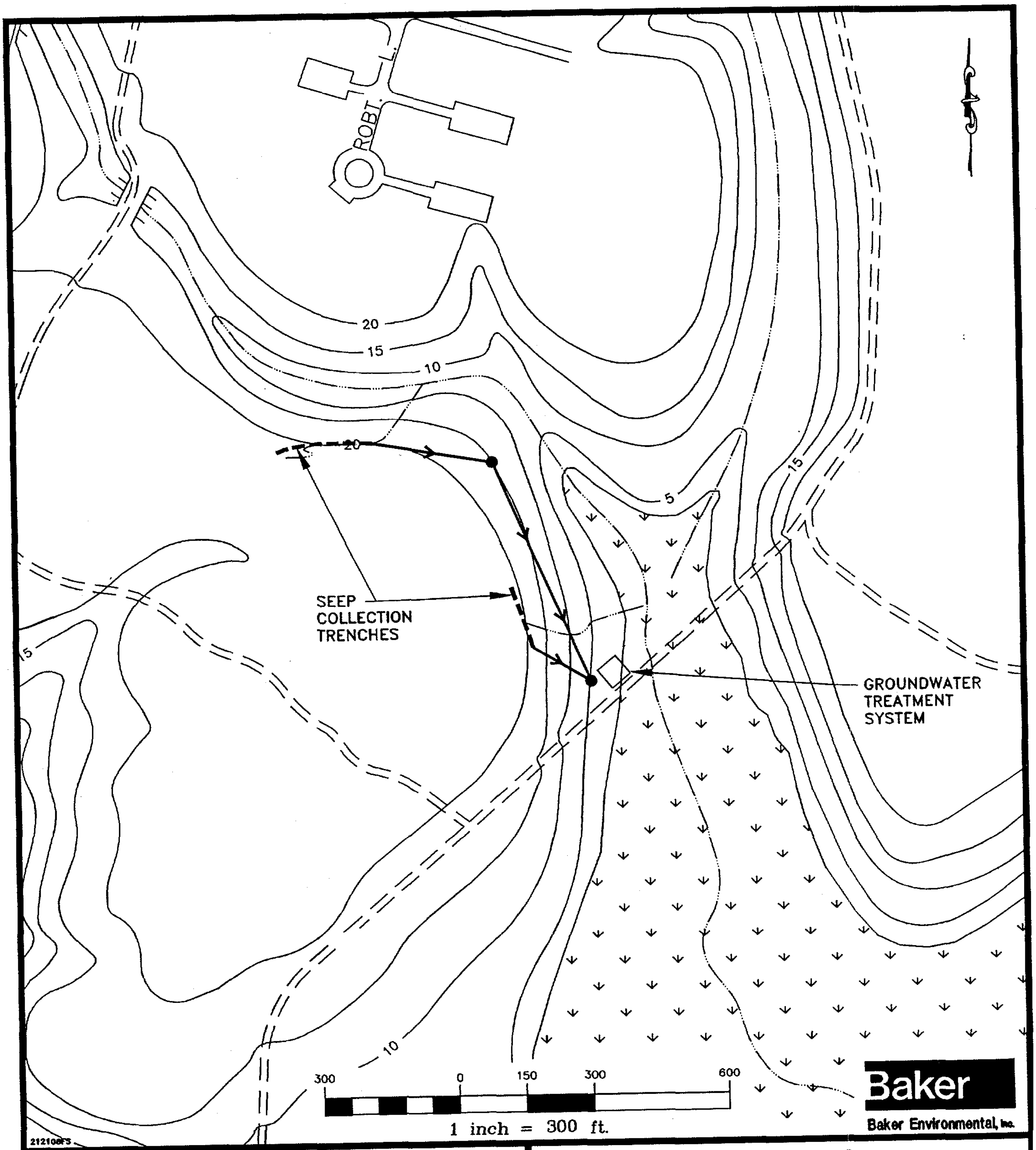
NOTES:

1. PLACE SEEP COLLECTION TRENCH SO ENTIRE SEEP FLOW IS INTERCEPTED BY COARSE AGGREGATE BACKFILL. EXACT LOCATION OF PIPE AND SEEP BOX TO BE DETERMINED IN THE FIELD AT TIME OF CONSTRUCTION.
2. LENGTH, L, OF PRIMARY COLLECTION PIPE CORRESPONDS TO SEEP LENGTH.

FIGURE 4-1
TYPICAL SEEP COLLECTION TRENCH
ALTERNATIVE 41GW-3 SITE 41 -
CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2120125



LEGEND
- MANHOLE
- SEEP COLLECTION TRENCH
- SEEP CONDUIT
- MARSH
- TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-2
SEEP COLLECTION AND PHYSICAL/ TREATMENT ALTERNATIVE 41GW-3a
SITE 41 - CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

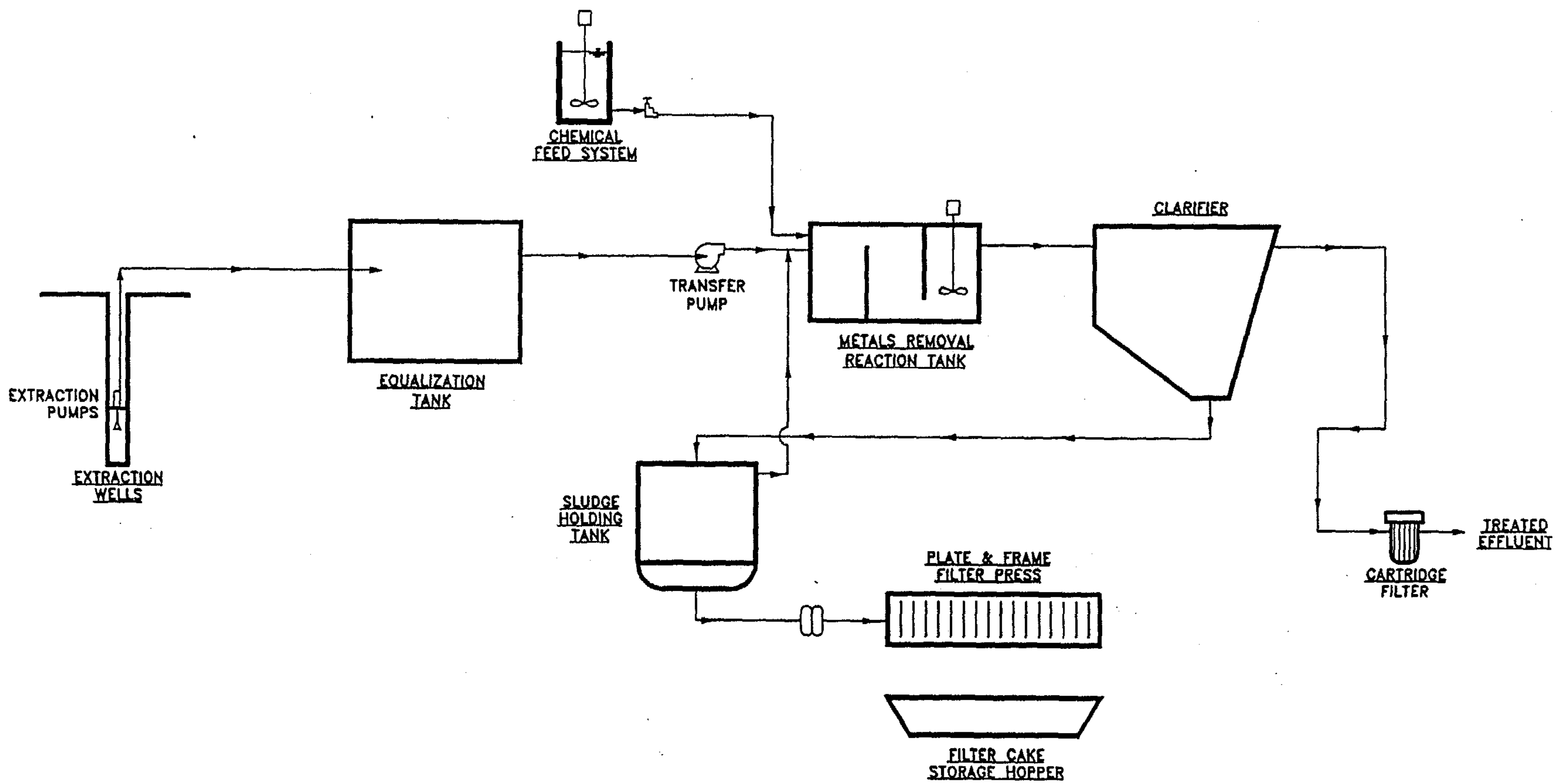


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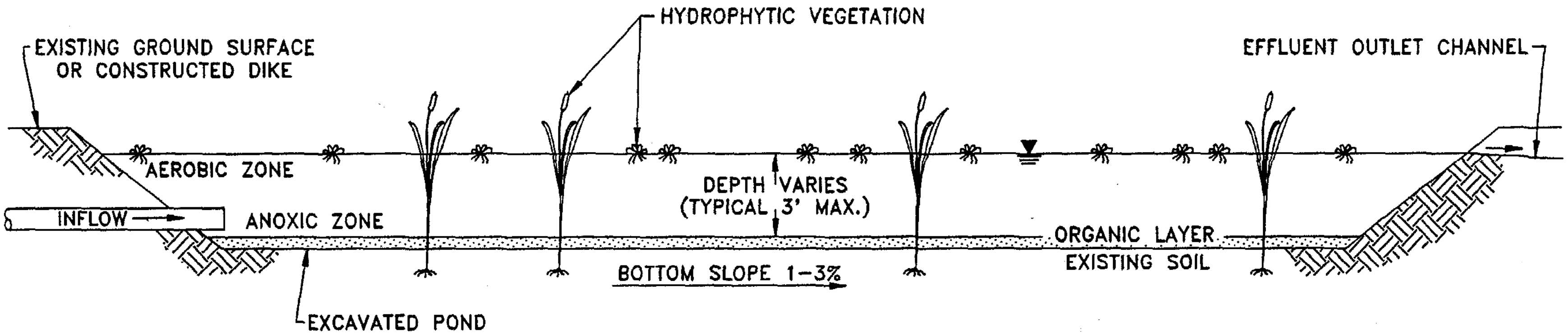
FIGURE 4-3
GROUNDWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM
ALTERNATIVES 41GW-3a & 41GW-4a
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212007FS



NOT TO SCALE

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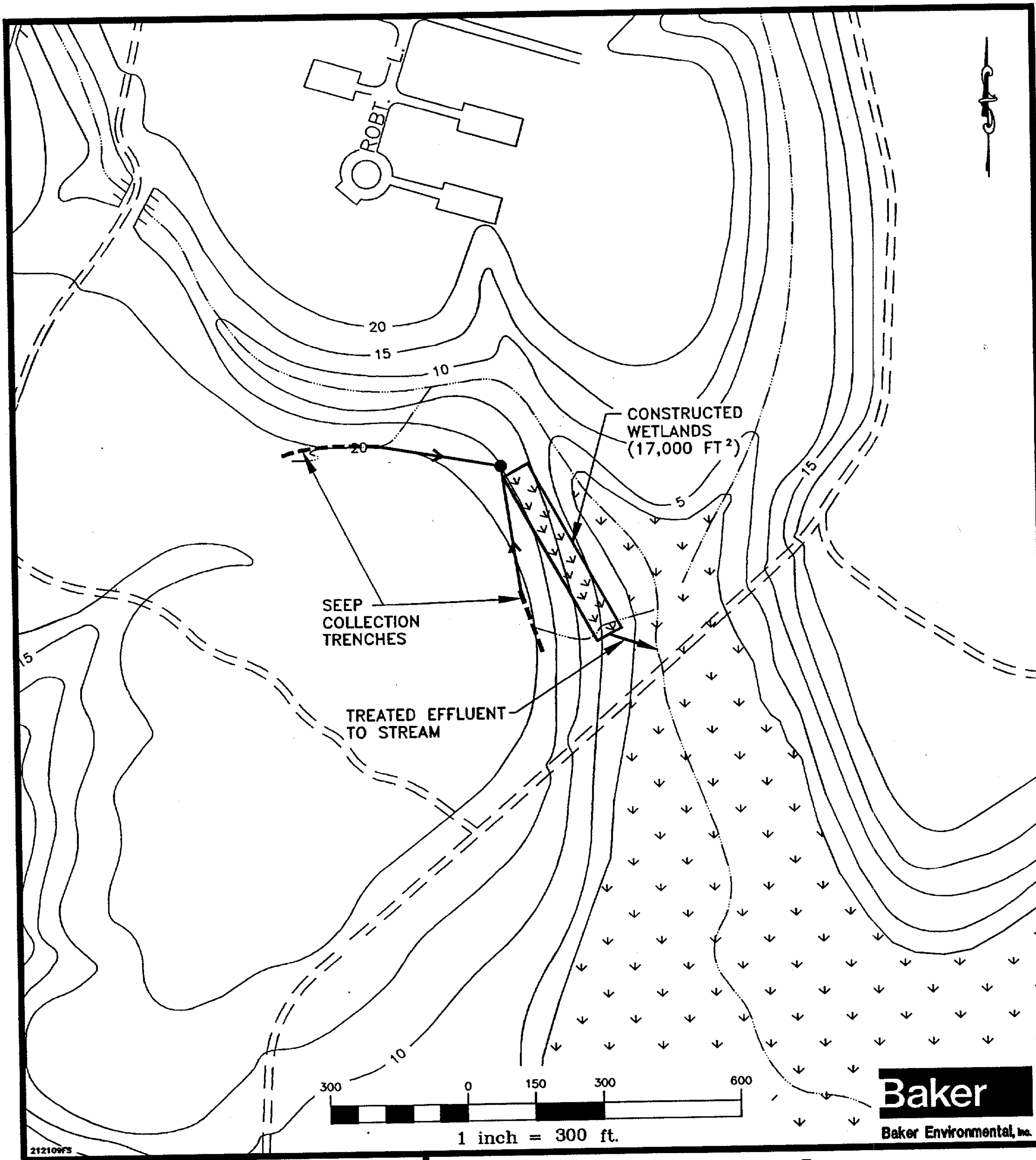
FIGURE 4-4
TYPICAL CONSTRUCTED WETLANDS TREATMENT SYSTEM
ALTERNATIVES 41GW-3 AND 41GW-4
SITE 41 - CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

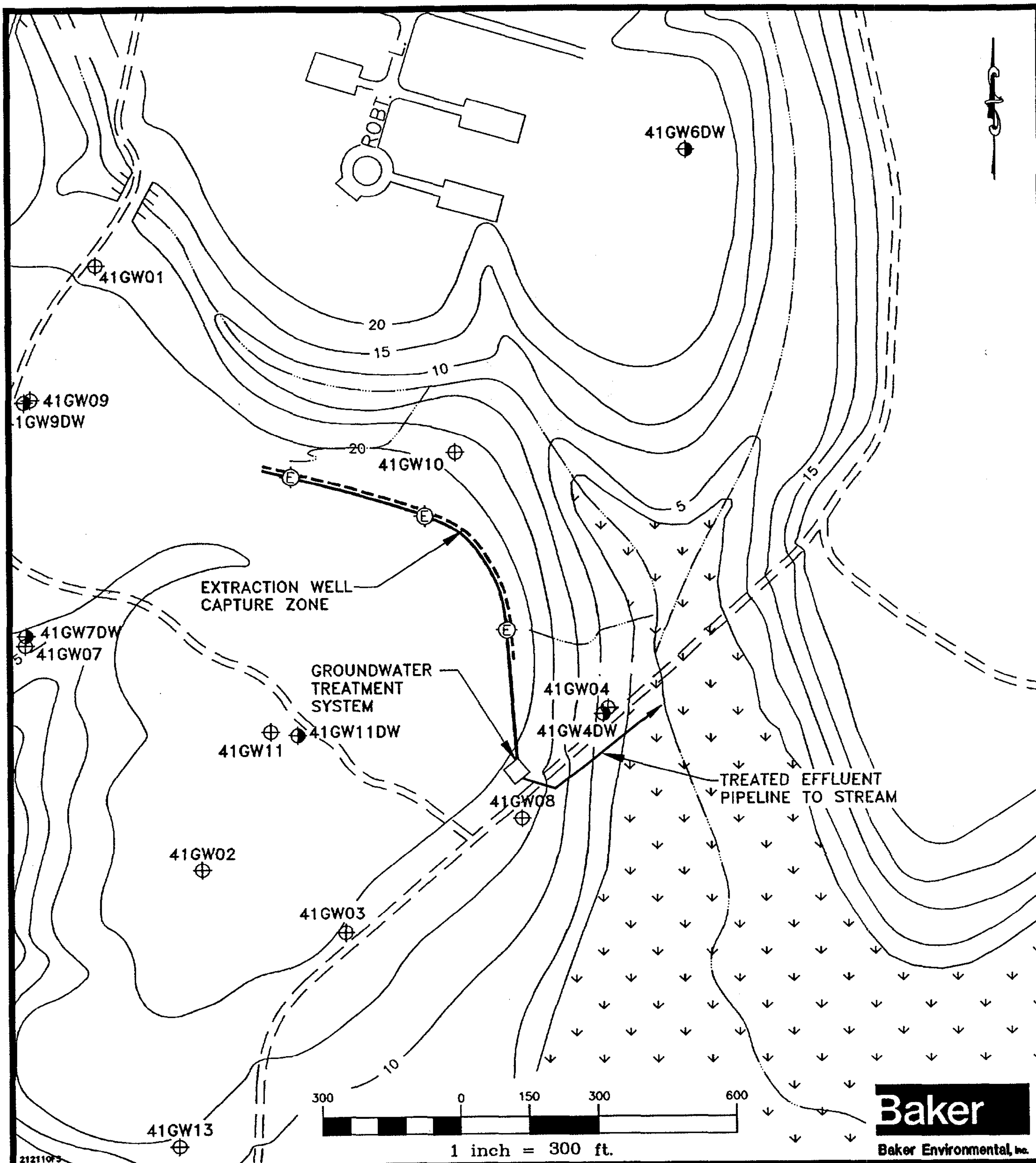


LEGEND

- MANHOLE
- SEEP COLLECTION TRENCH
- SEEP CONDUIT
- MARSH
- TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-5
SEEP COLLECTION AND CONSTRUCTED WETLANDS TREATMENT ALTERNATIVE 41GW-3b
SITE 41 - CAMP GEIGER DUMP
NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

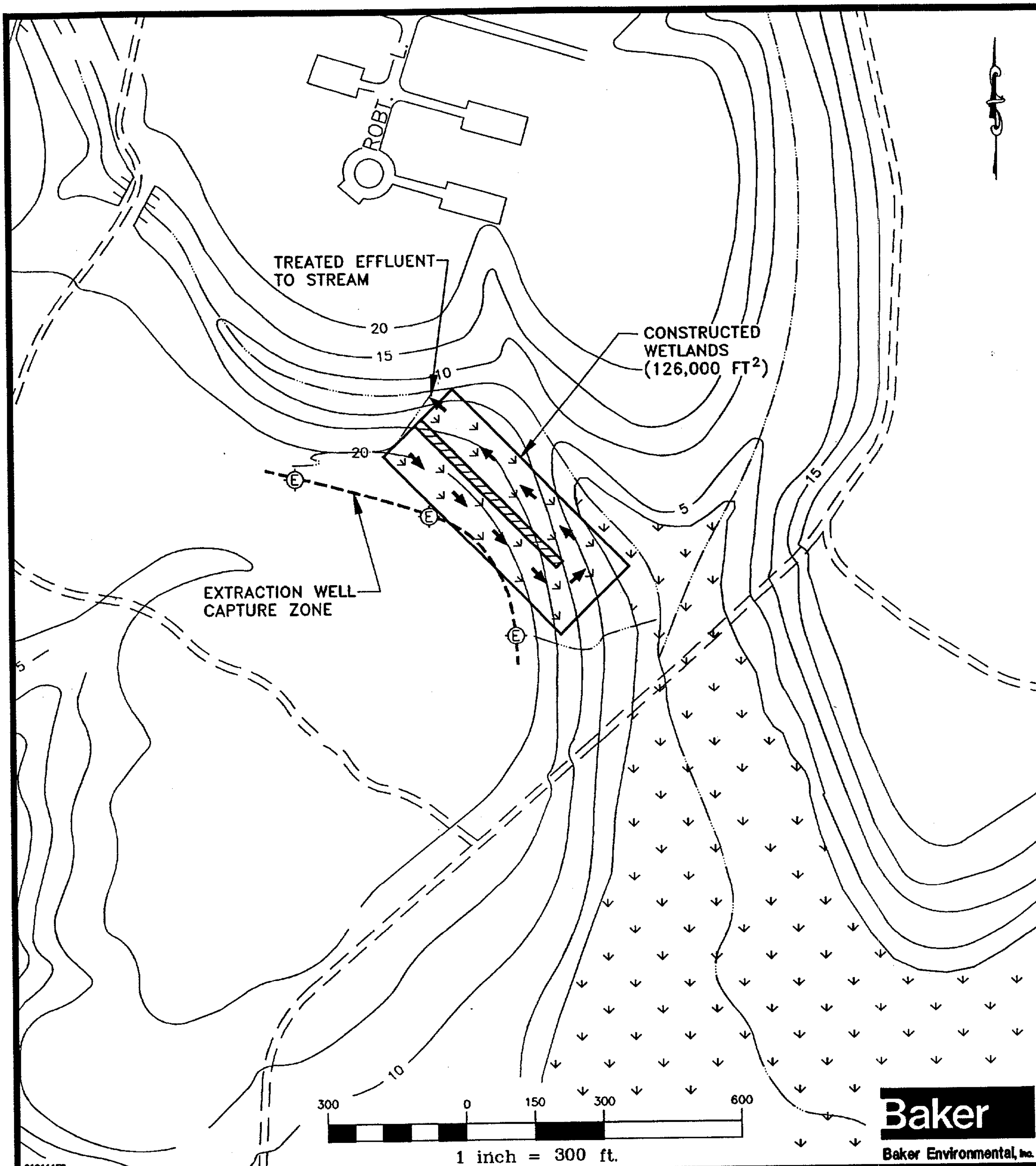


LEGEND

41GW01 – SHALLOW MONITORING WELL
41GW4DW – DEEP MONITORING WELL
– PROPOSED EXTRACTION WELL
5 – TOPOGRAPHIC ELEVATION LINES
– ROAD (IMPROVED)
– ROAD (UNIMPROVED)
– MARSH
– INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-6
GROUNDWATER EXTRACTION AND PHYSICAL/
CHEMICAL TREATMENT ALTERNATIVE 41GW-4
SITE 41 – CAMP GEIGER DUMP
NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- PROPOSED EXTRACTION WELL
- FLOW DIRECTION
- TOPOGRAPHIC ELEVATION LINES
- ROAD (IMPROVED)
- ROAD (UNIMPROVED)
- MARSH
- INTERMITTENT STREAM

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-7
GROUNDWATER EXTRACTION AND CONSTRUCTED WETLANDS TREATMENT ALTERNATIVE 41GW-4
SITE 41 - CAMP GEIGER DUMP
NEAR FORMER TRAILER PARK
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

5.0 DETAILED ANALYSIS OF SITE 74 REMEDIAL ALTERNATIVES

5.1 Site 74 Soil (SO) Alternatives

Site 74 soil (SO) (including buried waste) alternatives were developed based on the remedial action objective (RAO) and general response actions identified in Section 2.0 as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-11, the RAO for the soil and waste (landfilled material) at this site is as follows:

- Prevent future potential exposure to buried contaminated soil and waste.

The soil remedial alternatives developed for Site 74 and evaluated in Sections 5.1.1 and 5.1.2 are listed below:

- Alternative 74SO-1 - No Action
- Alternative 74SO-2 - Institutional Controls

A comparison of these soil alternatives is presented in Section 5.2.3.

Although a capping alternative is often considered for former landfill sites, a capping alternative was not developed for this site because of implementability and effectiveness concerns. Results of the human health risk assessment indicate that the surface soils currently do not pose an unacceptable risk to base personnel. Therefore, a cap is not necessary to eliminate contact with the surface soil. As indicated in Table 3-3 in Section 3.3, installation of a low-permeability cap would require extensive clearing, grubbing, and regrading activities that would disturb the landfill contents. Since the landfill may contain CWM and other hazardous wastes, implementation of a cap would pose a significant risk to human health and the environment during construction. Furthermore, because the site is heavily vegetated, regrowth of vegetation following cap installation could puncture the cap causing a long-term operational concern. Control of vegetation regrowth could require the application of an herbicide, which could pose additional environmental and human health risks. Finally, the waste materials are not underlain by a continuous low-permeability liner, and the water table is very close to the ground surface. These conditions would limit the ability of cap to protect groundwater. Any contaminants present in the landfill could continue to leach to groundwater even after the cap is installed. For these reasons, capping technologies were eliminated from further consideration in Section 3.3.

5.1.1 Alternative 74SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 74, which was used as a grease pit and disposal area from the early 1950s to 1960.

Overall Protection: Since no actions would be taken, exposure pathways would be unaffected by this alternative. During its operation, the site may have received drums containing either pesticides or transformer oil containing PCBs, pesticide-soaked bags, and possibly drums containing chemical surety agents. Only residual levels of contamination were detected in the surface and subsurface soils during the soil investigation. However, the potential still exists for waste materials and chemical training agents to be present within the landfill.

The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan.

There are no construction activities planned for this area. However, there are also currently no official institutional controls in place to prohibit potential construction activities from occurring at the site in the future. Thus, under this alternative, the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents) would not be reduced, therefore, the RAO for this site would not be achieved.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface and subsurface soils at Site 74 under current military, future residential, and future construction use scenarios. However, the potential still exists for waste materials and chemical training agents to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. Hence, this alternative would not provide a permanent, long-term remedy with respect to attainment of the RAO.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any residual contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as biodegradation, volatilization, and dispersion (i.e., leaching).

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

5.1.2 Alternative 74SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site, which was used as a grease pit and disposal area from the early 1950s to 1960. These institutional controls would consist of designation of the area as a restricted, or limited-use area. No remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at the site.

The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan. Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area as well as invasive construction activities. The site is currently fenced to restrict access. If needed, warning signs could be posted around the site to indicate that wastes are buried at the site and that construction activities are prohibited in the area.

Overall Protection: Under this alternative, institutional controls would be implemented, which would restrict the site to nonresidential uses and would significantly reduce the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents). Thus, this alternative would achieve the RAO for soil and waste at this site.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface and subsurface soils at Site 74 under current military, future residential, and future construction use scenarios. However, the potential still exists for waste materials and chemical training agents to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. With respect to attainment of the RAO, this alternative would provide a permanent, long-term solution through strict enforcement of the revised Base Master Plan to restrict site access and prohibit future invasive construction activities.

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any residual contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as biodegradation, volatilization, and dispersion (i.e., leaching).

Short-term Effectiveness: This alternative would not involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: This alternative should be administratively straightforward to implement. Appropriate access restrictions and land use designations could be readily incorporated into the Base Master Plan.

Cost: There are no estimated costs for this alternative. Labor costs associated with revision of the Base Master Plan have not been estimated.

5.1.3 Comparison of Site 74 Soil Alternatives

The soil alternative comparison for Site 74, based on the seven criteria, is provided in the following sections.

Overall Protection: The potential still exists for waste materials and chemical training agents to be present within the landfill. Alternative 74SO-1 would not reduce the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents), whereas Alternative 74SO-2 would reduce this risk through the use of institutional controls. Thus, only Alternative 74SO-2 would achieve the RAO for soil and waste at this site.

Compliance with ARARs: There are no State or federal contaminant-, location-, or action-specific ARARs associated with Alternatives 74SO-1 and 74SO-2 since no remedial actions would be taken under either alternative.

Long-term Effectiveness and Permanence: With respect to attainment of the RAO, only Alternative 74SO-2 would provide a permanent, long-term solution through revisions to the Base Master Plan to restrict site access, prohibit future invasive construction activities, and limit the area to non-residential uses.

Reduction of Toxicity, Mobility, or Volume: Neither Alternative 74SO-1 nor 74SO-2 would reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment.

Short-term Effectiveness: Neither Alternative 74SO-1 nor 74SO-2 would involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with Alternative 74SO-1, since no actions would be taken. Alternative 74SO-2 should be administratively straightforward to implement.

Cost: There are no costs associated with Alternatives 74SO-1 or 74SO-2.

5.2 Site 74 Groundwater (GW) Alternatives

Groundwater (GW) alternatives were developed based on the RAOs and general response actions identified in Section 2.0 as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-11, the RAO for the groundwater at this site is as follows:

- Prevent future potential exposure to contaminated groundwater.

The groundwater remedial alternatives developed for Site 74 and evaluated in Sections 5.2.1 and 5.2.2 are listed below:

- Alternative 74GW-1 - No Action
- Alternative 74GW-2 - Institutional Controls and Monitoring

A comparison of these groundwater alternatives is presented in Section 5.2.3.

5.2.1 Alternative 74GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat potentially contaminated groundwater at Site 74, which was used as a grease pit and disposal area from the early 1950s to 1960.

Groundwater contamination generally consists of total metals concentrations of chromium, lead, iron, and manganese detected in unfiltered samples collected from the shallow aquifer. Since no sources of these metals were identified within the landfill, the elevated total metals concentrations are most likely a result of turbidity (i.e., suspended solids) in the wells rather than from actual leaching of contaminants from the soils to groundwater.

Shallow groundwater generally flows in an eastern to northeastern direction across the site. Shallow groundwater on site currently is not used for any purpose. A potable water supply well, Supply Well HP-654, is located in the Castle Hayne Aquifer near the center of the site. This well is periodically sampled for full organic and inorganic analysis, and no contamination has been detected in the well to date. Both the shallow and upper Castle Hayne Aquifers are classified as GA waters under the North Carolina Water Quality Standards (NCWQS), which are current or potential sources of drinking water.

Overall Protection: Exposure pathways would be unaffected by the implementation of this alternative. This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment, should contaminant levels exceed NCWQS in the future. Any future contaminated groundwater would be allowed to migrate. Under this scenario, contaminant concentrations in the groundwater could eventually decrease below the NCWQS through natural dilution and dispersion.

With respect to achievement of RAOs, this alternative would not prevent future potential exposure to contaminated groundwater.

Compliance with ARARs: Contaminated groundwater exceeded federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for several metals (i.e., chromium, lead, iron, and manganese) during the first sampling round. Most of the high metals concentrations were detected in unfiltered samples in the shallow aquifer. As discussed in Section 1.4.2.2, these metals concentrations are most likely a result of suspended solids in the wells rather than from actual leaching of contaminants from the soils to groundwater. Only iron, which is elevated throughout the base, exceeded its NCWQS and MCL (secondary) during the low-flow sampling round.

The only action-specific ARAR associated with this alternative are the Corrective Action Requirements of the North Carolina Administrative Code, Chapter 2L, Section .0106. Since this alternative would not provide the best available technology for restoration of groundwater to the NCWQSs, a demonstration would need to be made in accordance with Corrective Action requirements. The demonstration would involve the use of existing groundwater data to show that groundwater treatment is not required to provide adequate protection of human health and environment.

There are no location-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: This alternative would not attain the RAO and would not provide a permanent, long-term solution for the site. If the groundwater in the shallow aquifer at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would exceed 1×10^{-4} by a factor of six, and the hazard index would exceed 1 by about an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the total metals concentrations detected in the aquifer.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant sources, which appear to be minimal based on the subsurface soil investigation.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

5.2.2 Alternative 74GW-2 - Institutional Controls and Monitoring

Under this alternative, a groundwater sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of potential contaminated groundwater would be sampled as well as a limited number of perimeter and upgradient wells. For costing purposes, it was assumed that, on average, five monitoring wells would be periodically sampled. Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Shallow groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the shallow aquifer. However, there is currently no official groundwater use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells on site.

Overall Protection: This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment, should contaminant levels exceed NCWQS in the future. Any future contaminated groundwater would be allowed to migrate. Under this scenario, contaminant concentrations in the groundwater could eventually decrease below the NCWQS through natural dilution and dispersion.

With respect to achievement of the RAO, this alternative would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring. The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

Compliance with ARARs: There are no location-specific ARARs associated with this alternative. Compliance with contaminant- and action-specific ARARs would be the same as with Alternative 74GW-1 (see Section 5.2.1, "compliance with ARARs").

Long-term Effectiveness and Permanence: This alternative would attain the RAO and would provide a permanent, long-term solution for the site since contaminant levels are marginal and periodic environmental sampling is a reliable means of tracking contaminant migration. Potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and strict enforcement of institutional controls.

The USEPA 5-year site review would be required to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant sources, which appear to be minimal based on the subsurface soil investigation.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: An environmental monitoring program could be readily implemented at the site. Appropriate groundwater use designations could also be readily incorporated into the Base Master Plan.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $22,300
- Net present worth (30-year): $342,000

5.2.3 Comparison of Site 74 Groundwater Alternatives

The groundwater alternative comparison for Site 74, based on the seven criteria, is provided in the following sections.

Overall Protection: Neither Alternatives 74GW-1 or 74GW-2 would actively restore contaminated groundwater to drinking water standards through extraction and treatment, should contaminant levels exceed NCWQS in the future. Any future contaminated groundwater would be allowed to migrate. With respect to achievement of RAO, only Alternative 74GW-2 would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring.

Compliance with ARARs: Under both Alternatives 74GW-1 and 74GW-2, contaminated groundwater would most likely continue to exceed the secondary MCL and the NCWQS for iron. However, the elevated iron concentrations are believed to be associated with background concentrations.

Long-term Effectiveness and Permanence: Alternative 74GW-1 would not achieve the RAO and would not provide a permanent, long-term solution for the site. Alternative 74GW-2 would attain the RAO and would provide a permanent, long-term solution for the site since contaminant levels are marginal and periodic environmental sampling is a reliable means of tracking contaminant migration. In addition, under Alternative 74GW-2, potential unacceptable risks associated with groundwater use would be permanently mitigated through provision of institutional controls.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by either Alternative 74GW-1 or 74GW-2.

Short-term Effectiveness: Neither Alternative 74GW-1 nor 74GW-2 would involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with Alternative 74GW-1 since no actions would be taken. Under Alternative 74GW-2, the environmental monitoring program and institutional controls could be readily implemented.

Cost: There are no costs associated with Alternative 74GW-1. The estimated 30-year present worth cost of Alternative 74GW-2 is $342,000.

6.0 REFERENCES

40 CFR 300. 1993. National Contingency Plan.

Baker Environmental, Incorporated (Baker). 1994. Remedial Investigation Report for Operable Unit No. 4 (Sites 41 and 74), Marine Corps Base, Camp Lejeune, North Carolina. Draft Final. Prepared for the Department of the Navy Atlantic Division Naval Facilities Engineering Command, Norfolk, Virginia. April 1994.

Eakes, Wallace, 1982. Trip Report for IAS Team. March 31, 1982.

Federal Facility Agreement (FFA) between USEPA Region IV, the NC DEHNR, and U.S. DON for MCB Camp Lejeune and Marine Corps Air Station, New River, North Carolina. December 6, 1989.

Greenhorne & O'Mara, Inc. 1992. Preliminary Draft Report - Wellhead Monitoring Study - Engineering Study 92-34. Prepared for the Department of the Navy Civil Branch. December 1992.

Means Site Work & Landscape Cost Data, 1993. 12th Annual Edition. R.S. Means Company, Inc. Construction Consultants & Publishers, Kingston, MA.

U.S. Army Chemical Materiel Destruction Agency (USACMDA), 1993. Non-Stockpile Chemical Materiel Program Survey and Analysis Report. November, 1993.

USEPA. 1992a. Region IV Waste Management Screening Values for Hazardous Waste Sites.

USEPA. 1991a. Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions. U.S. Department of Commerce. OSWER Directive 9355.0-30. April 1991.

USEPA. 1991b. Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Factors." Office of Solid Waste and Emergency Response, Washington, D.C. March 25, 1991. OSWER Directive 9285.6-03.

USEPA. 1989a. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. December 1989. EPA/540/1-89-002.

USEPA. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. Office of Emergency and Remedial Response, Washington, DC. USEPA/540/G-89004.

USEPA. 1988b. CERCLA Compliance With Other Laws Manual: Draft Guidance. Office of Emergency and Remedial Response, Washington, DC. USEPA/540/6-89-006.

APPENDIX A
RISK-BASED ACTION LEVEL CALCULATIONS

INGESTION OF GROUNDWATER ACTION LEVEL
FEASABILITY STUDY
CTO-0212
MCB CAMP LEJEUNE
CHILD RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	1
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	6
BW = body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Trichloroethene	1659	1	350	6	15	70	365	1.10E-02	1.0E-04
1,1,2,2-Tetrachlorethane	91	1	350	6	15	70	365	2.00E-01	1.0E-04
Heptachlor	4	1	350	6	15	70	365	4.50E+00	1.0E-04
4,4'-DDD	76	1	350	6	15	70	365	2.40E-01	1.0E-04
alpha-Chlordane	14	1	350	6	15	70	365	1.30E+00	1.0E-04
beta-BHC	10	1	350	6	15	70	365	1.80E+00	1.0E-04
Arsenic	11	1	350	6	15	70	365	1.70E+00	1.0E-04
Beryllium	4	1	350	6	15	70	365	4.30E+00	1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
Total 1,2-Dichloroethene	313	1	350	6	15	6	365	2.00E-02	1
Trichloroethene	94	1	350	6	15	6	365	6.00E-03	1
Heptachlor	8	1	350	6	15	6	365	5.00E-04	1
alpha-chlordane	1	1	350	6	15	6	365	6.00E-05	1
Arsenic	5	1	350	6	15	6	365	3.00E-04	1
Barium	1095	1	350	6	15	6	365	7.00E-02	1
Beryllium	78	1	350	6	15	6	365	5.00E-03	1
Cadmium	8	1	350	6	15	6	365	5.00E-04	1
Chromium	78	1	350	6	15	6	365	5.00E-03	1
Copper	580	1	350	6	15	6	365	3.71E-02	1
Nickel	313	1	350	6	15	6	365	2.00E-02	1
Manganese	78	1	350	6	15	6	365	5.00E-03	1
Mercury	5	1	350	6	15	6	365	3.00E-04	1
Selenium	78	1	350	6	15	6	365	5.00E-03	1
Vanadium	110	1	350	6	15	6	365	7.00E-03	1
Zinc	4693	1	350	6	15	6	365	3.00E-01	1

File Name: GWIC.WQ1

INGESTION OF GROUNDWATER ACTION LEVEL
FEASABILITY STUDY
CTO-0212
MCB CAMP LEJEUNE
ADULT RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	2
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	30
BW = body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Trichloroethene	774	2	350	30	70	70	365	1.10E-02	1.0E-04
1,1,2,2-Tetrachlorethane	43	2	350	30	70	70	365	2.00E-01	1.0E-04
Heptachlor	2	2	350	30	70	70	365	4.50E+00	1.0E-04
4,4'-DDD	35	2	350	30	70	70	365	2.40E-01	1.0E-04
alpha-Chlordane	7	2	350	30	70	70	365	1.30E+00	1.0E-04
beta-BHC	5	2	350	30	70	70	365	1.80E+00	1.0E-04
Arsenic	5	2	350	30	70	70	365	1.70E+00	1.0E-04
Beryllium	2	2	350	30	70	70	365	4.30E+00	1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
Total 1,2-Dichloroethene	730	2	350	30	70	30	365	2.00E-02	1
Trichloroethene	219	2	350	30	70	30	365	6.00E-03	1
Heptachlor	18	2	350	30	70	30	365	5.00E-04	1
alpha-chlordane	2	2	350	30	70	30	365	6.00E-05	1
Arsenic	11	2	350	30	70	30	365	3.00E-04	1
Barium	2555	2	350	30	70	30	365	7.00E-02	1
Beryllium	183	2	350	30	70	30	365	5.00E-03	1
Cadmium	18	2	350	30	70	30	365	5.00E-04	1
Chromium	183	2	350	30	70	30	365	5.00E-03	1
Copper	1354	2	350	30	70	30	365	3.71E-02	1
Nickel	730	2	350	30	70	30	365	2.00E-02	1
Manganese	183	2	350	30	70	30	365	5.00E-03	1
Mercury	11	2	350	30	70	30	365	3.00E-04	1
Selenium	183	2	350	30	70	30	365	5.00E-03	1
Vanadium	256	2	350	30	70	30	365	7.00E-03	1
Zinc	10950	2	350	30	70	30	365	3.00E-01	1

File Name: GWIA.WQ1

APPENDIX B
REMEDIAL ALTERNATIVE COST ESTIMATES

SITE 41 COST ESTIMATES

S.O. No. 62470-212-0000-00960

Subject: SEEP COLLECTION / FEASIBILITY STUDY

SITE 41 - CAMP GEIGER DUMP Sheet No. 1 of 1

SEEP COLLECTOR QUANTITY ESTIMATE Drawing No.

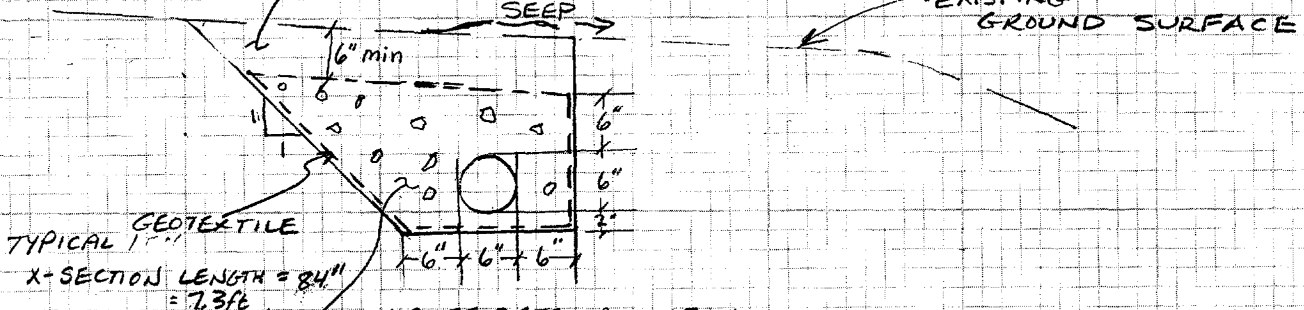
Computed by LMM Checked By GJR Date 10-7-94

Baker

QUANTITY ESTIMATES FOR SEEP COLLECTION TRENCH

ASSUME TYPICAL X-SECTION FOR COLLECTION TRENCH IS:

COMPACTED SOIL BACKFILL TYPICAL X-SECTION AREA = $\frac{6'' \times \left(\frac{34+40}{2}\right)}{144} = 1.54\ ft^2$



COARSE AGGREGATE BACKFILL

TYPICAL X-SECTION AREA = $\frac{(18'' \times 14'') + \frac{1}{2}(14'')^2}{144\ in^2/ft^2} = 2.43\ ft^2$

FOR NORTHERN SEEP:

ESTIMATE OF TRENCH LENGTH ≈ 250 ft

FOR EASTERN SEEP:

ESTIMATE OF TRENCH LENGTH ≈ 150 ft

∴ OVERALL SEEP COLLECTION TRENCH = 250' + 150' = 400 ft.

MATERIAL QUANTITY REQUIREMENTS:

EXCAVATION = $(1.54\ ft^2 + 2.43\ ft^2)(400\ ft) = 1588\ ft^3 \approx 60$ cy

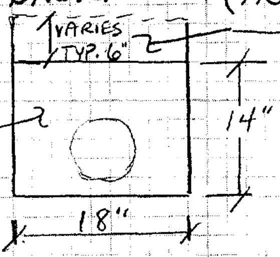
GEOTEXTILE = $(7.3\ ft)(400\ ft)(1.25) = 3650\ ft^2 \approx 400$ sy

OVERLAP ALLOWANCE

COARSE AGGREGATE = $(2.43\ ft^2)(400\ ft) = 972\ ft^3 \approx 40$ cy Assume 20% swell ∴ 50 cy LOOSE REQ

COMPACTED SOIL BACKFILL = $(1.54\ ft^2)(400\ ft) = 616\ ft^3 \approx 20$ cy

CONDUIT TRENCH:



COMMON BACKFILL

TYPICAL X SECTION AREA = $\frac{6'' \times 18''}{144} = 0.75\ ft^2$

$\frac{14'' \times 18''}{144} = 1.75\ ft^2$

CONDUIT LENGTH ≈ 900 FT.

∴ EXCAVATION = $900 \times (1.75 + 0.75) = 2250\ FT^3 \approx 8$

SELECT BACKFILL = $900 \times 1.75 = 1575\ FT^3 \approx 60$ c

S.O. No. 62470-212-0000-00960

Subject: GROUNDWATER TREATMENT/FEASIBILITY STUDY

SITE 41 - CAMP GEIGER DUMP

CONSTRUCTED WETLANDS SIZING

Sheet No. 1 of 3

Drawing No.

Computed by LMM Checked By GJR Date 10-7-94

Baker

SIZING OF CONSTRUCTED WETLANDS FOR TREATMENT

CURRENT LITERATURE CONTAINS SIZING/DESIGN PARAMETERS FOR TREATMENT OF TWO GENERAL TYPES OF WASTE WATERS:

1 - MUNICIPAL/SANITARY WASTEWATER

2 - ACID MINE DRAINAGE

GROUNDWATER CHARACTERISTICS AT SITE 41 MOST CLOSELY APPROXIMAT CHARACTERISTICS TYPICAL OF ACID MINE DRAINAGE (e.g., pH < 7, RELATIVELY HIGH CONCENTRATIONS OF METALS PARTICULARLY IRON).

TWO CURRENT EMPIRICALLY-DERIVED SIZING PROCEDURES ARE AVAILABLE:

1 - Bureau of Mines (BOM)

2 - Tennessee Valley Authority (TVA)

EACH IS UTILIZED TO EVALUATE SIZE REQUIREMENTS FOR SITE 41

BOM APPROACH

Guidelines are that 200 ft^2 of wetland is needed for each gal/min. of flow

TVA APPROACH

If influent pH < 5.5 then 2 m^2 (21.5 ft^2) of wetland is needed for each mg/min of Fe entering

If influent pH > 5.5 then 0.75 m^2 (8 ft^2) of wetland is needed for each mg/min of Fe entering

S.O. No. 62470-212-0000-00960

Subject: GROUNDWATER TREATMENT / FEASIBILITY STUDY
SITE 41 - CAMP GEIGER DUMP
CONSTRUCTED WETLANDS SIZING

Sheet No. 2 of 3

Drawing No.

Computed by LMM Checked By GJR Date 10-7-94

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SITE 41 DESIGN PARAMETERS

METAL OF CONCERN = Fe

USE MAXIMUM MEASURED Fe CONCENTRATION IN SEEPS FOR DESIGN ∴ Fe = 278 mg/L (total iron measured in eastern seep on 8/23/94 in sample no. 41-UN-SW24)

CONVERTING TO mg/gal yields:

$$278\ mg/L \cdot \frac{3.785\ L}{gal} = 1052\ mg/gal$$

Assume pH of groundwater and seeps are similar ∴ measured pH in groundwater indicates pH > 5.5

FLOW RATES: SEEPS - USE 1 gal/min/seep ∴ 2 gal/min total seep flow

EXTRACTION WELLS - Use 15 gal/min.

WETLANDS SIZING FOR SEEP TREATMENT

BOM Method:

$$2\ gal/min \times 200\ ft^2/gal/min = 400\ ft^2$$

TVA Method:

pH > 5.5 ∴ $8\ ft^2/mg\ Fe/min$ is required

$$\frac{8\ ft^2}{mg\ Fe/min} \cdot \frac{1052\ mg\ Fe}{gal} \cdot \frac{2\ gal}{min} = \boxed{16,830\ ft^2}$$

COMPARISON OF RESULTS:

BOM Method appears unrealistically low based upon existing case studies. ∴ FOR present cost estimating purposes use TVA methods for sizing

S.O. No. 62470-212-0000 -000960

Subject: GROUNDWATER TREATMENT/ FEASIBILITY STUDY
SITE 41 - CAMP GEIGER DUMP
CONSTRUCTED WETLANDS SIZING

Sheet No. 3 of 3

Drawing No.

Computed by LMM Checked By GJR Date 10-7-94

Baker

WETLANDS SIZING FOR TREATMENT OF GROUNDWATER COLLECTED BY EXTRACTION WELLS

ASSUME ALL PARAMETERS EXCEPT FLOW RATE ARE THE SAME AS FOR SEEP COLLECTION & TREATMENT.

WETLANDS SIZE REQUIREMENTS ARE SIMPLE PROPORTION:

$$16{,}830\,ft^2 \cdot \frac{15\,gpm}{2\,gpm} = \boxed{126{,}225\,ft^2}$$

APPROXIMATE AREA REQUIREMENTS:

Hydraulic Design Recommends Length to Width Ratio of 10:1 or greater

To estimate layout requirements

SEEP COLLECTION/ TREATMENT:

Area Required = $16{,}830\,ft^2$
Assume Width = 40 ft
Assume Length = 430 ft

GROUNDWATER EXTRACTION/ TREATMENT:

Area Required = $126{,}225\,ft^2$
Assume Width = 110 ft
Assume Length = 1150 ft.

S.O. No.	62470-212-0000-00980					
Subject	Groundwater Extraction System Conceptual Design					
Draft Final Feasibility Study			Sheet No.	1	of	1
ite 41, MCB Camp Lejeune, North Carolina			Drawing No.			
Computed by	GJR	Checked by TLB	Date	2-3-95		

Baker

Surficial Aquifer Groundwater Extraction System

Required Capture Length = 900 ft

From Keely and Tsang (Groundwater, December 1983):

$r = Q/(2\pi hnV_r)$ where:

r = distance to downgradient stagnation point
Q = pumping rate
n = porosity
h = saturated thickness
V_r = average linear velocity

$V_r = Ti/bn$ where:

T = transmissivity
i = gradient
b = aquifer thickness

$= Qbn/2\pi hnTi$

assume h = b, then

$r = Q/2\pi Ti$

πr = distance to cross-gradient stagnation point
$2\pi r$ = distance to upgradient stagnation point

Aquifer Parameters (From RI Report)

Average T = 33.6 ft^2/d = 251 gpd/ft
Average i = 0.009

Assume Q = 1 gpm for each well = 1440 pgd

$r = 1440/[2\pi(251 \text{ gpd/ft})(0.009)]$
r = 101 ft
πr = 317 ft

Calculated Well Spacing = 2 x 317 ft = 634 ft

For design and cost estimating purposes, use an extraction system consisting of:
3 wells 300 ft apart at 1 gpm/well
Total Q = 3 gpm

For treatment system design and cost estimating purposes, use a total Q of 15 gpm to allow for possible future increases in groundwater flow.

SITE 41: CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
ALTERNATE GW-2: INSTITUTIONAL CONTROLS AND MONITORING (SEEP, SURFACE WATER, SEDIMENT, GROUNDWATER)
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS / COMMENTS	SOURCE
O & M COST ESTIMATE (BIANNUAL SAMPLING - YEARS 1 - 30)							
Seep, Surface Water, sediment, Groundwater Monitoring							
Labor	Hours	168	$ 40	$ 6,720		Engineering Estimate	Biannual sampling of 14 locations: 2 samplers, 3 hours each location, 2 events per year
Laboratory Analyses - VOCs, Pesticides / PCBs, Metals	Sample	20	$ 173	$ 3,460		Baker Average 1994 BOAs (1)	Biannual sampling of 14 locations: Sediment Samples - 4 from seep area, 3 from creek, 3 QA/QC = 10 samples
	Sample	20	$ 337	$ 6,740			Surface Water Samples - 4 from seep area, 3 from creek, 3 QA/QC = 10 samples
	Sample	20	$ 501	$ 10,020			GW Samples - 7 from wells, 3 QA/QC = 10 samples
	Sample	20	$ 168	$ 3,360			QA/QC & Rinsate Samples - 10 samples
Misc. Expenses	Sample Event	2	$ 2,306	$ 4,612		1994 JTR, Vendor Quotes	Includes travel, lodging, air fare, supplies truck rental, equipment, cooler shipping
Reporting	Sample Event	2	$ 1,500	$ 3,000		Engineering Estimate	1 - report per sampling event
Well Maintenance	Year	1	$ 622	$ 622		Engineering Estimate	Includes repainting and annualized cpst of replacing 1 - well every 5 years.
					$ 38,534		

(Continued Next Page)

SITE 41: CAMP GEIGER DUMP NEAR FORMER TRAILER PARK
ALTERNATE GW-2: INSTITUTIONAL CONTROLS AND MONITORING (SEEP, SURFACE WATER, SEDIMENT, GROUNDWATER)
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS / COMMENTS	SOURCE
CAPITAL COST ESTIMATE							
No Capital Costs					$ -		
ANNUAL O & M COSTS (Years 1 - 30)					$ 38,534	NOTE (1) Sediments can be sampled every 3 years; therefore, sediment analytical divided by 3 to provide an annual cost.	
TOTAL CAPITAL COSTS					$ -		
TOTAL COST - ALTERNATE GW-2					$ 592,362		

ALTERNATIVE 41GW-3A
INDIRECT COSTS AND SUMMARY OF TOTAL COSTS
2 GPM SEEP COLLECTION AND PHYSICAL / CHEMICAL TREATMENT SYSTEM

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$49,544	15%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$49,544	15%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$33,030	10%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$49,544	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$49,544	15%	OF TOTAL DIRECT COST
TOTAL INDIRECT CAPITAL COSTS	$231,207		

SUMMARY OF COSTS:

TOTAL DIRECT CAPITAL COST	$330,295		REFER TO TOTAL DIRECT CAPITAL COST ESTIMATE
TOTAL INDIRECT CAPITAL COST	$231,207		REFER TO TOTAL INDIRECT CAPITAL COST ESTIMATE
PROFIT	$56,150	10%	TOTAL DIRECT AND INDIRECT COSTS
TOTAL CAPITAL COSTS	**$617,652**		
TOTAL ANNUAL O&M COSTS	**$81,994**		
PRESENT WORTH OF ALTERNATIVE	**$1,878,103**		

ALTERNATIVE 41GW-3A
SUMMARY OF DIRECT COSTS

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$73,648		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$27,915		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 - SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 - EQUIPMENT	$102,746		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 - FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 - SPECIAL CONSTRUCTION	$30,000		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 - CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 - MECHANICAL	$10,300		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 - ELECTRICAL	$85,686		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$330,295		---

ALTERNATIVE 41GW-3A

DIRECT COST BREAKDOWN BY DIVISION - 2 GPM SEEP COLLECTION AND PHYSICAL / CHEMICAL TREATMENT SYSTEM

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. PRECONSTRUCTION SUBMITTALS					
1. WORK PLAN	250	HOURS	$50.00	$12,500	ESTIMATED - 200 MANHRS, $50/MANHR
2. HEALTH AND SAFETY PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
3. E&S CONTROL PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
4. EQUIPMENT DATA AND DWGS.	100	HOURS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
1B. MOBILIZATION/DEMOBILIZATION					
1. CONSTRUCTION EQUIPMENT	1	LS	$2,500.00	$2,500	DOZER, BACKHOE, LOADER, BOBCAT, TRUCKS, AIR COMPRESSOR, GENERATORS, ETC.
2. TEMPORARY FACILITIES	3	EACH	$100.00	$300	OFFICE TRAILERS, STORAGE TRAILERS
3. PERSONNEL	10	EACH	$500.00	$5,000	10 MEN @ $500 EACH
1C. DECONTAMINATION PAD					
1. 6"-SLAB ON GRADE	12	CY	$91.00	$1,092	20'X30'X0.5' SLAB, MEANS SITE 1993: 033-130-4700
2. 6"X4" PERIMETER CURBS	80	LF	$5.00	$400	80' OF 6"HX4"W CONCRETE CURB
3. CONCRETE SEALANT	1	LS	$200.00	$200	SEALANT & LABOR
4. PRECAST CONCRETE SUMP W/PUMP	1	LS	$1,000.00	$1,000	ESTIMATED
1D. E&S PLAN IMPLEMENTATION					
1. SILT FENCE	1,000	LF	$1.50	$1,500	100 FT SILT FENCE @$1.50/LF
2. SEEDING/FERTILIZING	1	LS	$1,000.00	$1,000	ESTIMATED
1E. POST-CONSTRUCTION SUBMITTALS					
1. O&M MANUAL	200	HRS	$50.00	$10,000	ESTIMATED - 200 MANHRS, $50/MANHR
2. AS-BUILT DRAWINGS	100	HRS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
3. SPECIFICATIONS MARK-UP	40	HRS	$50.00	$2,000	ESTIMATED - 40 MANHRS, $50/MANHR
1F. DISTRIBUTIVE COSTS					
1. TEMPORARY FACILITY RENTAL	36	MO	$171.00	$6,156	3 TR., 12 MO EA, MEANS SITE 1993: 015-904-0350
2. TEMPOARY UTILITIES	12	MO	$500.00	$6,000	ESTIMATED - $500/MO FOR 12 MONTHS
3. TRAVEL	12	EA	$750.00	$9,000	12 SUPERVISORY SITE VISITS, $750/EA.
SUBTOTAL DIVISION 1				$73,648	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2A. CLEARING AND GRUBBING	4	ACRE	$2,625.00	$10,500	MEANS SITE, 1993: 021-104-0010
2B. EXCAVATION					
1. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$5.08	$1,372	MEANS SITE, 1993: 022-238-0200
2. SEEP COLLECTION PIPING TRENCH	140	CY	$5.05	$707	MEANS SITE, 1994: 022-254-0050
2C. BACKFILL					
1. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$6.85	$1,850	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. ROADWAY	100	SY	$6.00	$600	MEANS SITE, 1994: 022-308-0100
3. AGGREGATE IN SEEP TRENCH	50	SY	$23.16	$1,158	MEANS SITE, 1994: 033-102-1100, 1200; 022-254-302
4. COMPACTED SOIL IN SEEP TRENCH	40	SY	$2.88	$115	MEANS SITE, 1994: 022-254-3020;022-226
2D. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2E. SITE REVEGETATION	1	ACRE	$2,000.00	$2,000	ESTIMATE
2F. GEOTEXTILE IN SEEP TRENCH	400	SY	$1.73	$692	MEANS SITE, 1994: 027-054-0110
2G. PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	100	LF	$2.50	$250	
2. 4" PVC CASING PIPE	100	LF	$3.50	$350	
3. 6" HDPE PIPING FOR SEEP COLLECTO	1,300	LF	$2.04	$2,652	MEANS SITE, 1994: 027-111-0060
2H. MANHOLE	2	EA	$1,290.00	$2,580	MEANS SITE, 1994: A-12.3-710
SUBTOTAL DIVISION 2				$27,915	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 3				$0	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11A. METALS REMOVAL SYSTEM (15 GPM) INCLUDING ALL REQUIRED ANCILLA EQUIPMENT (E.G. PIPING, TANKS, ETC)	1	EACH	$50,000.00	$50,000	VENDOR QUOTE
SYSTEM INSTALLATION	1	EACH	$12,500.00	$12,500	25% OF EQUIPMENT COSTS FOR INSTALLATION
11B. SLUDGE HOLDING TANK - 2000 GAL.	1	EACH	$6,500.00	$6,500	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTOR
11C. SERVICE TANK - 2000 GAL.	1	EACH	$6,500.00	$6,500	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTOR
11D. SUMP PUMPS					
1. COLLECTION SUMP PUMPS	2	EACH	$3,500.00	$7,000	VENDOR QUOTE
PUMP INSTALLATION	16	HOURS	$47.73	$764	RICHARDSONS ENGINEERING SERVICES, 1986
11E. MULTIMEDIA POLISHING FILTERS	2	EACH	$1,000.00	$2,000	VENDOR QUOTE
11F. PLATE & FRAME FILTER PRESS	1	EACH	$15,000.00	$15,000	VENDOR QUOTE
SUBTOTAL DIVISION 11				$102,746	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
TREATMENT SYSTEM BUILDING	400	SF	$75.00	$30,000	
SUBTOTAL DIVISION 13				$30,000	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEMS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15B. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15C. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
SUBTOTAL DIVISION 15				$10,300	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$25,686	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	3,000	LF	$20.00	$60,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTING
SUBTOTAL DIVISION 16				$85,686	

MCB Camp Lejeune North Carolina
Operable Unit Number 4 Site 41
Groundwater Treatment System - Alternative 41GW-3A
Estimate of Annual Operation & Maintenance Costs - 2 GPM Facility

Item No.	Description	Unit	Unit Cost	Hours Per Day	Days Per Year	Total Annual Cost
1	Routine Operations	Hours	$29.10	4	180	$20,952
2	Sludge Processing	Hours	$29.10	5	10	$1,455
3	Sampling	Hours	$29.10	8	12	$2,794
	Total Items 1-3					*$25,201*
Item No.	**Sampling**	**Unit**	**Unit Cost**		**Samples Year**	**Cost Per Year**
4	NPDES Metals	Sample	$305.00		12	$3,660
5	Miscellaneous	Sample	$50.00		12	$600
	Total Items 4-5					*$4,260*
	Electrical Costs Cost /KWH =	**$0.10**	**Size**	**Efficiency**	**Utilization**	**Cost Per Year**
6	Influent Pumps	Horsepower	1	70%	50%	$229
7	Chemical Feed	Horsepower	0.25	40%	50%	$33
8	Air Compressor	Horsepower	10	70%	30%	$1,372
9	Mixers/Agitators	Horsepower	2	60%	50%	$392
10	Miscellaneous	Horsepower	0.5	70%	50%	$114
	Total Items 6-10					*$2,140*
	Treatment Reagents	**Unit**	**Unit Cost**	**GPM (lb/min)**	**Annual Consumption**	**Annual Cost**
11	Polymer	LB	$1.10	(0.0001)	32.9	$36
12	50% NaOH	Drum	$80.00	0.0015	7.2	$573
13	37% Sulfuric Acid	Drum	$44.00	0.00050	2.4	$105
	Total Item 11-13					*$715*
	Disposal				**Annual Volume**	**Annual Cost**
14	SludgeTransportation	Trip	$750		1	$750
15	Sludge Disposal	Ton	$1,200		0.5	$600
	Total Items 14-15					*$1,350*
	Other Costs	**Description**				**Annual Cost**
16	Equipment Maintenance	Percentage of Division of 11 Cost			10%	$10,275
17	GW Monitoring	Lump Sump Cost / Yr				$35,534
18	Administrative	Percentage of Routine Labor Items			10%	$2,520
	Total Items 16-18					*$48,329*

Total Annual O&M Cost	$81,994

NOTES:
1. For assumptions and calculations see back-up sheets.

ALTERNATIVE 41GW-3A

CONCEPTUAL DESIGN - 2 GPM SEEP COLLECTION AND PHYSICAL / CHEMICAL TREATMENT SYSTEM

0 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$617,652	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994
3. Annual Expenditures	$617,652	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$617,652	$78,090	$74,371	$70,830	$67,457	$64,245	$61,185	$58,272	$55,497	$52,854	$50,337

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994
3. Annual Expenditures	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$47,940	$45,657	$43,483	$41,413	$39,441	$37,562	$35,774	$34,070	$32,448	$30,903	$29,431

COST COMPONENT	YEAR									TOTAL PRESENT WORTH FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	
3. Annual Expenditures	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	$81,994	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$28,030	$26,695	$25,424	$24,213	$23,060	$21,962	$20,916	$19,920	$18,972	$1,878,103

ALTERNATIVE 41GW-3B

INDIRECT COSTS AND SUMMARY OF TOTAL COSTS

2 GPM SEEP COLLECTION AND CONSTRUCTED WETLANDS TREATMENT

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$21,159	15%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$21,159	15%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$14,106	10%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$21,159	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$21,159	15%	OF TOTAL DIRECT COST
TOTAL INDIRECT COST	$98,744		---

SUMMARY OF COSTS:

TOTAL DIRECT CAPITAL COST	$141,063		REFER TO TOTAL DIRECT CAPITAL COST ESTIMATE
TOTAL INDIRECT CAPITAL COST	$98,744		REFER TO TOTAL INDIRECT CAPITAL COST ESTIMATE
PROFIT	$23,981	10%	TOTAL DIRECT AND INDIRECT COSTS
TOTAL CAPITAL COSTS	**$263,787**		
TOTAL ANNUAL O&M COSTS	**$49,786**		
PRESENT WORTH OF ALTERNATIVE	**$1,029,119**		

ALTERNATIVE 41GW-3B
SUMMARY OF DIRECT COSTS

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$73,648		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$67,415		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 - SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 - EQUIPMENT	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 - FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 - SPECIAL CONSTRUCTION	$0		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 - CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 - MECHANICAL	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 - ELECTRICAL	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$141,063		---

ALTERNATIVE 41GW-3B

DIRECT COST BREAKDOWN BY DIVISION - 2 GPM SEEP COLLECTION AND CONSTRUCTED WETLANDS TREATMENT

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. PRECONSTRUCTION SUBMITTALS					
1. WORK PLAN	250	HOURS	$50.00	$12,500	ESTIMATED - 200 MANHRS, $50/MANHR
2. HEALTH AND SAFETY PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
3. E&S CONTROL PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
4. EQUIPMENT DATA AND DWGS.	100	HOURS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
1B. MOBILIZATION/DEMOBILIZATION					
1. CONSTRUCTION EQUIPMENT	1	LS	$2,500.00	$2,500	DOZER, BACKHOE, LOADER, BOBCAT, TRUCKS, AIR COMPRESSOR, GENERATORS, ETC.
2. TEMPORARY FACILITIES	3	EACH	$100.00	$300	OFFICE TRAILERS, STORAGE TRAILERS
3. PERSONNEL	10	EACH	$500.00	$5,000	10 MEN @ $500 EACH
1C. DECONTAMINATION PAD					
1. 6"-SLAB ON GRADE	12	CY	$91.00	$1,092	20'X30'X0.5' SLAB, MEANS SITE 1993: 033-130-4700
2. 6"X4" PERIMETER CURBS	80	LF	$5.00	$400	80' OF 6"HX4"W CONCRETE CURB
3. CONCRETE SEALANT	1	LS	$200.00	$200	SEALANT & LABOR
4. PRECAST CONCRETE SUMP W/PUMP	1	LS	$1,000.00	$1,000	ESTIMATED
1D. E&S PLAN IMPLEMENTATION					
1. SILT FENCE	1,000	LF	$1.50	$1,500	100 FT SILT FENCE @$1.50/LF
2. SEEDING/FERTILIZING	1	LS	$1,000.00	$1,000	ESTIMATED
1E. POST-CONSTRUCTION SUBMITTALS					
1. O&M MANUAL	200	HRS	$50.00	$10,000	ESTIMATED - 200 MANHRS, $50/MANHR
2. AS-BUILT DRAWINGS	100	HRS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
3. SPECIFICATIONS MARK-UP	40	HRS	$50.00	$2,000	ESTIMATED - 40 MANHRS, $50/MANHR
1F. DISTRIBUTIVE COSTS					
1. TEMPORARY FACILITY RENTAL	36	MO	$171.00	$6,156	3 TR., 12 MO EA, MEANS SITE 1993: 015-904-0350
2. TEMPOARY UTILITIES	12	MO	$500.00	$6,000	ESTIMATED - $500/MO FOR 12 MONTHS
3. TRAVEL	12	EA	$750.00	$9,000	12 SUPERVISORY SITE VISITS, $750/EA.
SUBTOTAL DIVISION 1				$73,648	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2A. CLEARING AND GRUBBING	1.5	ACRE	$2,625.00	$3,938	MEANS SITE, 1993: 021-104-0010
2B. EXCAVATION					
1. SEEP COLLECTION PIPING TRENCH	140	CY	$5.05	$707	MEANS SITE, 1994: 022-254-0050
2C. BACKFILL					
1. ROADWAY	100	SY	$6.00	$600	MEANS SITE, 1994: 022-308-0100
2. AGGREGATE IN SEEP TRENCH	50	SY	$23.16	$1,158	MEANS SITE, 1994: 033-102-1100, 1200; 022-254-302
3. COMPACTED SOIL IN SEEP TRENCH	40	SY	$2.88	$115	MEANS SITE, 1994: 022-254-3020;022-226
2D. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2E. SITE REVEGETATION	1	ACRE	$2,000.00	$2,000	ESTIMATE
2F. GEOTEXTILE IN SEEP TRENCH	500	SY	$1.73	$865	MEANS SITE, 1994: 027-054-0110
2G. PIPING INSTALLATION					
1. 6" HDPE PIPING FOR SEEP COLLECTOR	1,300	LF	$2.04	$2,652	MEANS SITE, 1994: 027-111-0060
2H. MANHOLE	1	EA	$1,290.00	$1,290	MEANS SITE, 1994: A-12.3-710
2I. CONSTRUCTED WETLANDS	17,000	SF	$3.00	$51,000	ESTIMATED - TVA CASE HISTORIES (MAX.)
SUBTOTAL DIVISION 2				$67,415	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 3				$0	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 11				$0	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 13				$0	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 15				$0	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 16				$0	

MCB Camp Lejeune North Carolina
Operable Unit Number 4 Site 41
Groundwater Treatment System - Alternative 41GW-3B
Estimate of Annual Operation & Maintenance Costs - Constructed Wetlands

Item No.	Description	Unit	Unit Cost	Hours Per Day	Days Per Year	Total Annual Cost
1	Sampling	Hours	$29.10	8	12	$2,794
	Total Items 1					*$2,794*
Item No.	**Effluent Sampling**	**Unit**	**Unit Cost**		**Samples Year**	**Cost Per Year**
2	NPDES Metals	Sample	$305.00		12	$3,660
3	Miscellaneous	Sample	$50.00		12	$600
	Total Items 2-3					*$4,260*
	Electrical Costs Cost /KWH =	**$0.10**	**Size**	**Efficiency**	**Utilization**	**Cost Per Year**
	Treatment Reagents	**Unit**	**Unit Cost**	**GPM (lb/min)**	**Annual Consumption**	**Annual Cost**
	Disposal				**Annual Volume**	**Annual Cost**
	Other Costs	**Description**				**Annual Cost**
4	Wetlands Maintenance	Percentage of Wetlands Cost			3%	$1,698
5	GW Monitoring	Lump Sump Cost / Yr				$38,534
6	Administrative	Lump Sump Cost / Yr				$2,500
	Total Items 4-6					*$42,732*

Total Annual O&M Cost	**$49,786**
One time cost of Wetlands Replacement at 30 yrs.	**$9,675**

NOTES:
1. For assumptions and calculations see back-up sheets.

ALTERNATIVE 41GW-3B

CONCEPTUAL DESIGN - 2 GPM SEEP COLLECTION AND CONSTRUCTED WETLANDS TREATMENT

0 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$263,787	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786
3. Annual Expenditures	$263,787	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$263,787	$47,415	$45,157	$43,007	$40,959	$39,009	$37,151	$35,382	$33,697	$32,092	$30,564

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786
3. Annual Expenditures	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$29,109	$27,723	$26,403	$25,145	$23,948	$22,807	$21,721	$20,687	$19,702	$18,764	$17,870

COST COMPONENT	YEAR									TOTAL PRESENT WORTH FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	
3. Annual Expenditures	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	$49,786	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$17,019	$16,209	$15,437	$14,702	$14,002	$13,335	$12,700	$12,095	$11,519	$1,029,119

ALTERNATIVE 41GW-4A

INDIRECT COSTS AND SUMMARY OF TOTAL COSTS - 15 GPM SYSTEM

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$54,158	15%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$54,158	15%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$36,105	10%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$54,158	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$54,158	15%	OF TOTAL DIRECT COST
TOTAL INDIRECT CAPITAL COST	$252,737		—

SUMMARY OF COSTS:

TOTAL DIRECT CAPITAL COST	$361,052		REFER TO TOTAL DIRECT CAPITAL COST ESTIMATE
TOTAL INDIRECT CAPITAL COST	$252,737		REFER TO TOTAL INDIRECT CAPITAL COST ESTIMATE
PROFIT	$61,379	10%	TOTAL DIRECT AND INDIRECT COSTS
TOTAL CAPITAL COSTS	**$675,168**		
TOTAL ANNUAL O&M COSTS	**$83,540**		
PRESENT WORTH OF ALTERNATIVE	**$1,959,385**		

ALTERNATIVE 41GW-4A

SUMMARY OF DIRECT COSTS - 15 GPM PHYSICAL / CHEMICAL TREATMENT SYSTEM

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$73,648		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$44,972		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$3,848		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 - SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 - EQUIPMENT	$106,627		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 - FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 - SPECIAL CONSTRUCTION	$30,000		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 - CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 - MECHANICAL	$15,300		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 - ELECTRICAL	$86,657		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$361,052		---

ALTERNATIVE 41GW-4A

DIRECT COST BREAKDOWN BY DIVISION - 15 GPM PHYSICAL / CHEMICAL TREATMENT SYSTEM

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. PRECONSTRUCTION SUBMITTALS					
1. WORK PLAN	250	HOURS	$50.00	$12,500	ESTIMATED - 200 MANHRS, $50/MANHR
2. HEALTH AND SAFETY PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
3. E&S CONTROL PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
4. EQUIPMENT DATA AND DWGS.	100	HOURS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
1B. MOBILIZATION/DEMOBILIZATION					
1. CONSTRUCTION EQUIPMENT	1	LS	$2,500.00	$2,500	DOZER, BACKHOE, LOADER, BOBCAT, TRUCKS, AIR COMPRESSOR, GENERATORS, ETC.
2. TEMPORARY FACILITIES	3	EACH	$100.00	$300	OFFICE TRAILERS, STORAGE TRAILERS
3. PERSONNEL	10	EACH	$500.00	$5,000	10 MEN @ $500 EACH
1C. DECONTAMINATION PAD					
1. 6"-SLAB ON GRADE	12	CY	$91.00	$1,092	20'X30'X0.5' SLAB, MEANS SITE 1993: 033-130-4700
2. 6"X4" PERIMETER CURBS	80	LF	$5.00	$400	80' OF 6"HX4"W CONCRETE CURB
3. CONCRETE SEALANT	1	LS	$200.00	$200	SEALANT & LABOR
4. PRECAST CONCRETE SUMP W/PUMP	1	LS	$1,000.00	$1,000	ESTIMATED
1D. E&S PLAN IMPLEMENTATION					
1. SILT FENCE	1,000	LF	$1.50	$1,500	100 FT SILT FENCE @$1.50/LF
2. SEEDING/FERTILIZING	1	LS	$1,000.00	$1,000	ESTIMATED
1E. POST-CONSTRUCTION SUBMITTALS					
1. O&M MANUAL	200	HRS	$50.00	$10,000	ESTIMATED - 200 MANHRS, $50/MANHR
2. AS-BUILT DRAWINGS	100	HRS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
3. SPECIFICATIONS MARK-UP	40	HRS	$50.00	$2,000	ESTIMATED - 40 MANHRS, $50/MANHR
1F. DISTRIBUTIVE COSTS					
1. TEMPORARY FACILITY RENTAL	36	MO	$171.00	$6,156	3 TR., 12 MO EA, MEANS SITE 1993: 015-904-0350
2. TEMPOARY UTILITIES	12	MO	$500.00	$6,000	ESTIMATED - $500/MO FOR 12 MONTHS
3. TRAVEL	12	EA	$750.00	$9,000	12 SUPERVISORY SITE VISITS, $750/EA.
SUBTOTAL DIVISION 1				$73,648	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2A. CLEARING AND GRUBBING	1	ACRE	$2,625.00	$2,625	MEANS SITE, 1993: 021-104-0010
2B. EXCAVATION					
1. BASE SLAB (TREATMENT SYSTEM)	50	CY	$1.97	$99	MEANS SITE, 1993: 022-238-0200
2. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$5.08	$1,372	MEANS SITE, 1993: 022-238-0200
2C. BACKFILL					
1. AROUND SLAB	20	CY	$6.85	$137	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$6.85	$1,850	MEANS SITE, 1993: 022-238-0200, 022-226-8050
3. ROADWAY	100	SY	$6.00	$600	MEANS SITE, 1994: 022-308-0100
2D. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2E. EXTRACTION WELLS					
1. SHALLOW EXT'N WELL INSTALL	3	EACH	$9,000.00	$27,000	PREVIOUS CONTRACT
2F. SITE REVEGETATION	1	ACRE	$2,000.00	$2,000	ESTIMATE
2G. PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	800	LF	$2.50	$2,000	
2. 4" PVC CASING PIPE	800	LF	$3.50	$2,800	
3. 2" PVC CASING PIPE	400	LF	$3.50	$1,400	
SUBTOTAL DIVISION 2				$44,972	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
3A. CONCRETE FORMWORK 1. 6"-SLAB ON GRADE (20' X 20')	80	LF	$3.00	$240	MEANS SITE, 1994: 031-170-3000
3B. CONCRETE REINFORCEMENT 1. 6"-SLAB ON GRADE	1	TONS	$2,000.00	$2,000	MEANS SITE, 1994: 032-107-0600
3C. JOINTS IN CONCRETE	40	LF	$2.71	$108	MEANS SITE, 1994: 031-132-0100
3D. CAST-IN-PLACE CONCRETE 1. 6"-SLAB ON GRADE	10	CY	$150.00	$1,500	MEANS SITE, 1994: 033-130-4700
SUBTOTAL DIVISION 3				$3,848	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11A. METALS REMOVAL SYSTEM (15 GPM) INCLUDING ALL REQUIRED ANCILLAR EQUIPMENT (E.G. PIPING, TANKS, ETC)	1	EACH	$50,000.00	$50,000	VENDOR QUOTE
SYSTEM INSTALLATION	1	EACH	$12,500.00	$12,500	25% OF EQUIPMENT COSTS FOR INSTALLATION
11B. SLUDGE HOLDING TANK - 2000 GAL.	1	EACH	$6,500.00	$6,500	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11C. SERVICE TANK - 2000 GAL.	1	EACH	$6,500.00	$6,500	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11D. WELL PUMPS					
1. EXTRACTION WELL PUMPS	3	EACH	$3,500.00	$10,500	VENDOR QUOTE
PUMP INSTALLATION	24	HOURS	$47.73	$1,146	RICHARDSONS ENGINEERING SERVICES, 1986
11E. MULTIMEDIA POLISHING FILTERS	2	EACH	$1,000.00	$2,000	VENDOR QUOTE
11F. PLATE & FRAME FILTER PRESS	1	EACH	$15,000.00	$15,000	VENDOR QUOTE AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
SUBTOTAL DIVISION 11				$106,627	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
13A. 400 SQUARE FOOT BUILDING	400	SF	$75.00	$30,000	ESTIMATE
SUBTOTAL DIVISION 13				$30,000	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. BASIC MECHANICAL REQUIREMENTS	1	LS	$5,000.00	$5,000	ESTIMATED
15B. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15C. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15D. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
SUBTOTAL DIVISION 15				$15,300	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$26,657	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	3,000	LF	$20.00	$60,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTIN
SUBTOTAL DIVISION 16				$86,657	

MCB Camp Lejeune North Carolina
Operable Unit Number 4 Site 41
Groundwater Treatment System - Alternative 41GW-4A
Estimate of Annual Operation & Maintenance Costs - 15 GPM Facility

Item No.	Description	Unit	Unit Cost	Hours Per Day	Days Per Year	Total Annual Cost
1	Routine Operations	Hours	$29.10	4	180	$20,952
2	Sludge Processing	Hours	$29.10	5	26	$3,783
3	Sampling	Hours	$29.10	8	12	$2,794
	Total Items 1-3					*$27,529*
Item No.	**Sampling**	**Unit**	**Unit Cost**		**Samples Year**	**Cost Per Year**
4	NPDES Metals	Sample	$305.00		12	$3,660
5	Miscellaneous	Sample	$50.00		12	$600
	Total Items 4-5					*$4,260*
	Electrical Costs Cost /KWH = $0.10		**Size**	**Efficienc**	**Utilization**	**Cost Per Year**
6	Groundwater Pumps	Horsepower	4	60%	40%	$627
7	Influent Pumps	Horsepower	2	70%	50%	$457
8	Chemical Feed	Horsepower	0.25	40%	50%	$33
9	Air Compressor	Horsepower	10	70%	30%	$1,372
10	Mixers/Agitators	Horsepower	2	60%	50%	$392
11	Miscellaneous	Horsepower	0.5	70%	50%	$114
	Total Items 6-11					*$2,996*
	Treatment Reagents	**Unit**	**Unit Cost**	**GPM (lb/min)**	**Annual Consumption**	**Annual Cost**
12	Polymer	LB	$1.10	(0.0004)	98.7	$109
13	50% NaOH	Drum	$80.00	0.0015	7.2	$573
14	37% Sulfuric Acid	Drum	$44.00	0.00050	2.4	$105
	Total Item 12-14					*$787*
	Disposal	**Unit**	**Unit Cost**		**Annual Volume**	**Annual Cost**
15	SludgeTransportation	Trip	$750		1	$750
16	Sludge Disposal	Ton	$1,200		0.5	$600
	Total Items 15-16					*$1,350*
	Other Costs	**Description**				**Annual Cost**
17	Equipment Maintenance	Percentage of Division of 11 Cost			5%	$5,331
18	GW Monitoring	Lump Sump Cost / Yr				$38,534
19	Administrative	Percentage of Routine Labor Items			10%	$2,753
	Total Items 17-19					*$46,618*

Total Annual O&M Cost	**$83,540**

NOTES:
1. For assumptions and calculations see back-up sheets.

ALTERNATIVE 41GW-4A

CONCEPTUAL DESIGN - 15 GPM PHYSICAL / CHEMICAL TREATMENT SYSTEM

30 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$675,168	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540
3. Annual Expenditures	$675,168	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$675,168	$79,562	$75,773	$72,165	$68,729	$65,456	$62,339	$59,370	$56,543	$53,851	$51,286

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540
3. Annual Expenditures	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$48,844	$46,518	$44,303	$42,193	$40,184	$38,271	$36,448	$34,713	$33,060	$31,485	$29,986

COST COMPONENT	YEAR									TOTAL PRESENT WORTH FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	
3. Annual Expenditures	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	$83,540	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$28,558	$27,198	$25,903	$24,670	$23,495	$22,376	$21,311	$20,296	$19,329	$1,959,385

ALTERNATIVE 41GW-4B
INDIRECT COSTS AND SUMMARY OF TOTAL COSTS
GROUNWATER EXTRACTION WELLS WITH CONSTRUCTED WETLANDS SYSTEM

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$75,206	15%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$75,206	15%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$50,138	10%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$75,206	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$75,206	15%	OF TOTAL DIRECT COST
TOTAL INDIRECT CAPITAL COST	$350,963		---

SUMMARY OF COSTS:

TOTAL DIRECT CAPITAL COST	$501,376		REFER TO TOTAL DIRECT CAPITAL COST ESTIMATE
TOTAL INDIRECT CAPITAL COST	$350,963		REFER TO TOTAL INDIRECT CAPITAL COST ESTIMATE
PROFIT	$85,234	10%	TOTAL DIRECT AND INDIRECT COSTS
TOTAL CAPITAL COSTS	**$937,573**		
TOTAL ANNUAL O&M COSTS	**$61,761**		
PRESENT WORTH OF ALTERNATIVE	**$1,886,993**		

ALTERNATIVE 41GW-4B

SUMMARY OF DIRECT COSTS

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$73,648		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$342,871		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 - SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 - EQUIPMENT	$11,646		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 - FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 - SPECIAL CONSTRUCTION	$0		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 - CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 - MECHANICAL	$10,300		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 - ELECTRICAL	$62,911		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$501,376		---

ALTERNATIVE 41GW-4B

DIRECT COST BREAKDOWN BY DIVISION - GROUNDWATER EXTRACTION WELLS WITH CONSTRUCTED WETLANDS TREATMENT SYSTEM

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. PRECONSTRUCTION SUBMITTALS					
1. WORK PLAN	250	HOURS	$50.00	$12,500	ESTIMATED - 200 MANHRS, $50/MANHR
2. HEALTH AND SAFETY PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
3. E&S CONTROL PLAN	50	HOURS	$50.00	$2,500	ESTIMATED - 50 MANHRS, $50/MANHR
4. EQUIPMENT DATA AND DWGS.	100	HOURS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
1B. MOBILIZATION/DEMOBILIZATION					
1. CONSTRUCTION EQUIPMENT	1	LS	$2,500.00	$2,500	DOZER, BACKHOE, LOADER, BOBCAT, TRUCKS, AIR COMPRESSOR, GENERATORS, ETC.
2. TEMPORARY FACILITIES	3	EACH	$100.00	$300	OFFICE TRAILERS, STORAGE TRAILERS
3. PERSONNEL	10	EACH	$500.00	$5,000	10 MEN @ $500 EACH
1C. DECONTAMINATION PAD					
1. 6"-SLAB ON GRADE	12	CY	$91.00	$1,092	20'X30'X0.5' SLAB, MEANS SITE 1993: 033-130-4700
2. 6"X4" PERIMETER CURBS	80	LF	$5.00	$400	80' OF 6"HX4"W CONCRETE CURB
3. CONCRETE SEALANT	1	LS	$200.00	$200	SEALANT & LABOR
4. PRECAST CONCRETE SUMP W/PUMP	1	LS	$1,000.00	$1,000	ESTIMATED
1D. E&S PLAN IMPLEMENTATION					
1. SILT FENCE	1,000	LF	$1.50	$1,500	100 FT SILT FENCE @$1.50/LF
2. SEEDING/FERTILIZING	1	LS	$1,000.00	$1,000	ESTIMATED
1E. POST-CONSTRUCTION SUBMITTALS					
1. O&M MANUAL	200	HRS	$50.00	$10,000	ESTIMATED - 200 MANHRS, $50/MANHR
2. AS-BUILT DRAWINGS	100	HRS	$50.00	$5,000	ESTIMATED - 100 MANHRS, $50/MANHR
3. SPECIFICATIONS MARK-UP	40	HRS	$50.00	$2,000	ESTIMATED - 40 MANHRS, $50/MANHR
1F. DISTRIBUTIVE COSTS					
1. TEMPORARY FACILITY RENTAL	36	MO	$171.00	$6,156	3 TR., 12 MO EA, MEANS SITE 1993: 015-904-0350
2. TEMPOARY UTILITIES	12	MO	$500.00	$6,000	ESTIMATED - $500/MO FOR 12 MONTHS
3. TRAVEL	12	EA	$750.00	$9,000	12 SUPERVISORY SITE VISITS, $750/EA
SUBTOTAL DIVISION 1				$73,648	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2A. CLEARING AND GRUBBING	4	ACRE	$2,625.00	$10,500	MEANS SITE, 1993: 021-104-0010
2B. EXCAVATION					
1. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$5.08	$1,372	MEANS SITE, 1993: 022-238-0200
2C. BACKFILL					
1. INFLUENT/EFFLUENT PIPING TRENCH	270	CY	$6.85	$1,850	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. ROADWAY	100	SY	$6.00	$600	MEANS SITE, 1994: 022-308-0100
2D. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2E. EXTRACTION WELLS					
1. SHALLOW EXT'N WELL INSTALL	3	EACH	$9,000.00	$27,000	PREVIOUS CONTRACT
2F. SITE REVEGETATION	1	ACRE	$2,000.00	$2,000	ESTIMATE
2G. PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	800	LF	$2.50	$2,000	
2. 4" PVC CASING PIPE	800	LF	$3.50	$2,800	
3. 2" PVC CASING PIPE	400	LF	$3.50	$1,400	
2H. CONSTRUCTED WETLANDS	126,200	SF	$2.30	$290,260	ESTIMATED BASED ON TVA CASE HISTORIES
SUBTOTAL DIVISION 2				$342,871	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 3				$0	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11D. WELL PUMPS					
1. EXTRACTION WELL PUMPS	3	EACH	$3,500.00	$10,500	VENDOR QUOTE
PUMP INSTALLATION	24	HOURS	$47.73	$1,146	RICHARDSONS ENGINEERING SERVICES, 1986
SUBTOTAL DIVISION 11				$11,646	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 13				$0	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15B. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15C. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
SUBTOTAL DIVISION 15				$10,300	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$2,911	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	3,000	LF	$20.00	$60,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTING
SUBTOTAL DIVISION 16				$62,911	

MCB Camp Lejeune North Carolina
Operable Unit Number 4 Site 41
Groundwater Treatment System - Alternative 41GW-4B
Estimate of Annual Operation & Maintenance Costs - Constructed Wetlands

Item No.	Description	Unit	Unit Cost	Hours Per Day	Days Per Year	Total Annual Cost
1	Routine Operations	Hours	$29.10	2	50	$2,910
2	Sampling	Hours	$29.10	8	12	$2,794
	Total Items 1-2					*$5,704*
Item No.	**Effluent Sampling**	**Unit**	**Unit Cost**		**Samples Year**	**Cost Per Year**
3	NPDES Metals	Sample	$305.00		12	$3,660
4	Miscellaneous	Sample	$50.00		12	$600
	Total Items 3-4					*$4,260*
	Electrical Costs Cost /KWH = $0.10		**Size**	**Efficiency**	**Utilization**	**Cost Per Year**
5	Groundwater Pumps	Horsepower	7	60%	40%	$1,098
	Total Item 5					*$1,098*
	Treatment Reagents	**Unit**	**Unit Cost**	**GPM (lb/min)**	**Annual Consumption**	**Annual Cost**
	Disposal				**Annual Volume**	**Annual Cost**
	Other Costs	**Description**				**Annual Cost**
6	Wetlands Maintenance	Percentage of Wetlands Cost			3%	$9,666
7	GW Monitoring	Lump Sump Cost / Yr				$38,534
8	Administrative	Lump Sump Cost / Yr				$2,500
	Total Items 6-8					*$50,700*

Total Annual O&M Cost	**$61,761**
One time cost of Wetlands Replacement at 30 yrs.	**$9,675**

NOTES:
1. For assumptions and calculations see back-up sheets.

ALTERNATIVE 41GW-4B

CONCEPTUAL DESIGN - 15 GPM PHYSICAL / CHEMICAL TREATMENT SYSTEM

'0 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$937,573	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761
3. Annual Expenditures	$937,573	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$937,573	$58,820	$56,019	$53,352	$50,811	$48,391	$46,087	$43,892	$41,802	$39,812	$37,916

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761
3. Annual Expenditures	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$36,110	$34,391	$32,753	$31,194	$29,708	$28,293	$26,946	$25,663	$24,441	$23,277	$22,169

COST COMPONENT	YEAR									TOTAL PRESENT WORTH FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	
3. Annual Expenditures	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	$61,761	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$21,113	$20,108	$19,150	$18,238	$17,370	$16,543	$15,755	$15,005	$14,290	$1,886,993

SITE 74 COST ESTIMATES

SITE 74: MESS HALL GREASE PIT DISPOSAL AREA
ALTERNATE GW-2: INSTITUTIONAL CONTROLS AND MONITORING (GROUNDWATER)
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE (BIANNUAL SAMPLING - YEARS 1 - 30)							
Groundwater Monitoring							
Labor	Hours	60	$ 40	$ 2,400		Engineering Estimate	Biannual sampling of 5 locations: 2 samplers, 3 hours each location, 2 events per year
Laboratory Analyses - VOCs, Pesticides / PCBs, Metals	Sample	20	$ 155	$ 3,100		Baker Average 1994 BOAs	Biannual sampling of 8 locations: GW Samples - 5 from wells, 5 QA/QC - VOCs
	Sample	18	$ 159	$ 2,862			GW Samples - 5 from wells, 4 QA/QC - Pest/PCBs
	Sample	18	$ 182	$ 3,276			GW Samples - 5 from wells, 4 QA/QC - Metals (Total)
	Sample	16	$ 182	$ 2,912			GW Samples - 5 from wells, 3 QA/QC - Metals (Dissolved)
Misc. Expenses	Sample Event	2	$ 2,056	$ 4,112		1994 JTR, Vendor Quotes	Includes travel, lodging, air fare, supplies, truck rental, equipment, cooler shipping
Report	Sample Event	2	$ 1,500	$ 3,000		Engineering Estimate	1 - report per sampling event
Well Maintenance	Year	1	$ 602	$ 602		Engineering Estimate	Includes repainting and annualized cost of replacing 1 - well every 5 - years
					$ 22,264		

(Continued Next Page)

SITE 74: MESS HALL GREASE PIT DISPOSAL AREA
ALTERNATE GW-2: INSTITUTIONAL CONTROLS AND MONITORING (GROUNDWATER)
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
CAPITAL COST ESTIMATE							
No Capital Costs							
					$ -		
ANNUAL O & M COSTS (Years 1 - 30)					$ 22,264		
TOTAL CAPITAL COSTS					$ -		
TOTAL COST - ALTERNATE GW-2					$ 342,252		