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FINAL

INTERIM REMEDIAL ACTION FOCUSED FEASIBILITY STUDY FOR THE SHALLOW AQUIFER AT THE HADNOT POINT INDUSTRIAL AREA OPERABLE UNIT CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0017

Prepared For:

NAVAL FACILITIES
ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under:

Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

MAY 21, 1992

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APRIL 16, 1992

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirements
bls	below land surface
BOD	biological oxygen demand
BTX	benzene, toluene, xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
1,2-DCE	1,2-dichloroethene or 1,2-dichloroethylene
DoN	Department of the Navy
EPA	United States Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
FFA	Federal Facilities Agreement
ft	feet
ft/ft	foot per foot
GAC	granular activated carbon
gpm	gallons per minute
GRI	Gas Research Industry
HI	hazard index
HPIA	Hadnot Point Industrial Area
IAS	Initial Assessment Study
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MDL	method detection limit
MGD	million gallons per day

mg/l	milligram per liter
NACIP	Navy Assessment and Control of Installation Pollutants
N.C. DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operation and maintenance
PAH	polynuclear aromatic hydrocarbon
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
RA	risk assessment
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SMCL	Secondary Maximum Contaminant Level
STP	sewage treatment plant
TCE	trichloroethene or trichloroethylene
TCLP	toxicity characteristic leachate procedure
μg/L	micrograms per liter
VOC	volatile organic compound

EXECUTIVE SUMMARY

Purpose

This report documents the interim remedial action (IRA) focused Feasibility Study (FS) completed for the shallow aquifer at the Hadnot Point Industrial Area (HPIA) at Camp Lejeune Military Reservation and Marine Corps Base (MCB) located in North Carolina. The HPIA has been identified as Site 78 at MCB Camp Lejeune. The HPIA, along with Site 21 (Transformer Storage Yard) and Site 24 (Industrial Area Fly Ash Dump), make-up the HPIA Operable Unit. This interim remedial action focused FS addresses the shallow groundwater within the HPIA (Site 78). A remedial investigation/feasibility study (RI/FS) will be conducted in the near future that addresses the entire operable unit (i.e., Sites 21, 24, and 78) and all media.

An interim remedial action is appropriate for a site in two circumstances: (1) a quick action is needed to protect human health and the environment from an immediate threat in the short term, while a final remedial solution is being developed, and/or (2) temporary measures can be instituted to stabilize the site and/or prevent further migration or degradation, while a final remedial solution is being developed. The objectives of this FS are: (1) to establish an interim remedial action which will contain and/or initiate remediation of the contaminated groundwater plume in the shallow aquifer at HPIA, and (2) reduce the contaminants of concern in the two source area plumes to established Federal and/or State drinking water standards or ambient water quality criteria, or to background levels if no other standards are established. The second objective may be revised after work has been completed to support a final remedial decision.

This FS has been conducted in accordance with the guidelines and procedures delineated in the National Contingency Plan (NCP) for interim remedial actions (40 CFR 300.430). These NCP regulations were promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986.

This IRA FS has been based on existing data collected during various studies conducted at the HPIA since 1983 by other consultants to the DoN, such as Environmental Science and Engineering, Inc. (ESE).

Site Description

Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina. The base covers approximately 170 square miles and is bounded to the southeast by the Atlantic Ocean, to the northeast by State Road 24, and to the west by U.S. 17. The town of Jacksonville, North Carolina is north of the base.

The focused study area for this FS is the shallow aquifer in the area of the the HPIA (Site 78). The HPIA is bounded by Sneads Ferry Road to the north, Holcomb Boulevard to the west, Louis Road to the east, and Main Service Road to the south.

Site Background

The HPIA, constructed in the late 1930s, was the first facility at MCB Camp Lejeune. It was comprised of approximately 75 buildings and facilities including: maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, storage yards, and a dry cleaning facility. A steam plant and training facility occupy the southwest portion of the HPIA. A transformer storage yard (Site 21) and an industrial area fly ash dump (Site 24) are part of the overall HPIA operable unit. These two areas are not included in the scope of this IRA FS but will be considered in a separate RI/FS study of the entire operable unit.

In addition to the transformer storage yard and the fly ash dump, a fuel tank farm is located within the HPIA operable unit. This tank farm is not being administered under CERCLA regulations, therefore it is not included as part of the HPIA operable unit. A fuel recovery/groundwater treatment option is currently being implemented at the tank farm.

Several areas at the HPIA have been investigated for potential contamination due to Marine operations and activities resulting in the generation of potentially hazardous wastes. The investigations indicate that contamination has resulted at HPIA due to improper waste disposal, underground storage tank leakage, solvent spills, and sludge disposal.

Since 1983, investigations have been conducted at the HPIA. These studies include:

- Initial Assessment Study of HPIA, 1983
- Confirmation Study, 1984-1988
- Contaminated Groundwater Supply at the Hadnot Point Fuel Farm, 1988

- Feasibility Study for HPIA, 1988
- Supplemental Characterization, 1990-1991
- Remedial Investigation for HPIA, 1991
- Preliminary Risk Assessment, 1992

Nature and Extent of Contamination

Following a review of the existing data resulting from the above-mentioned investigations, two contaminated groundwater plumes have been identified in the shallow aquifer at the HPIA Site. Preliminary risk assessment identified the following contaminants of concern contained in these plumes: benzene, 1,2-dichloroethene (1,2-DCE), trichloroethene (TCE), antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, nickel, and oil & grease. One of the plumes is located in the northeast portion of the site, the other in the southwest portion of the site.

Development and Evaluation of Interim Remedial Action Alternatives

Seven interim remedial action alternatives were developed to address the contaminated groundwater in the shallow aquifer at HPIA. The alternatives were developed by initially identifying a set of remedial action technologies and corresponding process options potentially applicable to the site. These technologies/options were subjected to a preliminary screening and then a process option evaluation to narrow the list of potential technologies/options.

The candidate technologies were then combined to form seven remedial action alternatives, which included: a no action alternative, a no action alternative with institutional controls, three on-site pump and treat alternatives, and two off-site pump and treat alternatives. Each of the on-site pump and treat alternatives included extraction of the groundwater, pretreatment, off-site discharge, and institutional controls. The two off-site pump and treat alternatives included extraction of the groundwater, pretreatment (for one of the alternatives only), and off-site treatment. The major difference between all five of the pump and treat alternatives was in the primary treatment technology (i.e., trickling filter, carbon adsorption, air stripping, thermal treatment, and RCRA facility). A summary of each of the seven potential alternatives follows.

Alternative 1: No Action

Under the No Action Alternative, the groundwater in the shallow aquifer is left as is and no remedial actions are implemented. The No Action Alternative is required by the NCP to provide a baseline for comparison with other groundwater alternatives. Implementation of the No Action Alternative will result in the potential for the further migration of the contaminated groundwater plumes identified in the shallow aquifer. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

The results of the detailed evaluation indicate that although this alternative is the easiest to implement, it will not be protective of human health or the environment. There are no capital or operation and maintenance (O&M) costs associated with the No Action Alternative.

Alternative 2: No Action With Institutional Controls

Under the No Action With Institutional Controls Alternative, the groundwater in the shallow aquifer will remain as is. No remedial actions with the exception of institutional controls (i.e., long-term groundwater monitoring, aquifer-use restrictions, and well installation restrictions) will be implemented. The long-term groundwater monitoring program will consist of quarterly sampling 20 existing monitoring wells. The aquifer-use restrictions will be placed on the existing supply wells within or near the study area. In addition, no new water wells will be permitted to be installed within or near this area.

The results of the detailed evaluation indicate that this alternative will be the second easiest alternative to implement. Similar to the No Action Alternative, this alternative will not be protective of human health or the environment. Minimal capital costs are associated with this alternative (costs for obtaining aquifer-use and well installation restrictions). Low O&M costs, approximately $60,000 annually, would be associated with the implementation of this alternative due to the groundwater monitoring program. The present worth value of this alternative is estimated to be $970,000.

Alternative 3: Biological Treatment at the STP/Groundwater Collection/Pretreatment

In general, the Biological Treatment at the STP/Groundwater Collection/Pretreatment Alternative consists of groundwater extraction, pretreatment for oil and grease and for inorganic chemicals, treatment for volatile organic compounds (VOCs) at the existing Hadnot Point Sewage Treatment Plant (STP), and institutional controls.

Groundwater will be extracted through a series of extraction wells (up to a maximum of 32 wells) placed within both of the contaminated plumes within the shallow aquifer. The installation of the extraction wells will be through a phased approach. The pretreatment systems will include an oil/water separator for the oils and grease. The inorganic chemicals will be removed from the extracted groundwater using a combination of technologies including but not limited to precipitation, chemical reduction, and sedimentation. The pretreated groundwater will then be discharged to the Hadnot Point STP for biological treatment of VOCs via an aerated equalization lagoon and two trickling filters.

The same institutional controls identified in Alternative 2 will be included in this alternative.

The results of the detailed evaluation indicate that this alternative will be relatively easy to implement. Since this alternative includes treatment of the contaminated groundwater, it will be protective of human health and the environment. Capital costs in the order of $1.3 million are associated with this alternative (part of this cost is for upgrading the existing sanitary sewer lines to the Hadnot Point STP). The O&M costs are in the range of $334,000 annually. The present worth value of this alternative is estimated to be approximately $6.9 million.

Alternative 4: Physical/Chemical Treatment (Air Stripping)/Groundwater Collection/ Pretreatment/STP Discharge

Alternative 4 is similar to Alternative 3 with the exception of the method of groundwater treatment. In general, this alternative includes groundwater extraction, pretreatment for oil and grease and for inorganic chemicals, treatment for volatile organic compounds via an on-site air stripper, discharge to the Hadnot Point STP, and institutional controls.

Groundwater will be extracted through a series of extraction wells placed within both of the contaminated plumes within the shallow aquifer. The installation of the extraction wells will be through a phased approach. This is the same as for Alternative 3. The pretreatment systems will be the same as for Alternative 3 which include an oil/water separator and a inorganic chemical removal system. The pretreated groundwater will undergo further treatment for VOCs via on-site air strippers.

The same institutional controls identified in Alternative 2 will be included in this alternative.

The results of the detailed evaluation indicate that this alternative will be relatively easy to implement. Since this alternative includes treatment of the contaminated groundwater, it will be protective of human health and the environment. Capital costs in the order of $1.0 million are associated with this alternative (majority of this cost is for the pretreatment systems and two air stripper units). The O&M costs are in the range of $393,000 annually. The present worth value of this alternative is estimated to be approximately $7.6 million.

Alternative 5: Physical/Chemical Treatment (Carbon Adsorption)/Groundwater Collection/Pretreatment/STP Discharge

Alternative 5 is similar to Alternatives 3 and 4 with the exception of the method of groundwater treatment. In general, this alternative includes groundwater extraction, pretreatment for oil and grease and for inorganic chemicals, treatment for VOCs via on-site carbon adsorption units, discharge to the Hadnot Point STP, and institutional controls.

Groundwater will be extracted through a series of extraction wells placed within both of the contaminated plumes within the shallow aquifer as described for Alternative 4. The pretreatment systems will be the same as for Alternatives 3 and 4 which includes an oil/water separator and a inorganic chemical removal system. The pretreated groundwater will undergo further treatment for VOCs via on-site carbon adsorption units.

The same institutional controls identified in Alternative 2 will be included in this alternative.

The results of the detailed evaluation indicate that this alternative will be relatively easy to implement. Since this alternative includes treatment of the contaminated groundwater, it will be protective of human health and the environment. Capital costs in the order of $940,000 are associated with this alternative (majority of this cost is for the pretreatment systems and two activated carbon units). The O&M costs are in the range of $400,000 annually. The present worth value of this alternative is estimated to be approximately $7.6 million.

Alternative 6: Thermal Treatment/Groundwater Collection/ Pretreatment

Alternative 6 is similar to Alternatives 3, 4 and 5 with the exception of the method of groundwater treatment. In general, this alternative includes groundwater extraction, pretreatment for oil and grease and for inorganic chemicals, treatment for VOCs via an on-site liquid injection incinerator, and institutional controls.

Groundwater will be extracted through a series of extraction wells placed within both of the contaminated plumes within the shallow aquifer as described for Alternative 4. The pretreatment systems will be the same as for Alternatives 3, 4 and 5 which includes an oil/water separator and a inorganic chemical removal system. The pretreated groundwater will undergo further treatment for VOCs via an on-site liquid injection incinerator.

The same institutional controls identified in Alternative 2 will be included in this alternative.

The results of the detailed evaluation indicate that this alternative will not be as easy to implement as the other alternatives (dependent on the availability of a packaged liquid injection incinerator). Since this alternative includes treatment of the contaminated groundwater, it will be protective of human health and the environment. Capital costs in the order of $1.5 million are associated with this alternative (majority of this cost is for the one incinerator). The O&M costs are in the range of $627,000 annually. The present worth value of this alternative is estimated to be approximately $11.8 million.

Alternative 7: RCRA Facility/Groundwater Collection

Alternative 7 is somewhat similar to Alternatives 3, 4, 5 and 6 with the exception of the method of groundwater treatment. In general, this alternative includes groundwater extraction, off-site treatment at an approved RCRA facility, and institutional controls.

Groundwater will be extracted through a series of extraction wells placed within both of the contaminated plumes within the shallow aquifer as described for Alternative 4. No pretreatment systems are included with this alternative. The extracted groundwater will be temporarily stored in holding tanks, then transported to an approved RCRA facility for complete treatment of oil and grease, inorganics, and VOCs.

The same institutional controls identified in Alternative 2 will be included in this alternative.

The results of the detailed evaluation indicate that this alternative may not be as easy to implement as most of the other alternatives (dependent on the availability, capacity, and location of an appropriate RCRA facility). Since this alternative includes treatment of the contaminated groundwater, it will be protective of human health and the environment. Capital costs in the order of $900,000 are associated with this alternative. The O&M costs are in the range of $4.2 million annually (due to off-site transportation and treatment charges). The present worth value of this alternative is estimated to be approximately $68.9 million.

1.0 INTRODUCTION

This report presents the interim remedial action (IRA) focused Feasibility Study (FS) completed for the shallow aquifer at the Hadnot Point Industrial Area (HPIA) at Camp Lejeune Military Reservation and Marine Corps Base (MCB), North Carolina. This IRA FS has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division Naval Facilities Engineering Command (LANTDIV). The development of this FS is based on Task 6 of the Implementation Plan and Fee Proposal for Contract Task Order 0017 (Interim Remedial Action at the Hadnot Point Industrial Area Shallow Aquifer and Review of ESE Documents).

The FS has been conducted in accordance with the guidelines and procedures delineated in the National Contingency Plan (NCP) for interim remedial actions (40 CFR 300.430). These NCP regulations were promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. The EPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988) has been used as guidance for preparing this document. Additionally, draft Interim Remedial Action Report Guidelines provided to Baker by LANTDIV were utilized.

The FS has been based only on existing data collected during various studies conducted at the HPIA since 1983 by other consultants to the DoN, such as Environmental Science and Engineering, Inc. (ESE). Most of the site information used for this report was obtained from the following three previous studies conducted by ESE: (1) the FS for the shallow aquifer (May, 1988); (2) the Draft Remedial Investigation (RI) for the shallow and deeper groundwater aquifers (June, 1991); and (3) the Preliminary Draft Baseline Risk Assessment for the surface soils and intermediate and deep groundwater aquifers (July, 1991).

1.1 The Feasibility Study Process

The FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated so that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. The FS involves two major phases: (1) development and screening of remedial action alternatives, and (2) detailed analysis of remedial action alternatives.

The first phase includes the following major activities: (1) developing remedial action objectives, (2) developing general response actions, (3) identifying volumes or areas of affected media, (4) identifying and screening potential treatment/containment technologies, and process options (5) evaluating process options, (6) assembly alternatives, (7) defining alternatives, and (8) screening and evaluating alternatives.

The second 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.

1.2 Site Background Information

1.2.1 Site Location

Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina (Figure 1-1). The base covers approximately 170 square miles and is bounded to the southeast by the Atlantic Ocean, to the northeast by State Road 24, and to the west by U.S. 17. The town of Jacksonville, North Carolina is north of the base.

The focused study area for this FS is the shallow aquifer in the area of the HPIA. The HPIA is defined as Site 78 at MCB Camp Lejeune. Site 78, along with Site 21 (Transformer Storage Yard) and Site 24 (Industrial Area Fly Ash Dump), comprised the HPIA Operable Unit at MCB Camp Lejeune. The HPIA is bounded by Sneads Ferry Road to the north, Holcomb Boulevard to the west, Louis Road to the east, and Main Service Road to the south (Figure 1-2). Site 21 is also located within this boundary. Site 24 is located along Louis Road across from Site 78.

1.2.2 Site Description

The HPIA, constructed in the late 1930s, was the first facility at MCB Camp Lejeune. It was comprised of approximately 75 buildings and facilities including: maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, storage yards, and a dry cleaning facility. A steam plant and training facility occupy the southwest portion of the HPIA. A transformer storage yard (Site 21) and an industrial area fly ash dump (Site 24) are part of the overall HPIA Operable Unit. These two areas are not included in the scope of this

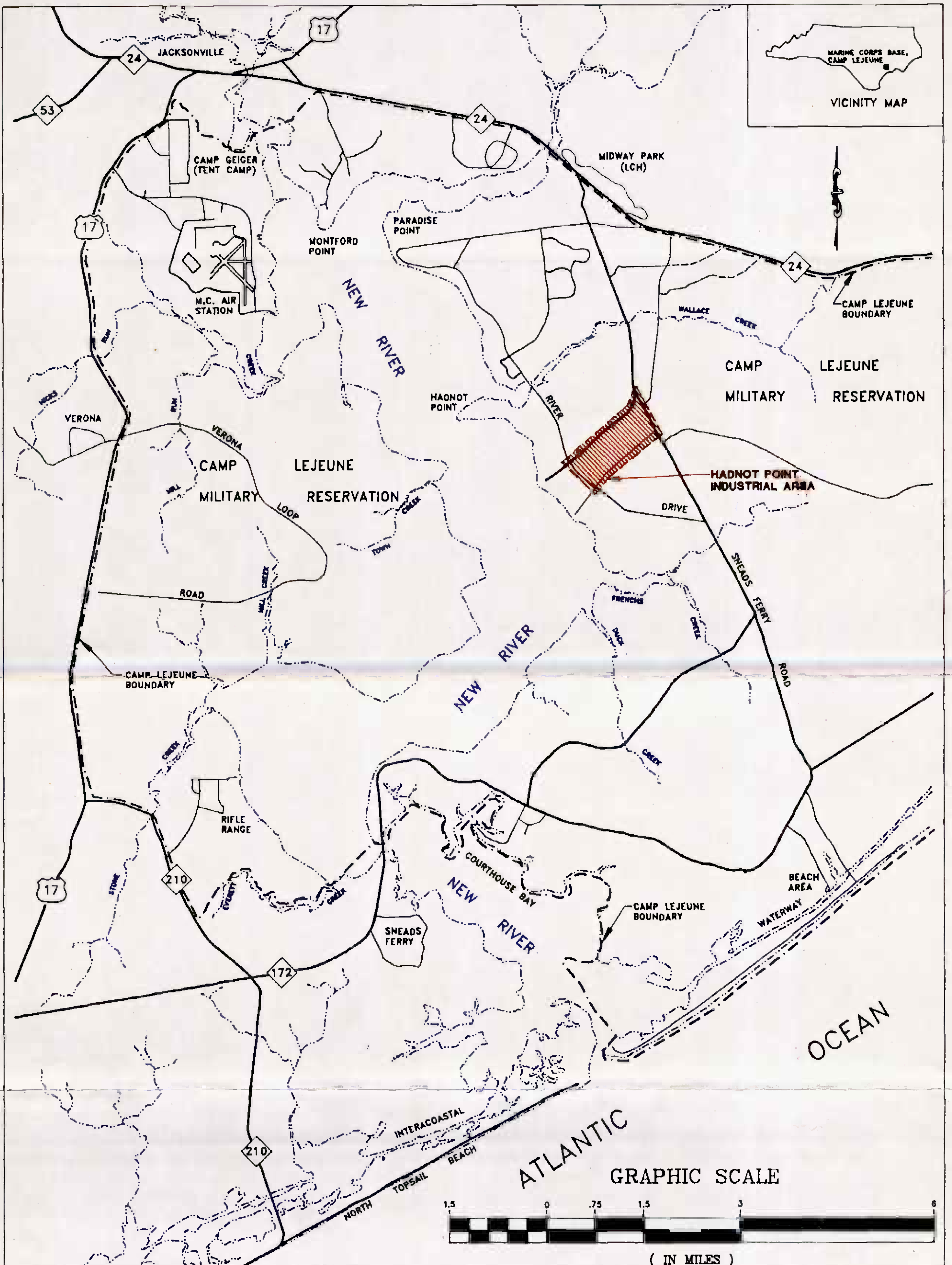

FIGURE 1-1
LOCATION MAP
MCB CAMP LEJEUNE, NORTH CAROLINA

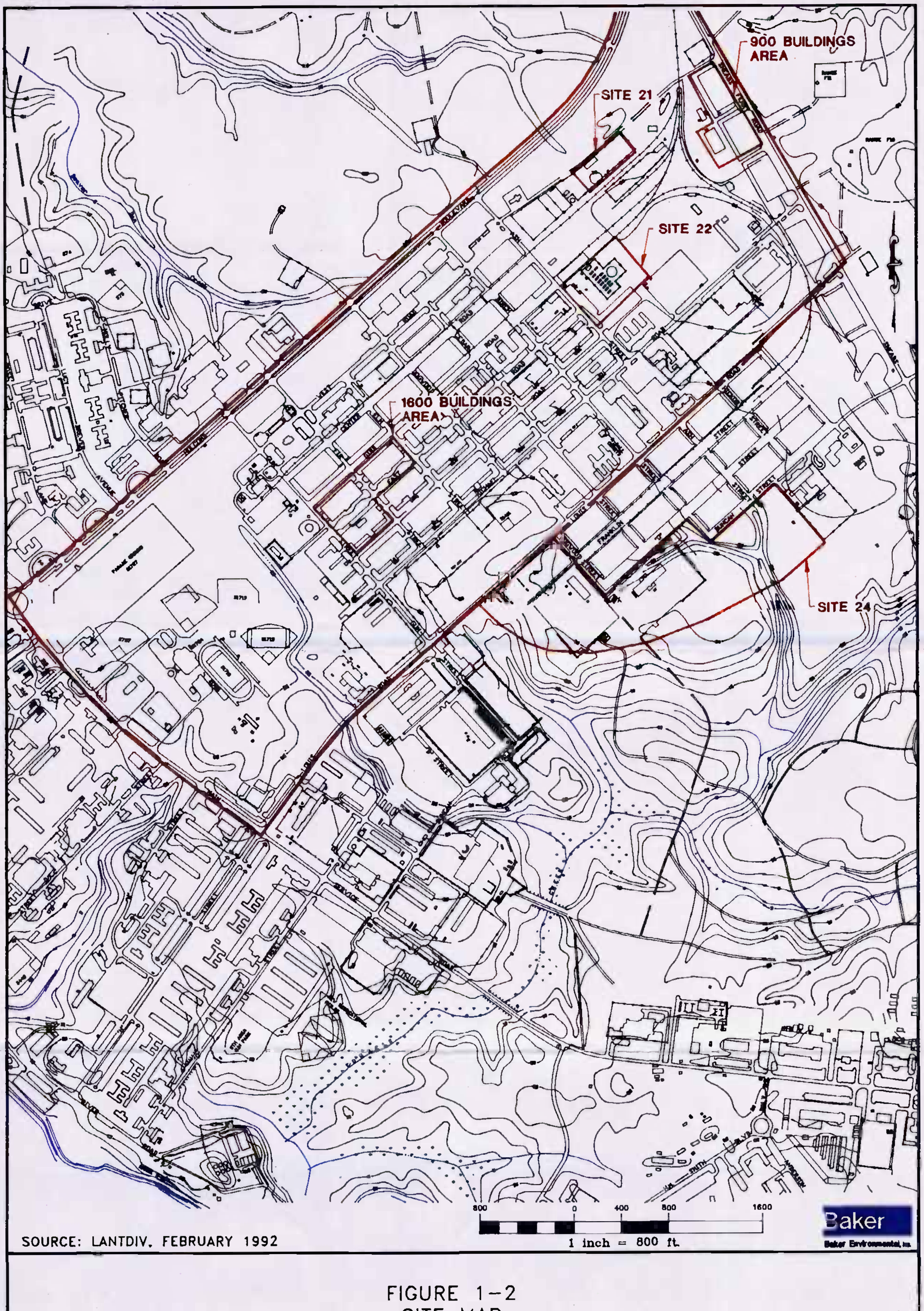

FIGURE 1-2
SITE MAP
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

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focused FS but will be considered in a separate RI/FS for the entire Operable Unit. Figure 1-2 identifies the location of these other areas.

In addition to Sites 21 and 24, a fuel tank farm (Site 22) is located within the HPIA operable unit near the 1000 series buildings. The fuel farm is an underground storage tank site which is not being administered under CERCLA regulations. Therefore, Site 22 is not included as part of the HPIA operable unit. Please note that a fuel recovery/groundwater treatment option is currently being implemented at the tank farm. Discussions of previous and present investigations at the tank farm may be included in this report for purposes of evaluating potential remedial alternatives for the shallow aquifer.

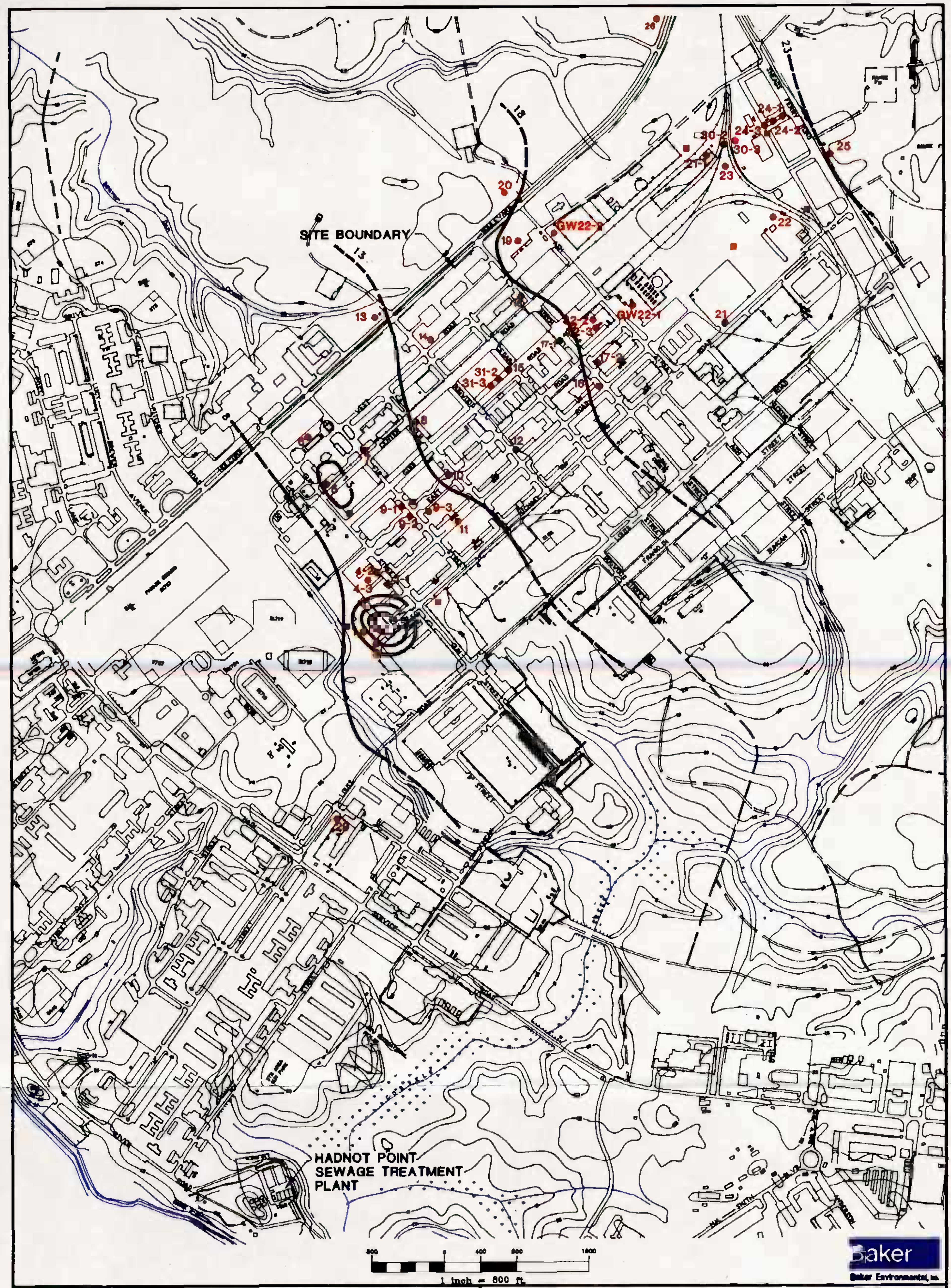
Several areas at the HPIA have been investigated for potential soil and groundwater contamination due to Marine operations and activities resulting in the generation of potentially hazardous wastes. The investigations indicate that contamination has resulted at HPIA due to improper waste disposal, underground storage tank leakage, solvent spills, and sludge disposal (ESE, 1991b).

1.3 Hydrology

The hydrologic system at Camp Lejeune consists of an unconfined (water table) aquifer and underlying semiconfined aquifers. The unconfined aquifer extends from the water table to the first significant confining layer, approximately 25 feet below land surface (bls) (ESE, 1991b).

The water table within HPIA was at an elevation ranging between 8.48 and 25.56 mean sea level during January 1991. The depth to the water table ranged from 6.67 to 23.18 feet bls (ESE, 1991b).

Groundwater flow in the shallow aquifer is predominantly to the southwest in the southern portion of HPIA and to the west-southwest in the northern and central portions of the site. There is some groundwater mounding in the southern corner of the site. Generally, the shallow groundwater flows toward the New River (ESE, 1991b). Figure 1-3 presents a potentiometric surface map of the water table aquifer constructed from water level measurements taken in shallow monitoring wells on February 20, 1991 by ESE. Water in the lower water bearing zones trends generally in the same direction (southwest) as that in the surficial (ESE, 1991c).



LEGEND

EXISTING MONITORING WELL LOCATION

8 GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INFERRED)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-3
SHALLOW GROUNDWATER ELEVATION CONTOUR MAP (2-20-91)
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

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As determined from February 1991 potentiometric surface maps, the horizontal hydraulic gradient in the shallow aquifer is approximately 0.003 feet per foot (ft/ft). The estimated gradient for the intermediate and deep zones are approximately 0.0015 ft/ft and 0.0021 ft/ft, respectively (ESE, 1991b).

1.4 Meteorology

Camp Lejeune is influenced by mild winters and humid summers with elevated temperatures. Rainfall averages more than 50 inches per year. The winter and summer months are typically the wet seasons. Evapotranspiration varies from 34 to 36 inches of rainfall equivalent per year (ESE,1991b).

Typical temperatures in January range from 33 to 53 degrees Fahrenheit. Average temperatures in July range from 71 to 88 degrees Fahrenheit. The growing season for the area is approximately 230 days (ESE, 1991b).

Winds are generally from the south-southwest during the warm seasons and from the north-northwest during the cooler seasons (ESE, 1991b).

1.5 Investigation and Study History

In response to the passage of CERCLA, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations conducted by the DoN consisted of Initial Assessment Studies (IAS), similar to EPA's Preliminary Assessments/Site Investigations, and Confirmation Studies, similar to EPA's RI/FS. When SARA was passed in 1986, the DoN aborted the NACIP program in favor on the Installation Restoration Program (IRP), which adopted EPA Superfund procedures.

A summary of the previous studies conducted at the HPIA either under the NACIP program or the IRP is presented in the following subsections.

1.5.1 Initial Assessment Study of HPIA, 1983

An IAS was conducted under the NACIP program at MCB Camp Lejeune in 1983. The IAS report prepared by Water and Air Research identified a number of areas within MCB Camp

Lejeune as potential sources of contamination. As a result of this study, ESE was contracted by LANTDIV to investigate these potential source areas as per NACIP program protocol. A number of these potential source areas are located within HPIA.

1.5.2 Confirmation Study, 1984-1988

ESE conducted a two part confirmation study which focused on the potential source areas at HPIA identified in the IAS. The confirmation study included a Verification Step and a Characterization Step. The findings from both of these studies are described below.

1.5.2.1 Verification Step

The Verification Step at HPIA was conducted from April 1984 through January 1985. This step identified the presence of volatile organic compounds (VOCs) in the shallow aquifer near the HPIA Fuel Farm and in Supply Well 602. Maximum contaminant levels detected in the shallow aquifer included: benzene at 17,000 micrograms per liter (μg/l) and toluene at 27,000 μg/l. Benzene was detected in Supply Well 602 at a level of 38 μg/l.

As of result of this investigation, Camp Lejeune closed Supply Well 602 and sampled other supply wells in the area. Four additional supply wells (601, 608, 634, and 637) were found to be contaminated with VOCs and were also closed. Maximum contaminant levels in these supply wells included: trichloroethene (TCE) at 230 μg/l in Well 601, TCE at 110 μg/l in Well 608, and methylene chloride at 130 μg/l in Well 634.

1.5.2.2 Characterization Step

The Characterization Step was performed at HPIA during 1986-1988. The investigation was designed to evaluate the extent of the VOC contamination identified in the Verification Step. The Characterization Step consisted of the following tasks:

- Records search including review of available base records and a physical inspection of each building within HPIA.

- Soil gas survey targeted to those areas identified by the records search as being potential contamination sources.

- Installation of 27 shallow, three intermediate, and three deep monitoring wells.

- Sampling of all HPIA monitoring wells and nearby water supply wells.

- Aquifer testing to evaluate the hydraulic parameters of the deep aquifer.

1.5.3 Groundwater Study at the Hadnot Point Fuel Farm, 1988

O'Brien and Gere Engineers, Inc. conducted a groundwater study at the Hadnot Point Fuel Farm (Site 22) as presented in their December 1988 Final Report. The fuel farm, constructed around 1941, consisted of 14 underground storage tanks and one above ground storage tank. These tanks contain either diesel fuel, leaded gasoline, unleaded gasoline, or kerosene. The purpose of this study was to provide follow-up hydrogeologic services to investigate the hydrogeology and evaluate the extent of fuel leakage from the underground storage tanks and associated transfer lines. The study included installation of 20 groundwater monitoring wells in the vicinity of the fuel farm, measurement of groundwater elevation and floating product thickness, and sampling and analysis of groundwater for VOCs. The study concluded that fuel losses of gasoline have likely occurred predominantly through leaks in the transfer lines or valves. Laboratory analyses indicate that the floating product has contributed significant levels of dissolved petroleum compounds including benzene, toluene, xylene, and ethylbenzene into the groundwater. Trace levels of non-petroleum VOCs including TCE and tetrachloroethylene were also detected within the fuel farm.

Following this investigation, O'Brien and Gere conducted a pump test to determine the hydraulic characteristics of the shallow aquifer. Based on these results, O'Brien and Gere designed a product recovery system and contaminated groundwater treatment system for the fuel farm. The system consisted of four recovery wells, a product recovery tank, an oil/water separator, an air stripper, and activated carbon canisters. The system began operation in that latter part of 1991. It is important to note that the treatment system implemented at the fuel farm is addressing a different yet complimentary phase of the groundwater problem in the shallow aquifer (i.e., this system is addressing the recovery of free phase product). Since the fuel farm area is a leaking underground storage tank problem, it is not included as part of the CERCLA RI/FS process, but will be handled as a separate study.

1.5.4 Feasibility Study for HPIA, 1988

A focused FS for HPIA was conducted by ESE in May 1988. The purpose of this FS was to provide information to select a cost- effective remedial alternative for the cleanup of detected contamination within the shallow aquifer at HPIA. This FS was a preliminary study and did not follow all of the FS requirements under CERCLA.

1.5.5 Supplemental Characterization, 1990-1991

The Supplemental Characterization Step, performed at HPIA in 1990-1991 by ESE, was designed to further evaluate the extent of contamination in the lower water bearing zones and to characterize the contamination within the shallow soils at suspected source locations. The work activities completed during the Supplemental Characterization Step included: (1) the completion of 30 soil borings at three suspected source locations to characterize shallow soil contamination, (2) installation of four intermediate (75 feet) and four deep (150 feet) monitoring wells, and (3) sampling of all new and existing HPIA monitoring wells and nearby water supply wells.

1.5.6 Remedial Investigation for HPIA, 1991

ESE conducted an RI for HPIA as presented in the June 1991 RI report. The purpose of this investigation was to delineate the horizontal and vertical extent of contamination within the surficial and lower water bearing zones. The investigation included: (1) installation of shallow, intermediate, and deep monitoring wells downgradient of potential source areas, (2) collection of soil gas samples and analytical samples, (3) determination of groundwater flow direction and gradients, and (4) collection of groundwater analytical data to characterize the plume.

1.5.7 Preliminary Risk Assessment, 1992

Baker conducted a Preliminary Risk Assessment (RA) for the shallow aquifer at HPIA in 1992. This preliminary RA is a component of the Interim Remedial Action RI/FS for MCB Camp Lejeune. The Preliminary RA concluded that potential usage of the shallow aquifer, or migration of contaminants from the shallow aquifer to the deep aquifer, may result in increased health risks due primarily to elevated levels of TCE and benzene. The Final Baseline RA (to be prepared following completion of the additional studies at the site) will determine if other potential contaminants pose potential threats to human health and the environment.

1.6 Nature and Extent of Contamination

Previous studies indicate that the shallow groundwater is contaminated primarily with fuel related compounds, 1,2-dichloroethene (1,2-DCE), TCE, solvents, and metals, such as antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, and nickel. A summary of the existing data for the site is presented in the appendix to this report. Upon review of this existing data, it is apparent that several compounds were detected at concentrations exceeding the Federal and North Carolina drinking water standards for groundwater.

The most recent shallow groundwater data was collected in January 1991 by ESE. This data is similar to the results of the earlier studies with the exception that the compound concentrations from the January data were generally lower than the concentrations identified in the earlier studies. Based upon the results of the 1991 sampling, the following compounds were identified as potential contaminants of concern for the shallow aquifer at HPIA: benzene, 1,2-DCE, TCE, antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, nickel, and oil and grease. Table 1-1 presents a summary of the 1991 shallow aquifer groundwater data with respect to the contaminants of concern. Oil & grease data is not included on Table 1-1 due to the fact that this analysis was not conducted on any of the 1991 samples. The maximum concentration of benzene (7900 µg/l) was detected in a monitoring well immediately adjacent to the fuel tank farm (Site 22). Maximum concentrations of 1,2-DCE (42,000 µg/l) and TCE (14,000 µg/l) were detected in the northeast corner of the site (near the 1600 series buildings) and in the southwestern portion of the site (near the 900 series buildings), respectively. Metals concentrations were elevated throughout most of the site, especially near the fuel farm (lead).

Based on review of existing site data, two major areas of contaminated groundwater (source areas) have been identified in the shallow aquifer at HPIA as shown on Figure 1-4. The first area or plume is located northeast of Cedar Street near the 900 series buildings. The other plume is located southwest of Cedar Street near the 1600 series buildings.

TABLE 1-1

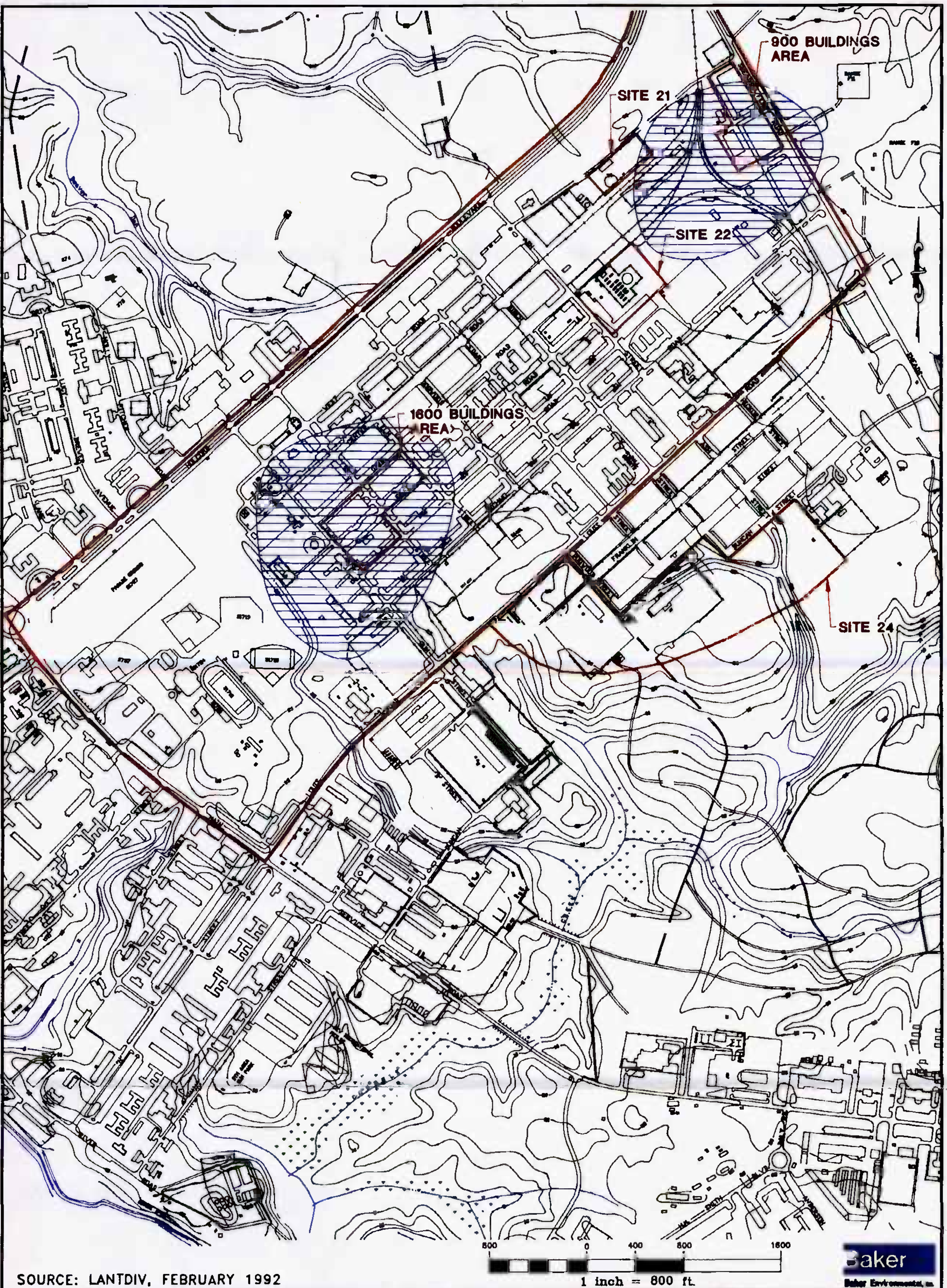
SUMMARY OF CONTAMINANTS OF CONCERN DETECTED IN THE SHALLOW GROUNDWATER AQUIFER, JANUARY 1991

Potential Contaminants of Concern	HPGW1	HPGW2	HPGW3	HPGW4-1	HPGW5	HPGW6	HPGW7	HPGW8	HPGW9-1	HPGW10	HPGW11	HPGW12	HPGW13	HPGW14	HPGW15	HPGW16
VOCs (µg/l): Benzene	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<	5<
1,2-Dichloroethene (1,2,-DCE)	73	5<	5<	5<	5<	5<	5<	5<	1200	5<	5<	5<	5<	5<	7	5<
Trichloroethene (TCE)	91	5<	5<	0.9J	5<	5<	5<	2J	14000	5<	5<	5<	5<	5<	4J	5<
Inorganics (µg/l): Chromium	87	64.3	16.7	187	3.6B	1590	313	91.8	66.4	310	140	25.5	48.9	127	21.4	209
Iron	64100	34800	10400	100000	3100	265000	65700	40900	19800	119000	31800	5600	33500	87200	4800	47200
Lead	16.6	29.4	11.4	66.6	13.6	60.7	112	54.1	128	186	45.2	15.7	9	66.5	16.6	100
Manganese	168	77	53.9	425	162	487	136	46.5	45	255	103	18.3	30.3	80	18.3	98.3
Antimony	13.3<	15.6B	46.5B	21.9B	13.3<	13.3<	22<	22	17.6B	22<	22<	22<	13.3<	13.3<	22<	22<
Arsenic	8B	24.1	15.6	15.5	1.5<	31.5	18.3	28.4	3B	39.9	9.1B	1.8<	47	45.6	1.8<	17.3
Beryllium	6	1.7B	1.2B	6.7	0.86B	20	4.8B	2.1	0.79B	5.6	2.1<	2.1<	0.59B	2.7B	2.1<	5.3
Mercury	0.1<	0.1<	0.1<	0.1<	0.1<	1.4	0.25	0.13	0.1<	0.82	0.1B	0.1<	0.1<	0.26	0.1<	0.13B
Nickel	31.3B	16.9B	12.1B	57	5.2<	161	50.7	25.2	15.1B	92.2	23.6B	11<	21.2B	41.6	11<	41

Potential Contaminants of Concern	HPGW17-1	HPGW18	HPGW19	HPGW20	HPGW21	HPGW22	HPGW23	HPGW24	HPGW25	HPGW26	HPGW29	22GW1	22GW2
VOCs (µg/l): Benzene	5<	N/A	5<	5<	5<	5<	24	3J	5<	5<	5<	7900	5<
1,2-Dichloroethene (1,2,-DCE)	5<	N/A	0.8J	5<	5<	5<	8900	42000D	5<	5<	5<	5<	5<
Trichloroethene (TCE)	5<	N/A	2J	5<	3J	5<	3700	180	5<	5<	5<	5J	5<
Inorganics (µg/l): Chromium	37	N/A	13.8	424	45	79.8	76.3	26.3	205	13	179	457	26.3
Iron	10500	N/A	36200	152000	56600	24400	23300	19200	46600	19000	76200	101000	16200
Lead	23.7	N/A	31.7	20	49.4	39.4	45	21.4	71.6	9	29.1	307	16.2
Manganese	31.3	N/A	79	217	136	94.1	68.8	54.8	118	10.6B	236	284	763
Antimony	22<	N/A	13.3	21.9B	13.3<	24.6B	24.6B	22<	13.3<	13.3<	13.3<	20.9B	13.3
Arsenic	1.8<	N/A	5B	49.4	12.1	7.2B	6.6B	4.2B	13.2	1.5<	25.6	50.3	11
Beryllium	2.1<	N/A	2.3B	9.5	3.7B	0.6B	1B	2.1<	2.8B	0.5<	8.7	5.8	0.5
Mercury	0.1<	N/A	N/A	0.5	0.1<	0.1<	0.1<	0.1<	0.1<	0.1<	0.1<	0.35	0.1
Nickel	11.9B	N/A	7.3B	168	30.8B	23.2B	33.2B	14<	39.2B	5.2<	93.5	186	17

Notes:

N/A = Not analyzed
< = Compound was analyzed, but not detected at the listed detection limit
J = Value is estimated
B = Reported value is < contract required detection limit, but > instrument detection limit (IDL)
D = Compound identified in an analysis at a secondary dilution factor



SOURCE: LANTDIV, FEBRUARY 1992

LEGEND

APPROXIMATE SOURCE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER

FIGURE 1-4
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

1.7 Data Limitations

An overall limitation to the preparation of this FS was that the analytical data was only available in summary table form. No raw analytical data was available for review. Therefore, the accuracy of the report-generated summary tables could not be checked.

1.8 Report Organization

The FS Report is organized in five sections. This introduction (Section 1.0) presents a brief discussion of the FS process, site background information, and summary of nature and extent of contamination at the site. Section 2.0 contains the identification and preliminary screening of the remedial action technologies. Section 3.0 contains the development and preliminary screening of remedial action alternatives. Section 4.0 presents the results of the detailed analysis of the remedial alternatives and a comparative analysis of the alternatives. The detailed analysis is based on a set of nine criteria including effectiveness, implementability, cost, acceptance, and overall protection of human health and the environment. The references are listed in Section 5.0. A summary of existing data is presented in the appendix.

2.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES

This section of the FS includes the steps involved with identifying and screening a set of remedial action technologies that may be applicable for the interim remediation of the shallow aquifer at the HPIA Site. Section 2.1 presents a discussion of the remedial action objectives identified for the interim remedial action. Section 2.2 identifies a set of general response actions that may be applicable to the site. Section 2.3 includes the identification and preliminary screening of a set of remedial technologies applicable to groundwater remediation. Section 2.4 presents a summary of the preliminary screening, and Section 2.5 presents the process option evaluation.

2.1 Remedial Interim Action Objectives

Remedial action objectives are medium-specific or operable unit-specific goals established for protecting human health and the environment. The remedial action objectives identified for this focused FS are: (1) to establish an interim remedial action which will contain and/or initiate remediation of the contaminated groundwater plume in the shallow aquifer at HPIA while a final remedial measure can be developed, and (2) reduce the contaminants of concern in the two source area plumes to established Federal and/or State drinking water standards or ambient water quality criteria, or to background levels if no other standards are established. The second objective may be revised after work has been completed to support a final remedial decision.

Based on the results of the Preliminary Risk Assessment conducted by Baker (and presented in the Interim Remedial Action Remedial Investigation Report) for the shallow aquifer, the primary contaminants of concern in the shallow aquifer include TCE, 1,2-DCE, benzene, antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury and nickel. Table 2-1 presents a listing of the Federal (drinking water MCLs) and State water quality criteria for groundwater for these compounds.

Please note that the Preliminary Risk Assessment presented a conservative estimate of potential risks at the site. Since the shallow aquifer is not used as a drinking water source, the risk evaluation may be an overestimation of concerns.

TABLE 2-1

FEDERAL AND STATE CRITERIA FOR THE CONTAMINANTS OF CONCERN IDENTIFIED FOR THE SHALLOW AQUIFER

Contaminant of Concern	North Carolina Water Quality Criteria for Groundwater (µg/L)	Federal Drinking Water MCLs (µg/L)
TCE	2.8	5
1,2-DCE	--(1)	--
Benzene	1	5
Antimony	--	10/5(2)
Arsenic	50	50
Beryllium	0.5	1(3)
Chromium	50	100
Iron	300	--
Lead	50	15(4)
Manganese	50	--
Mercury	1.1	2
Nickel	150	100(3)

(1) -- = No standard established.
(2) Two proposed MCLs.
(3) Proposed MCL.
(4) MCL is action level for public water supply systems.

2.2 General Response Actions

General response actions are broad-based categories of actions that can be identified to satisfy the remedial action objectives of an FS. Six general response actions have been identified for the HPIA Site: (1) No Action, (2) Institutional Controls, (3) Containment, (4) Collection, (5) Treatment, and (6) Discharge. A brief description of each of these response actions follows.

2.2.1 No Action

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 an alternative response action may cause a greater environmental or health danger or will result in no significant environmental benefit than the no action alternative itself. The NCP requires the evaluation of the no action response action as part of the FS process.

2.2.2 Institutional Controls

Institutional controls are various "institutional" actions that can be implemented at a site as part of a complete remedial alternative to minimize exposure to potential hazards at the site. Institutional controls may include monitoring programs, access restrictions, building ordinances, land use restrictions, and aquifer-use restrictions.

2.2.3 Containment

Containment measures include various technologies which contain and/or isolate the constituents of concern on a site. The measures provide isolation and prevent direct exposure with or migration of contaminated media without disturbing or removing the waste from the site. Containment measures generally consists of measures which cover, seal, chemically stabilize, or provide an effective barrier against specific areas of contamination.

2.2.4 Collection

Collection measures are typically associated with groundwater or surface water collection. Collection of contaminated groundwater may be achieved via withdrawal techniques such as pumping or interceptor trenches.

2.2.5 Treatment

Various treatment options exist for the treatment of contaminated water and soils. For groundwater, on-site treatment systems are often required in conjunction with collection actions to reduce contaminant levels. General treatment techniques include chemical, biological, thermal, or physical removal systems, or in-situ treatment systems.

2.2.6 Discharge

Discharge measures typically refer to methods to dispose of extracted and/or treated groundwater. Discharge options may include discharge of water to a nearby surface water body, discharge of water to a local wastewater treatment plant, or discharge of water to the groundwater via reinjection.

2.3 Identification and Preliminary Screening of Remedial Technologies

2.3.1 Identification of Remedial Action Technologies

Typically, at this stage of an FS, an extensive list of potential treatment technologies associated with the general response actions are identified for a site. Since this is an interim remedial action FS focused only on the shallow aquifer, the set of potential technologies has been limited to groundwater technologies as shown on Table 2-2. Also shown on Table 2-2 are the general response actions and process options associated with each listed technology.

2.3.2 Preliminary Screening of Remedial Technologies

The preliminary screening of each of the potential technologies listed on Table 2-2 is presented below and summarized in Section 2.4. This preliminary screening was based on technical implementability (contaminant types and concentrations and site-specific characteristics). Technologies considered ineffective or whose use would be precluded by site characteristics have been eliminated from further consideration at this time.

TABLE 2-2

INITIAL SET OF REMEDIAL ACTION TECHNOLOGIES IDENTIFIED FOR THE SHALLOW AQUIFER AT THE HPIA OPERABLE UNIT

General Response Action	Remedial Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Monitoring	Groundwater Monitoring
	Ordinances	Aquifer-Use Restrictions
	Access Restrictions	Deed Restrictions
		Fencing
Containment	Surface Barriers	Capping
	Vertical Barriers	Grout Curtain
		Slurry Wall
		Sheet Piling
		Rock Grouting
	Horizontal Barriers	Grout Injection
		Block Displacement
Collection	Extraction	Extraction Wells
		Extraction/Injection Wells
	Subsurface Drains	Interceptor Trenches
Treatment	Biological	Aerobic-Aerated Lagoon
		Aerobic-Activated Sludge
		Aerobic-Powered Activated Carbon Treatment
		Aerobic - Trickling Filter
		Aerobic-Rotating Biological Contactor
		Anaerobic-Biological Treatment
	Physical/Chemical	Air Stripping
		Steam Stripping
		Carbon Adsorption
		Reverse Osmosis
		Ion Exchange
		Chemical Reduction
		Chemical Oxidation
		Neutralization
		Precipitation
		Oil/Water Separator
		Filtration
		Flocculation
		Sedimentation

TABLE 2-2 (Continued)

INITIAL SET OF REMEDIAL ACTION TECHNOLOGIES IDENTIFIED FOR THE SHALLOW AQUIFER AT THE HPIA OPERABLE UNIT

General Response Action	Remedial Technology	Process Option
Treatment (continued)	Thermal Treatment	Incineration - Liquid Injection
		Incineration - Rotary Kiln
		Incineration - Fluidized Bed
		Incineration - Multiple Hearth
		Molten Salt
		Plasma Arc Torch
		Pyrolysis
		Wet Air Oxidation
	Off-Site Treatment	POTW
		RCRA Facility
		Sewage Treatment Plant
	In Situ Treatment	Biodegradation
Discharge	On-Site Discharge	Surface Water
	Off-Site Discharge	POTW
		Pipeline to River
		Deep Well Injection
		Sewage Treatment Plant

2.3.2.1 No Action

The no action response provides a baseline for comparison with other groundwater response actions. Under the no action response for HPIA, the groundwater in the shallow aquifer will be left as is. As required by the NCP, the no action response will be retained for further evaluation.

2.3.2.2 Institutional Controls

Groundwater Monitoring

A long-term groundwater monitoring program could be implemented at the HPIA as an institutional control. This program would continue to provide information regarding the effectiveness of any remedial activities conducted on site. Groundwater monitoring will be retained for further evaluation.

Aquifer-Use Restrictions

An ordinance restricting the use of the shallow aquifer at the HPIA as a drinking water source could be implemented as an institutional control. This restriction ordinance would help reduce the risk to both human and nonhuman populations from ingestion and direct contact with the contaminants in the aquifer. This restriction ordinance will be retained for further evaluation.

Deed Restrictions

Deed restrictions or land use restrictions may be used as an institutional control measure. Selected areas within a site may be subject to a deed restriction thereby limiting the future use of that land. A typical example is a RCRA landfill. After a landfill has been closed, that area of land becomes subject to a deed restriction providing that no future disturbance (development, excavation, etc.) is permitted. This control measure appears to be applicable to the HPIA operable unit for the shallow aquifer with respect to installing drinking water wells within or near the study area.

Fencing

Limiting access to a site via fencing can be considered an institutional control. Based on the current use and physical development at the HPIA, this control will not be retained for further evaluation.

2.3.2.3 Containment

Capping

Capping techniques are employed whenever contaminated materials are to be buried or left in place at a site. There are many variations in cap designs and materials that are available. Potential capping materials include: synthetic membranes, bentonite clay, natural soils, admixed soils, portland cement, and bitumen (emulsified asphalt). Most caps consist of multiple layers of material. Single layer designs are typically used for special purposes such as a physical contact barrier.

Capping is a reliable technology for sealing off contamination from the aboveground environment, for minimizing underground migration of wastes, and for use as a physical contact barrier. Based on the current use and physical development at the HPIA, this technology will not be retained for further evaluation.

Grout Curtain

A grout curtain is a vertical barrier which consists of material injected into voids of water-bearing strata either to cover, bottom seal, or bind together the subsurface materials at a site. Spacing of injection points depends on the site conditions; most granular soils require a multi-layer pattern of injection points. Grouts are not suitable to poorly permeable soils (USEPA, 1982). The heterogeneity of the fill material at the HPIA Site prevents the construction of a "gap-free" grout curtain. Therefore, grout curtains will not be evaluated for the HPIA Site due to this fact and due to the physical development at the site.

Slurry Wall

A slurry wall is a subsurface vertical barrier of low permeability that is constructed in place. It is usually located below the water table and surrounds a site or area of concern to limit the horizontal migration of contaminants in the saturated zone. A slurry wall is usually 2 to 3 feet across and can be constructed as deep as 100 feet. It must make full contact with underlying bedrock or an impermeable formation. A slurry wall is constructed by excavating a trench to the required depth with a backhoe or clamshell. The trench is backfilled with a soil/bentonite/water "slurry" as excavation progresses. The slurry prevents the trench from collapsing while forming a filter cake on the trench walls. The filter cake acts similarly to a drilling fluid by preventing fluid losses into the aquifer materials.

Slurry walls are particularly effective in applications where a shallow water table aquifer is underlain by a laterally extensive confining layer; a situation which occurs in many glacial and alluvial deposits. The use of slurry walls is limited or restricted in applications involving consolidated or highly fractured rock. Slurry walls are typically used in conjunction with other remedial responses which involve groundwater recovery to reduce the hydrostatic pressure on the barrier (USEPA, 1982).

Even though a slurry wall is a feasible technology for containing a contaminated groundwater plume, it will not be considered for the shallow aquifer at HPIA. The reason for the elimination of this technology is due to the physical development of the site area (i.e., numerous buildings and roadways) and due to the fact that there is not a continuous confining layer under the shallow portion of the aquifer.

Sheet Piling

Sheet pilings are used as a groundwater barrier. Various designs of sheet pilings are available; each has an interlocking joint to connect adjacent sheets. Sheet piling is installed by a drop hammer or a vibratory hammer and, therefore, the presence of rocks within the soil matrix may result in damage to the sheet piling during installation. When first installed, sheet piling is not an effective barrier because the interlocking joints allow water to easily pass. After a period of time, fine soil particles will wash into the joints and create an effective groundwater barrier. However, in very coarse, sandy soils, the interlocking joints may never completely seal. The integrity of sheet piling for use as a groundwater barrier is, therefore, unpredictable (USEPA, 1982). Due to this unpredictability, to the heterogeneity of the fill materials, and to the physical development at the HPIA Site, sheet piling for use as a groundwater containment measure will not be evaluated further.

Rock Grouting

Rock grouting is a specialty operation which consists of sealing fractures, fissures, solution cavities, or other voids in rock in order to control the flow of groundwater. Rock grouting is very dependent on thorough site characterization (exploratory investigation, geologic mapping, remote sensing techniques, and rock coring). This technique has rarely, if ever, been used for controlling highly contaminated groundwater. Due to the physical development at the HPIA Site, rock grouting will not be evaluated further (Wagner, 1986).

Grout Injection

Grout injection is a horizontal barrier technology which places a bottom seal of grout across a site at a specified depth. This technique involve drilling through the site, or directional drilling from the site perimeter, and injecting grout to form a horizontal or curved barrier. This technique is in the developmental stage (Wagner, 1986). Because of the lack of operational proof of this technique and also due to the physical development at the HPIA Site, grout injection will not be evaluated any further.

Block Displacement

Block displacement is an experimental horizontal barrier technique used for isolating and raising a contaminated block of earth. A perimeter barrier is constructed by slurry trenching or grouting. Grout is injected into specially notched holes bored through the site. Continued grout pumping causes displacement of the block of earth isolated by the perimeter barrier and forms a bottom seal beneath the block. This technique has been laboratory and field tested, but not yet used at a hazardous waste site (Wagner, 1986). Because of the lack of operational proof of this technique and also due to the physical development at the HPIA Site, block displacement will not be evaluated any further.

2.3.2.4 Collection

Extraction Wells

The extent and migration of a contaminated groundwater plume may be contained or controlled via pumping techniques. Existing wells or additional extraction wells, strategically located according to the hydrogeologic and chemical characteristics of an aquifer and constituents of concern, are typically used. The extraction wells are pumped at specific rates such that the cone of influence from the well system intercepts the contaminant plume. Groundwater pumping may be combined with treatment technologies to allow for discharge to a publicly owned treatment works (POTW) facility or to a surface water body.

Pumping techniques utilizing extraction wells are reliable and proven techniques for the management of groundwater contamination and aquifer restoration. Installation is relatively easy and quick. Operational and maintenance costs are high, especially when used as a long term remedial action (Wagner, 1986). Groundwater pumping and collecting via extraction wells is a feasible remedial technology and will be evaluated for the HPIA Site.

Extraction/Injection Wells

An addition to extraction wells, a set of injection wells can be installed at a site, typically upgradient of the contamination. A combination of extraction and injection wells is frequently used in containment or removal where the hydraulic gradient is relatively flat and hydraulic conductivities are only moderate. The function of the injection well is to direct contaminants to the extraction wells. Injection wells can suffer from many operational problems, including air locks and the need for frequent maintenance and well rehabilitation (Wagner, 1986).

Based on the physical characteristics of the shallow aquifer at the Hadnot Point area, injection wells will not be effective in directing contaminants to the extraction wells. Therefore, this technology will be eliminated from further evaluation.

Interceptor Trenches

Interceptor trenches are a type of subsurface drain which are underground, gravel-filled trenches typically lined with perforated pipe or tile that intercept infiltrating water. These trenches are used to collect water in any clay or silty clay soil where the permeability is not adequate to maintain sufficient flow. Collection by subsurface drains is generally limited to shallow depths (Wagner, 1986). Although technically feasible, installation of this type of a drainage system at HPIA would be extremely difficult due to the excavation required as well as the numerous physical barriers (i.e., buildings, roadways) on site. In addition, the costs of temporary shoring and actual dewatering during installation would be prohibitive. Therefore, this collection technology will be eliminated from further consideration.

2.3.2.5 Biological Treatment

Various biological treatment technologies exist that are effective in the removal of constituents of concern in wastewater streams. Typical compounds removed effectively through biological treatment include benzene, methylene chloride, toluene, trichloroethene and vinyl chloride. Actual removal efficiencies for these compounds, as well as the other compounds detected in the shallow aquifer at HPIA, can be determined during pilot testing. Lead removal is typically not removed through biological treatment, and may even be inhibitory to biological populations at concentrations greater than 10 milligram per liter (mg/l). Additionally, xylene may be inhibitory to microbial populations at concentrations greater than 500 mg/l (ESE, 1988).

Several types of biological treatment systems have been considered for the HPIA Site. They are described and screened below.

Aerobic-Aerated Lagoon

Aerated lagoons are completely mixed biological reactors without biomass recycle. They are mixed and aerated using either fixed or floating surface aerators. Removal of soluble organic matter can be achieved with the proper mix of retention time and aeration. The primary purpose of this process is to remove soluble organic matter by conversion to biological mass. The main differences between an aerated lagoon and an activated sludge system is that the microorganisms in the lagoon are grown in the disperse state rather than as a flocculent mass, and biomass is not recycled from the sedimentation step to the aeration step. The performance of aerated lagoons depends of detention time, temperature, and the nature of the waste (USEPA, 1990).

With respect to the constituents of concern at the HPIA Site, an aerated lagoon has been shown to be effective in removing benzene and TCE. Low removal rates have been documented for lead, chromium, and iron (USEPA, 1990). Based on the organic constituents of concern at the HPIA Site, this technology would appear to be effective. The existing sewage treatment plant (STP) at Hadnot Point already has an aerated lagoon. Therefore, this technology will be retained for further evaluation as part of an off-site treatment technology at the Hadnot Point STP.

Aerobic-Activated Sludge

The activated sludge process is an aerobic biological treatment technology that uses microorganisms to degrade a wide variety of organic constituents in aqueous waste streams. The process utilizes solids settling and recycling as part of the entire process. Typically, aqueous waste flows into an aeration basin where microbial oxidation and assimilation (treatment) occur. In the basin, organic components of the wastewater serve as carbon and energy sources for microbial growth. Organic matter is converted to microbial cell tissue and carbon dioxide. The mixture of microbial mass and wastewater (i.e., sludge) is settled out in a clarifier. A portion of the settled sludge is recycled to the aeration basin while the remaining sludge requires proper disposal. Clarified water can be discharged or may require further processing (Wagner, 1986).

Activated sludge is the most widely used biological wastewater treatment process. Its effectiveness is dependent of organic loading, sludge retention time, mixed liquor suspended solids concentration, hydraulic detention time, and oxygen supply. VOCs may be air\stripped to a certain extent during the aeration process, and metals are partially removed and accumulate in the sludge. With respect to the constituents of concern at the HPIA Site, activated sludge has been shown to be effective in removing benzene and TCE. Lower removal rates have been documented for inorganics (USEPA, 1990).

Based on the constituents of concern at the HPIA Site, this technology may appear to be effective. Therefore, this technology will be evaluated further.

Aerobic-Powered Activated Carbon Treatment

Powered activated carbon treatment (PACT) is the addition of powdered activated carbon to a biological process (typically activated sludge). The PAC is added to the aeration tank of an activated sludge system. Following aeration, the solids are separated in the final clarifier and a portion of the solids are recycled to meet the requirements of the activated sludge system (USEPA, 1990). This technology may be applicable in conjunction with the activated sludge technology. It will be retained for further evaluation.

Aerobic-Trickling Filter

A trickling filter is a biological treatment technique typically consisting of a bed of crushed rocks, or other medium, coated with biological film. Contaminated water is sprayed over this filter medium. As the contaminated water passes over the microbial growths, an appreciable amount of the organic material is removed along with molecular oxygen. Aerobic processes occur and the oxidized organic and inorganic end products are released into the moving water film. The wastewater passes through a filter, while the organic materials are retained for several hours as they undergo bio-oxidation. (Wentz,1989).

With respect to the constituents of concern at the HPIA Site, a trickling filter has been shown to be effective in removing benzene and TCE. Lower removal rates have been documented for lead, chromium, and iron (USEPA, 1990). Based on the constituents of concern at the HPIA Site, this technology would appear to be effective. The Hadnot Point STP has two trickling filters used for biological treatment. Therefore, this technology will be retained for further evaluation as part of an off-site treatment technology at the Hadnot Point STP.

Aerobic-Rotating Biological Contactor

Rotating biological contactors (RBCs) provide a fixed-film biological treatment method for the removal of BOD from wastewaters. The most common type of RBC consists of corrugated plastic discs mounted on horizontal shafts to which a biological mass attaches. The biological mass adsorbs, coagulates, and biodegrades organic pollutants from the wastewater (USEPA, 1990). With respect to the constituents of concern at the HPIA Site, this technology does not appear to be as applicable as some of the other biological treatment technologies, therefore it will not be evaluated further.

Anaerobic Biological Treatment

Anaerobic biological treatment involves bacterial reduction of organic matter in an oxygen-free environment. There are two main types of anaerobic systems and reactor types: a suspended-growth reactor system and a fixed-film reactor. Anaerobic treatment is best utilized specifically to reduce high strength organic wastewaters to concentrations that can be degraded aerobically. Anaerobic systems can break down some halogenated organic compounds and can treat the high strength organic waste that cannot be treated efficiently by aerobic systems. Anaerobic treatment has had unfavorable past experiences and is a poorly understood process (USEPA, 1990).

With respect to the constituents of concern at the HPIA Site, anaerobic treatment may be applicable especially for TCE. This technology will not be retained for further evaluation, though, since other aerobic biological systems (like the existing system at the Hadnot Point STP) appear to be applicable to the majority of the constituents of concern at the site.

2.3.2.6 Physical/Chemical Treatment

Physical treatment involves a wide variety of separation techniques including screening, sedimentation, centrifugation, flotation, filtration, gravity separation, adsorption, evaporation, stripping, distillation, and reverse osmosis. Physical technologies are typically used whenever a waste containing liquids and solids must be treated because these technologies are generally cost-effective methods and the least complicated solutions to many waste management solutions (Wentz, 1989).

Chemical treatment involves the use of reactions to transform hazardous waste streams into less hazardous substances. Typical chemical treatment technologies include solubility, neutralization, precipitation, coagulation/flocculation, oxidation, reduction, ion exchange, and stabilization (Wentz, 1989).

Several types of physical/chemical treatment technologies have been identified for the HPIA Site. These technologies are described and screened below.

Air Stripping

Air stripping is a treatment process in which water and air are brought into contact with each other for the purpose of transferring volatile substances from solution in a liquid to solution in gas. Air stripping uses the natural tendency of dissolved substances to move from areas of high concentration to areas of low concentration. Such mass transfer is directly related to the concentration gradient from within the liquid to the gas, the coefficient of mass transfer from liquid to gas, and the area of interface between the liquid and the gas. Air stripping technology seeks to maximize all of these factors in order to strip volatile organic compounds as effectively as possible (Rich, 1987).

Air stripping has been most cost-effectively used for the treatment of low concentrations of volatiles or as a pretreatment step prior to activated carbon. The equipment is relatively simple, and the modular design of countercurrent packed towers makes the technology suited for hazardous waste site applications. In addition, it provides the most liquid interfacial area, high air-to-water volume ratios are possible, and they can be readily connected to vapor recovery equipment (Wagner, 1986). There are air pollution implications associated with air stripping. The gas stream generated during treatment may require collection and subsequent treatment.

Air stripping has been effective in removing ammonia, chlorinated solvents, monoaromatics, and other VOCs from aqueous streams, or in general, components with Henry's Law constants of greater than 0.003 (e.g., 1,1,1-trichloroethane, TCE, chlorobenzene, vinyl chloride, DCE). With respect to the contaminants of concern for the HPIA Site, this technology has effectively removed benzene, TCE, and DCE. The influent to an air stripper must be low in suspended solids. Air stripping is often followed by another process such as biological treatment or carbon adsorption (Wagner, 1986). With respect to HPIA, air stripping will be retained as a potential technology for further evaluation.

Steam Stripping

Steam stripping or steam distillation is a process in which steam is in direct contact with the distilling system in either a batch or continuous operation. Typical uses of steam stripping include removing trace quantities of volatile impurities from various aqueous materials. Stripping will remove volatile and semivolatile contaminants from an aqueous waste stream and make them part of the vapor from the treatment process. The overhead from a steam stripper will contain water and volatile components of the waste requiring a condenser for further separation (Wentz, 1989).

Typically, air stripping is more cost-effective for volatile compounds than steam stripping. Steam stripping is used where more difficult compounds are present, or where air discharge limits may be restrictive. With respect to the HPIA Site, steam stripping is applicable for removing benzene and TCE. Therefore, this technology will be evaluated further.

Carbon Adsorption

The process of adsorption onto activated carbon involves contacting a waste stream with carbon, usually by flow through a series of packed-bed reactors. Carbon adsorption is a physical process that binds organic molecules to the surface of the activated carbon particles. Adsorption depends on the strength of the molecular attraction between adsorbent and adsorbate, molecular weight, concentration, type and characteristics of adsorbent, electrokinetic charge, pH, and surface area. Once the micropore surfaces of the carbon are saturated with organics, the carbon is "spent" and must be either replaced or regenerated. If the spent carbon is shipped off site, it must follow required manifesting procedures and be disposed of properly. The time to reach breakthrough or exhaustion of the carbon is the most critical operating parameter (Rich, 1987).

Common carbon adsorption systems utilize activated carbon adsorbents in granular or powdered form. Due to operational constraints and difficulty associated with regeneration of powdered carbon, granular carbon is selected more often for continuous wastewater treatment operations. Granular activated carbon (GAC) is generally used in fixed-bed reactors in a down flow mode, operated in series or parallel (Rich, 1987).

The process is frequently used following biological treatment in order to reduce the organic and suspended solids load on the carbon columns. Air stripping may also be applied prior to carbon adsorption to remove a portion of the volatile contaminants. Pretreatment is required for oil and grease and suspended solids. Influent concentrations of oil and grease should be limited to 10 parts per million (ppm), and suspended solids should be less than 50 ppm. The final design of a carbon adsorption system is determined based on cost-effectiveness and operational parameters, including contact time required to establish a definite mass transfer zone and desired effluent concentrations. Normally, the final design is determined by pilot testing.

Activated carbon is well suited for removal of mixed organics from aqueous wastes. With respect to the contaminants of concern for the HPIA Site, this technology has been effective in removing benzene, TCE, DCE, and to a much lesser degree the inorganics. Carbon adsorption will be retained for further evaluation.

Reverse Osmosis

Osmosis is the spontaneous flow of solvent from a dilute solution through a semipermeable membrane to a more concentrated solution. Reverse osmosis is the application of sufficient pressure to the concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward the dilute phase. This allows the concentration of solute to be built up in a circulating system on one side of the membrane while relatively pure water is transported through the membrane (Wagner, 1986).

Reverse osmosis is used to reduce the concentrations of dissolved solids. This technology is very susceptible to fouling and plugging, and it has not been widely used for treatment of hazardous wastes. Reverse osmosis will not reliably treat waste with a high organic content, as the membrane may dissolve in the wastewater. Lower levels of organic compounds may also be detrimental to the system's reliability, as biological growth may form on a membrane fed an influent containing biodegradable organics (Wagner, 1986). Based on the constituents of concern at the HPIA Site, reverse osmosis will not be an applicable technology and therefore will be eliminated from further evaluation.

Ion Exchange

Ion exchange is the process of exchanging selected dissolved ionic contaminants in a wastewater with a set of substitute ions. The exchange occurs on a synthetic or natural resin containing the substitute ions and is reversible. Undesirable ions are removed from a wastewater by contacting the wastewater with the resin. Since the process is reversible, backwashing with regeneration solutions can remove the ions from the resin. Regeneration solutions can be either strong or weak acids or bases, depending on the application (USEPA, 1990).

Generally, ion exchange is used to remove selected dissolved metals, nitrate, and TDS. Organic compounds are not usually removed with this technology. For ion exchange to be applicable the wastewater must: (1) have low suspended solids, (2) have low total dissolved solids, and (3) not contain cyanide, ferrous iron, strong oxidants, oil and grease, or cadmium-cyanide compounds. Other treatment methods such as oxidation, precipitation, or reduction may be required to treat the residual backwash (USEPA, 1990). With respect to the constituents of concern at the HPIA Site, ion exchange may be applicable to some of the inorganics at the site. This technology will be retained for further evaluation.

Chemical Reduction

Chemical reduction involves the addition of a reducing agent (e.g., sulfite salts and base metals) to lower the oxidation of a substance in order to reduce toxicity or solubility or to transform it to a form which can be more easily handled. In the reaction, the compound supplying the oxygen (or chlorine or other negative ion) is called the oxidizer or oxidizing agent while the compound accepting the oxygen is called the reducing agent. Typical reducing agents include iron, aluminum, zinc and sodium compounds. The reaction can be enhanced by catalysis, electrolysis or irradiation. It is likely that other treatment processes may be used in conjunction with chemical reduction (USEPA, September 1987). Complex waste streams containing other potentially reducible compounds require a laboratory and pilot scale test to determine the appropriate chemical feed rates and reactor retention times (Wagner, 1986).

The equipment required for chemical reduction includes storage vessels for the reduction agents and waste, metering equipment, and contact vessels with agitators. The equipment and reagents for this technology are readily available.

Chemical reduction is typically used for reduction of hexavalent chromium, mercury, and lead (Rich, 1987). Applications of reduction of organics do not appear to be practicable (USEPA, 1990). With respect to the constituents of concern at the HPIA Site, chemical reduction may be effective for the removal of chromium and lead, therefore, it will be retained for further evaluation.

Chemical Oxidation

Chemical oxidation is a chemical reaction in which one or more electrons are transferred from the chemical being oxidized to an oxidizing agent. The process can be controlled to oxidize undesirable compounds through control of pH and choice of oxidizing agent. Chemical oxidation is not a selective process, and therefore bench-scale testing is typically required prior to design of a full-scale system (USEPA, 1990).

Oxidation can transform a variety of compounds (both inorganics and organics) into more stable, less toxic forms. Chemical oxidation has been used for the destruction of cyanide, the transformation of selected organics to biodegradable forms, or the detoxification of organics and inorganics. When used in conjunction with precipitation, inorganics are transformed to less toxic forms. Used alone or followed by biological degradation, organics can be permanently transformed to less toxic forms (USEPA, 1990).

Chemical oxidation may be applicable to many of the constituents of concern at the HPIA Site, and therefore it will be retained for further evaluation.

Neutralization

Neutralization is the interaction of an acid with a base or vice versa (pH adjustment) to yield a final pH of approximately 7.0. This technology is one of the common types of chemical treatment used by industrial wastewater treatment facilities. Neutralization is suitable for the treatment of water with high or low pH levels. Treated water may require additional treatment. In addition, pretreatment may be required for streams containing large amounts of suspended solid, and oils and greases. The major limitation of neutralization is that it is subject to the influence of temperature and the resulting heat effects common to most chemical reactions (USEPA, 1990).

With respect to the HPIA Site, neutralization may be an applicable technology and will be retained for further evaluation.

Precipitation

Precipitation is a process in which materials in solution are transferred into a solid phase for removal. Removal of heavy metals as hydroxides, carbonates or sulfides is the most common precipitation application in wastewater treatment. Generally, lime or sodium sulfide is added to the wastewater in a rapid mixing tank along with flocculating agents such as alum, ferric chloride, and ferric sulfate. The wastewater then flows to a flocculation chamber where additional mixing is conducted and retention time provided resulting in the agglomeration of precipitate particles (Rich, 1987). The insoluble precipitate is then removed for recovery of disposal using solids separation technologies such as sedimentation or filtration. The precipitation process can be preceded by chemical oxidation or chemical reduction to change the valence of certain metal ions to a form that can be precipitated (USEPA, 1990).

The precipitation process is simple and reliable. Typical metals removed by this process are arsenic, copper, lead, nickel, cadmium, iron, zinc, manganese, and chromium. Pre- and/or post-treatment is necessary to remove other contaminants such as organics, suspended solids, oil and grease, or residual metals. The level of metal removal partially depends on how well the waste characteristics were evaluated with bench- and pilot-scale tests (USEPA, 1990). With respect to the constituents of concern at the HPIA Site, precipitation has been demonstrated to remove the inorganic contaminants. This technology will be retained for further evaluation.

Oil/Water Separator

Gravity separation is a physical technology primarily used to treat two-phased aqueous wastes such as oil in water or fuel oil in a fuel contaminated aquifer. For a separator to be efficient, the nonaqueous phase should have a significantly different specific gravity than water and should be present as a nonemulsified substance. Emulsion between water is common, and an emulsion breaking chemical may have to be added to this type of waste prior to treatment. (Rich,1987)

Oil/water gravity separation involves retaining wastewater in a holding tank and allowing oil and other materials with a specific gravity less than or greater than water to float to the surface or to sink, respectively. Separated oil is removed be surface skimming and bottom collection systems in the tank. (GRI,1990)

Gravity separators are generally designed small and simple to reduce costs. Typical design configurations include horizontal cylindrical decanters, vertical cylindrical decanters, and cone bottomed settlers. Baffles are frequently installed to provide additional surface area which promotes oil droplet coalescence. (Wagner,1986)

Gravity separation is a reliable method for the removal of oil and grease, suspended organic material,and suspended PAHs due to the simplicity of the process. This type of treatment is not directly applicable for the removal of particulate metals or VOCs. Due to the open tank construction, VOC air emission losses are probable. Oil/sludge disposal may be regulated and must satisfy solid and/or hazardous waste requirements (GRI,1990).

A gravity separator may be applicable for the HPIA Site since one of the contaminants of concern is oil & grease. Therefore, this technology will be retained for further evaluation.

Filtration

Filtration is a physical process used to remove suspended solids and biological fluc from wastewater. The separation is accomplished by passing water through a physically restrictive medium, resulting in the entrapment of suspended particulate matter. The media used for filtration includes sand, coal, garnet, and diatomaceous earth. Filtration is typically preceded by chemical precipitation and neutralization. The process can be followed by carbon adsorption or ion exchange. Filtration will not remove contaminants other than suspended solids. Pretreatment to remove oil and grease is required. The performance of a filtration system should be determined from pilot studies (USEPA, 1990). With respect to the HPIA Site, filtration will be retained for further evaluation.

Flocculation

Flocculation is used to describe the process by which small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger, more settleable particles. The mechanisms by which flocculation occurs involve surface chemistry and particle change phenomena. Flocculation involves three basic steps: (1) addition of flocculating agent to the waste stream, (2) rapid mixing to disperse the flocculating agent, and (3) slow and gently mixing to allow for contact between small particles. Typical chemicals used to cause flocculation include alum, lime, iron salts, and polyelectrolytes (Wagner, 1986).

Flocculation is applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to sedimentation or other types of treatment. Flocculation is typically preceded by chemical precipitation (Wagner,1986). With respect to the HPIA Site, flocculation will be retained for further evaluation.

Sedimentation

Sedimentation is a process used to remove suspended solids from aqueous waste streams by gravity separation. A clarifier system, equipped with solids collection and skimming devices, is typically used for sedimentation. Sedimentation is frequently preceded by precipitation or flocculation (Wagner, 1986). With respect to the HPIA Site, sedimentation will be retained for further evaluation in conjunction with precipitation.

2.3.2.7 Thermal Treatment

Treatment via thermal destruction uses high temperature oxidation under controlled conditions to degrade a substance into other products (Wagner, 1986). Several types of thermal treatment technologies have been identified for the HPIA Site. These technologies are described and screened below.

Incineration-Liquid Injection

Liquid injection systems typically consist of a double refractory-lined combustion chamber and a series of atomizing nozzles. The primary chamber is usually a burner where combustible liquid and gaseous wastes are introduced. Noncombustible liquid and gaseous waste are introduced downstream of the burner in the secondary chamber (Wagner, 1986).

Liquid injection incinerators can destroy most pumpable waste or gas. Most organic-contaminated wastes can be treated by incineration. Unlikely candidates for destruction include heavy metals and other wastes high in inorganics. With respect to the HPIA Site, this technology will be retained for further evaluation.

Incineration-Rotary Kiln

A rotary kiln is a cylindrical, refractory-lined shell fueled by natural gas, oil, or pulverized coal. Waste is fed into the higher end of the rotating, tilted cylinder. As the cylinder rotates, the waste proceeds toward the other end of the cylinder where it exits the system. Most rotary kilns are equipped with wet scrubber emission controls (Wagner, 1986).

Rotary kiln incinerators can process a large variety of waste (solids and liquids) with minimal preprocessing. Solids and liquids can be incinerated independently or in combination (Wagner, 1986). With respect to the constituents of concern at the HPIA Site, rotary kiln incineration will be retained for further evaluation.

Incineration-Fluidized Bed

A fluidized bed incinerator consists of a cylindrical vertical refractory-lined vessel containing a bed of inert granular material, usually sand on a perforated metal plate. Combustion air is introduced at the bottom of the incinerator and rises vertically fluidizing the bed and maintaining turbulent mixing of bed particles. Waste material is injected into the bed and combustion occurs within the bubbling bed. Heat is transferred from the bed into the injected wastes (Wagner, 1986).

The most typical wastes treated in fluidized bed incinerators include slurries and sludges (Wagner, 1986), therefore it will not be retained for further evaluation for the HPIA Site.

Incineration-Multiple Hearth

A multiple hearth incinerator consists of a refractory-lined shell with a rotating central shaft. Rabble arms with teeth are used to move waste down a series of solid flat hearths as it is burned. Due to the large number of moving parts, mechanical reliability can be a problem (Wagner, 1986).

Multiple hearths can be used for the destruction of all forms of combustible waste materials including sludges, tars, solids, liquids, and gases. It is best suited for sludges (Wagner, 1986). With respect to the HPIA Site, this technology will not be retained for further evaluation since it is more suitable to sludges and not liquids.

Molten Salt

Molten salt incineration is an emerging technology. A molten salt incinerator can be used for the destruction of hazardous liquids and solids. Wastes undergo catalytic destruction when they contact hot molten salt. Hot gases rise through the molten salt bath, pass through a secondary reaction zone, and through an off-gas clean-up system before discharging to the atmosphere (Wagner, 1986).

Molten salt incinerators can handle liquid, sludges, and shredded solid wastes. It has been demonstrated to be effective for chlorinated hydrocarbons, chlorinated solvents and malathion. It appears to be sensitive to materials containing high ash content or high chlorine content (Wagner, 1986). With respect to the HPIA Site, this technology will be retained for further evaluation.

Plasma Arc Torch

A plasma arc torch is an emerging technology used to destroy wastes by pyrolyzing them into combustible gases in contact with a gas which has been energized to its plasma state by an electrical discharge. Wastes are atomized, ionized and destroyed in contact with the plasma (Wagner, 1986).

Plasma arc torch incineration is applicable to pumpable organic wastes and finely divided, fluidizable sludges. The application of this incineration is hindered by a lack of operation experience (USEPA, September 1987). Therefore, plasma arc torch incineration will not be evaluated any further.

Pyrolysis

Pyrolysis is the thermal conversion of organic material into solid, liquid and gaseous components. Pyrolysis takes place in an oxygen-deficient atmosphere. VOCs generated in the process are burned in a second stage fume incinerator at higher temperatures. The two\stage process minimizes the volatilization of inorganic components and ensures that inorganics form an insoluble solid residue. Pyrolysis can not handle wastes containing nitrogen, sulfur, or sodium contents (Wagner, 1986).

Pyrolysis can be used to treat viscous liquids, sludges, solids, high-ash material, salts and metals or halogenated waste that are not conducive to conventional incineration (USEPA, September 1987). Since the constituents of concern appear to be conducive to conventional incineration, this technology will not be evaluated any further.

Wet Air Oxidation

Wet air oxidation involves aqueous phase oxidation of dissolved or suspended organic substances at elevated temperatures and pressures. Waste is pumped into the system by a high pressure pump and mixed with air from an air compressor. The mixture passes through a heat exchanger, and then into the reactor where oxygen in the air reacts with organic matter in the waste. The oxidation is accompanied by a temperature rise. The gas and liquid phases are separated after the reactor, and the liquid passes through the heat exchanger, heating the incoming material (Wagner, 1986).

Waste streams for which wet air oxidation is particularly applicable include concentrated streams containing pesticides, herbicides or other complex organics which are not readily biodegradable (Wagner, 1986). It is not recommended for aromatic halogenated organics, inorganics or for treating large volumes of waste (USEPA, September 1987). Therefore, this technology will not be evaluated further.

2.3.2.8 Off-Site Treatment

Publicly Owned Treatment Works

Off-site discharge of extracted groundwater to a publicly owned treatment works (POTW) for treatment may be a viable method of remediation. The effectiveness of this technology depends on if the water to be treated is suitable to the particular wastewater treatment system (i.e., the contaminated water does not disrupt the POTW biological system) and if the chemical contaminants can be reduced to an acceptable level at the POTW. This treatment method is practical when the treatment facility is located within a range allowing contaminated water to be transported from the area of contamination to the facility economically. With respect to the HPIA Site, the extracted groundwater could be discharged to the City of Jacksonville POTW. Pretreatment of the groundwater may be required. This technology will be retained for further evaluation.

RCRA Facility

This technology consists of transporting the extracted groundwater to a RCRA-permitted facility for treatment and ultimate disposal. With respect to the HPIA Site, this is an applicable technology and will be retained for further evaluation.

Sewage Treatment Plant

This technology is similar to the POTW treatment option. Discharge of extracted and/or treated groundwater to a nearby sewage treatment plant such as the Hadnot Point STP for treatment may be a viable method of remediation. The effectiveness of this technology depends on if the water to be treated is suitable to the particular wastewater treatment system (i.e., the contaminated water does not disrupt the STP biological system) and if the chemical contaminants can be reduced to an acceptable level at the STP. With respect to the HPIA Site, the existing NPDES permit for the Hadnot Point STP would require a modification or a new permit will have to be obtained for this activity. The permit would specify the effluent requirements that must be met during the treatment operation. This technology will be retained for further evaluation.

2.3.2.9 In-Situ Treatment

Biodegradation

In-situ biological degradation is the enhancement of bacterial biodegradation of organic constituents within an aquifer. The implementation of this type of technology typically involves the installation of a system of shallow pumping and injection wells. Bacteria and nutrients required for bacterial growth and oxygen supply for aerobic degradation are introduced into the aquifer via injection wells. Downgradient recovery wells withdraw groundwater containing biodegraded constituents. The recovered groundwater is then fortified with additional bacteria, nutrients, and oxygen, and then reinjected into the aquifer.

The effectiveness of this technology is constrained by the biodegradability of the contaminants of concern, environmental factors which affect microbial activity, and site hydrogeology. Generally, aerobic degradation techniques are suitable for petroleum hydrocarbons, PAHs, aromatics, halogenated aromatics, phenols, biphenyls, and most pesticides. Anaerobic degradation under very reducing conditions is more feasible for halogenated lower molecular weight hydrocarbons, such as PCE and TCE, and saturated alkyl halides like 1,1,1-trichloroethane and trihalomethane. With respect to the HPIA Site, this technology appears to be applicable to many of the constituents of concern. But the physical characteristics of the aquifer are not potentially suitable for reinjection. Therefore, in-situ biodegradation will not be retained for further evaluation.

2.3.2.10 Discharge of Treated Water

Extracted groundwater will require some form of disposal. Five discharge options are considered for the HPIA Site. These options are discussed and screened below.

Surface Water

Recovered groundwater may be directly discharged to a nearby (on-site) surface water body. This technology by itself is effective for groundwater with dilute contaminant concentrations.

This type of discharge must meet the requirements specified by a National Pollutant Discharge Elimination System (NPDES) permit. With respect to the HPIA Site, Cogdels Creek is the closest surface water body. Due to the limited flow capacity of this creek (the creek is very flat and shallow), this technology will not be evaluated further.

Publicly Owned Treatment Works

Off-site discharge of extracted and/or treated groundwater to a POTW may be a viable method of remediation. The effectiveness of this technology depends on if the water to be treated is suitable to the particular wastewater treatment system (i.e., the contaminated water does not disrupt the POTW biological system) and if the chemical contaminants can be reduced to an acceptable level at the POTW. This discharge option is practical when the treatment facility is located within a range allowing contaminated water to be transported from the area of contamination to the facility economically. With respect to the HPIA Site, the extracted groundwater could be discharged to the City of Jacksonville POTW. Pretreatment of the groundwater may be required. This technology will be retained for further evaluation.

Pipeline to River

Another discharge option is to pipe extracted groundwater to a river. With respect to the HPIA Site, the groundwater could be piped to the New River. This type of discharge must meet the requirements specified by a NPDES permit. With respect to the HPIA Site, treatment of the extracted groundwater may be required prior to discharge. This technology will be retained for further evaluation.

Reinjection

Following extraction and/or treatment, recovered groundwater may be discharged to one or a series of reinjection wells. A reinjection system is a potential application for discharging extracted/treated water. The physical characteristics of the aquifer at Hadnot Point may not be suitable to reinjection. In addition, injection of hazardous waste via injection wells is prohibited under North Carolina General Statues, Chapter 143, Section 143-214.2(b). Therefore, the reinjection technology will not be retained for further evaluation.

Sewage Treatment Plant

This technology is similar to the POTW discharge option. Discharge of extracted and/or treated groundwater to a nearby sewage treatment plant such as the Hadnot Point STP may be a viable method of remediation. The Hadnot Point STP is currently being used as a discharge point for treated water from the Fuel Farm (Site 22) recovery system. The effectiveness of this technology depends on if the water to be treated is suitable to the particular wastewater treatment system (i.e., the contaminated water does not disrupt the STP biological system) and if the chemical contaminants can be reduced to an acceptable level at the STP. With respect to the HPIA Site, the existing NPDES permit for the Hadnot Point STP would require a modification or a new permit will have to be obtained for this activity. The permit would specify the effluent requirements that must be met during the treatment operation. This technology will be retained for further evaluation.

2.4 Summary of Preliminary Remedial Action Technology Screening

The results of the preliminary technology screening are summarized on Table 2-3. The screening eliminated several remedial action technologies since they were determined to be inappropriate for the site-specific characteristics of the HPIA Site. The technologies that were eliminated included:

- Access restrictions-fencing
- Capping
- Vertical barriers
- Horizontal barriers
- Extraction/injection well combination
- Subsurface drains
- Biological treatment-rotating biological contactor
- Biological treatment-anaerobic treatment
- Physical/chemical treatment-reverse osmosis
- Thermal destruction-fluidized bed
- Thermal destruction-multiple hearth
- Thermal destruction-plasma arc torch
- Thermal destruction-pyrolysis
- Thermal destruction-wet air oxidation
- In-situ treatment-biodegradation

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
No Action	Not Applicable	Not Applicable	No action	Required for consideration by NCP
Institutional Controls	Monitoring	Groundwater Monitoring	On-going monitoring of wells	Potentially applicable
	Ordinances	Aquifer-Use Restrictions	Restricted use of drinking water supply wells/aquifers	Potentially applicable
	Access Restrictions	Deed Restrictions	Deeds for property in the area of influence would include restrictions on installation of wells.	Potentially applicable
		Fencing	Install fencing affected area to limit access.	Not feasible due to the physical development at the site
Containment	Capping	Single Layer or Multilayer Caps	One or multiple layers of material used to seal off contamination from the aboveground environment.	Not feasible due to the physical development at the site
	Vertical Barrier	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes	Not feasible due to the physical development at the site and the heterogeneity of fill material
		Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry	Not feasible due to the physical development at the site and due to site geology.
		Sheet Piling	Sheets of interlocking walls installed in the ground via drop or vibrating hammer.	Not feasible due to the physical development at the site and due to site geology.
		Rock Grouting	Sealing fractures, fissures, solution cavities, or other voids in rocks with grout.	Not feasible due to the physical development at the site
	Horizontal Barrier	Grout Injection	Pressure injection of grout at depth through closely spaced drilled holes	Not feasible due to the physical development at the site and due to unproveness of the technology.
		Block Displacement	In conjunction with vertical barriers, injection of slurry in notched injection holes	Not feasible due to the physical development at the site and due to unproveness of the technology.

(tab2-3)

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Collection/Discharge	Extraction	Extraction Wells	Series of wells to extract contaminated groundwater	Potentially applicable
		Extraction/Injection Wells	Injection wells inject uncontaminated water to increase flow to extraction wells	Potentially applicable
	Subsurface Drains	Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated water	Not feasible due to the number of physical barriers in the areas that that would require excavation
	On-site Discharge	Surface Water	Extracted water discharged to stream located on the site	Potentially applicable
	Off-site Discharge	POTW	Extracted water discharged to Jacksonville POTW	Potentially applicable
		Pipeline to River	Extracted water discharged to river off site	Potentially applicable
		Reinjection	Extracted water discharged to one or more reinjection wells.	Potentially applicable
		Sewage Treatment Plant	Extracted water discharged to Hadnot Point Sewage Treatment Plant	Potentially applicable

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Collection/Treatment/ Discharge	Extraction	Extraction Wells	Series of wells to extract contaminated groundwater	Potentially applicable
		Extraction/Injection Wells	Injection wells inject uncontaminated water to increase flow to extraction wells	Potentially applicable
	Subsurface Drains	Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated water	Not feasible due to the number of physical barriers in the areas that would require excavation
	Biological Treatment	Aerobic - Aerated Lagoon	Degradation of organics using microorganisms in in an aerobic environment	Potentially applicable - will be retained for off-site treatment only (since the Hadnot Point STP has a lagoon)
		Aerobic - Activated Sludge	Degradation of organics using microorganisms in in an aerobic environment	Potentially applicable
		Aerobic - Powdered Activated Carbon Treatment	Addition of activated carbon to a biological treatment system such as activated sludge	Potentially applicable
		Aerobic - Trickling Filter	Degradation of organics using microorganisms in in an aerobic environment	Potentially applicable - will be retained for off-site treatment only (since the Hadnot Point STP two trickling filters.)
		Aerobic - Rotating Biological Contactor	Degradation of organics using microorganisms in in an aerobic environment	Not applicable to most of the constituents of concern
		Anaerobic Biological Treatment	Degradation of organics using microorganisms in in an anaerobic environment	Not applicable to most of the constituents of concern

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Collection/Treatment/ Discharge (Continued)	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air	Potentially applicable
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air	Potentially applicable
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column	Potentially applicable
		Reverse Osmosis	Using high pressure to force water through a membrane leaving contaminants behind	Not applicable for most of the constituents of concern
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water	Potentially applicable
		Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility	Potentially applicable
		Chemical Oxidation	Addition of a oxidizing agent to raise the oxidation state of a substance	Potentially applicable
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH	Potentially applicable
		Precipitation	Materials in solution are transferred into a solid phase for removal.	Potentially applicable
		Oil/Water Separation	Separation of two-phased aqueous wastes with different densities via gravity	Potentially applicable
		Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium	Potentially applicable
		Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents	Potentially applicable
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation	Potentially applicable

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Collection/Treatment/ Discharge (Continued)	Thermal Destruction	Incineration - Liquid Injection	Combustion in a single or double refractory-lined combustion chamber and a seriers of atomizing nozzles	Potentially applicable
		Incineration-Rotary Kiln	Combustion in a horizontally rotating cylinder designed for uniform heat transfer	Potentially applicable
		Incineration-Fluidized Bed	Waste injected into hot agitated bed of sand where combustion occurs	More suitable for slurries and sludges
		Incineration-Multiple Hearth	Combustion in a refractory-lined steel shell, a rotaing central shaft, and a series of solid flat hearths	More suitable for sludges
		Molten Salt	Advanced incineration; waste contacts hot molten salt to undergo catalytic destruction	Potentially applicable
		Plasma Arc Torch	Advance incineration; pyrolyzing wastes into combustible gases in contact with a gas which has been energized to its plasma state by an electrical discharge	Lack of operational experience
		Pyrolysis	Advanced incineration; thermal conversion of organic material into solid, liquid, and gaseous components; takes place in an oxygen-deficient atmosphere	Typically used for compounds not conducive to conventional incineration; HPIA compounds are suitable to other incineration methods
		Wet Air Oxidation	Advance incineration; aqueous phase oxidation of dissolved or suspended organic substances at elevated temperatures and pressures	Not recommended for treating large volumes of water

Table 2-3 SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Collection/Treatment/ Discharge (Continued)	Off-site Treatment	POTW	Extracted groundwater discharged to Jacksonville POTW for treatment	Potentially applicable
		RCRA Facility	Extracted groundwater discharged to liscensed RCRA facility for treatment and/or disposal	Potentially applicable
		Sewage Treatment Plant	Extracted groundwater discharged to Hadnot Point STP for treatment	Potentially applicable
	In Situ Treatment	Biodegradation	System of injection and extraction wells introduce bacteria and nutrients to degrade contamination	Potentially applicable
	On-site Discharge	Surface Water	Extracted water discharged to stream on the site	Potentially applicable
	Off-site Discharge	POTW	Extracted water discharged to local POTW	Potentially applicable
		Pipeline to River	Extracted water discharged to river off site	Potentially applicable
		Reinjection	Extracted water discharged to one or more reinjection wells	Potentially applicable
		Sewage Treatment Plant	Extracted water discharged to local Sewage Treatment Plant	Potentially applicable

(tab2-3)

- On-site discharge-surface water
- Off-site discharge-reinjection

The remaining technologies that passed the preliminary screening will be considered further in this FS process.

2.5 Process Option Evaluation

This section of the report contains the results of the evaluation conducted on the individual process options that passed the preliminary technology screening. The objective of this 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 criteria used for this evaluation was effectiveness, implementability, and cost.

The results of this evaluation are presented on Table 2-4. The evaluation eliminated several technology/process options. The eliminated technologies include:

- All of the technologies associated with the collection/discharge general response action. Based on the expected organic and inorganic concentrations in the groundwater, some method of treatment would be required.

- Activated sludge - since a biological system (trickling filter) already exists at the Hadnot Point STP.

- Steam stripping - since air stripping is capable of removing the HPIA organic constituents of concern and is more economical than steam stripping.

- Ion exchange - since other more economical methods are available to remove inorganics found at the site.

TABLE 2-4: SUMMARY OF PROCESS OPTION EVALUATION

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	EVALUATION RESULTS
No Action	Not Applicable	Not Applicable	Does not achieve remedial action objectives.	Not an acceptable alternative.	None	Retain
Institutional Controls	Monitoring	Groundwater Monitoring	Does not achieve remedial action objectives by itself, but is useful for documenting conditions.	Alone not an acceptable alternative. Easily implemented since many wells already in place and have previously been sampled.	Low capital, low O&M	Retain
	Ordinances	Aquifer-Use Restrictions	Effectiveness depends on continued future implementation. Effective in preventing use of contaminated groundwater. Does not reduce contamination.	Easily implemented. Legal requirements and authority.	Negligible cost	Retain
		Access Restrictions	Effectiveness depents on continued future implementation. Effective in preventing use of contaminated groundwater. Does not reduce contamination.	Easily implemented. Legal requirements and authority.	Negligible cost	Retain
Collection/Discharge	Extraction	Extraction Wells	Effective for collecting and/or containing a contaminated groundwater plume.	Easily implemented -- other wells previously installed at the site.	Moderate capital, low O&M	Eliminate
		Extraction/Injection Wells	Effective for collecting and/or containing a contaminated groundwater plume.	State of North Carolina does not permit reinjection.	Moderate capital, low O&M	Eliminate
	On-site Discharge	Surface Water	Effective and reliable.	Discharge to Cogdell's Creek not permitted due to water quality issues	Low capital, very low O&M	Eliminate
	Off-site Discharge	POTW	Effective and reliable discharge method. May not eliminate contamination.	Discharge permits required.	Low capital, moderate O&M	Eliminate
		Pipeline to River	Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	Moderate capital, low O&M	Eliminate
		Reinjection	Effectiveness dependent on the site geology. Does not eliminate contamination.	Permits required. State of North Carolina does not permit reinjection.	Moderate capital, moderate O&M	Eliminate
		Sewage Treatment Plant	Effective and reliable discharge method. May not eliminate contamination.	Discharge permit may need modified.	Low capital, low O&M	Eliminate

TABLE 2-4: SUMMARY OF PROCESS OPTION EVALUATION (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	EVALUATION RESULTS
Collection/Treatment/ Discharge	Extraction	Extraction Wells	Effective for collecting and/or containing a contaminated groundwater plume.	Easily implemented -- other wells previously installed at the site.	Moderate capital, low O&M	Retain
		Extraction/Injection Wells	Effective for collecting and/or containing a contaminated groundwater plume.	Easily implemented -- but North Carolina does not permit injection.	Moderate capital, low O&M	Eliminate
Collection/Treatment/ Discharge (Continued)	Physical/Chemical Treatment	Activated Sludge	Effective for a wide variety of organic constituents. Effectiveness dependent on organic loading, and sludge retention time.	Most widely used biological wastewater treatment system.	Moderate capital, moderate O&M	Eliminate
		Air Stripping	Effectiveness dependent on volatility and concentration of compounds. Off-gas and/or tower scale treatment may be required. Pretreatment may be required for metals and oils and grease. Feasible for large volumes of VOC-contaminated (>100 ppm) groundwater. Lower efficiency in cold weather.	Readily implementable. Standard design and skid-mounted units available from many vendors. May require air emissions permit.	Moderate capital, low O&M	Retain
		Steam Stripping	Effectiveness dependent on volatility and concentration of compounds. Off-gas and/or tower scale treatment may be required. Pretreatment may be required for metals and oils and grease. Feasible for large volumes of VOC-contaminated (>100 ppm) groundwater.	Readily implementable. May require air emissions permit.	Moderate capital, moderate to high O&M	Eliminate
		Carbon Adsorption	Applicable to a wide variety of organics and inorganics. It is a permanent remedy and is insensitive to toxics. Spent carbon must be either incinerated, landfilled, or regenerated.	System is compact. Prefabricated packages readily available. Treatability information typically available. Full-scale designs require frequent monitoring to determine breakthrough.	Moderate capital, moderate to high O&M	Retain

(tab2-4)

TABLE 2-4: SUMMARY OF PROCESS OPTION EVALUATION (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	EVALUATION RESULTS
Collection/Treatment/ Discharge (Continued)		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. Residuals include waste solutions and spent resins. Pretreatment for oil & 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, moderate to high O&M	Eliminate
		Chemical Reduction	Well studied and understood reaction. It is not a selective process. Limited to a few selected metals (chromium, mercury, lead). Typically followed by precipitation. If complex wastewater - oxidized chemicals may be reduced to more toxic forms.	Simple and readily available equipment. The continuous process configuration is easily automated. Easily implemented.	Low to moderate capital, moderate to high O&M	Retain
		Chemical Oxidation	Reliable and proven on industrial wastewaters for metals (manganese, iron) treatment. Can be used alone or in conjuction with precipitation. A sludge or off-gas may be generated.	Well-demonstrated at hazardous waste sites in pilot- and full-scale. Readily available, conventional equipment required. Bench testing normally required.	Low to moderate capital, moderate to high O&M	Retain
		Neutralization	Common and effective treatment. Effectiveness dependent on the pH of the influent stream and the reaction time. Off-gas treatment and/or solids handling may be required.	Well-demonstrated. Readily available equipment. Easily implemented.	Moderate capital, moderate to high O&M	Retain
		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. Requires bench- or pilot-scale tests.	Low capital, moderate O&M	Retain
		Oil/Water Separation	Reliable and well demonstrated. Can successfully achieve and maintain high levels of protection to public health and the environment. Oils and sludge must be handled/disposed.	Readily available and easy to install. Available in wide variety of packaged units. Low maintenance required.	Low capital, low O&M	Retain

(tab2-4)

TABLE 2-4: SUMMARY OF PROCESS OPTION EVALUATION (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	EVALUATION RESULTS
Collection/Treatment/ Discharge (Continued)		Filtration	Conventional, proven method of removing suspended solids from wastewater. Does not remove other contaminants. Pretreatment for oil & grease required. Generates a sludge which requires proper handling.	Equipment is relatively simple to install and no chemicals are required. Pilot study is required. Package units available.	Low capital, low O&M	Retain
		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	Retain
		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 retention time. Effluent streams include the effluent water, scum, and settled solids.	Sedimentation tanks demonstrated and proven successful at hazardous waste sites. Feasible for large volumes of water to be treated.	Moderate capital, moderate O&M	Retain
	Thermal Destruction	Incineration - Liquid Injection	Applicable for pumpable organic wastes. Highly sensitive to waste composition and flow changes. No applicable to heavy metals.	Conventional and well demonstrated. No moving parts and require the least maintenance of all incinerators. Requires a supplemental fuel. May require emission control system.	High capital, moderate to high O&M	Retain
		Incineration-Rotary Kiln	Capable of burning waste in any physical form. Can accept waste feed without any preparation. Susceptible to thermal shock. Low thermal efficiency. Generates exhaust gases and ash residue.	Commercially available and widely used. Requires air emission controls and extensive maintenance. Requires additional air due to leakage.	High capital, moderate to high O&M	Eliminate
		Molten Salt	Applicable for the destruction of liquids and solids. Appears to be sensitive to materials containing high ash content or high chlorine content. Molten salt produced may be corrosive.	Emerging technology. Developmental, pilot-scale units available.	High capital, moderate to high O&M	Eliminate

TABLE 2-4: SUMMARY OF PROCESS OPTION EVALUATION (Continued)

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	EVALUATION RESULTS
Collection/Treatment/ Discharge (Continued)	Off-site Treatment	POTW	Effectiveness and reliability require pilot test to determine.	Readily implementable. Permit required.	Low capital, moderate O&M	Eliminate
		RCRA Facility	Effective and reliable treatment; transportation required.	Dependent on availability of and distance to nearest RCRA facility.	Low capital, high transportation costs.	Retain
		Sewage Treatment Plant (1)	Effectiveness and reliability require pilot test to determine.	Really implementable. Modifications to permits may be required.	Low capital, low O&M	Retain
	In Situ Treatment	Biodegradation	Aerobic techniques most suitable for petroleum hydrocarbons, aromatics, halogenated aromatics, phenols, and pesticides. Anaerobic techniques appear to be suitable for halogenated lower molecular weight hydrocarbons (TCE, PCE, 1,1,1-TCA). Dependent on site geology and hydrogeology.	Aerobic methods have been demonstrated. Could take longer than conventional pump and treat approach. Treatability tests required. Anaerobic methods not as promising as aerobic -- the logistics or fendering a site anaerobic have not been developed.	Moderate to high capital, moderate O&M	Retain
	On-site Discharge	Surface Water	Effective and reliable.	Not permitted to use Cogdell's Creek due to water quality issues.	Low capital, very low O&M	Eliminate
	Off-site Discharge	POTW	Effective and reliable discharge method.	Discharge permits required.	Low capital, moderate O&M	Eliminate
		Pipeline to River	Effective and reliable discharge method.	Discharge permits required.	Moderate capital, low O&M	Retain
		Reinjection	Effectiveness dependent on the site geology.	Permits required. State of North Carolina does not permit reinjection.	Moderate capital, moderate O&M	Eliminate
		Sewage Treatment Plant	Effective and reliable discharge method.	Discharge permit may need modified.	Low capital, low O&M	Retain

(1) This technology\process options includes biological treatment via aerated lagoon and trickling filter at the Hadnot Point STP.

(tab2-4)

- Rotary kiln incinerator - since liquid injection incinerator appears to be more applicable to liquids.

- Molten salt thermal destruction - since it is an emerging technology and liquid injection incineration appears to be very applicable to the constituents found at the site.

- Off-site treatment at the Jacksonville POTW - since the Hadnot Point STP exists and would be more economical.

- Off-site discharge to the Jacksonville POTW - since the Hadnot Point STP exists and would be more economical.

Please note that the elimination of a process option does not mean that the technology can never be reconsidered for the site. As stated above, the purpose of this part of the FS process is to simplify the development and evaluation of potential alternatives.

Table 2-5 identifies the final set of technologies/process options to be used to develop potential remedial alternatives.

TABLE 2-5

FINAL SET OF POTENTIAL REMEDIAL ACTION TECHNOLOGIES

General Response Action	Remedial Technology	Process Option
No Action	None	Not Applicable
Institutional Controls	Monitoring	Groundwater Monitoring
	Ordnances	Aquifer-Use Restrictions
	Access Restrictions	Deed Restrictions
Collection/Treatment/ Discharge	Extraction	Extraction Wells
	Biological Treatment	Aerobic - Aerated Lagoon(1)
		Aerobic - Trickling Filter(1)
	Physical/Chemical Treatment	Air Stripping
		Carbon Adsorption
		Chemical Reduction
		Chemical Oxidation
		Neutralization
		Precipitation
		Oil/Water Separating
		Filtration
		Flocculation
		Sedimentation
	Thermal Destruction	Incineration - Liquid Injection
	Off-Site Treatment	RCRA Facility
		Sewage Treatment Plant
	Off-Site Discharge	Pipeline to River
		Sewage Treatment Plant

(1) This technology/process option is being considered for off-site treatment at the Hadnot Point STP.

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, general response actions and the process options chosen to represent the various technology types applicable for the shallow aquifer will be combined to form alternatives for the site. Following development, each alternative will be evaluated against the short-term and long-term aspects of three criteria (effectiveness, implementability, and cost). The results of the evaluation are included in this section. The alternatives with the most favorable composite evaluation of all criteria factors will be retained for further consideration during the detailed evaluation (Section 4.0).

3.1 Development of Alternatives

The general response actions and process options chosen to represent the various applicable technologies identified on Table 2-5 have been combined into seven IRA alternatives potentially applicable for the shallow groundwater aquifer at HPIA. The set of alternatives are shown on Table 3-1. Please note that all of the process options that passed the screening evaluation presented in Section 2.5 are represented by the options listed on Table 3-1.

The first alternative is the no action alternative. The second alternative is the no action alternative with institutional controls (i.e., groundwater monitoring, aquifer-use restrictions, and well installation restrictions. The third alternative includes groundwater collection, pretreatment, and final treatment at the Hadnot Point STP. The next two alternatives are similar to each other with respect to general response actions (i.e., groundwater collection, pretreatment, treatment, and discharge). In these two alternatives, groundwater is collected, pretreated, and discharged in the same manner. The main treatment method is the difference between these alternatives. The sixth alternative includes on-site thermal treatment of the extracted groundwaters. The seventh alternative is treatment of the extracted groundwater at a RCRA-approved facility. No pretreatment is included with this alternative. All of the alternatives, except for the No Action Alternative, include the institutional controls of a long-term groundwater monitoring program, restrictions on the use of the shallow aquifer, and restrictions on the installation of new water wells. A description of each of the potential alternatives is included below.

TABLE 3-1

POTENTIAL SET OF REMEDIAL ACTION ALTERNATIVES

General Response Action			1	2	3	4	5	6	7
Technology Type	Process Options	Area or Volume	No Action	No Action with Institutional Controls	Biological Treatment STP	Physical/ Chemical Treatment (Air Stripping)	Physical/ Chemical Treatment (Carbon Adsorption)	Thermal Treatment	RCRA Facility
Monitoring	Groundwater Monitoring	20 Existing Monitoring Wells		●	●	●	●	●	●
Ordinances	Aquifer-Use Restrictions	All Supply Wells in or near Affected Area		●	●	●	●	●	●
Access Restrictions	Deed Restrictions	Affected Area		●	●	●	●	●	●
Groundwater Collection	Extraction Wells	All Affected Groundwater			●	●	●	●	●
Pretreatment for Oil and Grease	Oil/Water Separator	All Extracted Groundwater			●	●	●	●	
Pretreatment for Inorganics	Precipitation, Chemical Reduction, Sedimentation	All Extracted Groundwater			●	●	●	●	
Physical/ Chemical Treatment	Air Stripping	All Pretreated Groundwater				●			
	Carbon Adsorption	All Pretreated Groundwater					●		
Thermal Treatment	Liquid Injection	All Pretreated Groundwater						●	
Off-Site Treatment	Sewage Treatment Plant (Biological Treatment)(1)	All Pretreated Groundwater			●				
	RCRA Facility	All Extracted Groundwater							●
Off-Site Discharge	Sewage Treatment Plant	Treated Groundwater				●	●		

(1) Biological treatment at the STP consists of an aerated lagoon and trickling filters.

3.1.1 Alternative 1: No Action

Under the No Action Alternative, the groundwater in the shallow aquifer will remain as is. No remedial actions will be implemented. The no action alternative is required by the NCP to provide a baseline for comparison with other groundwater alternatives. Under this alternative, the contaminants identified in the shallow aquifer will remain, which will result in the potential for the further migration of the contaminated plumes. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

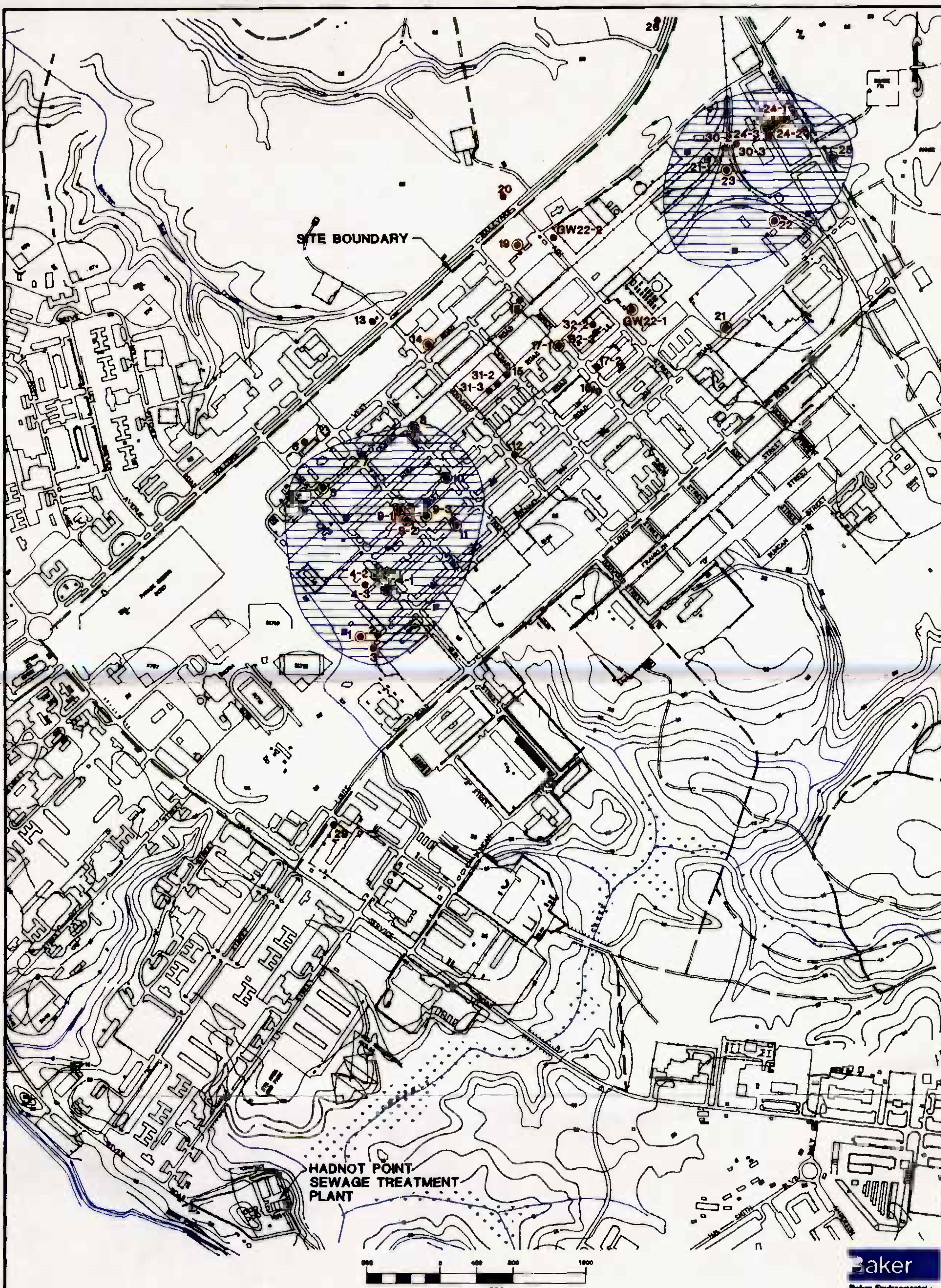
Since hazardous contaminants will remain at the site under this alternative, the EPA is required by the NCP (40 CFR 300.515(e)(ii)) to review the effects of this alternative no less often than every five years.

3.1.2 Alternative 2: No Action With Institutional Controls

Under Alternative 2, the groundwater in the shallow aquifer will remain as is. No remedial actions with the exception of institutional controls (i.e., monitoring and ordinances) will be implemented. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

This alternative will include three institutional controls: long-term groundwater monitoring, aquifer-use restrictions, and deed restrictions. The alternative will include quarterly sampling of 20 existing monitoring wells at the HPIA site. As shown on Figure 3-1, the monitoring wells to be sampled are located upgradient to detect contamination from other sources, within each of the two contaminated source plume areas to track the response of the movement of the contamination, and downgradient to detect either anticipated or unanticipated plume movement. The wells to be monitored include 16 shallow monitoring wells, 2 intermediate wells, and 2 deep wells. Additional wells will be added to the monitoring program, if necessary. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Please note that the 30 year duration is an EPA-suggested time range for remedial alternatives for FS purposes. The first year data will be used to further characterize the aquifer and to identify locations for additional monitoring.

In the event that the monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. In addition, since hazardous contaminants will



LEGEND

- EXISTING MONITORING WELL LOCATION
- APPROXIMATE SOURCE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER
- PROPOSED EXTRACTION WELL LOCATION
- MANHOLES
- 1 — MONITORING WELLS INCLUDED IN THE LONG-TERM MONITORING PROGRAM

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 3-1
MONITORING WELLS INCLUDED IN THE LONG-TERM MONITORING PROGRAM
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

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remain at the site under this alternative, the EPA is required by the NCP (40 CFR 300.515(e)(ii)) to review the effects of this alternative no less often than every five years.

3.1.3 Alternative 3: Biological Treatment at the STP/Groundwater Collection/ Pretreatment

In general, Alternative 3, which will be referred to as the Biological STP Treatment Alternative, includes groundwater extraction, pretreatment, groundwater treatment at the Hadnot Point STP, and institutional controls. The on-site pretreatment system will consist of an oil/water gravity separator, and a combination of one of several inorganic removal technologies including but not limited to precipitation, chemical reduction, and sedimentation. The existing biological system (aerated equalization lagoon and trickling filters) at the Hadnot Point STP will be used for the off-site treatment of the pretreated groundwater. A long-term groundwater monitoring program will be implemented, and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells. Details of each of the components making up this alternative are discussed below.

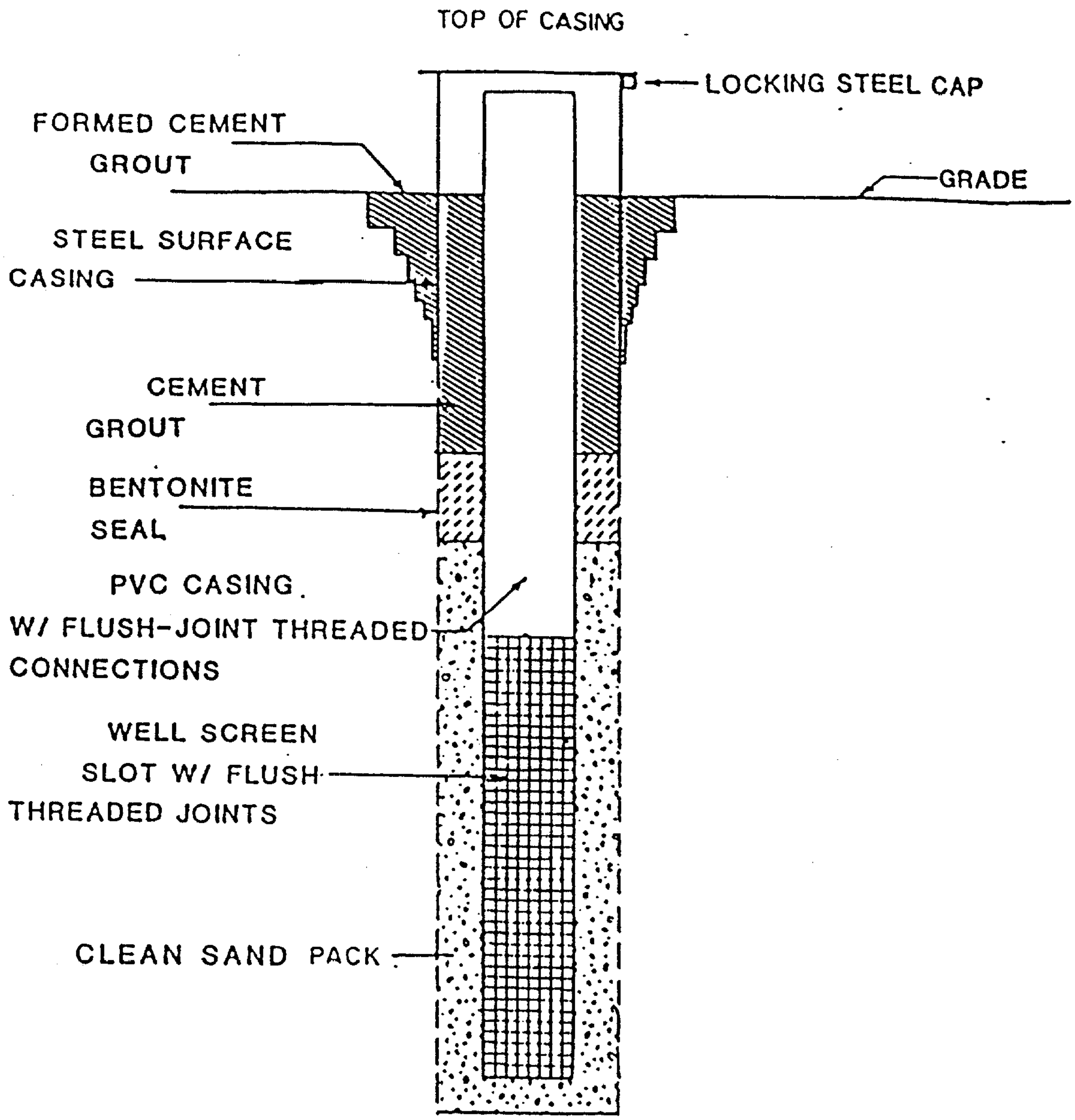
3.1.3.1 Groundwater Collection System

Groundwater in the shallow aquifer at HPIA will be withdrawn through a series of extraction wells. The details of the extraction system (i.e., number, location, and pumping rates of the extraction wells) will be determined through a phased approach. Preliminary aquifer characteristics were previously estimated by O'Brien and Gere based on the results of an eight-hour pump test on two wells screened in the shallow aquifer. O'Brien and Gere estimated a well yield of three gallons per minute (gpm), a transmissivity of 500 gallons per day per foot (gpd/ft), and a radius of influence of 300 to 400 feet. These estimates will be confirmed or reevaluated as extraction wells are installed and the groundwater is monitored.

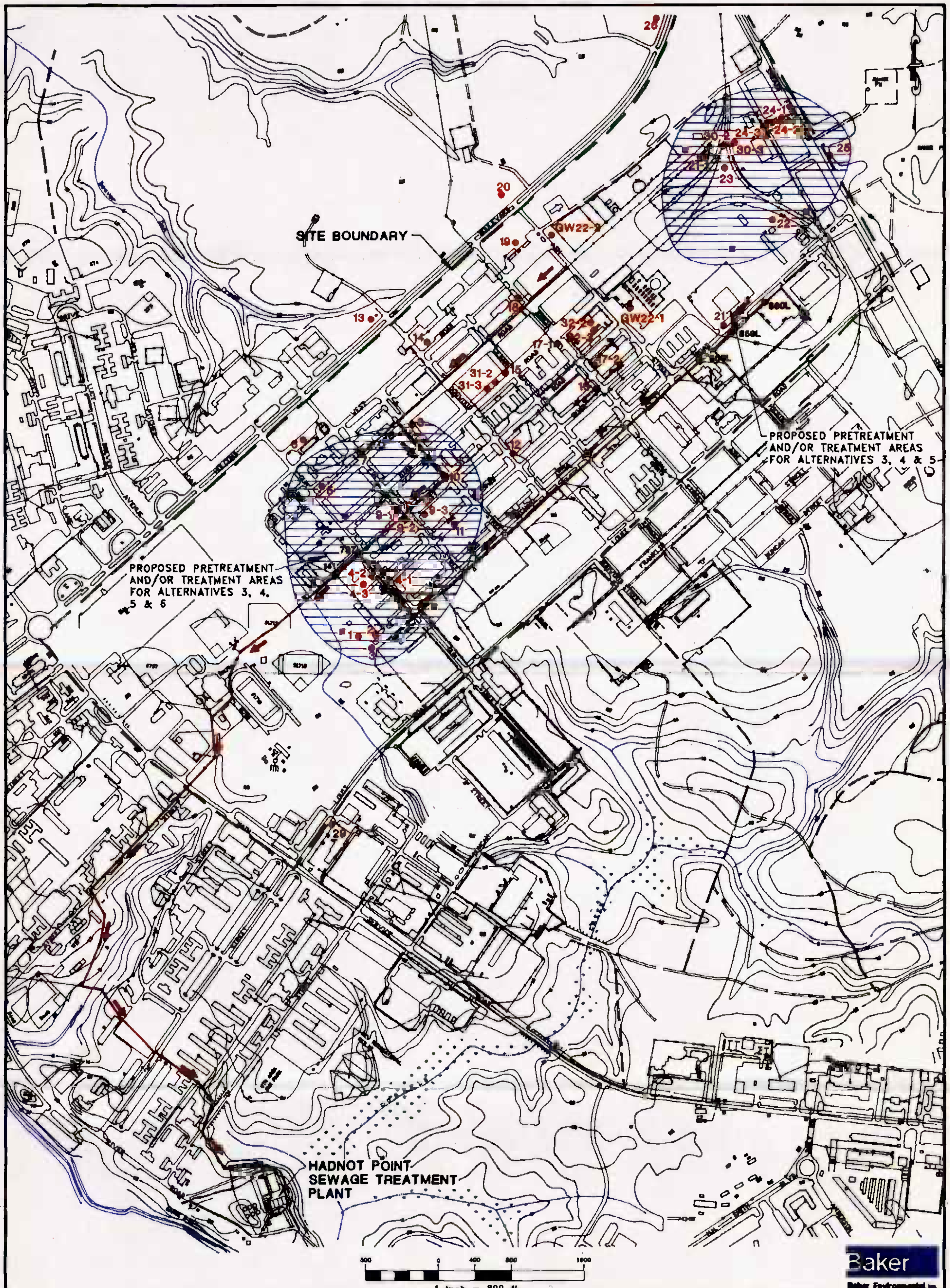
Initially, four 4-inch wells will be installed at each of the two groundwater plumes and pumped at a rate of two to five gpm. A typical extraction well is shown on Figure 3-2. These wells will be placed within each plume as shown on Figure 3-3. Additional wells will be added to the system as dictated by monitoring results. For costing purposes only, it will be assumed that eight additional extraction wells (four within each plume area) will be installed at three different times during the first few years of operation. Therefore, the complete extraction system will include 32 wells. Please note that the total number of extraction wells required to

FIGURE 3-2

TYPICAL EXTRACTION WELL DIAGRAM



NOT TO SCALE



LEGEND

29 EXISTING MONITORING WELL LOCATION

APPROXIMATE SOURCE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER

PROPOSED EXTRACTION WELL LOCATION

MANHOLES

PROPOSED SEWER LINES TO BE USED

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 3-3
LOCATION OF INITIAL PHASE EXTRACTION WELLS, ON-SITE TREATMENT SYSTEMS AND PROPOSED SANITARY SEWER LINES
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

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successfully implement the IRA will be determined as the wells are installed, and testing and monitoring of the groundwater will provide a means of evaluating the need for additional wells. The location of these additional wells has not been determined at this time.

3.1.3.2 Pretreatment System

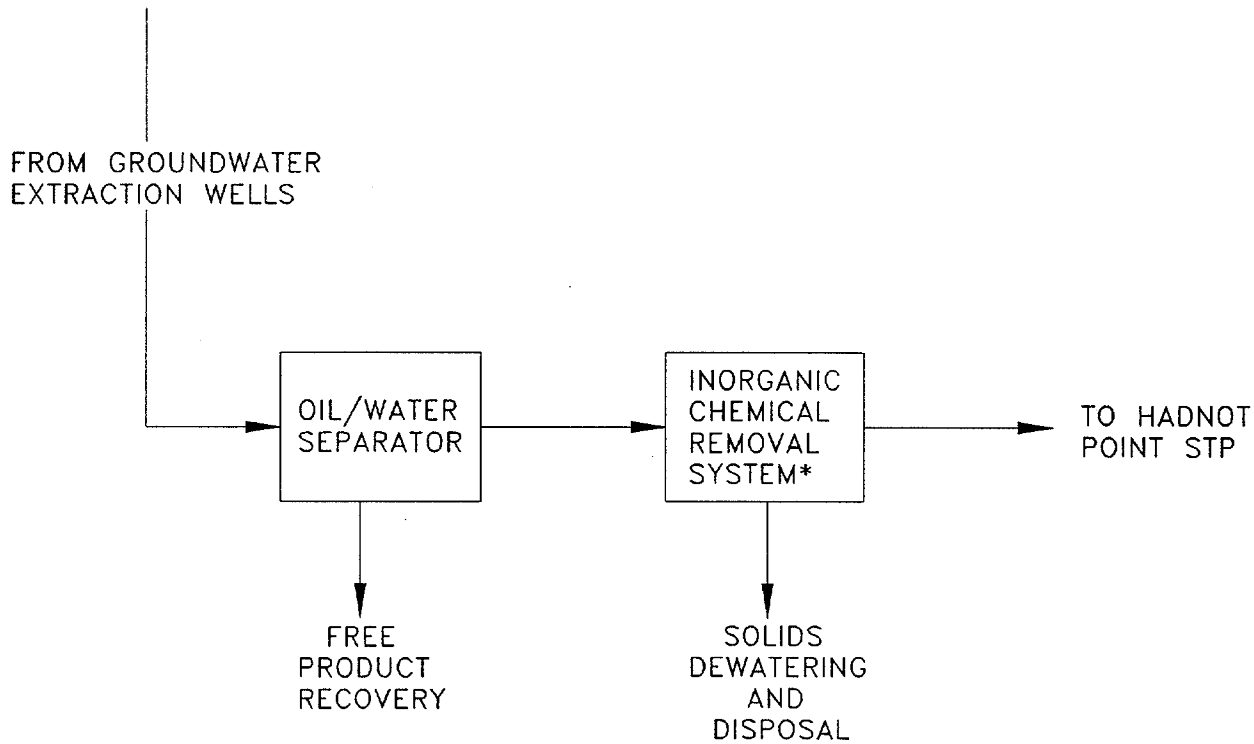
Once extracted, the contaminated groundwater will be pumped an on-site pretreatment system. A pretreatment system will be located within the area of each plume (Figure 3-3). The first step in the pretreatment system will consist of a gravity oil/water separation process for the removal of floating oils and/or oily wastes that are heavier than water. The oil/water gravity separation system will include a holding tank for retention of the extracted groundwater, and a surface skimming and bottom collection system. Baffles will be included in the design of the gravity separator in order to provide additional surface area. Collected free product will be either sold to a waste oil recycler or incinerated in a RCRA-permitted facility.

The aqueous effluent from the gravity separation system will be transferred to an inorganic chemical removal system for the removal of the inorganic contaminants of concern (e.g., chromium, lead, manganese, iron, etc.). The inorganic system will include but not be limited to the following technologies: precipitation, chemical reduction, and sedimentation. Please note that the other process options that passed the screening in Section 2.5 (i.e., neutralization, chemical oxidation, filtration, and flocculation) are still potential technologies and are represented by the three technologies included for this alternative. Bench-scale treatability studies and/or literature searches will be required during the design stage of the pretreatment system. Figure 3-4 presents a schematic of the proposed inorganic chemical pretreatment system.

Residuals generated from the pretreatment systems will be disposed of properly.

3.1.3.3 Hadnot Point STP

The pretreated effluent from the inorganic reduction system will be pumped to the closest sanitary sewer manholes for discharge to the existing biological treatment system at the Hadnot Point STP for the treatment of benzene, TCE, and 1,2-DCE (Figure 3-3).



* REFER TO SECTION 3.1.3.2 FOR TREATMENT OPTIONS

Baker
Baker Environmental, Inc.

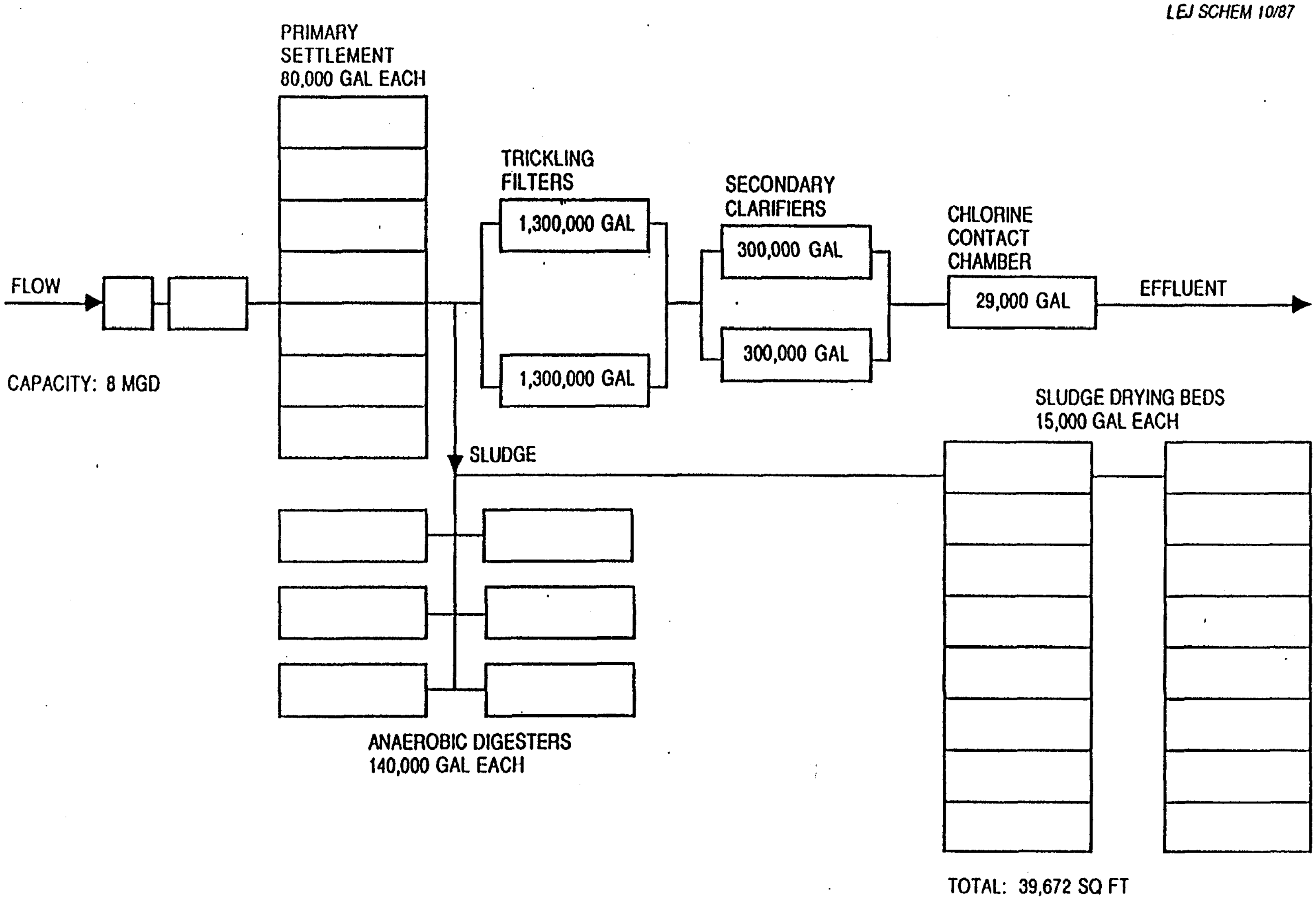
FIGURE 3-4
PROPOSED INORGANIC CHEMICAL
PRETREATMENT SYSTEM
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

The existing Hadnot Point STP, located south-southeast of the HPIA area, has an operating capacity of 8 million gallons per day. The STP is a biological treatment system consisting of an aerated equalization lagoon, primary clarifiers, trickling filters, secondary clarifiers, chlorine contact chamber, anaerobic digesters, and sludge drying beds as shown on Figure 3-5. Designs for a new STP at Hadnot Point with a capacity of 15 million gallons per day are presently being prepared. The new plant is anticipated to be built in 1997. Baker conducted a study on the capacity and potential effectiveness of both the existing and future Hadnot Point STPs. The results of this study are presented in the Supplement Report to this FS. A brief description of the existing STP follows.

The STP receives sanitary wastewater from both residential and industrial areas. The influent into the plant enters the aerated equalization lagoon (two million gallon capacity). The lagoon is aerated with five floating aerators. The aerated wastewater is pumped from the lagoon to the primary influent chamber and then to one of eight 80,000 gallon primary clarifiers. The resulting aqueous effluent from the primary clarifiers is pumped to the secondary treatment area consisting of two 1.3-million gallon trickling filters followed by two 300,000-gallon secondary clarifiers, followed by a 29,000-gallon chlorine contact chamber. Sludge and oil and grease collected in the primary and secondary clarifiers is pumped to one of six 140,000-gallon anaerobic digesters. Digested sludge is pumped to one of twenty-five drying beds. The final effluent from the chlorine contact chamber is discharged to the New River.

Under Alternative 3, the groundwater will be mixed in-line with the sewage the plant is currently receiving. Since the groundwater will be mixed with the current plant influent, effluent discharge and sludge disposal will continue to be handled by the STP in the same manner as currently used with the exception that the sludge will be initially sampled and analyzed for toxicity characteristic leachate procedure (TCLP) constituents to confirm that the sludge is not characteristically hazardous. Disposal of the sludge will required approval by the N.C. DEHNR. The resulting effluent will be discharged to the New River.

Prior to discharging the contaminated groundwater to the STP, several requirements would have to be satisfied. A modification to the existing NPDES permit or a new permit must be approved by the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management. Proof would also have to be established that the plant treatment capacity would not be exceeded, and that the trickling filter system would not be disrupted due to the additional load or concentration of contaminants. As previously stated, Baker recently completed an evaluation of the Hadnot



LEJEUNE HADNOT 1087 B

Figure 3-5
HADNOT POINT WASTEWATER TREATMENT PLANT SCHEMATIC DIAGRAM — BLDG 22

SOURCE: Camp Lejeune, 1987.

CONFIRMATION STUDY
MARINE CORPS BASE
CAMP LEJEUNE

Point STP with respect to treating contaminated groundwater extracted from the shallow aquifer at the HPIA. The results from this study indicate that both the existing and future STPs should have adequate capacity to handle the maximum expected flow (160 gpm) from the HPIA Site. In addition, the plants should be effective in treating the pretreated waste stream. The STP evaluation report (Supplemental Report to this FS) is in draft form and therefore, its results must yet be reviewed and approved by EPA and the N.C.DEHR.

3.1.3.4 Institutional Controls

In order to track the effectiveness of the "pump and treat" method, a long-term groundwater monitoring program will be implemented. The monitoring program will include periodic sampling of approximately 20 wells (same wells as mentioned with Alternative 2). The wells to be sampled have been identified on Figure 3-1. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Restrictions will be placed on the use of the shallow aquifer, the water supply wells will remain closed, and no new wells will be permitted to be installed in the area.

3.1.4 Alternative 4: Physical-Chemical Treatment (Air Stripping)/Groundwater Collection/Pretreatment/STP Discharge

Alternative 4 is similar to Alternative 3 with the exception of the method of groundwater treatment. In general, Alternative 4, which will be referred to as the Physical-Chemical Treatment (Air Stripping) Alternative, includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system. In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells. Each of the main components of this alternative are described below.

3.1.4.1 Groundwater Collection System

Groundwater in the shallow aquifer at HPIA will be withdrawn through a series of extraction wells. This groundwater collection system has already been discussed in Alternative 3.

3.1.4.2 Pretreatment System

Once extracted, the contaminated groundwater will first be pumped to a gravity oil/water separation unit, and then to an inorganic chemical removal system. This is the same as Alternative 3.

3.1.4.3 Physical/Chemical Treatment (Air Stripping System)

The aqueous effluent from the inorganic chemical removal system will be pumped to an on-site treatment system consisting of two air stripping units (one location within each source plume area). The on-site air stripping units will be designed for the treatment of benzene, 1,2-DCE, and TCE. Figure 3-3 identifies the proposed piping diagram and location of the treatment systems for Alternative 4. Residuals generated from this process will include air emissions contaminated with organics. It is assumed that vapor recovery equipment will be needed to prevent the release of stripped organics into the atmosphere. The vapor recovery equipment will generate additional waste contaminated with organics which will require proper off-site disposal or regeneration.

3.1.4.4 Off-site Discharge to Hadnot Point STP

The treated water will be pumped to the closest sanitary sewer manholes for discharge to the existing Hadnot Point STP for final discharge.

3.1.4.5 Institutional Controls

In order to track the effectiveness of the "pump and treat" method, a long-term groundwater monitoring program will be implemented. The monitoring program will include periodic sampling of approximately 20 wells (same wells as mentioned with Alternative 2). The wells to be sampled have been identified on Figure 3-1. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Restrictions will be placed on the use of the shallow aquifer, the water supply wells will remain closed, and no new wells will be permitted to be installed in the area.

3.1.5 Alternative 5: Physical-Chemical Treatment (Carbon Adsorption)/ Groundwater Collection/Pretreatment/STP Discharge

Alternative 5 is similar to Alternative 4 with the exception of the method of groundwater treatment. In general, Alternative 5, which will be referred to as the Physical-Chemical Treatment (Carbon Adsorption) Alternative, includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system. In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells. Each of the main components of this alternative are described below.

3.1.5.1 Groundwater Collection System

Groundwater in the shallow aquifer at HPIA will be withdrawn through a series of extraction wells. This groundwater collection system has already been discussed in Alternative 3.

3.1.5.2 Pretreatment System

Once extracted, the contaminated groundwater will first be pumped to a gravity oil/water separation unit, and then to an inorganic chemical removal system. This is the same as Alternative 3.

3.1.5.3 Physical/Chemical Treatment (Carbon Adsorption System)

The aqueous effluent from the inorganic chemical removal system will be pumped to an on-site treatment system consisting of two activated carbon adsorption units (one location within each source plume area). The on-site carbon adsorption systems will include granular activated carbon (GAC) units for the treatment of benzene, 1,2-DCE, TCE. This option entails pumping the contaminated extracted groundwater through either of the two GAC adsorption systems. Figure 3-3 identifies the proposed piping diagram and the location of the treatment systems for Alternative 5. Please note that both Alternatives 4 and 5 would have some of the same details (e.g., location of treatment systems and piping), and therefore both alternatives are depicted on one figure. The final design of the system will be based on the contact time determined from bench-scale test results. Spent carbon waste generated can be either be properly disposed off site, shipped to a regeneration facility, or regenerated on site. If the carbon is regenerated on site, a source of steam and cooling water will be required and an additional waste stream will be generated. The selection of one of the three spent carbon regeneration/ disposal options will be based on cost. Typically, off-site disposal or off-site regeneration of spent carbon is more economical than on-site regeneration if small volumes of water are treated.

A combined treatment system consisting of an air stripper followed by an activated carbon adsorption system may be implemented at the site if it is determined to be more economical than any one system alone or if an air stripper will not be effective in treating all of the contaminants of concern. This option will involve the use of both of the systems mentioned in Alternatives 4 and 5.

3.1.5.4 Off-site Discharge to Hadnot Point STP

The treated water will be pumped to the closest sanitary sewer manholes for discharge to the existing Hadnot Point STP for final discharge.

3.1.5.5 Institutional Controls

In order to track the effectiveness of the "pump and treat" method, a long-term groundwater monitoring program will be implemented. The monitoring program will include periodic sampling of approximately 20 wells (same wells as mentioned with Alternative 2). The wells to be sampled have been identified on Figure 3-1. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Restrictions will be placed on the use of the shallow aquifer, the water supply wells will remain closed, and no new wells will be permitted to be installed in the area.

3.1.6 Alternative 6: Thermal Treatment/Groundwater Collection/ Pretreatment/STP Discharge

Alternative 6 is similar to Alternatives 4 and 5 with the exception of the method of groundwater treatment. In general, Alternative 6, which will be referred to as the Thermal Treatment Alternative, includes groundwater extraction, pretreatment, on-site treatment, long-term groundwater monitoring, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system. In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer including the installation of new wells. Each of the main components of this alternative are described below.

3.1.6.1 Groundwater Collection System

Groundwater in the shallow aquifer at HPIA will be withdrawn through a series of extraction wells. This groundwater collection system has already been discussed in Alternative 3.

3.1.6.2 Pretreatment System

Once extracted, the contaminated groundwater will first be pumped to a gravity oil/water separation unit, and then to an inorganic chemical removal system. This is the same as Alternative 3.

3.1.6.3 Thermal Treatment

The aqueous effluent from the inorganic chemical removal system will be pumped to an on-site thermal treatment system consisting of a liquid injection incinerator. Note that with this alternative, only one treatment system (the incinerator) will be installed (Figure 3-3). Therefore, additional piping from the extraction system will be required.

3.1.6.4 Off-site Discharge to Hadnot Point STP

After obtaining the appropriate NPDES permits or modifications, the treated water will be pumped to the closest sanitary sewer manholes for discharge to the existing Hadnot Point STP for final discharge.

3.1.6.5 Institutional Controls

In order to track the effectiveness of the "pump and treat" method, a long-term groundwater monitoring program will be implemented. The monitoring program will include periodic sampling of approximately 20 wells (same wells as mentioned with Alternative 2). The wells to be sampled have been identified on Figure 3-1. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Restrictions will be placed on the use of the shallow aquifer, the water supply wells will remain closed, and no new wells will be permitted to be installed in the area.

3.1.7 Alternative 7: Treatment at RCRA Facility/Groundwater Collection

Alternative 7, which will be referred to as the RCRA Facility Alternative, includes groundwater extraction and treatment of the water at an off-site RCRA-approved facility. The alternative also includes a long-term groundwater monitoring program and restrictions placed on the use of the shallow aquifer and on the installation of new wells. Each of the main components of this alternative are described below.

3.1.7.1 Groundwater Collection System

Groundwater in the shallow aquifer at HPIA will be withdrawn through a series of extraction wells. This groundwater collection system has already been discussed in Alternative 3.

3.1.7.2 Treatment at an Off-site RCRA-Approved Facility

Once extracted, the contaminated groundwater will be stored in holding tanks then transferred into a tank truck and transported to a RCRA-approved treatment facility capable of handling the constituents of concern from the shallow aquifer.

3.1.7.3 Institutional Controls

In order to track the effectiveness of the "pump and treat" method, a long-term groundwater monitoring program will be implemented. The monitoring program will include periodic sampling of approximately 20 wells (same wells as mentioned with Alternative 2). The wells to be sampled have been identified on Figure 3-1. Samples will be collected on a quarterly basis for 30 years and analyzed for the constituents of concern. Restrictions will be placed on the use of the shallow aquifer, the water supply wells will remain closed, and no new wells will be permitted to be installed in the area.

3.2 Screening of Alternatives

3.2.1 Introduction

This section presents the initial screening that was conducted on the potential remedial action alternatives developed for the shallow aquifer. The objective of this screening is to make comparisons between similar alternatives, so that only the most promising ones are carried forward for further evaluation. Therefore, the alternatives will be evaluated more generally in this phase than during the detailed analysis.

As per EPA guidance, the alternatives were evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost.

The effectiveness criteria is in terms of protecting human health and the environment. Short-term effectiveness will be evaluated based on construction and implementation period, and long-term will be based on the period after the IRA is complete.

The implementability criteria includes both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative with respect to site-specific conditions.

The focus of the cost evaluation is to make comparative estimates for alternatives with relative accuracy. The cost estimates have been based on cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates.

3.2.2 Alternative 1: No Action

3.2.2.1 Description

Under the No Action Alternative, the groundwater in the shallow aquifer will remain as is. No remedial actions will be implemented. The no action alternative is required by the NCP to provide a baseline for comparison with other groundwater alternatives. Under this alternative, the contaminants identified in the shallow aquifer will remain, which will result in the potential for the further migration of the contaminated plumes. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

3.2.2.2 Evaluation

Effectiveness

The No Action Alternative would not provide any short-term or long-term protection to human health or the environment. In addition, the alternative would not provide any short-term reduction in toxicity, mobility, or volume of contaminants in the shallow aquifer. There may be a reduction of the toxicity, mobility, or volume of contaminants in the long-term if natural processes such as degradation, attenuation, and dispersion occur.

Implementability

The No Action Alternative would be both technically and administratively easy to implement since there are no activities associated with the alternative.

Cost

No capital or operation and maintenance (O&M) costs are associated with the No Action Alternative.

3.2.3 Alternative 2: No Action With Institutional Controls

3.2.3.1 Description

Under Alternative 2, the groundwater in the shallow aquifer will remain as is. No remedial actions with the exception of institutional controls (i.e., long-term groundwater monitoring, aquifer-use restrictions, and deed restrictions for the installation of new wells) will be implemented. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

3.2.3.2 Evaluation

Effectiveness

The No Action with Institutional Controls Alternative would provide limited short-term and long-term protection to human health or the environment. This limited protection would be provided by the restrictions placed on the use of the aquifer and the installation of new wells.

The alternative would not provide any short-term reduction in toxicity, mobility, or volume of contaminants in the shallow aquifer. There may be a reduction of the toxicity, mobility, or volume of contaminants in the long-term if natural processes such as degradation, attenuation, and dispersion occur.

Implementability

The No Action with Institutional Controls Alternative would be both technically and administratively easy to implement. Technically this alternative does not require any construction activities. The monitoring wells to be sampled were previously installed. The administrative activities associated with this alternative include obtaining ordinances for restricting the use of the shallow aquifer and restricting the installation of new wells in the area. These ordinances should be easily obtained.

Cost

Minimal capital and low O&M (approximately $60,000) costs are associated with the No Action with Institutional Controls Alternative. The capital costs would be associated with obtaining the ordinances to restrict the use of the shallow aquifer and to restrict the installation of new wells in the area. The O&M costs would be associated with the quarterly sampling and analysis of the 20 groundwater monitoring wells.

3.2.4 Alternative 3: Biological Treatment at the STP/Groundwater Collection/Pretreatment

3.2.4.1 Description

In general, Alternative 3 (the Biological STP Treatment Alternative) includes groundwater extraction, pretreatment, groundwater treatment at the Hadnot Point STP, and institutional controls. The on-site pretreatment system will consist of an oil/water gravity separator, and a combination of one of several inorganic removal technologies including but not limited to precipitation, chemical reduction, and sedimentation. The existing biological system (aerated equalization lagoon and trickling filters) at the Hadnot Point STP will be used for the off-site treatment of the pretreated groundwater. A long-term groundwater monitoring program will be implemented, and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

3.2.4.2 Evaluation

Effectiveness

The Biological STP Treatment Alternative will provide both short-term and long-term protection to human health and the environment since the source of contamination will be removed and treated. Additionally, the alternative will provide short-term and long-term reduction of toxicity, mobility, and volume of the contaminants in the shallow aquifer.

Implementability

Technically, the Biological STP Treatment Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, and associated piping to connect the units to the sanitary sewer system. The biological system already exists at the Hadnot Point STP. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. The existing sanitary sewer lines would require upgrading and/or replacement.

Once in operation, the maintenance of the treatment units associated with this alternative should not be labor intensive. Items of concern would be the extraction pumps and the pretreatment system.

In terms of administrative feasibility, this alternative will require the Hadnot Point STP to obtain either a new NPDES permit or a modified permit to allow for the treatment and discharge of the additional waste stream from the HPIA Site. In addition, Pretreatment Standards would have to be met. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer. Treatability testing (bench- and/or pilot-scale) of the pretreatment systems and the biological system would be required.

Cost

Moderate capital and low O&M cost have been estimated for the Biological Treatment at STP Alternative. The capital costs would include the costs of purchasing and installing the groundwater extraction system, the pretreatment system, and the pumping facilities to deliver the pretreated wastewater to the STP. The O&M costs would be associated with the operation and upkeep of the groundwater recovery system, the pretreatment system, and the pumping facilities.

Preliminary costing of this alternative has estimated the capital costs between $1 million and $1.5 million, and the annual O&M costs between $250,000 and $500,000.

3.2.5 Alternative 4: Physical-Chemical Treatment (Air Stripping)/Groundwater Collection/Pretreatment/STP Discharge

3.2.5.1 Description

In general, Alternative 4 (the Physical/Chemical Treatment-Air Stripping Alternative) includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

3.2.5.2 Evaluation

Effectiveness

The Physical/Chemical Treatment (Air Stripping) Alternative will provide both short-term and long-term protection to human health and the environment since the source of contamination will be removed and treated. Additionally, the alternative will provide short-term and long-term reduction of toxicity, mobility, and volume of the contaminants in the shallow aquifer.

Implementability

Technically, the Physical/Chemical Treatment (Air Stripping) Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and the air stripping towers. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Mobile air stripping towers are readily available.

Once in operation, the maintenance of the treatment units associated with this alternative should not be extremely labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, and the air stripping towers.

In terms of administrative feasibility, this alternative will require the Hadnot Point STP to obtain either a new NPDES permit or a modified permit to allow for the discharge of the additional treated waste stream from the HPIA Site. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer. Treatability testing (bench- and/or pilot-scale) of the pretreatment systems and the air strippers would be required.

Cost

Moderate capital costs and low O&M costs have been estimated for the Physical/Chemical Treatment (Air Stripping) Alternative. The capital costs would include the costs of purchasing and installing the groundwater extraction system, the pretreatment system, the air stripping equipment, and the effluent pumping facilities. The O&M costs would consist of the operation and upkeep of the groundwater recovery system, the pretreatment system, the air stripping system, and the pumping facilities.

Preliminary costing of this alternative has estimated the capital costs between $1 million and $1.5 million, and the annual O&M costs between $250,000 and $500,000.

3.2.6 Alternative 5: Physical-Chemical Treatment (Carbon Adsorption)/ Groundwater Collection/Pretreatment/STP Discharge

3.2.6.1 Description

In general, Alternative 5 (the Physical/Chemical Treatment-Carbon Adsorption Alternative) includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

3.2.6.2 Evaluation

Effectiveness

The Physical/Chemical Treatment (Carbon Adsorption) Alternative will provide both short-term and long-term protection to human health and the environment since the source of contamination will be removed and treated. Additionally, the alternative will provide short-term and long-term reduction of toxicity, mobility, and volume of the contaminants in the shallow aquifer.

Implementability

Technically, the Physical/Chemical Treatment (Carbon Adsorption) Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and GAC units. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Packaged GAC units are readily available.

Once in operation, the maintenance of the treatment units associated with this alternative would be somewhat labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, the GAC units, and the spent carbon. More time would be required in this alternative since the spent carbon would routinely require removal and replacement.

In terms of administrative feasibility, this alternative will require the Hadnot Point STP to obtain either a new NPDES permit or a modified permit to allow for the discharge of the additional treated waste stream from the HPIA Site. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer. Treatability testing (bench- and/or pilot-scale) of the pretreatment systems and the carbon units would be required.

Cost

Low capital costs and low O&M costs have been estimated for the Physical/Chemical Treatment (Carbon Adsorption) Alternative. The capital costs would include the costs of purchasing and installing the groundwater extraction system, the pretreatment system, the GAC equipment, and the effluent pumping facilities. The O&M costs would consist of the operation and upkeep of the groundwater recovery system, the pretreatment system, the GAC system, and the pumping facilities.

Preliminary costing of this alternative has estimated the capital costs between \$500,000 and \$1 million, and the annual O&M costs between \$250,000 and \$500,000.

3.2.7 Alternative 6: Thermal Treatment/Groundwater Collection /Pretreatment/ STP Discharge

3.2.7.1 Description

In general, Alternative 6 (the Thermal Treatment Alternative) includes groundwater extraction, pretreatment, on-site treatment, discharge to surface water body, long-term groundwater monitoring, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical removal system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer including the installation of new wells.

3.2.7.2 Evaluation

Effectiveness

The Thermal Treatment Alternative will provide both short-term and long-term protection to human health and the environment since the source of contamination will be removed and treated. Additionally, the alternative will provide short-term and long-term reduction of toxicity, mobility, and volume of the contaminants in the shallow aquifer.

Implementability

Technically, the Thermal Treatment Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and the liquid injection incinerator. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Liquid injection incinerators are commercially available, although they are not as readily available as air strippers or activated carbon units.

Once in operation, the maintenance of the treatment units associated with this alternative would be somewhat labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, and the incinerator. Operation and maintenance of the incinerator would require more manpower than with air strippers or activated carbon units.

In terms of administrative feasibility, this alternative will require approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer. Treatability testing (bench- and/or pilot-scale) of the pretreatment systems and the incinerator would be required.

Cost

High capital costs and moderate O&M costs have been estimated for the Thermal Treatment Alternative. The capital costs would include the costs of purchasing and installing the groundwater extraction system and the liquid injection incinerator. The O&M costs would consist of the operation and upkeep of the groundwater recovery system and the incinerator system, including the air pollution control equipment.

Preliminary costing of this alternative has estimated the capital costs between $1.25 million and $1.5 million, and the annual O&M costs between $500,000 and $750,000.

3.2.8 Alternative 7: Treatment at RCRA Facility/Groundwater Collection

3.2.8.1 Description

Alternative 7 (the RCRA Facility Alternative) includes groundwater extraction and treatment of the water at an off-site RCRA-approved facility. The alternative also includes a long-term groundwater monitoring program and restrictions placed on the use of the shallow aquifer and on the installation of new wells.

3.2.8.2 Evaluation

Effectiveness

The RCRA Facility Alternative will provide both short-term and long-term protection to human health and the environment since the source of contamination will be removed from the site. Additionally, the alternative will provide short-term and long-term reduction of toxicity, mobility and volume of the contaminants in the shallow aquifer.

Implementability

Technically, the RCRA Facility Alternative should be easy to implement. Construction activities would only include the installation of extraction wells and pumps. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. This alternative would require limited maintenance time; mainly for the extraction system.

In terms of administrative feasibility, this alternative would require approval for the off-site transportation of the waste stream to the RCRA-approved facility. Approval of the off-site treatment facility would also be required. The availability and capacity of the closest RCRA facility may present a problem in implementing this alternative in a timely manner.

Cost

Moderate capital costs and high O&M costs have been estimated for the RCRA Facility Alternative. The capital costs would include the costs of purchasing and installing the groundwater extraction system, the on-site storage tanks and the transfer facilities. The O&M costs would consist of the operation and upkeep of the groundwater recovery system and the storage/transfer equipment, plus the cost of off-site disposal at the RCRA Facility.

Preliminary costing of this alternative has estimated the capital costs between $750,000 and $1 million, and the annual O&M costs in excess of $1 million.

3.3 Summary of Screening of Alternatives

Table 3-2 presents of summary of the preliminary screening of the seven remedial action alternatives. General comparisons between the alternatives in terms of effectiveness, implementability, and order of magnitude costs are presented below.

All of the alternatives with the exception of the No Action and the No Action with Institutional Controls Alternatives provide both short-term and long-term protection of human health and the environment, and provide both short-term and long-term reduction of toxicity, mobility and/or volume of contaminants in the groundwater.

TABLE 3-2

SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION ALTERNATIVES

Alternative	Effectiveness	Implementability	Order of Magnitude Cost
Alternative 1: No Action	• No short-term or long-term protection of human health and the environment • No short-term reduction in toxicity, mobility, or volume of contaminants in the groundwater • Long-term reduction of contaminants is unpredictable	• Easily implemented in terms of technical and administrative feasibility	• No capital or O&M Costs
Alternative 2: No Action with Institutional Controls	• No short-term or long-term protection of human health and the environment • No short-term reduction in toxicity, mobility, or volume of contaminants in the groundwater • Long-term reduction of contaminants is unpredictable	• Easily implemented in terms of technical and administrative feasibility. Existing monitoring well at the site.	• Minimal capital costs (for administrative purposes) • Extremely low O&M Costs (~$60,000)

TABLE 3-2 (Continued)

SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION ALTERNATIVES

Alternative	Effectiveness	Implementability	Order of Magnitude Cost
Alternative 3: Biological Treatment at the STP	• Will provide short-term and long-term protection of human health and the environment. • Will provide short-term and long-term reduction in toxicity, mobility, and volume of contaminants in the groundwater.	• Relatively easy to technically implement - the biological system already exists at the Hadnot Point STP; pretreatment equipment readily available. • Administrative requirements would include permits (discharge for water and/or air emissions) and treatability testing.	• High Capital Costs ($1M to $1.5M) • Low O&M Costs ($250,000 to $500,000)
Alternative 4: Physical/Chemical (Air Stripping)	• Will provide short-term and long-term protection of human health and the environment. • Will provide short-term and long-term reduction in toxicity, mobility, and volume of contaminants in the groundwater.	• Relatively easy to technically implement - the required equipment readily available. • Administrative requirements would include permits (discharge for water and/or air emissions) and treatability testing.	• High Capital Costs ($1M to $1.5M) • Low O&M Costs ($250,000 to $500,000)
Alternative 5: Physical/ Chemical (Carbon Adsorption)	• Will provide short-term and long-term protection of human health and the environment. • Will provide short-term and long-term reduction in toxicity, mobility, and volume of contaminants in the groundwater.	• Relatively easy to technically implement. The operation of the carbon system would be somewhat labor intensive due to required changes in carbon. • Administrative requirements would include permits (discharge for water and/or air emissions) and treatability testing.	• Moderate Capital Costs ($500,000 to $1M) • Low O&M Costs ($250,000 to $500,000)

TABLE 3-2 (Continued)

SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ACTION ALTERNATIVES

Alternative	Effectiveness	Implementability	Order of Magnitude Cost
Alternative 6: Thermal Treatment	• Will provide short-term and long-term protection of human health and the environment. • Will provide short-term and long-term reduction in toxicity, mobility, and volume of contaminants in the groundwater.	• Not as relatively easy to technically implement - required pretreatment equipment available. Incinerator may not be as readily available. • Administrative requirements would include possible permits for air emissions and treatability testing.	• High Capital Costs ($1M to $1.5M) • Moderate O&M Costs ($500,000 to $750,000)
Alternative 7: RCRA Facility	• Will provide short-term and long-term protection of human health and the environment. • Will provide short-term and long-term reduction in toxicity, mobility, and volume of contaminants in the groundwater.	• May be easy to technically implement. Availability of an off-site facility may present a problem. • Administrative requirements would include approval of off-site facility and transportation.	• Moderate Capital Costs ($500,000 to $1M) • High O&M Costs (Greater than $1M)

All of the alternatives, in terms of technical feasibility, should be relatively easy to implement. The easiest to implement would be the No Action Alternative. The most difficult to implement would be either the Thermal Treatment Alternative or the RCRA Facility Alternative due to the unpredicted availability of either treatment equipment or capacity.

In terms of capital costs, the two no action alternatives (Alternatives 1 and 2) would be the least expensive alternatives. Alternatives 5 and 7 are estimated to have moderate capital costs ($500,000 to $1,000,000). Alternatives 3, 4, and 5 are estimated to have high capital costs in the range of $1,000,000 to $1,500,000.

In terms of O&M costs, again the two no action alternatives would be the least expensive to operate. Alternatives 3, 4, and 5 are estimated to have low O&M costs in the range of $250,000 to $500,000 annually. Alternative 6 has been estimated to have a moderate O&M cost ranging from $500,000 to $750,000 annually. Alternative 7 has been estimated to have a high O&M cost exceeding $1,000,000 annually.

From the results from this preliminary screening of alternatives, it appears that all of the treatment alternatives would be effective (i.e., protective of human health and the environment and would reduce the toxicity, mobility, and/or mobility of the contaminants in the shallow aquifer) and would be relatively easy to implement. In terms of costs, the RCRA Facility Alternative would be the most expensive alternative to implement. Although, at this stage, Alternative 7 could be eliminated from further evaluation based on cost factors, it will be retained in order to keep a broad range of potential alternatives for the shallow aquifer. Therefore, all seven alternatives will undergo a detailed evaluation as presented in the next section.

4.0 DETAILED ANALYSIS OF ALTERNATIVES

4.1 Introduction

This section of the FS contains the detailed analysis of the set of remedial action alternatives remaining after the initial screening process. This analysis is conducted to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for a site (i.e., the shallow aquifer), and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD) (USEPA, 1988).

The extent to which alternatives are analyzed during this detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening (USEPA, 1988).

The following nine evaluation criteria serve as the basis for conducting the detailed analysis:

1. Overall protection of human health and the environment.
2. Compliance with applicable or relevant and appropriate requirements (ARARs).
3. Long-term effectiveness and permanence.
4. Reduction of toxicity, mobility, or volume.
5. Short-term effectiveness.
6. Implementability.
7. Cost.
8. EPA/State acceptance.
9. Community acceptance.

The first two criteria (Threshold Criteria) relate directly to statutory findings; the next five criteria (Primary Balancing Criteria) are the primary criteria upon which the analysis is based; and the final two criteria (Modifying Criteria) are typically evaluated following comment on the RI/FS report and the proposed plan.

4.2 Individual Analysis of Alternatives

The individual analysis of the five alternatives are presented in the following subsections. This analysis includes an assessment and a summary profile of each of the alternative against the evaluation criteria, and a comparative analysis among the alternatives to assess the relative performance of each of the alternatives with respect to each of the evaluation criterion.

The cost estimates that have been developed for each of the alternatives include both capital and operational expenditures. The cost evaluation presents the present worth values for each of the alternatives in order that the options can be easily compared. The accuracy of each cost estimate depends upon the assumptions made and the availability of costing information. The present worth costs were calculated assuming a 30-year operational period (based on EPA guidance) for all of the alternatives, a five percent discount factor, and a zero percent inflation rate. All costs presented in the following sections have been updated to 1991 dollar values using the Chemical Engineering Plant Construction Index.

4.2.1 Alternative 1: No Action

4.2.1.1 Description

Under the No Action Alternative, the groundwater in the shallow aquifer will remain as is. No remedial actions will be implemented. The no action alternative is required by the NCP to provide a baseline for comparison with other groundwater alternatives. Under this alternative, the contaminants identified in the shallow aquifer will remain, which will result in the potential for the further migration of the contaminated plumes. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

4.2.1.2 Assessment

Overall Protection of Human Health and the Environment

With the No Action Alternative, the existing contaminated groundwater plumes in the shallow aquifer will have the potential for further migration both horizontally in the shallow aquifer and vertically into the deeper aquifer. Therefore, the No Action Alternative does not provide any protection to human health or to the environment.

Compliance With ARARs

Under the No Action Alternative, groundwater quality in the shallow aquifer will potentially exceed Federal and/or North Carolina MCLs for volatile organic compounds and inorganic compounds. No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the site, the No Action Alternative will not significantly reduce any potential risks present at the site. As time elapses, natural bacteriological attenuation may lessen the potential for risks. Since the contaminants will remain at the site, the EPA will be required to conduct a review of the site every five years.

In terms of the adequacy and reliability of controls used to manage treatment residuals or untreated wastes that remain at the site, the No Action Alternative does not include any type of controls.

In summary, the No Action Alternative can not be considered as an effective or permanent alternative.

Reduction of Toxicity, Mobility, or Volume

The No Action Alternative does not include any form of treatment with the exception of natural biodegradation. Therefore, a very limited amount, if any, of the contamination in the shallow groundwater will be destroyed or treated. No reduction in toxicity, mobility, or volume of toxic contaminants is anticipated.

Short-Term Effectiveness

In terms of short-term effectiveness, since there are no remedial action activities associated with the No Action Alternative, therefore, there are no risks to the community or to workers by implementing this alternative. In addition, there are no environmental impacts expected with respect to implementation. The time until the remedial response objectives for the shallow aquifer are achieved with this alternative can not be estimated.

Implementability

With respect to technical feasibility, the No Action Alternative is easily implemented since no activities are conducted, and therefore no technologies need to be constructed and operated. This alternative does not include any type of monitoring activities.

In terms of administrative feasibility, this alternative should not require coordination with other agencies. The availability of services and materials is not applicable to this alternative.

Cost

There are no capital costs or operation and maintenance (O&M) costs associated with the No Action Alternative.

EPA/State Acceptance

Since this alternative does not remove or destroy the constituents of concern, and may ultimately endanger other drinking water supply wells, the EPA and the State are not expected to favor this alternative.

Community Acceptance

It is unlikely that the community will support any form of a No Action Alternative.

4.2.2 Alternative 2: No Action With Institutional Controls

4.2.2.1 Description

Under Alternative 2, the groundwater in the shallow aquifer will remain as is. No remedial actions with the exception of institutional controls (i.e., long-term groundwater monitoring, aquifer-use restrictions, and deed restrictions for the installation of new wells) will be implemented. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

If this alternative is implemented, the existing supply wells will have to remain closed until the results from the groundwater monitoring indicate that the aquifer meets drinking water levels. In addition, no new wells will be allowed to be installed in the area.

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.2.2 Assessment

Overall Protection of Human Health and the Environment

With the No Action with Institutional Controls Alternative, the existing contaminated groundwater plumes in the shallow aquifer will have the potential for further migration both horizontally in the shallow aquifer and vertically into the deeper aquifer. Therefore, the No Action Alternative does not provide any protection to human health or to the environment.

Compliance With ARARs

Under the No Action Alternative, groundwater quality in the shallow aquifer will potentially exceed Federal and/or North Carolina MCLs for volatile organic compounds and inorganic compounds. No action-specific or location-specific ARARs apply to this alternative.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the site, the No Action with Institutional Controls Alternative will not significantly reduce any potential risks present at the site. As time elapses, natural bacteriological attenuation may lessen the potential for risks.

Since the contaminants will remain at the site, the EPA will be required to conduct a review of the site every five years.

In terms of the adequacy and reliability, the existing monitoring wells (the only controls associated with the No Action with Institutional Controls Alternative) should provide adequate and reliable analytical results.

In summary, the No Action with Institutional Controls Alternative can not be considered as an effective or permanent alternative.

Reduction of Toxicity, Mobility, or Volume

The No Action with Institutional Controls Alternative does not include any form of treatment with the exception of natural biodegradation. Therefore, a very limited amount, if any, of the contamination in the shallow groundwater will be destroyed or treated. No reduction in toxicity, mobility, or volume of toxic contaminants is anticipated.

Short-Term Effectiveness

In terms of short-term effectiveness, there are no remedial action activities associated with the No Action with Institutional Controls Alternative with the exception of quarterly groundwater sampling and analysis. Therefore, there are no anticipated risks to the community or to workers by implementing this alternative. In addition, there are no environmental impacts expected with respect to implementation. The time until the remedial response objectives for the shallow aquifer are achieved with this alternative can not be estimated.

Implementability

With respect to technical feasibility, the No Action with Institutional Controls Alternative is easily implemented since no activities are conducted except for quarterly groundwater monitoring.

In terms of administrative feasibility, this alternative should not require coordination with other agencies. No problems with the availability of laboratory services and materials are anticipated.

Cost

There are minimal capital costs associated with the No Action With Institutional Controls Alternative. Operation and maintenance (O&M) costs of approximately $60,000 annually are projected for the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of approximately $970,000. Table 4-1 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative does not remove or destroy the constituents of concern, and may ultimately endanger other drinking water supply wells, the EPA and the State is not expected to favor this alternative.

Community Acceptance

It is unlikely that the community will support any form of a No Action Alternative.

4.2.3 Alternative 3: Biological Treatment at the STP/ Groundwater Collection/Pretreatment

4.2.3.1 Description

In general, Alternative 3 (the Biological STP Treatment Alternative) includes groundwater extraction, pretreatment, groundwater treatment at the Hadnot Point STP, and institutional controls. The on-site pretreatment system will consist of an oil/water gravity separator, and a combination of one of several inorganic removal technologies including but not limited to precipitation, chemical reduction, and sedimentation. The existing biological system (aerated equalization lagoon and trickling filters) at the Hadnot Point STP will be used for the off-site treatment of the pretreated groundwater. A long-term groundwater monitoring program will be implemented, and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

The pretreatment systems will be sized to handle a maximum flow of 160 gpm. Approximately 1.5 miles of the existing sanitary sewer pipeline will require upgrading.

TABLE 4-1
DETAIL COSTING EVALUATION OF THE NO ACTION WITH INSTITUTIONAL CONTROLS ALTERNATIVE

ANNUAL GROUNDWATER MONITORIING COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COS ($)	BASIS OR COMMENTS	SOURCE
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	120	21	2520		32 hr per quarter	Engineering estimate
Technician	Hour	160	13	2080		40 hr per quarter	
Lab analysis	Sample	80	400	32000		20 samples/qtr @$400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
Total Annual O&M Costs					$54,080		

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.3.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 3 will provide overall protection to human health and the environment because the constituents of concern will be removed from the aquifer and treated.

Compliance With ARARs

Alternative 3 will potentially meet the chemical-specific ARARs (the Federal and North Carolina MCLs) for the VOCs and inorganics. The action-specific ARAR (NPDES permit) will also be met. No location-specific ARARs are associated with this alternative.

Long-Term Effectiveness and Permanence

After the remedial action is completed, there should be no residual risks remaining at the site with respect to the shallow aquifer since the source of contamination will be removed and treated.

It is likely that the pretreatment and biological treatment technologies associated with this alternative will meet the required performance specifications. All of the technologies are proven and commercially used.

As with most equipment, there is a potential that the extraction well/pump equipment and the pretreatment equipment may need replaced after a period of years (may assume that the equipment is replaced once during the remediation effort). In addition, the integrity of the sanitary sewer lines will need monitored. It is highly possible that sections of the lines will need upgraded or replaced during the remediation effort. During any replacement activities, the extraction/treatment system would have to be shut down. Minimal risks would be expected to occur during these inoperable times.

Reduction of Toxicity, Mobility, or Volume

The treatment process associated with this alternative directly addresses the principal threats from the shallow aquifer. The majority of the extent of VOC contamination within the shallow aquifer is anticipated to be removed and treated with this alternative. Therefore, a significant reduction in toxicity, mobility, and volume of toxic contaminants is expected. Since the contaminated groundwater is extracted from the shallow aquifer, this alternative would be irreversible. A very limited amount of residuals are expected to remain within the aquifer at the completion of the remedial action.

Short-Term Effectiveness

There will be limited risks to the community during the remedial actions associated with this alternative. The pretreatment equipment will be closed or equipped with emission control devices, if necessary. If required, the biological systems at the Hadnot Point STP will be equipped with emission control devices (this is not anticipated to be needed).

Risk to workers will be limited to VOC emissions. These will be addressed as discussed above.

There are no environmental impacts anticipated to be associated with implementing this alternative.

It is anticipated that once implemented, the alternative will immediately start to reduce the levels of contaminants in the shallow aquifer. The time until the remedial response objectives (MCLs) are achieved are estimated to be several years, most likely longer than 10 years.

Implementability

Technically, the Biological STP Treatment Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, and associated piping to connect the units to the sanitary sewer system. The biological system already exists at the Hadnot Point STP. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. The existing sanitary sewer lines would require upgrading and/or replacement.

Once in operation, the maintenance of the treatment units associated with this alternative should not be labor intensive. Items of concern would be the extraction pumps and the pretreatment system.

In terms of administrative feasibility, this alternative will require coordination with other agencies such as for the NPDES permit and possible for air permits. The Hadnot Point STP may need to obtain either a new NPDES permit or a modified permit to allow for the treatment and discharge of the additional waste stream from the HPIA Site. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer.

No problems with the availability of the extraction wells or pumps, the pretreatment equipment, or laboratory services and any associated materials are anticipated.

Cost

The estimated capital costs associated with the Biological STP Treatment Alternative is approximately $1,275,000. Operation and maintenance (O&M) costs of approximately $334,000 annually are projected for the operation of the treatment system and the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of $6.9 Million. Table 4-2 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative removes and treats the constituents of concern, and reduces the migration of the contaminated groundwater plumes, it is expected that both the EPA and the State will be in favor of this alternative.

Community Acceptance

It is expected that the community will be in favor of this type of alternative for the same reasons as stated above.

TABLE 4-2
DETAIL COSTING EVALUATION OF THE BIOLOGICAL STP TREATMENT ALTERNATIVE

CAPITAL COST ESTIMATE 4/8/92

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump sum	1	15000	15000			Other feasibility studies
Miscellaneous	Lump sum	1	10000	10000		Utilities hook up, site preparation	Other feasibility studies
					25000		
Extraction Well System							
Drill Rig Mobilization	Lump sum	1	2000	2000			Other feasibility studies
Wells	Each	8	1250	10000		4-inch wells, 25-ft deep @ $50/LF	Other feasibility studies
Pumping Equipment	Each	8	4000	32000		1/2HP submersible pumps	MEANS Construction Cost Data, 1988 '026-704-1510
Surface Infrastructure	Per well	8	4000	32000		Connect to treatment system	Engineering Estimate
					76000	This cost incurred during years 1 through 3	
Treatment Equipment							
Site Office/Lab	Lump sum	1	34300	34300		50'x 12' trailer ($14300) + lab equip/furniture ($20000)	MEANS Construction Cost Data, 1991
Onsite pretreatment systems (80 gpm)	Lump sum	2	206000	412000			
Onsite storage tanks and transfer facilities	Lump sum	2	50000	100000			EPA/625/6-85/006
Ancillary piping/equip/and startup	Lump sum	2	20600	41200		Engineering Estimate	
					587500		
Sewer Line Rebilitation	Per foot	8000	30	240000	240000		MEANS Construction Cost Data, 1991
Demobilization							
Administrative Activities	Lump sum	1	10000	10000		Administration/reporting/etc	Other feasibility studies
Site Restoration	Lump sum	1	5000	5000			Engineering Estimate
					15000		
Subtotal Capital Cost					943500		
Engineering @ 10%				94350			
Contingencies @ 20%				188700			
Pilot Studies @ 5%				47175			
Total Capital Cost					1273725		

TALBLE 4-2 (CONTINUED)
DETAIL COSTING EVALUATION OF THE BIOLOGICAL STP TREATMENT ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
System Operation							
Extraction well system	Per well	12	1000	12000			Engineering estimate
Pretreatment and transfer system	Per year	2	55000	110000			EPA/625/6-85/006
Sludge dewatering system	Per year	2	15000	30000			
Misc.	Per month	12	250	3000			Engineering estimate
Oversite of system	Per hour	12	1600	19200		1 operator @ $25/hr x 96 hr/mo	Engineering estimate
					174200		
Contract cost for liquid disposal	Gallon	0	0.01	0	0	Treatment cost @ $0.01/gall	Engineering Estimate
Effluent Sampling							
Labor	Hours	0	0	0		Collected by operators	Engineering estimate
Lab analysis	Samples	56	200	11200		1 sample/week + 1 sample/quarte	Engineering estimate
Reporting	Lump sum	4	1500	6000		Laboratory reports, etc.	Engineering estimate
					17200		
Miscellaneous							
Decontamination activities	Week	52	200	10400		Protective clothing, decontaminat etc.	Engineering estimate
Health and safety officer	Month	12	3500	42000		H&S officer for 4 days/mo @ $50/ plus expences	Engineering estimate
					52400		
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	128	21	2688		32 hr per quarter	Engineering estimate
Technician	Hour	160	13	2080		40 hr per quarter	
Lab analysis	Sample	80	400	32000		20 samples/qtr x $400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
					56768		
Total Annual O&M Costs					300568		

4.2.4 Alternative 4: Physical-Chemical Treatment (Air Stripping)/ Groundwater Collection/Pretreatment/STP Discharge

4.2.4.1 Description

In general, Alternative 4 (the Physical/Chemical Treatment-Air Stripping Alternative) includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical reduction system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

The pretreatment and physical/chemical treatment systems will be sized to handle a maximum flow of 160 gpm.

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.4.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 4 will provide overall protection to human health and the environment because the constituents of concern will be removed from the aquifer and treated.

Compliance With ARARs

Alternative 4 will potentially meet the chemical-specific ARARs (the Federal and North Carolina MCLs) for the VOCs and inorganics. The action-specific ARAR (NPDES permit and any air emission permits) will also be met. No location-specific ARARs are associated with this alternative.

Long-Term Effectiveness and Permanence

After the remedial action is completed, there should be no residual risks remaining at the site with respect to the shallow aquifer since the source of contamination will be removed and treated.

It is likely that the pretreatment and air stripping technologies associated with this alternative will meet the required performance specifications. All of the technologies are proven and commercially used.

As with most equipment, there is a potential that the extraction well/pump equipment, the pretreatment equipment and the air stripping equipment may need replaced after a period of years (may assume that the majority of the pumps and pretreatment equipment is replaced once during the remediation effort and that the air stripper will be repaired annually). In addition, the integrity of the sanitary sewer lines will need monitored. It is highly possible that sections of the lines will need upgraded or replaced during the remediation effort. During any replacement activities, the extraction/treatment system would have to be shut down. Minimal risks would be expected to occur during these inoperable times.

Reduction of Toxicity, Mobility, or Volume

The treatment process associated with this alternative directly addresses the principal threats from the shallow aquifer. The majority of the extent of VOC contamination within the shallow aquifer is anticipated to be removed and treated with this alternative. Therefore, a significant reduction in toxicity, mobility, and volume of toxic contaminants is expected. Since the contaminated groundwater is extracted from the shallow aquifer, this alternative would be irreversible. A very limited amount of residuals are expected to remain within the aquifer at the completion of the remedial action.

Short-Term Effectiveness

There will be limited risks to the community during the remedial actions associated with this alternative. All treatment equipment will be closed or equipped with emission control devices, if necessary.

Risk to workers will be limited to VOC emissions. These will be addressed as discussed above.

There are no environmental impacts anticipated to be associated with implementing this alternative.

It is anticipated that once implemented, the alternative will immediately start to reduce the levels of contaminants in the shallow aquifer. The time until the remedial response objectives (MCLs) are achieved are estimated to be several years, most likely longer than 10 years.

Implementability

Technically, the Physical/Chemical Treatment (Air Stripping) Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and the air stripping towers. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Mobile air stripping towers are readily available.

Once in operation, the maintenance of the treatment units associated with this alternative should not be extremely labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, and the air stripping towers.

In terms of administrative feasibility, this alternative will require coordination with other agencies such as for the NPDES permit and possible for air permits. The Hadnot Point STP to obtain either a new NPDES permit or a modified permit to allow for the treatment and discharge of the additional waste stream from the HPIA Site. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer.

No problems with the availability of the extraction wells or pumps, the pretreatment equipment, the air stripping units, or laboratory services and any associated materials are anticipated.

Cost

The estimated capital costs associated with the Physical/Chemical Treatment (Air Stripping) Alternative is approximately $1,012,000. Operation and maintenance (O&M) costs of approximately $393,000 annually are projected for the operation of the treatment system and the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of $7.6 Million. Table 4-3 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative removes and treats the constituents of concern, and reduces the migration of the contaminated groundwater plumes, it is expected that both the EPA and the State will be in favor of this alternative.

Community Acceptance

It is expected that the community will be in favor of this type of alternative for the same reasons as stated above.

4.2.5 Alternative 5: Physical-Chemical Treatment (Carbon Adsorption)/Groundwater Collection/Pretreatment/STP Discharge

4.2.5.1 Description

In general, Alternative 5 (the Physical/Chemical Treatment-Carbon Adsorption Alternative) includes groundwater extraction, pretreatment, on-site treatment, off-site discharge, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical reduction system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer and on the installation of new wells.

The pretreatment and physical/chemical treatment systems will be sized to handle a maximum flow of 160 gpm.

TABLE 4-3
DETAIL COSTING EVALUATION OF THE PHYSICAL/CHEMICAL (AIR STRIPPING) ALTERNATIVE

CAPITAL COST ESTIMATE 4/8/92

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump sum	1	15000	15000			Other feasibility studies
Miscellaneous	Lump sum	1	10000	10000		Utilities hook up, site preparation	Other feasibility studies
					25000		
Extraction Well System							
Drill Rig Mobilization	Lump sum	1	2000	2000			Other feasibility studies
Wells	Each	8	1250	10000		4-inch wells, 25-ft deep @ $50/LF	Other feasibility studies
Pumps	Each	8	4000	32000		Pneumatic pump with controller	Engineering estimate (vender quote)
Surface infrastructure	Per well	8	4000	32000		Connect to treatment system	Engineering Estimate
					76000	This cost incurred at the beginning of year 0,1,2,3	
Treatment Equipment							
Site Office/Lab	Lump sum	1	34300	34300		50'x 12' trailer ($14300) + lab equip/furniture ($20000)	MEANS Construction Cost Data, 1988 015-904-0500/116-001-6380
Pretreatment Systems (80 gpm)	Lump sum	2	206000	412000			
Air Stripping System (80 gpm)	Each	2	75000	150000			EPA/625/6-85/006
Ancillary piping/equip/and startup	Lump sum	1	37500	37500			Engineering Estimate
					633800		
Demobilization							
Administrative Activities	Lump sum	1	10000	10000		Administration/reporting/etc	Other feasibility studies
Site Restoration	Lump sum	1	5000	5000			Engineering Estimate
					15000		
Subtotal Capital Cost					749800		
Engineering @ 10%				74980			
Contingencies @ 20%				149960			
Pilot Studies @ 5%				37490			
Total Capital Cost					1012230		

TABLE 4-3 (CONTINUED)
DETAIL COSTING EVALUATION OF THE PHYSICAL/CHEMICAL (AIR STRIPPING) ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
System Operation							
Extraction well system	Per well	8	1000	8000			Engineering estimate
Pretreatment system	Per year	2	52000	104000			EPA/625/6-85/006
Air stripping system	Per year	2	30000	60000			EPA/625/6-87-015
Sludge dewatering system	Per year	2	15000	30000		Based on operating 40 hr/mo	EPA/625/6-85/006
Misc.	Month	12	250	3000			Engineering estimate
Oversite of system	Month	12	1600	19200		1 operator @ $25/hr x 96 hr/mo	Engineering estimate
					224200		
Effluent Sampling							
Labor	Hours	0	0	0		Collected by operators	Engineering estimate
Lab analysis	Samples	56	300	16800		1 sample/week + 1 sample/quarter	Engineering estimate
Reporting	Lump sum	1	1500	1500		Laboratory reports, etc.	Engineering estimate
					18300		
Miscellaneous							
Decontamination activities	Week	52	200	10400		Protective clothing, decontamination, etc etc.	Engineering estimate
Health and safety officer	Month	12	3500	42000		H&S officer for 4 days/mo @ $50/hr plus expences	Engineering estimate
					52400		
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	120	21	2520		32 hr per quarter	Engineering estimate
Technician	Hour	160	13	2080		40 hr per quarter	
Lab analysis	Sample	80	400	32000		20 samples/qtr @$400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
					56600		
Total Annual O&M Costs					351500		

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.5.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 5 will provide overall protection to human health and the environment because the constituents of concern will be removed from the aquifer and treated.

Compliance With ARARs

Alternative 5 will potentially meet the chemical-specific ARARs (the Federal and North Carolina MCLs) for the VOCs and inorganics. The action-specific ARAR (NPDES permit and any air emission permits) will also be met. No location-specific ARARs are associated with this alternative.

Long-Term Effectiveness and Permanence

After the remedial action is completed, there should be no residual risks remaining at the site with respect to the shallow aquifer since the source of contamination will be removed and treated.

It is likely that the pretreatment and activated carbon adsorption technologies associated with this alternative will meet the required performance specifications. All of the technologies are proven and commercially used.

As with most equipment, there is a potential that the extraction well/pump equipment, the pretreatment equipment and the GAC units may need replaced after a period of years (may assume that the majority of the pumps and pretreatment equipment is replaced once during the remediation effort, and the carbon units are repaired annually). In addition, the integrity of the sanitary sewer lines will need monitored. It is highly possible that sections of the lines will need upgraded or replaced during the remediation effort. During any replacement activities, the extraction/treatment system would have to be shut down. Minimal risks would be expected to occur during these inoperable times.

Reduction of Toxicity, Mobility, or Volume

The treatment process associated with this alternative directly addresses the principal threats from the shallow aquifer. The majority of the extent of VOC contamination within the shallow aquifer is anticipated to be removed and treated with this alternative. Therefore, a significant reduction in toxicity, mobility, and volume of toxic contaminants is expected. Since the contaminated groundwater is extracted from the shallow aquifer, this alternative would be irreversible. A very limited amount of residuals are expected to remain within the aquifer at the completion of the remedial action.

Short-Term Effectiveness

There will be limited risks to the community during the remedial actions associated with this alternative. All treatment equipment will be closed or equipped with emission control devices, if necessary.

Risk to workers will be limited to VOC emissions. These will be addressed as discussed above.

There are no environmental impacts anticipated to be associated with implementing this alternative.

It is anticipated that once implemented, the alternative will immediately start to reduce the levels of contaminants in the shallow aquifer. The time until the remedial response objectives (MCLs) are achieved are estimated to be several years, most likely longer than 10 years.

Implementability

Technically, the Physical/Chemical Treatment (Carbon Adsorption) Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and GAC units. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Packaged GAC units are readily available.

Once in operation, the maintenance of the treatment units associated with this alternative would be somewhat labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, the GAC units, and the spent carbon. More time would be required in this alternative since the spent carbon would routinely require removal and replacement.

In terms of administrative feasibility, this alternative will require coordination with other agencies such as for the NPDES permit and possible for air permits. The Hadnot Point STP to obtain either a new NPDES permit or a modified permit to allow for the treatment and discharge of the additional waste stream from the HPIA Site. Approval and/or permits from the state air pollution agency would have to be obtained because of the anticipated VOCs in the shallow aquifer.

No problems with the availability of the extraction wells or pumps, the pretreatment equipment, the carbon units, or laboratory services and any associated materials (e.g., virgin carbon) are anticipated.

Cost

The estimated capital costs associated with the Physical/Chemical Treatment (Carbon Adsorption) Alternative is approximately $935,000. Operation and maintenance (O&M) costs of approximately $400,000 annually are projected for the operation of the treatment system and the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of $7.6 Million. Table 4-4 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative removes and treats the constituents of concern, and reduces the migration of the contaminated groundwater plumes, it is expected that both the EPA and the State will be in favor of this alternative.

TABLE 4-4
DETAIL COSTING EVALUATION OF THE PHYSICAL/CHEMICAL (CARBON ABSORPTION) ALTERNATIVE

CAPITAL COST ESTIMATE 4/8/92

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump sum	1	15000	15000			Other feasibility studies
Miscellaneous	Lump sum	1	10000	10000		Utilities hook up, site preparation	Other feasibility studies
					25000		
Extraction Well System							
Drill Rig Mobilization	Lump sum	1	2000	2000			Other feasibility studies
Wells	Each	8	1250	10000		4-inch wells, 25-ft deep @ $50/LF	Other feasibility studies
Pumps	Each	8	4000	32000		Pneumatic pump with controller	Engineering estimate (vender quote)
Surface infrastructure	Per well	8	4000	32000		Connect to treatment system	Engineering Estimate
					76000	This cost incurred at the beginning of year 0,1,2,3	
Treatment Equipment							
Site Office/Lab	Lump sum	1	34300	34300		50'x 12' trailer ($14300) + lab equip/furniture ($20000)	MEANS Construction Cost Data, 1988 015-904-0500/116-001-6380
Pretreatment Systems (80 gpm)	Lump sum	2	206000	412000			EPA/625/6-85/006
Carbon Adsorption system (80 gpm)	Each	2	52000	104000			EPA/625/6-85/006
Ancillary piping/equip/and startup	Lump sum	1	26000	26000			Engineering Estimate
					576300		
Demobilization							
Administrative Activities	Lump sum	1	10000	10000		Administration/reporting/etc	Other feasibility studies
Site Restoration	Lump sum	1	5000	5000			Engineering Estimate
					15000		
Subtotal Capital Cost					692300		
Engineering @ 10%				69230			
Contingencies @ 20%				138460			
Pilot Studies @ 5%				34615			
Total Capital Cost					934605		

TABLE 4-4 (CONTINUED)
DETAIL COSTING EVALUATION OF THE
PHYSICAL/CHEMICAL (CARBON ABSORPTION) ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
System Operation							
Extraction well system	Per well	8	1000	8000			Engineering estimate
Carbon adsorption system	Per year	2	7000	14000			EPA/625/6-87-015
Carbon replacement	Per year	2	20000	40000		20000 lb of carbon @ $1/lb	Engineering estimate
Pretreatment system	Per year	2	55000	110000			EPA/625/6-85/006
Sludge dewatering system	Per year	2	15000	30000		Based on operating 40 hr/mo	EPA/625/6-85/006
Misc.	Month	12	250	3000			Engineering estimate
Oversite of system	Month	12	2400	28800		1 operator @ $25/hr x 96 hr/mo	Engineering estimate
					233800		
Effluent Sampling							
Labor	Hours	0	0	0		Collected by operators	Engineering estimate
Lab analysis.	Samples	56	300	16800		1 sample/week + 1 sample/quarter	Engineering estimate
Reporting	Lump sum	1	1500	1500		Laboratory reports, etc.	Engineering estimate
					18300		
Miscellaneous							
Decontamination activities	Week	52	200	10400		Protective clothing, decontamination, etc etc.	Engineering estimate
Health and safety officer	Month	12	3500	42000	52400	H&S officer for 4 days/mo @ $50/hr plus expences	Engineering estimate
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	128	21	2688		32 hr per quarter	Engineering estimate
Technician	Hour	160	13	2080		40 hr per quarter	
Lab analysis	Sample	80	400	32000		20 samples/qtr @ $400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
					56768		
Total Annual O&M Costs					361268		

Community Acceptance

It is expected that the community will be in favor of this type of alternative for the same reasons as stated above.

4.2.6 Alternative 6: Thermal Treatment/Groundwater Collection/Pretreatment

4.2.6.1 Description

In general, Alternative 6 (the Thermal Treatment Alternative) includes groundwater extraction, pretreatment, on-site treatment, discharge to surface water body, long-term groundwater monitoring, and institutional controls. The pretreatment system will consist of an oil/water gravity separator and an inorganic chemical reduction system (the same as for Alternative 3). In addition, a long-term groundwater monitoring program will be implemented and restrictions will be placed on the use of the shallow aquifer including the installation of new wells.

The pretreatment systems will be sized to handle a maximum flow of 160 gpm. The thermal treatment system will be sized to handle a maximum flow of 160 gpm.

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.6.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 6 will provide overall protection to human health and the environment because the constituents of concern will be removed from the aquifer and treated.

Compliance With ARARs

Alternative 6 will potentially meet the chemical-specific ARARs (the Federal and North Carolina MCLs) for the VOCs and inorganics. The action-specific ARAR (NPDES permit and any air emission permits) will also be met. No location-specific ARARs are associated with this alternative.

Long-Term Effectiveness and Permanence

After the remedial action is completed, there should be no residual risks remaining at the site with respect to the shallow aquifer since the source of contamination will be removed and treated.

It is likely that the pretreatment and the incinerator technologies associated with this alternative will meet the required performance specifications. All of the technologies are proven and commercially used.

As with most equipment, there is a potential that the extraction well/pump equipment, the pretreatment equipment and the incinerator may need replaced or repaired after a period of years (may assume that the majority of the pumps and pretreatment equipment is replaced once during the remediation effort and that the incinerator is repaired annually). In addition, the integrity of the sanitary sewer lines will need monitored. It is highly possible that sections of the lines will need upgraded or replaced during the remediation effort. During any replacement activities, the extraction/treatment system would have to be shut down. Minimal risks would be expected to occur during these inoperable times.

Reduction of Toxicity, Mobility, or Volume

The treatment process associated with this alternative directly addresses the principal threats from the shallow aquifer. The majority of the extent of VOC contamination within the shallow aquifer is anticipated to be removed and treated with this alternative. Therefore, a significant reduction in toxicity, mobility, and volume of toxic contaminants is expected. Since the contaminated groundwater is extracted from the shallow aquifer, this alternative would be irreversible. A very limited amount of residuals are expected to remain within the aquifer at the completion of the remedial action.

Short-Term Effectiveness

There will be limited risks to the community during the remedial actions associated with this alternative. All treatment equipment will be closed or equipped with emission control devices, if necessary.

Risk to workers will be limited to VOC emissions. These will be addressed as discussed above.

There are no environmental impacts anticipated to be associated with implementing this alternative.

It is anticipated that once implemented, the alternative will immediately start to reduce the levels of contaminants in the shallow aquifer. The time until the remedial response objectives (MCLs) are achieved are estimated to be several years, most likely longer than 10 years.

Implementability

Technically, the Thermal Treatment Alternative should be relatively easy to implement. Construction activities would include the installation of extraction wells and pumps, pretreatment units, associated piping to connect the units to the sanitary sewer system, and the liquid injection incinerator. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. The pretreatment equipment is readily available in packaged units. Sufficient time would be required for assembling the units together and connecting them to the sewer system. Liquid injection incinerators are commercially available, although they are not as readily available as air strippers or activated carbon units.

Once in operation, the maintenance of the treatment units associated with this alternative would be somewhat labor intensive. Items of concern would be the extraction pumps, the pretreatment systems, and the incinerator. Operation and maintenance of the incinerator would require more manpower than with air strippers or activated carbon units.

In terms of administrative feasibility, this alternative will require coordination with other agencies such as for approval and/or permits from the state air pollution agency because of the anticipated VOCs in the shallow aquifer.

No problems with the availability of the extraction wells or pumps, the pretreatment equipment, or laboratory services and any associated materials are anticipated. The availability of a packaged liquid injection incinerator may present a problem.

Cost

The estimated capital cost associated with the Thermal Treatment Alternative is approximately $1.5 million. Operation and maintenance (O&M) costs of approximately $627,000 annually are projected for the operation of the treatment system and the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of $11.8 million. Table 4-5 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative removes and treats the constituents of concern, and reduces the migration of the contaminated groundwater plumes, it is expected that both the EPA and the State will be in favor of this alternative.

Community Acceptance

It is expected that the community will be in favor of this type of alternative for the same reasons as stated above.

4.2.7 Alternative 7: Treatment at RCRA Facility/Groundwater Collection

4.2.7.1 Description

Alternative 7 (the RCRA Facility Alternative) includes groundwater extraction and treatment of the water at an off-site RCRA-approved facility. The alternative also includes a long-term groundwater monitoring program and restrictions placed on the use of the shallow aquifer and on the installation of new wells.

The pretreatment systems will be sized to handle a maximum flow of 160 gpm.

TABLE 4-5
DETAIL COSTING EVALUATION OF THE THERMAL TREATMENT ALTERNATIVE

CAPITAL COST ESTIMATE 4/8/92

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump sum	1	15000	15000			Other feasibility studies
Miscellaneous	Lump sum	1	10000	10000		Utilities hook up, site preparation	Other feasibility studies
					25000		
Extraction Well System							
Drill Rig Mobilization	Lump sum	1	2000	2000			Other feasibility studies
Wells	Each	8	1250	10000		4-inch wells, 25-ft deep @ $50/LF	Other feasibility studies
Pumping equipment	Each	8	4000	32000		Pneumatic pump with controller	Engineering Estimate (vender quote)
Surface infrastructure	Per well	8	4000	32000		Connect to treatment system	Engineering Estimate
					76000	This cost incurred at the beginning of yea year 0,1,2,3	
Treatment Equipment							
Site Office/Lab	Lump sum	1	34300	34300		50'x 12' trailer ($14300) + lab equip/furniture ($20000)	MEANS Construction Cost Data, 1988 015-904-0500/116-001-6380
Liquid injection incinerator	Lump sum	1	868000	868000		Vender supplied system	EPA/625/6-85/006
Ancillary piping/equip/and startup	Lump sum	1	86800	86800			
					989100		
Demobilization							
Administrative Activities	Lump sum	1	10000	10000		Administration/reporting/etc	Other feasibility studies
Site Restoration	Lump sum	1	5000	5000			Engineering Estimate
					15000		
Subtotal Capital Cost					1105100		
Engineering @ 10%				110510			
Contingencies @ 20%				221020			
Pilot Studies @ 5%				55255			
Total Capital Cost					1491885		

TABLE 4-5 (CONTINUED)
DETAIL COSTING EVALUATION OF THE THERMAL TREATMENT ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
System Operation							
Extraction well system	Per well	8	1000	8000			Engineering estimate
Incineration system	Per year	1	431000	431000		Includes labor, fuel, electric power ash disposal,waste analysis,insurance, maintenance, depreciation	EPA/625/6-85/006
Misc.	Month	12	250	3000			Engineering estimate
Oversite of systen	Month	12	2400	28800		1 operator @ $25/hr x 96 hr/mo	Engineering estimate
					442000		
Effluent Sampling							
Labor	Hours	0	0	0		Collected by operators	Engineering estimate
Lab analysis	Samples	56	300	16800		1 sample/week + 1 sample/quarter	Engineering estimate
Reporting	Lump sum	1	1500	1500		Laboratory reports, etc.	Engineering estimate
					18300		
Miscellaneous							
Decontamination activities	Week	52	200	10400		Protective clothing, decontamination, etc etc.	Engineering estimate
Health and safety officer	Month	12	3500	42000	52400	H&S officer for 4 days/mo @ $50/hr plus expences	Engineering estimate
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	128	21	2688		32 hr per quarter	Engineering estimate
Technician	Hour	160	13	2080		40 hr per quarter	Engineering estimate
Lab analysis	Sample	80	400	32000		20 samples/qtr @ $400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
					56768		
Total Annual O&M Costs					569468		

The long-term monitoring program will consist of sampling and analyzing the groundwater from 20 existing monitoring wells at the site. The samples will be analyzed for the constituents of concern at the site which include VOCs and inorganics. This monitoring will be conducted on a quarterly basis over a 30 year duration.

4.2.7.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 7 will provide overall protection to human health and the environment because the constituents of concern will be removed from the aquifer and treated off site.

Compliance With ARARs

Alternative 7 will potentially meet the chemical-specific ARARs (the Federal and North Carolina MCLs) for the VOCs and inorganics. The action-specific ARAR (any air emission permits) will also be met. The location-specific ARARs (RCRA-related regulations for the transportation of wastes) will be met by this alternative.

Long-Term Effectiveness and Permanence

After the remedial action is completed, there should be no residual risks remaining at the site with respect to the shallow aquifer since the source of contamination will be removed and treated off site.

In terms of the adequacy and reliability, the extraction well/pump systems (the only on-site controls associated with the RCRA Facility Alternative) should provide adequate and reliable analytical results. As with most equipment, there is a potential that the extraction well system may need replaced or repaired after a period of years (may assume that the pumps will be replaced once during the remediation). During any replacement activities, the extraction/treatment system would have to be shut down. Minimal risks would be expected to occur during these inoperable times.

Reduction of Toxicity, Mobility, or Volume

The treatment process associated with this alternative directly addresses the principal threats from the shallow aquifer. The majority of the extent of VOC contamination within the shallow aquifer is anticipated to be removed and treated with this alternative. Therefore, a significant reduction in toxicity, mobility, and volume of toxic contaminants is expected. Since the contaminated groundwater is extracted from the shallow aquifer, this alternative would be irreversible. A very limited amount of residuals are expected to remain within the aquifer at the completion of the remedial action.

Short-Term Effectiveness

There will be limited risks to the community during the remedial actions associated with this alternative. Transportation of the groundwater will be in compliance with all applicable RCRA and Department of Transportation regulations.

Risk to workers will be limited to VOC emissions during extraction and loading activities.

There are no environmental impacts anticipated to be associated with implementing this alternative.

It is anticipated that once implemented, the alternative will immediately start to reduce the levels of contaminants in the shallow aquifer. The time until the remedial response objectives (MCLs) are achieved are estimated to be several years, most likely longer than 10 years.

Implementability

Technically, the RCRA Facility Alternative should be easy to implement. Construction activities would only include the installation of extraction wells and pumps. The extraction wells should be easy to install since numerous groundwater monitoring wells have previously been installed at the site. This alternative would require limited maintenance time; mainly for the extraction system.

In terms of administrative feasibility, this alternative will require coordination with other agencies such as the Department of Transportation for the off-site transportation of the extracted groundwater. EPA and State approval of the off-site treatment facility would also be required.

No problems with the availability of the extraction wells or pumps, or laboratory services and any associated materials are anticipated. The availability and capacity of the closed RCRA facility may present a problem in implemented this alternative in a timely manner.

Cost

The estimated capital costs associated with the RCRA Facility Treatment Alternative is approximately $880,000. Operation and maintenance (O&M) costs of approximately $4.2 million annually are projected for the transporting and treating of the groundwater and the sampling of 20 existing monitoring wells. Assuming a monitoring period of 30 years and an annual percentage rate of 5%, this equates to a net present worth of $68.9 million. Table 4-6 presents the details of this cost estimate.

EPA/State Acceptance

Since this alternative removes and treats the constituents of concern, and reduces the migration of the contaminated groundwater plumes, it is expected that both the EPA and the State will be in favor of this alternative.

Community Acceptance

It is expected that the community will be in favor of this type of alternative for the same reasons as stated above.

4.3 Comparative Analysis

This FS has identified and evaluated a limited range of remedial action alternatives potentially applicable to the shallow aquifer at the HPIA Site. Table 4-7 presents a summary of this evaluation. A comparative analysis in which the alternatives are evaluated in relation to one another with respect to each of the nine evaluation criteria is presented below. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative.

TABLE 4-6
DETAIL COSTING EVALUATION OF THE RCRA FACILITY ALTERNATIVE

CAPITAL COST ESTIMATE 4/8/92

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump sum	1	15000	15000			Other feasibility studies
Miscellaneous	Lump sum	1	10000	10000		Utilities hook up, site preparation	Other feasibility studies
					25000		
Extraction Well System							
Drill Rig Mobilization	Lump sum	1	2000	2000			Other feasibility studies
Wells	Each	8	1250	10000		4-inch wells, 25-ft deep @ $50/LF	Other feasibility studies
Pumping Equipment	Each	8	4000	32000		1/2HP submersible pumps	MEANS Construction Cost Data, 1988 '026-704-1510
Surface Infrastructure	Per well	8	4000	32000		Connect to treatment system	Engineering Estimate
					76000	This cost incurred during years 1 through 3	
Treatment Equipment							
Site Office/Lab	Lump sum	1	34300	34300		50'x 12' trailer ($14300) + lab equip/furniture ($20000)	MEANS Construction Cost Data, 1988 015-904-0500/116-001-6380
Onsite storage tanks and transfer facilities	Lump sum	1	400000	400000			EPA/625/6-85/006
Ancillary piping/equip/and startup	Lump sum	1	100000	100000		Engineering Estimate	
					534300		
Demobilization							
Administrative Activities	Lump sum	1	10000	10000		Administration/reporting/etc	Other feasibility studies
Site Restoration	Lump sum	1	5000	5000			Engineering Estimate
					15000		
Subtotal Capital Cost					650300		
Engineering @ 10%				65030			
Contingencies @ 20%				130060			
Pilot Studies @ 5%				32515			
Total Capital Cost					877905		

TABLE 4-6 (CONTINUED)
DETAIL COSTING EVALUATION OF THE RCRA FACILITY ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST ($)	TOTAL COST ($)	BASIS OR COMMENTS	SOURCE
System Operation							
Extraction well system	Per well	12	1000	12000			Engineering estimate
Liquid storage and transfer system	Per year	1	60000	60000			EPA/625/6-85/006
Misc.	Per month	12	250	3000			Engineering estimate
Oversite of system	Per hour	1000	25	25000		1 operator @ $25/hr x 32 hr/mo	Engineering estimate
					100000		
Contract cost for liquid disposal	Gallon	80000000	0.05	4000000	4000000	Treatment cost @ $.05/gall	Engineering Estimate
Effluent Sampling							
Labor	Hours	0	0	0		Collected by operators	Engineering estimate
Lab analysis	Samples	56	300	16800		1 sample/week + 1 sample/quarte	Engineering estimate
Reporting	Lump sum	1	1500	1500		Laboratory reports, etc.	Engineering estimate
					18300		
Miscellaneous							
Decontamination activities	Week	52	200	10400		Protective clothing, decontaminat etc.	Engineering estimate
Health and safety officer	Month	12	3500	42000		H&S officer for 4 days/mo @ $50/ plus expences	Engineering estimate
					52400		
Quarterly Groundwater Monitoring							
Labor: Geologist	Hour	120	21	2520		32 hr/qtr x4 qtr	Engineering estimate
Technician	Hour	160	13	2080		40 hr/qtr x 4 qtr	Engineering estimate
Lab analysis	Sample	80	400	32000		20 samples/qtr x $400/sample	Engineering estimate
Misc.	Trip	4	2000	8000		Sampler's travel & expences	Engineering estimate
Reporting	Each	4	3000	12000		1report/quarter @ $3000/report	Engineering estimate
					56600		
Total Annual O&M Costs					4227300		

TABLE 4-7

SUMMARY OF DETAILED ANALYSIS

	Alternative 1: No Action	Alternative 2: No Action with Institutional Controls	Alternative 3: Biological STP Treatment	Alternative 4: Physical/Chemical Treatment (Air Stripping)
Overall Protection of Human Health and the Environment	Not protective of human health or the environment.	Not protective of human health or the environment.	Protective of human health and the environment.	Protective of human health and the environment.
Compliance with ARARs	Will potentially exceed federal and state MCLs.	Will potentially exceed federal and state MCLs.	Will potentially meet ARARs.	Will potentially meet ARARs.
Long-Term Effectiveness and Permanence	Not an effective or permanent alternative.	Not an effective or permanent alternative.	Effective and permanent alternative.	Effective and permanent alternative.
Reduction of Toxicity, Mobility, or Volume	No reduction in toxicity, mobility, or volume anticipated.	No reduction in toxicity, mobility, or volume anticipated.	Significant reduction of toxicity, mobility and volume.	Significant reduction of toxicity, mobility and volume.
Short-Term Effectiveness	No risks to workers or community via implementation. No short-term effectiveness.	No risks to workers or community via implementation. No short-term effectiveness.	Limited risks during implementation. Immediate effectiveness.	Limited risks during implementation. Immediate effectiveness.
Implementability	Easy to implement no actions.	Easy to implement the monitoring wells already exist.	Relatively easy to implement - existing STP at Hadnot Point.	Relatively easy to implement - equipment readily available.
Costs	No capital or O&M cost.	Capital: Minimal O&M: $60,000 annually Present Worth (PW): $970,000	Capital: $1.28M O&M: $334,000 annually PW: $6.9M	Capital: $1.0M O&M: $393,000 annually PW: $7.6M
EPA/State Acceptance	Not expected to be favorable.	Not expected to be favorable.	Expected to be favorable.	Expected to be favorable.
Community Acceptance	Not expected to be favorable.	Not expected to be favorable.	Expected to be favorable.	Expected to be favorable.

TABLE 4-7

SUMMARY OF DETAILED ANALYSIS

	Alternative 5: Physical/Chemical Treatment (Carbon Adsorption)	Alternative 6: Thermal Treatment	Alternative 7: RCRA Facility
Overall Protection of Human Health and the Environment	Protective of human health and the environment.	Protective of human health and the environment.	Protective of human health and the environment.
Compliance with ARARs	Will potentially meet ARARs.	Will potentially meet ARARs.	Will potentially meet ARARs.
Long-Term Effectiveness and Permanence	Effective and permanent alternative.	Effective and permanent alternative.	Effective and permanent alternative.
Reduction of Toxicity, Mobility, or Volume	Significant reduction of toxicity, mobility and volume.	Significant reduction of toxicity, mobility and volume.	Significant reduction of toxicity, mobility and volume.
Short-Term Effectiveness	Limited risks during implementation. Immediate effectiveness.	Limited risks during implementation. Immediate effectiveness.	Limited risks during implementation. Immediate effectiveness.
Implementability	Relatively easy to implement - existing STP at Hadnot Point.	Should be relatively easy to implement - dependent on availability of packaged liquid injection incinerator.	May be relatively easy to implement - dependent on capacity and location of appropriate RCRA facility.
Costs	Capital: $935,000 O&M: $400,000 annually PW: $7.6M	Capital: $1.5M O&M: $627,000 annually PW: $11.8M	Capital: $880,000 O&M: $4.2M PW: $68.9M
EPA/State Acceptance	Expected to be favorable.	Expected to be favorable.	Expected to be favorable.
Community Acceptance	Expected to be favorable.	Expected to be favorable.	Expected to be favorable.

4.3.1 Overall Protection of Human Health and the Environment

All of the alternatives, except the two no action alternatives (Alternatives 1 and 2) provide adequate protection of human health and the environment. Alternatives 3 through 7 prevent further migration of the contaminated shallow aquifer by extracting and treating the plumes to drinking water levels.

4.3.2 Compliance with ARARs

All of the alternatives, except for Alternatives 1 and 2 will meet their respective ARARs (chemical-specific and action-specific). There are no known location-specific ARARs for the shallow aquifer.

4.3.3 Long-Term Effectiveness and Permanence

All of the alternatives with the exception of Alternatives 1 and 2 provide long-term effectiveness and permanence because they use treatment technologies to reduce hazards posed by the contaminants of concern within the shallow aquifer.

The long-term effectiveness and permanence of the two no action alternatives is uncertain. Natural biodegradation and attenuation processes may occur which may reduce the contaminants within the aquifer.

4.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Once again, all of the alternatives with exception to the two no action alternatives will provide reduction of toxicity, mobility and/or volume of contaminants in the groundwater in the shallow aquifer.

The two no action alternatives do not use any treatment technologies. All of the contaminants in the shallow aquifer would remain; only the actions of natural biodegradation and attenuation will occur.

4.3.5 Short-Term Effectiveness

All of the alternatives with the exception for the no action alternatives will provide short-term effectiveness and present less risk to workers, the community, and the environment.

The time require to implement each of the "treatment" alternatives would be relatively similar. All of these alternatives have similar potential of releasing VOCs to the atmosphere during extraction operations. Only the on-site treatment alternatives (Alternatives 4, 5, and 6) would have an additional potential of VOC emissions. Each of these same alternatives have the disadvantage of requiring on-site treatment equipment which could increase the risk to workers in the event of a failure. Alternative 6 would have the highest degree of potential risk since it consists of incineration equipment. Careful implementation of standard safety protocols would lessen this risk.

4.3.6 Implementability

All of the alternatives, in terms of technical feasibility, should be relatively easy to implement. The easiest to implement would be the No Action Alternative. The most difficult to implement would be either the Alternative 6 or 7 due to the unpredicted availability of either treatment equipment required for Alternative 6 or the capacity at an appropriate facility for Alternative 7.

In addition, Alternative 6 includes incineration equipment, the most technically complex equipment of any of the alternatives. Construction requirements for the other treatment alternatives are fairly simple.

4.3.7 Cost

In terms of present worth costs, the two no action alternatives (Alternatives 1 and 2) would be the least expensive alternatives to implement. Alternative 3, the Biological Treatment at the STP Alternative, has the lowest present worth cost of all of the treatment alternatives. Alternatives 4 and 5 have relatively similar present worth costs. Alternative 6 has the second to highest present worth cost because of the expense to construct and operate an on-site incinerator. Alternative 7 has the highest present worth cost due to the fact that it is an off-site treatment alternative and has high transportation costs.

4.3.8 EPA/State Acceptance

To be addressed in the ROD.

4.3.9 Community Acceptance

To be addressed in the ROD.

5.0 REFERENCES

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APPENDIX A

SUMMARY OF EXISTING ANALYTICAL DATA - SHALLOW AQUIFER

TABLE 4-1
CONSTITUENTS DETECTED IN GROUNDWATER
TANK FARM AREA

WELL NUMBER	22GW1				22GW2				STANDARDS NORTH CAROLINA*	STANDARDS PRIMARY MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/9/87	3/8/87	5/27/87	1/18/91	1/9/8	3/8/8	5/27/87	1/18/91	ug/L	ug/L
VOLATILES:										
Benzene	12000	10000	13000	7900	< 1	< 1	< 1	< 5	1	5
Dichloroethane,1,2-	< 28	< 2800	< 2800	110 B	< 3	< 3	< 3	< 5	0.38	5
Ethyl benzene	1800	< 7200	< 7200	1900 J	< 7	< 7	< 7	< 5	29	700
Methylene chloride	< 28	< 2800	< 50000	5 U	7	< 3	< 50	< 5	5	5(1)
Trichloroethylene	< 30	< 1000	< 1000	5 J	< 1	< 3	< 1	< 5	2.8	5
Toluene	15000	18000	24000	16000	< 6	< 6	< 6	< 5	1000	1000
Xylene (total)	9000	< 12000	< 12000	9800	< 12	< 12	< 12	< 5	400	10000
SEMIVOLATILES:										
Methylnaphthalene,2-	NA	NA	NA	10 J	NA	NA	NA	< 10	-	-
Methylphenol,2-	NA	NA	NA	230	NA	NA	NA	< 10	-	-
Naphthalene	NA	NA	NA	28	NA	NA	NA	< 10	-	-
Oil & Grease	7000	11000	9000	NA	800	< 100	< 200	NA	-	-
Total Lead	33	29	78	307	28	< 27	< 49.2	16.2	50	15(2)
INORGANICS:										
Aluminum	NA	NA	NA	587000	NA	NA	NA	16900	-	-
Antimony				20.9 B				13.3 U	-	10/5(3)
Arsenic				50.3				11	50	50
Barium				804				67 B	1000	2000
Beryllium				5.8				0.5 U	-	1(1)
Calcium				33800				127000	-	-
Chromium				457				26.3	50	100
Cobalt				30.9 B				10.9 B	-	-
Copper				81.4				11.2 B	1000	1300(2)
Iron				101000				16200	300	-
Mercury				0.35				0.1 U	1.1	2
Nickel				186				17 B	150	100(1)
Potassium				24000				3030 B	-	-
Selenium				3.4 U				4.2 B	10	50
Silver				4.1 B				1.6 U	50	50(4)
Sodium				9560				8570	-	-
Vanadium				518				40.3 B	-	-
Zinc				295				91.8	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
< - Less than detection limit
1 - Proposed maximum contaminant level (MCL)
2 - MCL is Action Level for Public Water Supply Systems, effective November 6, 1991.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 4-2
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1709 AND 1710

WELL NUMBER	HPGW1				HPGW2				HPGW3				STANDARDS NORTH CAROLINA*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L				ug/L				ug/L	ug/L
DATE SAMPLED	1/9/87	3/8/87	5/27/8	1/18/91	1/9/87	3/8/87	5/27/8	1/18/91	1/9/87	3/8/87	5/27/8	1/18/91		
VOLATILES:														
Acetone	NA	NA	NA	10 J	NA	NA	NA	10 U	NA	NA	NA	10 U	-	-
Benzene	43	3.9	< 1	5 U	12	< 1	< 1	5 U	1.4	< 1	< 1	5 U	1	5
Chloromethane	< 4.3	< 4.3	< 4.3	10 U	5	< 4.3	< 4.3	10 U	< 4.3	< 4.3	< 4.3	10 U	-	'-
Dichloroethylene, trans-1,2-	< 1.6	< 1.6	< 1.6	N/A	< 1.6	< 1.6	< 1.6	NA	< 1.6	< 1.6	< 1.6	NA	-	100
Dichloroethylene, (total),1,2-	NA	NA	NA	73	NA	NA	NA	5 U	NA	NA	NA	5 U	-	-
Ethyl benzene	12	< 7.2	< 7.2	5 U	< 7.2	< 7.2	< 7.2	5 U	8.2	9	< 7.2	5 U	29	700
Methylene chloride	< 2.8	< 2.8	< 50	5 U	< 2.8	< 2.8	< 50	5 U	< 2.8	< 2.8	< 50	5 U	5	5 (1)
Trichloroethylene	< 3	< 3	< 1	91	< 3	< 3	< 1	5 U	< 3	< 3	< 1	5 U	2.8	5
Toluene	100	12	< 6	5 U	38	< 6	< 6	5 U	< 6	< 6	< 6	5 U	1000	1000
Trichloroethane, 1,1,1-	< 3.8	< 3.8	< 3.8	5 U	< 3.8	< 3.8	< 3.8	5 U	< 3.8	13	< 3.8	5 U	200	200
Xylene (total)	62	< 12	< 12	5 U	28	< 12	< 12	5 U	< 12	< 12	< 12	5 U	400	10000
Oil & Grease	700	< 100	< 200	NA	700	< 100	< 200	NA	800	200	< 200	NA	-	-
Total Lead	27	< 27	< 49.2	16.6	< 27	< 27	< 49.2	29.4	40	< 27	< 49.2	11.4	50	15 (2)

NOTES:
* - North Carolina water quality criteria for groundwater.
< - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed maximum contaminant level (MCL)
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of July 30, 1992 silver will no longer have a primary MCL,its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-2 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1709 AND 1710

WELL NUMBER	HPGW1				HPGW2				HPGW3				STANDARDS NORTH CAROLINA*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L				ug/L					
DATE SAMPLED	1/9/87	3/8/87	5/27/8	1/18/91	1/9/87	3/8/87	5/27/8	1/18/91	1/9/87	3/8/87	5/27/8	1/18/91	ug/L	ug/L
INORGANICS:														
Aluminum	NA	NA	NA	30600	NA	NA	NA	56000	NA	NA	NA	19300	-	-
Antimony				13.3 U				15.6 B				46.5 B	-	10/5(3)
Arsenic				8 B				24.1				15.6	50	50
Barium				166 B				84.4 B				55.5 B	1000	2000
Beryllium				6				1.7 B				1.2 B	-	1 (1)
Calcium				30100				46800				29800	-	-
Chromium				87				64.3				16.7	50	100
Cobalt				6 U				6.1 B				8 U	-	-
Copper				17.4 B				17.3 B				5.5 B	1000	1300(2)
Iron				64100				34800				10400	300	-
Lead				16.6				29.4				11.4	50	15(2)
Magnesium				5590				3980 B				2580 B	-	-
Manganese				168				77.7				53.9	50	-
Mercury				0.1 U				0.1 U				0.1 U	1.1	2
Nickel				31.3 B				16.9 B				12.1 B	150	100(1)
Potassium				3940 B				4820 B				2230 B	-	-
Selenium				3.4 U				3.6 B				3.4 U	10	50
Silver				4.7 B				1.6 U				1.6 U	50	50 (4)
Sodium				10900				3680 B				6390	-	-
Vanadium				92.1				160				35.9 B	-	-
Zinc				163				88.2				59.8	5000	-
Cyanide				10 U				11.2 U				11.2	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
< - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems, effective November 6, 1991.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of July 30, 1992 silver will no longer have a primary MCL,its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-2 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1709 AND 1710

WELL NUMBER	HPGW4-1				HPGW4-1	STANDARDS NORTH CAROLINA*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L	ug/L	ug/L
DATE SAMPLED	1/12/8	3/8/87	5/27/8	1/18/91	1/18/91		
VOLATILES:							
Acetone	NA	NA	NA	40	26	-	-
Benzene	25	3.2	1.6	5 U	5 U	1	5
Chloromethane	< 4.3	4.3	< 4.3	10 U	10 U	-	-
Dichloroethylene, trans-1,2-	1.9	2.2	4.4	NA	NA	-	100
Dichloroethylene, (total),1,2-	NA	NA	NA	5 U	0.6 J	-	-
Ethyl benzene	< 7.2	7.2	< 7.2	5 U	5 U	29	700
Methylene chloride	< 2.8	2.8	< 50	5 U	2 J	5	5 (1)
Trichloroethylene	3.4	3	7.7	0.9 J	1 J	2.8	5
Toluene	35	8.2	< 6	5 U	5 U	1000	1000
Trichloroethane, 1,1,1-	< 3.8	3.8	< 3.8	5 U	5 U	200	200
Xylene (total)	< 12	12	< 12	5 U	5 U	400	10000
Oil & Grease	300	300	< 200	NA	-	-	-
Total Lead	29	27	< 49.2	66.6	-	50	15 (2)

NOTES:
* - North Carolina water quality criteria for groundwater.
< - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed maximum contaminant level (MCL)
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of July 30, 1992 silver will no longer have a primary MCL,its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-2 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1709 AND 1710

WELL NUMBER	HPGW4-1				HPGW4-1	STANDARDS NORTH CAROLINA*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L		
DATE SAMPLED	1/12/8	3/8/87	5/27/8	1/18/91	1/18/91	ug/L	ug/L
INORGANICS:							
Aluminum	NA	NA	NA	97000	96800	-	-
Antimony				21.9 B	34.6 B	-	10/5(3)
Arsenic				15.5	19.4	50	50
Barium				268	273	1000	2000
Beryllium				6.7	6.4	-	1 (1)
Calcium				296000	310000	-	-
Chromium				187	195	50	100
Cobalt				14.4 B	18.2 B	-	-
Copper				35.4	39.2	1000	1300(2)
Iron				100000	106000	300	-
Lead				66.6	45.6	50	15(2)
Magnesium				12100	12500	-	-
Manganese				425	436	50	-
Mercury				0.1 U	0.1 U	1.1	2
Nickel				57	64.3	150	100(1)
Potassium				9710	9520	-	-
Selenium				3.4 U	3.4 U	10	50
Silver				1.6 U	2.4 B	50	50 (4)
Sodium				11400	11100	-	-
Vanadium				213	222	-	-
Zinc				228	272	5000	-
Cyanide				10 U	10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
< - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems, effective November 6, 1991.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of July 30, 1992
silver will no longer have a primary MCL,its secondary MCL
of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 4-3
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDING 1613

WELL NUMBER	HPGW5				HPGW6				HPGW7				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L				ug/L					
DATE SAMPLED	1/12/87	3/8/87	5/27/87	1/18/91	1/12/87	3/8/87	5/27/87	1/18/91	1/12/87	3/9/87	5/27/87	1/18/91	ug/L	ug/L
Oil & Grease	900	< 100	< 200	NA	200	< 100	< 200	NA	3000	200	< 200	NA	-	-
Total Lead	< 27	< 27	< 49.2	13.6	< 27	< 27	< 49.2	60.7	< 27	29	< 49.2	112	50	15 (1)
INORGANICS:														
Aluminum	NA	NA	NA	3580	NA	NA	NA	1050000	NA	NA	NA	161000	-	-
Antimony				13.3 U				13.3 U				22 U	-	10/5(2)
Arsenic				1.5 U				31.5				18.3	50	50
Barium				13.6 B				1960				670	1000	2000
Beryllium				0.86 B				20				4.8 B	-	1 (3)
Calcium				80100				11200				10500	-	-
Chromium				3.6 B				1590				313	50	100
Cobalt				6 U				51.9				17.7 B	-	-
Copper				4.1 B				194				44.2	1000	1300(1)
Iron				3100				265000				65700	300	-
Lead				13.6				60.7				112	50	15 (1)
Magnesium				11100				49700				18200	-	-
Manganese				162				487				136	50	-
Mercury				0.1 U				1.4				0.25	1.1	2
Nickel				5.2 U				161				50.7	150	100(3)
Potassium				3930 B				55300				12000	-	-
Selenium				4.4 B				3.4 U				2.6 B	10	50
Silver				1.6 U				2.3 B				6.2 U	50	50 (4)
Sodium				22400				14800				11500	-	-
Vanadium				2.4 U				1610				285	-	-
Zinc				71.3				537				218	5000	-
Cyanide				10 U				10 U				10 U	154	200(3)

NOTES:
* - These standards are water quality standards applicable to the groundwaters of North Carolina.
<X - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Maximum contaminant level (MCL) is Action Level for Public Water Supply System.
2 - Two proposed MCLs
3 - Proposed MCL
4 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Reported value is < Contract Required Detection Limit, but > Instrument Detection Limit, inorganics

TABLE 4-4
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1502, 1601 AND 1602

WELL NUMBER	HPGW8				HPGW9-1				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L					
DATE SAMPLED	3/13/87	3/9/87	5/28/87	1/18/91	1/14/87	3/9/87	5/28/87	1/18/91	ug/L	ug/L
VOLATILES:										
Carbon Disulfide	NA	NA	NA	5 U	NA	NA	NA	13	-	-
Chloroform	< 1.6	< 1.6	< 1.6	5 U	< 160	< 400	< 160	15	0.19	-
Chloromethane	7.2	< 4.3	< 4.3	10 U	< 430	< 1100	< 430	10 U	-	-
Dichloroethylene (total), 1,2-	< 2.8	< 2.8	< 2.8	5 U	< 280	< 700	< 280	1200	-	-
Dichlorothylene, trans,1,2-	< 1.6	< 1.6	< 1.6	NA	740	< 400	2700	NA	70	100
Ethyl Benzene	< 7.2	< 7.2	< 7.2	5 U	1100	< 1800	< 720	700	29	700
Methylene Chloride	20	< 2.8	< 50	5 U	< 280	< 700	< 280	5 U	5	5(1)
Toluene	< 6	< 6	< 6	5 U	< 600	< 1500	< 600	330 J	1000	1000
Trichloroethene	< 3	< 3	< 1	2 J	5000	6100	< 100	14000	2.8	5
Trichlorofluoromethane	14	96	< 3.2	NA	< 320	< 800	< 320	NA	-	-
Xylene (total)	< 12	< 12	< 12	5 U	4500	< 3000	4000	3300	400	10000
SEMI-VOLATILES:										
bis(2-Ethylhexyl)phthalate	NA	NA	NA	2 J	NA	NA	NA	10 U	-	-
Methylnaphthalene, 2-	NA	NA	NA	10 U	NA	NA	NA	49	-	-
Naphthalene	NA	NA	NA	10 U	NA	NA	NA	190	-	-
Oil & Grease	100	< 100	< 200	NA	32000	11000	6000	NA	-	-
Total Lead	< 27	< 27	< 49.2	54.1	130	92	70	128	50	15 (2)

NOTES:
* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems, effective November 6, 1991.
3 - Two proposed MCLs
QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Analyte found in associated blank, organics
 - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics

continued

TABLE 4-4 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1502, 1601 AND 1602

WELL NUMBER	HPGW8						HPGW9-1					STANDARDS North Carolina*	STANDARDS Primary MCLs
UNIT	ug/L						ug/L					ug/L	ug/L
DATE SAMPLED	3/13/87	3/9/87	5/28/87	1/18/91		1/14/87	3/9/87	5/28/87	1/18/91				
INORGANICS:													
Aluminum	NA	NA	NA	91700		NA	NA	NA	59100			-	-
Antimony				22	U				17.6	B		-	10/5 (3)
Arsenic				28.4					3	B		50	50
Barium				173	B				126	B		1000	2000
Beryllium				2.1	U				0.79	B		-	1 (1)
Calcium				10600					23500			-	-
Chromium				91.8					66.4			50	100
Cobalt				7.9	B				6	U		-	-
Copper				19.5	B				27.1			1000	1300 (2)
Iron				40900					19800			300	-
Lead				54.1					128			50	15 (2)
Magnesium				5780					11000			-	-
Manganese				46.5					45			50	-
Mercury				0.13	B				0.1	U		1.1	2
Nickel				25.2	B				15.1	B		150	100(1)
Potassium				5300					5370			-	-
Selenium				3.6	B				3.6	B		10	50
Sodium				8600					20400			-	-
Vanadium				945					75.3			-	-
Zinc				118					115			5000	-
Cyanide				10	U				10	U		154	200(1)

NOTES:
* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed maximum contaminant level (MCL)
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs

QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Analyte found in associated blank, organics
 - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics

continued

TABLE 4-4 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1502, 1601 AND 1602

WELL NUMBER	HPGW10				HPGW11				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNIT	ug/L				ug/L					
DATE SAMPLED	1/14/87	3/9/87	5/28/8	1/18/91	1/14/87	3/9/87	5/28/87	1/18/91	ug/L	ug/L
VOLATILES:										
Carbon Disulfide	NA	NA	NA	5 U	NA	NA	NA	11	-	-
Chloroform	< 1.6	< 1.6	< 1.6	5 U	3.2	2.2	2.6	5 U	0.19	-
Chloromethane	< 4.3	< 4.3	< 4.3	10 U	< 4.3	< 4.3	< 4.3	10 U	-	-
Dichloroethylene (total), 1,2-	< 2.8	< 2.8	< 2.8	5 U	< 2.8	< 2.8	< 2.8	5 U	-	-
Dichlorothylene, trans,1,2-	< 1.6	< 1.6	< 1.6	NA	13	7.2	6	NA	70	100
Ethyl Benzene	< 7.2	< 7.2	< 7.2	5 U	< 7.2	< 7.2	< 7.2	5 U	29	700
Methylene Chloride	< 2.8	< 2.8	< 50	5 U	< 2.8	< 2.8	< 50	5 U	5	5(1)
Toluene	< 6	< 6	< 6	5 U	< 6	< 6	< 6	5 U	1000	1000
Trichloroethene	7.4	8.6	< 1	5 U	49	34	24	5 U	2.8	5
Trichlorofluoromethane	< 3.2	< 3.2	< 3.2	NA	< 3.2	< 3.2	< 3.2	NA	-	-
Xylene (total)	< 12	< 12	< 12	5 U	< 12	< 12	< 12	5 U	400	10000
SEMI-VOLATILES:										
bis(2-Ethylhexyl)phthalate	NA	NA	NA	10 U	NA	NA	NA	10 U	-	-
Methylnaphthalene, 2-	NA	NA	NA	10 U	NA	NA	NA	10 U	-	-
Naphthalene	NA	NA	NA	10 U	NA	NA	NA	10 U	-	-
Oil & Grease	400	< 100	< 200	NA	300	600	< 200	NA	-	-
Total Lead	29	< 27	< 49.2	186	< 27	< 27	< 49.2	45.2	50	15 (2)

NOTES:
* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems, effective November 6, 1991.
3 - Two proposed MCLs

QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Analyte found in associated blank, organics
 - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics

continued

TABLE 4-4 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 1502, 1601 AND 1602

WELL NUMBER	HPGW10				HPGW11				STANDARDS	
									North Carolina*	Primary MCLs
UNIT	ug/L				ug/L					
DATE SAMPLED	1/14/87	3/9/87	5/28/8	1/18/91	1/14/87	3/9/87	5/28/87	1/18/91	ug/L	ug/L
INORGANICS:										
Aluminum	NA	NA	NA	348000	NA	NA	NA	95200	-	-
Antimony				22 U				22 U	-	10/5 (3)
Arsenic				39.9				9.1 B	50	50
Barium				492				298	1000	2000
Beryllium				5.6				2.1 U	-	1 (1)
Calcium				56200				9730	-	-
Chromium				310				140	50	100
Cobalt				31.4 B				6.4 U	-	-
Copper				72.2				30	1000	1300 (2)
Iron				119000				31800	300	-
Lead				186				45.2	50	15 (2)
Magnesium				14900				11200	-	-
Manganese				255				130	50	-
Mercury				0.82				0.1 B	1.1	2
Nickel				92.2				23.6 B	150	100(1)
Potassium				17100				7320	-	-
Selenium				1.6 U				3.7 B	10	50
Sodium				3950 B				5410	-	-
Vanadium				376				166	-	-
Zinc				224				94	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
(-) - No standard set
1 - Proposed maximum contaminant level (MCL)
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
QUALIFIERS:
U - Compound was analyzed, but not detected.
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics

TABLE 4-5
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDING 1202

WELL NUMBER	HPGW15				HPGW16				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/15/87	3/9/87	5/28/87	1/18/91	1/15/87	3/10/87	5/28/87	1/18/91	ug/L	ug/L
VOLATILES:										
Dichloroethylene (total), 1,2-	< 2.8	2.8	2.8	7	< 2.8	< 2.8	< 2.8	5 U	-	-
Trichloroethene	< 3	3	1	4 J	< 3	< 3	< 1	5 U	2.8	5
Trichlorofluoromethane	< 3.2	3.2	7.1	N/A	< 3.2	< 3.2	< 3.2	N/A	-	-
Oil & Grease	< 100	100	200	N/A	200	3000	< 200	N/A	-	-
Total Lead	46	27	49.2	16.6	45	41	< 49.2	100	50	15 (2)
INORGANICS:										
Aluminum	NA	NA	NA	18500	NA	NA	NA	213000	-	-
Antimony				22 U				22 U	-	10/5(3)
Arsenic				1.8 U				17.3	50	50
Barium				119 B				276	1000	2000
Beryllium				2.1 U				5.3	-	1 (4)
Calcium				12000				33400	-	-
Chromium				21.4				209	-	100
Cobalt				6.4 U				18.7 B	-	-
Copper				12.2 B				44.6 B	1000	1300 (2)
Iron				4800				47200	300	-
Lead				16.6				100	50	15 (2)
Magnesium				5650				8110	-	-
Manganese				18.3				98.3	50	-
Mercury				0.1 U				0.13 B	1.1	2
Nickel				11 U				41	150	100(4)
Potassium				3390 B				12100	-	-
Sodium				6950				4960	-	-
Thallium				1.1 U				1.4 B	-	2/1(3)
Vanadium				24.9 B				225	-	-
Zinc				88.1				157	5000	-
PESTICIDES:										
Dieldrin				0.1 U				0.1 U	-	-

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
<X - Less than detection limit
1 - Well HPGW18 could not be located during the supplemental investigation.
2 - Maximum contaminant level (MCL) is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Proposed MCL

QUALIFIERS:
U - Compound was analyzed, but not detected
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit
- but > Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-5 (cont)
CONSTITUENTS FOUND IN GROUNDWATER
BUILDING 1202

WELL NUMBER	HPGW17				HPGW18 (1)				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L				ug/L	ug/L
DATE SAMPLED	1/15/87	3/10/87	5/28/87	1/18/91	1/15/87	3/8/87	5/27/87	1/18/91		
VOLATILES:										
Dichloroethylene (total), 1,2-	< 2.8	< 2.8	< 2.8	5 U	< 2.8	< 2.8	< 2.8	NA	-	-
Trichloroethene	< 3	< 3	< 1	5 U	< 1	< 3	< 1	NA	2.8	5
Trichlorofluoromethane	< 3.2	< 3.2	< 3.2	N/A	< 3.2	< 3.2	< 3.2	NA	-	-
Oil & Grease	< 100	3000	< 200	N/A	< 100	2000	< 200	NA	-	-
Total Lead	< 27	< 27	< 49.2	23.7	< 27	< 27	< 49.2	NA	50	15 (2)
INORGANICS:										
Aluminum	NA	NA	NA	29000	NA	NA	NA	NA	-	-
Antimony				22 U					-	10/5(3)
Arsenic				1.8 U					50	50
Barium				70.1 B					1000	2000
Beryllium				2.1 U					-	1 (4)
Calcium				60800					-	-
Chromium				37					-	100
Cobalt				6.4 U					-	-
Copper				20 B					1000	1300 (2)
Iron				10500					300	-
Lead				23.7					50	15 (2)
Magnesium				6790					-	-
Manganese				31.3					50	-
Mercury				0.1 U					1.1	2
Nickel				11.9 B					150	100(4)
Potassium				3530 B					-	-
Sodium				4480 B					-	-
Thallium				1.1 U					-	2/1(3)
Vanadium				52.1					-	-
Zinc				76.5					5000	-
PESTICIDES:										
Dieldrin				0.11					-	-

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
<X - Less than detection limit
1 - Well HPGW18 could not be located during the supplemental investigation.
2 - Maximum contaminant level (MCL) is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Proposed MCL

QUALIFIERS:
U - Compound was analyzed, but not detected
B - Analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit
- but > Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 4-6
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDING 1100

						STANDARDS	
WELL NUMBER	HPGW19					North Carolina* ug/L	Primary MCLs ug/L
UNIT	ug/L						
DATE SAMPLED	1/16/87	3/10/87	5/28/87	1/18/91			
VOLATILES:							
Dichloroethylene (total),1,2-	NA	NA	NA	0.8	J	-	-
Dichloroethylene, trans,1,2-	2.5	< 1.6	< 1.6	NA		70	100
Tetrachloroethene	< 3	< 3	< 3	2	J	0.7	5
Trichloroethene	6	< 3	< 1	2	J	2.8	5
Oil & Grease	200	2000	< 200	NA		-	-
Total Lead	< 27	< 27	< 49.2	31.7		50	15 (1)
INORGANICS:							
Aluminum	NA	NA	NA	6840		-	-
Antimony				13.3	U	-	10/5 (2)
Arsenic				5	B	50	50
Barium				92.9	B	1000	2000
Beryllium				2.3	B	-	1 (1)
Calcium				3120	B	-	-
Chromium				13.8		50	100
Copper				8.6	B	1000	1300 (1)
Iron				36200		300	-
Lead				31.7		50	15 (1)
Magnesium				4200	B	-	-
Manganese				79		50	-
Nickel				7.3	B	150	100(1)
Potassium				2370	B	-	-
Silver				2.9	B	50	50 (4)
Sodium				23500		-	-
Vanadium				19.8	B	-	-
Zinc				81.1		5000	-

NOTES:
* - North Carolina water quality standards for groundwater.
NA - Not analyzed
(-) - No standard set
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
B - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit.
J - Estimated value

TABLE 4-7
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 901, 902, 903

WELL NUMBER	HPGW22				HPGW23				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/19/87	3/11/87	5/29/87	1/18/91	1/19/87	3/11/87	5/29/87	1/18/91	ug/L	ug/L
VOLATILES:										
Benzene	< 1	< 1	< 1	5 U	< 10	100	< 100	24	1	5
Carbon Disulfide	NA	NA	NA	5 U	NA	NA	NA	5	-	-
Dichloroethane,1,1-	< 4.7	< 4.7	< 4.7	5 U	< 47	470	< 470	5 U	-	-
Dichloroethane,1,2-	< 2.8	< 2.8	< 2.8	5 U	< 28	280	< 280	5 U	0.38	5
Dichloroethene,1,1-	NA	NA	NA	5 U	NA	NA	NA	5 U	7	7
Dichloroethylene (total), 1,2-	NA	NA	NA	5 U	NA	NA	NA	8900	-	-
Dichloroethylene, trans,1,2-	< 1.6	< 1.6	< 1.6	NA	830	6100	7100	NA	70	100
Ethyl Benzene	< 7.2	< 7.2	< 7.2	5 U	< 72	720	< 720	9	29	700
Methylene Chloride	< 2.8	< 2.8	< 50	9	< 28	300	< 5000	5 U	5	5 (1)
Tetrachloroethene	< 3	< 3	< 3	5 U	< 30	200	< 200	5 U	0.7	5
Toluene	< 6	< 6	< 6	5 U	< 60	600	< 600	13	1000	1000
Trichloroethene	< 3	< 1	< 1	5 U	830	13000	4300	3700	2.8	5
Trichloroethane, 1,1,2-	< 5	< 5	< 5	5 U	< 50	500	< 500	5 U	-	200
Vinyl Chloride	< 1	< 1	< 1	10 U	< 10	100	< 100	8 J	0.015	2
Xylene (total)	< 12	< 12	< 12	5 U	< 120	1200	< 1200	41	400	10000
SEMI-VOLATILES:										
Acenaphthene	NA	NA	NA	3 J	NA	NA	NA	10	-	-
Dibenzofuran				2 J				10	-	-
Fluorene				5 J				10	-	-
bis(2-ethylhexyl)Phthalate				10 U				3	-	-
Naphthalene				10 U				10	-	-
Methylnaphthalene, 2-				10 U				10	-	-
Oil & Grease	1000	2000	< 200	NA	600	3000	< 200	NA	-	-
Total Lead	27	< 27	< 49.2	39.4	38	27	< 49.2	45	50	15 (2)

continued

TABLE 4-7 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 901, 902, 903

WELL NUMBER	HPGW22				HPGW23				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/19/87	3/11/87	5/29/87	1/18/91	1/19/87	3/11/87	5/29/87	1/18/91	ug/L	ug/L
INORGANICS:										
Aluminum	NA	NA	NA	71800	NA	NA	NA	82500	-	-
Antimony				24.6 B				24.6 B	-	10/5(3)
Arsenic				7.2 B				6.6 B	50	50
Barium				102 B				196 B	1000	1000
Beryllium				0.6 B				1 B	-	1(1)
Calcium				96300				7890	-	-
Chromium				79.8				76.3	50	100
Cobalt				6 U				11.9 B	-	-
Copper				40				30.5	1000	1300(2)
Iron				24400				23300	300	-
Lead				39.4				45	50	15(2)
Magnesium				5210				6050	-	-
Manganese				94.1				68.8	50	-
Mercury				0.1 U				0.1 U	1.1	2
Nickel				23.2 B				33.2 B	150	100(1)
Potassium				6930				3880 B	-	-
Silver				2.5 B				6.6 B	50	50(4)
Sodium				5300				6260	-	-
Vanadium				100				77.6	-	-
Zinc				77.4				89.3	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
< - Less than detection limit
1 - Proposed maximum contaminant levels MCLs
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L;as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed but not detected
B - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - estimated value
D - Compound analyzed at a secondary dilution factor

continued

TABLE 4-7 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 901, 902, 903

WELL NUMBER	HPGW24				HPGW25				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/19/87	3/11/87	5/29/87	1/18/91	1/19/87	3/11/87	5/29/87	1/18/91	ug/L	ug/L
VOLATILES:										
Benzene	2	< 100	< 100	3 J	< 1	< 1	< 1	5 U	1	5
Carbon Disulfide	NA	NA	NA	7	NA	NA	NA	5 U	-	-
Dichloroethane,1,1-	12	< 470	< 470	5 U	< 4.7	< 4.7	< 4.7	5 U	-	-
Dichloroethane,1,2-	< 280	< 280	< 280	0.8 J	< 2.8	< 2.8	< 2.8	5 U	0.38	5
Dichloroethene,1,1-	NA	NA	NA	65	NA	NA	NA	5 U	7	7
Dichloroethylene (total), 1,2-	NA	NA	NA	42000 D	NA	NA	NA	5 U	-	-
Dichloroethylene, trans,1,2-	6400	4300	4000	NA	< 1.6	< 1.6	< 1.6	NA	70	100
Ethyl Benzene	< 720	< 720	< 720	3 J	< 7.2	< 7.2	< 7.2	5 U	29	700
Methylene Chloride	< 280	< 280	< 5000	5 U	< 2.8	2.9	< 50	5 U	5	5 (1)
Tetrachloroethene	< 300	< 200	< 200	5 U	< 3	< 3	< 3	5 U	0.7	5
Toluene	< 600	< 600	< 600	13	< 6	< 6	< 6	5 U	1000	1000
Trichloroethene	57	< 100	< 100	180	< 3	< 1	< 1	5 U	2.8	5
Trichloroethane, 1,1,2-	< 500	< 500	< 500	3 J	< 5	< 5	< 5	5 U	-	200
Vinyl Chloride	190	< 100	250	25000 U	< 1	< 1	< 1	10 U	0.015	2
Xylene (total)	< 1200	< 1200	< 1200	10	< 12	< 12	< 12	5 U	400	10000
SEMI-VOLATILES:										
Acenaphthene	NA	NA	NA	6 J	NA	NA	NA	10 U	-	-
Dibenzofuran				10 U				10 U	-	-
Fluorene				10 U				10 U	-	-
bis(2-ethylhexyl)Phthalate				10 U				10 U	-	-
Naphthalene				130				10 U	-	-
Methylnaphthalene, 2-				3 J				10 U	-	-
Oil & Grease	100	2000	< 200	NA	200	300	< 200	NA	-	-
Total Lead	< 27	< 27	< 49.2	21.4	< 27	< 27	< 49.2	71.6	50	15 (2)

continued

TABLE 4-7 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
BUILDINGS 901, 902, 903

WELL NUMBER	HPGW24				HPGW25				STANDARDS North Carolina*	STANDARDS Primary MCLs
UNITS	ug/L				ug/L					
DATE SAMPLED	1/19/87	3/11/87	5/29/87	1/18/91	1/19/87	3/11/87	5/29/87	1/18/91	ug/L	ug/L
INORGANICS:										
Aluminum	NA	NA	NA	15400	NA	NA	NA	218000	-	-
Antimony				22 U				13.3 U	-	10/5(3)
Arsenic				4.2 B				13.2	50	50
Barium				60.1 B				289	1000	1000
Beryllium				2.1 U				2.8 B	-	1(1)
Calcium				16600				6270	-	-
Chromium				26.3				205	50	100
Cobalt				6.4 U				10.5 B	-	-
Copper				11.5 B				57.7	1000	1300(2)
Iron				19200				46600	300	-
Lead				21.4				71.6	50	15(2)
Magnesium				2430 B				10000	-	-
Manganese				54.8				118	50	-
Mercury				0.1 U				0.1 U	1.1	2
Nickel				14 U				39.2 B	150	100(1)
Potassium				3130 B				13100	-	-
Silver				6.2 U				3.9 B	50	50(4)
Sodium				11800				18200	-	-
Vanadium				39.2 B				259	-	-
Zinc				70.5				119	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
< - Less than detection limit
1 - Proposed maximum contaminant levels MCLs
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCL of 50 ug/L;as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed but not detected
B - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics
J - estimated value
D - Compound analyzed at a secondary dilution factor

TABLE 4-8
CONSTITUENTS DETECTED IN GROUNDWATER
TRANSFORMER STORAGE AREA

			STANDARDS	
WELL NUMBER	21GW1		North Carolina*	Primary MCLs
UNITS	ug/L			
DATE SAMPLED	1/18/91		ug/L	ug/L
INORGANICS:				
Aluminum	40400		-	-
Antimony	17	B	-	10/5(1)
Arsenic	41.4		50	50
Barium	71	B	1000	2000
Beryllium	1.1	B	-	1 (2)
Calcium	60400		-	-
Chromium	39		50	100
Cobalt	10.8	B	-	-
Copper	13.2	B	1000	1300(3)
Iron	54900		300	-
Lead	15.8		50	15 (3)
Magnesium	10300		-	-
Manganese	200		50	-
Mercury	0.35		1.1	2
Nickel	21.4	B	150	100(2)
Potassium	4400	B	-	-
Sodium	17400		-	-
Vanadium	138		-	-
Zinc	233		5000	-
Cyanide	10	U	154	200(2)

NOTES:
* - North Carolina water quality criteria for groundwater.
1 - Two proposed MCLs
2 - Proposed MCL
3 - MCL is Action Level for Public Water Supply Systems.
4 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U - Compound was analyzed for but not detected
B - Reported value is < Contract Required Detection Limit but > Instrument Detection Limit, inorganics

TABLE 4-9
CONSTITUENTS DETECTED IN GROUNDWATER MONITORING WELLS PAIRED TO WATER SUPPLY WELLS

WELL NUMBER	HPGW2				HPGW13				HPGW20				STANDARDS North Carolina*	STANDARDS Primary MCLs
SUPPLY WELL NUMBER	Well 608				Well 601/660				Well 602					
UNITS	ug/L				ug/L				ug/L					
DATE SAMPLED	1/09/8	3/08/8	5/27/8	1/18/91	1/14/8	3/09/8	5/28/8	1/18/91	1/16/8	3/10/8	5/28/8	1/18/91	ug/L	ug/L
ORGANICS:														
Acetone	NA	NA	NA	10 U	NA	N/A	NA	10 U	NA	NA	NA	10 U	-	-
Benzene	12	< 1	< 1	5 U	< 1	< 1	< 1	5 U	< 1	< 1	< 1	5 U	1	5
Carbon disulfide	NA	NA	NA	5 U	NA	N/A	NA	5 U	NA	NA	NA	2 J	-	-
Chloromethane	5	< 4.3	< 4.3	10 U	< 4.3	< 4.3	< 4.3	10 U	< 4.3	< 4.3	< 4.3	10 U	-	-
Methylene chloride	< 2.8	< 2.8	< 50	5 U	< 2.8	< 2.8	< 50	1 J	< 2.8	3.4	< 50	0.9 J	5	5 (1)
Toluene	38	< 6	< 6	5 U	< 6	< 6	< 6	5 U	< 6	< 6	< 6	5 U	1000	1000
Xylene (total)	28	< 12	< 12	5 U	< 12	< 12	< 12	5 U	< 12	< 12	< 12	5 U	400	10000
Oil & Grease	700	< 100	< 200	NA	200	< 100	< 200	NA	< 100	3000	< 200	NA	-	-
Total Lead	< 27	< 27	< 49.2	29.4	< 27	< 27	< 49.2	9	46	33	< 49.2	20	50	15 (2)
INORGANICS:														
Aluminum	NA	NA	NA	56000	NA	NA	NA	13500	NA	NA	NA	289000	-	-
Antimony				15.6 B				13.3 U				21.9 B	-	10/5(3)
Arsenic				24.1				47				49.4	50	50
Barium				84.4 B				129 B				814	1000	2000
Beryllium				1.7 B				0.59 B				9.5	-	1 (1)
Calcium				46800				4100 B				6370	-	-
Chromium				64.3				48.9				424	50	100
Cobalt				6.1 B				9.3 B				80.8	-	-
Copper				17.3 B				17 B				97.7	1000	1300(2)
Iron				34800				33500				152000	300	-
Lead				29.4				9				20	50	15 (2)
Magnesium				3980 B				7700				18000	-	-
Manganese				77.7				30.3				217	50	-
Mercury				0.1 U				0.1 U				0.5	1.1	2
Nickel				16.9 B				21.1 B				168	150	100(1)
Potassium				4820 B				4520 B				16600	-	-
Selenium				3.6 B				3.4 U				3.4 U	10	50
Silver				1.6 U				2.1 B				4.3 B	50	50 (4)
Sodium				3680 B				18100				11000	-	-
Vanadium				160				40.5 B				419	-	-
Zinc				88.2				127				637	5000	-
Cyanide				11.2 U				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
<X - Less than detection limit
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCl of 50 ug/L; as of 7/30/92 silver will no longer have a MCL, it's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U- Compound was analyzed for but not detected.
B- Analyte found in associated blank, organics
- Reported value is <Contract Required Detection Limit
- but >Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-9 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
MONITORING WELLS PAIRED TO WATER SUPPLY WELLS

WELL NUMBER	HPGW25				HPGW26				STANDARDS North Carolina*	STANDARDS Primary MCLs
SUPPLY WELL NUMBER	Well 634				Well 637					
UNITS	ug/L				ug/L					
DATE SAMPLED	1/19/87	3/11/87	5/29/87	1/18/91	1/19/87	3/12/87	5/29/87	1/18/91	ug/L	ug/L
ORGANICS:										
Acetone	NA	NA	NA	10 U	NA	NA	NA	7 B	-	-
Benzene	< 1	< 1	< 1	5 U	< 1	< 1	< 1	5 U	1	5
Carbon disulfide	NA	NA	NA	5 U	NA	NA	NA	2 J	-	-
Chloromethane	< 4.3	< 4.3	< 4.3	10 U	< 4.3	< 4.3	< 4.3	10 U	-	-
Methylene chloride	< 2.8	2.9	< 50	5 U	< 2.8	6.5	< 50	3 J	5	5 (1)
Toluene	< 6	< 6	< 6	5 U	< 6	< 6	< 6	5 U	1000	1000
Xylene (total)	< 12	< 12	< 12	5 U	< 12	< 12	< 12	5 U	400	10000
Oil & Grease	200	300	< 200	NA	200	2000	< 200	NA *	-	-
Total Lead	< 27	< 27	< 49.2	71.6	31	< 27	< 49.2	9	50	15 (2)
INORGANICS:										
Aluminum	NA	NA	NA	218000	NA	NA	NA	10400	-	-
Antimony				13.3 U				13.3 U	-	10/5(3)
Arsenic				13.2				1.5 U	50	50
Barium				289				72 B	1000	2000
Beryllium				2.8 B				0.5 U	-	1 (1)
Calcium				6270				2830 B	-	-
Chromium				205				13	50	100
Cobalt				10.5 B				6 U	-	-
Copper				57.7				9.1 B	1000	1300(2)
Iron				46600				19000	300	-
Lead				71.6				9	50	15 (2)
Magnesium				10000				1830 B	-	-
Manganese				118				10.6 B	50	-
Mercury				0.1 U				0.1 U	1.1	2
Nickel				39.2 B				5.2 U	150	100(1)
Potassium				13100				2230 B	-	-
Selenium				3.4 U				3.4 U	10	50
Silver				3.9 B				1.6 U	50	50 (4)
Sodium				18200				5910	-	-
Vanadium				259				149	-	-
Zinc				119				68.1	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
(-) - No standard set
<X - Less than detection limit
1 - Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems.
3 - Two proposed MCLs
4 - Silver currently has an MCl of 50 ug/L; as of 7/30/92 silver will no longer have a MCL, it's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
U- Compound was analyzed for but not detected.
B- Analyte found in associated blank, organics
- Reported value is <Contract Required Detection Limit
- but >Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 4-10
CONSTITUENTS DETECTED IN GROUNDWATER
OTHER MONITORING WELLS

WELL NUMBER	HPGW12				HPGW14				STANDARDS North Carolina*	STANDARDS Primary MCLs
LOCATION DESCRIP	Midway between Bldgs. 1202 & 1501				Midway between HPIA & Well 601					
UNITS	ug/L				ug/L					
DATE SAMPLED	1/14/87	3/08/87	5/27/87	1/18/91	1/14/87	3/09/87	5/28/87	1/18/91	ug/L	ug/L
ORGANICS:										
Acetone	NA	NA	NA	10 U	NA	N/A	NA	10 U	-	-
Ethylbenzene	< 7.2	< 7.2	< 7.2	5 U	< 7.2	< 7.2	< 7.2	5 U	29	700
Methylene chloride	< 2.8	< 2.8	< 50	5 U	< 2.8	< 2.8	< 50	5 U	5	5 (1)
Tetrachloroethene	< 3	3.6	< 3	5 U	< 3	< 3	< 3	5 U	0.7	5
Trichloroethene	< 3	< 3	< 1	5 U	< 3	< 3	< 1	5 J	2.8	5
Xylene (total)	< 12	< 12	< 12	5 U	< 12	< 12	< 12	5 U	400	10000
Oil & Grease	200	< 100	< 200	NA	200	< 100	< 300	NA	-	-
Total Lead	< 27	< 27	< 49.2	15.7	< 27	< 27	< 49.2	66.5	50	15 (2)
INORGANICS:										
Aluminum	NA	NA	NA	24000	NA	NA	NA	109000	-	-
Antimony				22 U				13.3 U	-	10/5(3)
Arsenic				1.8 U				45.6	50	50
Barium				91.5 B				299	1000	2000
Beryllium				2.1 U				2.7 B	-	1 (1)
Calcium				34100				4340 B	-	-
Chromium				25.5				127	50	100
Cobalt				6.4 B				12.9 B	-	-
Copper				5.9 B				34.8	1000	1300(2)
Iron				5600				87200	300	-
Lead				15.7				66.5	50	15 (2)
Magnesium				7700				8770	-	-
Manganese				18.3				80	50	-
Mercury				0.1 U				0.26	1.1	2
Nickel				11 U				41.6	150	100(1)
Potassium				2600 B				6890	-	-
Selenium				5.8				3.4 U	10	50
Silver				6.2 U				2.5 B	50	50 (4)
Sodium				9310				11500	-	-
Vanadium				31.1				163	-	-
Zinc				46.6				206	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:

* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
1- Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems.
3 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.
4 - Two proposed MCLs

QUALIFIERS:

U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
Reported value is <Contract Required Detection Limit but >Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 4-10 (cont)
CONSTITUENTS DETECTED IN GROUNDWATER
OTHER MONITORING WELLS

									STANDARDS	
WELL NUMBER	HPGW21				HPGW29				North Carolina*	Primary MCLs
LOCATION DESCRIP	NW of Fuel Tank Farm				Next to Building 1801					
UNITS	ug/L				ug/L					
DATE SAMPLED	1/16/87	3/10/87	5/28/87	1/18/91	1/20/87	3/12/87	5/29/87	1/18/91	ug/L	ug/L
ORGANICS:										
Acetone	NA	NA	NA	4 B	NA	NA	NA	10 U	-	-
Ethylbenzene	< 7.2	< 7.2	< 7.2	0.9 J	< 7.2	< 7.2	< 7.2	5 U	29	700
Methylene chloride	< 2.8	< 2.8	< 50	4 J	< 2.8	< 2.8	< 50	0.9 J	5	5 (1)
Tetrachloroethene	< 3	< 3	< 3	5 U	< 3	< 3	< 3	5 U	0.7	5
Trichloroethene	< 3	< 1	< 1	3 J	< 3	< 3	< 1	5 U	2.8	5
Xylene (total)	< 12	< 12	< 12	5	< 12	< 12	< 12	5 U	400	10000
Oil & Grease	200	2000	< 200	NA	200	< 100	< 200	NA	-	-
Total Lead	< 27	< 27	< 49.2	49.4	< 27	52	< 49.2	29.1	50	15 (2)
INORGANICS:										
Aluminum	NA	NA	NA	38500	NA	NA	NA	47800	-	-
Antimony				13.3 U				13.3 U	-	10/5(3)
Arsenic				12.1				25.6	50	50
Barium				114 B				633	1000	2000
Beryllium				3.7 B				8.7	-	1 (1)
Calcium				26100				59200	-	-
Chromium				45				179	50	100
Cobalt				17.6 B				17.8 B	-	-
Copper				28.3				39.9	1000	1300(2)
Iron				56600				76200	300	-
Lead				49.4				29.1	50	15 (2)
Magnesium				10200				15000	-	-
Manganese				136				236	50	-
Mercury				0.1 U				0.1 U	1.1	2
Nickel				30.8 B				93.5	150	100(1)
Potassium				5160				5900	-	-
Selenium				3.5 B				3.4 U	10	50
Silver				1.6 U				3.1 B	50	50 (4)
Sodium				11800				7850	-	-
Vanadium				178				108	-	-
Zinc				273				329	5000	-
Cyanide				10 U				10 U	154	200(1)

NOTES:
* - North Carolina water quality standards for groundwater.
<X - Less than detection limit
NA - Not analyzed
1- Proposed MCL
2 - MCL is Action Level for Public Water Supply Systems.
3 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, its secondary MCL of 100 ug/L will become effective.
4 - Two proposed MCLs

QUALIFIERS:
U - Compound was analyzed for but not detected.
B - Analyte found in associated blank, organics
Reported value is <Contract Required Detection Limit but >Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 5-1
FREQUENCY SUMMARY TABLE FOR WELLS LOCATED SOUTHWEST OF CEDAR STREET

WELL NUMBER	MIN	MAX	FREQUENCY	MIN	MAX	FREQUENCY	STANDARDS		NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY	
UNIT	ug/L	ug/L	OF DETECTS	ug/L	ug/L	OF DETECTS	North Carolina* ug/L	Primary MCLs ug/L	North Carolina	Primary MCLs
DATE SAMPLED	1/87	1/87	1/87	3/87	3/87	3/87				
Acetone	NA	NA	NA	NA	NA	NA	-	-	-	-
Benzene	1.40	43.0	4	3.2	3.9	2	1	5	-	-
Carbon Disulfide	NA	NA	NA	NA	NA	NA	-	-	-	-
Chloroform	ND	3.2	1	ND	2.2	1	0.19	-	1/1	-
Chloromethane	5.0	7.2	2	ND	ND	-	-	-	-	-
Dichloroethene (total),1,2-	NA	NA	NA	NA	NA	NA	-	-	-	-
Dichloroethene,trans-1,2-	1.9	740.0	3	2.2	7.2	2	70	100	-	-
Ethylbenzene	8.2	1100.0	3	ND	9.0	1	29	700	1/1	1/1
Methylene Chloride	ND	20.0	1	ND	ND	-	5	5(1)	-	-
Tetrachloroethene	ND	ND	-	ND	3.6	1	0.7	5	-	-
Toluene	35.0	100.0	3	8.2	12.0	2	1000	1000	-	-
Trichloroethane,1,1,1-	ND	ND	-	ND	13.0	1	200	200	-	-
Trichloroethene	3.4	5000.0	4	8.6	6100.0	3	2.8	5	3/5	2/5
Trichlorofluoromethane	ND	14.0	1	ND	96.0	1	-	-	-	-
Xylene (total)	28.0	4500.0	3	ND	ND	-	400	10000	1/1	-
Oil & Grease	100.0	3000.0	15	200.0	11000.0	5	-	-	-	-
SEMI-VOLATILES:										
bis(2-Ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	-	-	-	-
Methylnaphthalene,2-							-	-	-	-
Naphthalene							-	-	-	-

NOTES:
* - North Carolina water quality standards for groundwater.
NA - Not analyzed
NE - Not evaluated
<X - Less than detection limit
(-) - No standard set or no detects
1 - Proposed MCL
2 - Two proposed MCLs
3 - MCL is Action Level for Public Water Supply Systems.
4 - Silver currently has an MCL of 50 ug/L. As of 7/30/92, silver's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
B - analyte found in associated blank, organics
- Reported value is < Contract Required Detcetion Limit but >Intrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 5-1 (cont)

FREQUENCY SUMMARY TABLE FOR WELLS LOCATED SOUTHWEST OF CEDAR STREET

WELL NUMBER	MIN	MAX	FREQUENCY	MIN	MAX	FREQUENCY	STANDARDS		NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY	
UNIT	ug/L	ug/L	OF DETECTS	ug/L	ug/L	OF DETECTS	North Carolina* ug/L	Primary MCLs ug/L	North Carolina	Primary MCLs
DATE SAMPLED	1/87	1/87	1/87	3/87	3/87	3/87				
INORGANICS:										
Aluminum	NA	NA	NA	NA	NA	NA	-	-	-	-
Antimony							-	10/5(2)	-	4/4
Arsenic							50	50	-	-
Barium							1000	2000	1/16	1/16
Beryllium							-	1(1)	-	9/12
Calcium							-	-	-	-
Chromium							50	100	11/16	7/16
Cobalt							-	-	-	-
Copper							1000(4)	1300(3)	-	-
Iron							300	-	16/16	-
Lead							50	15(3)	7/16	13/16
Magnesium							-	-	-	-
Manganese							50	-	11/16	-
Mercury							1	2	1/16	-
Nickel							150	100(1)	1/12	1/12
Potassium							-	-	-	-
Selenium							10	50	-	-
Silver							50	50(4)	-	-
Sodium							-	-	-	-
Vanadium							-	-	-	-
Zinc							5000	-	-	-

NOTES:

* - North Carolina water quality standards for groundwater.

NA - Not analyzed

NE - Not evaluated

<X - Less than detection limit

(-) - No standard set or no detects

1 - Proposed MCL

2 - Two proposed MCLs

3 - MCL is Action Level for Public Water Supply Systems.

4 - Silver currently has an MCL of 50 ug/L. As of 7/30/92, silver's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:

B - analyte found in associated blank, organics

- Reported value is < Contract Required Detcetion Limit but >Intrument Detection Limit, inorganics

J - Value is estimated

continued

TABLE 5-1 (cont)
FREQUENCY SUMMARY TABLE FOR WELLS LOCATED SOUTHWEST OF CEDAR STREET

WELL NUMBER / UNIT / DATE SAMPLED	MIN ug/L 5/87	MAX ug/L 5/87	FREQUENCY OF DETECTS 5/87	MIN ug/L 1/18/91	MAX ug/L 1/18/91	FREQUENCY OF DETECTS 1/18/91	AVG ug/L 1/18/91	GEOMETRIC MEAN 1/18/91	STANDARDS: North Carolina* ug/L	STANDARDS: Primary MCLs ug/L	NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY: North Carolina	NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY: Primary MCLs
Acetone	NA	NA	NA	10.0 J	40.0	2/16	7.4	5.9	-	-	-	-
Benzene	ND	1.6	1	ND	ND	-	-	-	1	5	-	-
Carbon Disulfide	NA	NA	NA	11.0	13.0	2/16	3.6	3.0	-	-	-	-
Chloroform	ND	2.6	1	ND	15.0	1/16	3.2	2.8	0.19	-	1/1	-
Chloromethane	ND	ND	-	ND	ND	-	-	-	-	-	-	-
Dichloroethene (total),1,2-	NA	NA	NA	7.0 J	1200.0	3/16	77.1	4.6	-	-	-	-
Dichloroethene,trans-1,2-	4.4	2700.0	3	NA	NA	NA	NA	NA	70	100	-	-
Ethylbenzene	ND	ND	-	ND	700.0	1/16	43.5	3.6	29	700	1/1	1/1
Methylene Chloride	ND	ND	-	0.9 J	3.0 B	4/16	2.4	2.3	5	5(1)	-	-
Tetrachloroethene	ND	ND	-	ND	ND	-	-	-	0.7	5	-	-
Toluene	ND	ND	-	ND	330.0 J	1/16	21.8	3.4	1000	1000	-	-
Trichloroethane,1,1,1-	ND	ND	-	ND	ND	-	-	-	200	200	-	-
Trichloroethene	7.7	24.0	2	0.9 J	14000.0	5/16	831.0	5.1	2.8	5	3/5	2/5
Trichlorofluoromethane	ND	7.1	1	NA	NA	NA	NA	NA	-	-	-	-
Xylene (total)	ND	4000.0	1	ND	3300.0	1/16	196.5	3.9	400	10000	1/1	-
Oil & Grease	200.0	600.0	2	NA	NA	NA	NA	NA	-	-	-	-
SEMI-VOLATILES:												
bis(2-Ethylhexyl)phthalate	NA	NA	NA	ND	2 J	2/16	4.8	4.7	-	-	-	-
Methylnaphthalene,2-				ND	49	1/16	7.8	5.8	-	-	-	-
Naphthalene				ND	190	1/16	16.6	6.3	-	-	-	-

NOTES:
* - North Carolina water quality standards for groundwater.
NA - Not analyzed
NE - Not evaluated
<X - Less than detection limit
(-) - No standard set or no detects
1 - Proposed MCL
2 - Two proposed MCLs
3 - MCL is Action Level for Public Water Supply Systems.
4 - Silver currently has an MCL of 50 ug/L. As of 7/30/92, silver's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
B - analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but >Instrument Detection Limit, inorganics
J - Value is estimated

continued

TABLE 5-1 (cont)
FREQUENCY SUMMARY TABLE FOR WELLS LOCATED SOUTHWEST OF CEDAR STREET

									STANDARDS		NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY	
WELL NUMBER	MIN	MAX	FREQUENCY	MIN	MAX	FREQUENCY	AVG	GEOMETRIC	North	Primary		
UNIT	ug/L	ug/L	OF DETECTS	ug/L	ug/L	OF DETECTS	ug/L	MEAN	Carolina*	MCLs		
DATE SAMPLED	5/87	5/87	5/87	1/18/91	1/18/91	1/18/91	1/18/91	1/18/91	ug/L	ug/L	North Carolina	Primary MCLs
INORGANICS:												
Aluminum	NA	NA	NA	3580.0	1050000	16/16	139017.5	56533.4	-	-	-	-
Antimony				15.6 B	46.5 B	4/16	13	11.0	-	10/5(2)	-	4/4
Arsenic				3.0 B	47.0	13/16	19.6	10.7	50	50	-	-
Barium				13.6 B	1960	6/16	348.6	191.1	1000	2000	1/16	1/16
Beryllium				0.6 B	20	12/16	4	2.3	-	1(1)	-	9/12
Calcium				4100.0 B	91900	6/16	44891.9	23164.3	-	-	-	-
Chromium				3.6 B	1590	16/16	204.5	82.9	50	100	11/16	7/16
Cobalt				6.1 B	51.9	10/16	12.2	8.0	-	-	-	-
Copper				4.1 B	194	16/16	36	22.4	1000(4)	1300(3)	-	-
Iron				3100.0	265000	16/16	60118.8	33308.8	300	-	16/16	-
Lead				9.0	186	16/16	53.8	36.3	50	15(3)	7/16	13/16
Magnesium				2580.0 B	49700	16/16	11934.4	9323.5	-	-	-	-
Manganese				18.3	487	16/16	146.6	93.4	50	-	11/16	-
Mercury				0.1 B	1.4	6/16	0.2	0.1	1	2	1/16	-
Nickel				12.1 B	161	12/16	40.9	24.4	150	100(1)	1/12	1/12
Potassium				2230.0 B	55300	16/16	9395	6301.9	-	-	-	-
Selenium				2.6 B	5.8	7/16	2.6	2.2	10	50	-	-
Silver				2.1 B	4.7 B	5/16	2.3	2.0	50	50(4)	-	-
Sodium				3680.0 B	22400	16/16	10821.3	9501.9	-	-	-	-
Vanadium				24.9 B	1610	15/16	270.4	102.7	-	-	-	-
Zinc				46.6	4590	16/16	169.6	137.6	5000	-	-	-

NOTES:
* - North Carolina water quality standards for groundwater.
NA - Not analyzed
NE - Not evaluated
<X - Less than detection limit
(-) - No standard set or no detects
1 - Proposed MCL
2 - Two proposed MCLs
3 - MCL is Action Level for Public Water Supply Systems.
4 - Silver currently has an MCL of 50 ug/L. As of 7/30/92, silver's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
B - analyte found in associated blank, organics
- Reported value is < Contract Required Detection Limit but >Instrument Detection Limit, inorganics
J - Value is estimated

TABLE 5-2
DATA SUMMARY FOR WELLS NORTHEAST OF CEDAR STREET

WELL NUMBER	MIN	MAX	FREQUENCY	MIN	MAX	FREQUENCY	MIN	MAX	FREQUENCY
UNIT	ug/L	ug/L	OF DETECTS	ug/L	ug/L	OF DETECTS	ug/L	ug/L	OF DETECTS
DATE SAMPLED	1/87	1/87	1/87	3/87	3/87	3/87	5/87	5/87	5/87
ORGANICS:									
Acetone	NA	NA	NA	NA	N/A	NA	NA	NA	NA
Benzene	2.0	12000.0	2.0	ND	10000.0	1.0	ND	13000.0	1.0
Carbon Disulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichloroethane,1,1-	ND	12.0	1.0	ND	ND	None	ND	ND	-
Dichloroethane,1,2-	ND	ND	None	ND	ND	None	ND	ND	-
Dichloroethene,1,1-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichloroethene (total),1,2-	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichloroethene,trans-1,2-	2.5	6400.0	3.0	4300.0	6100.0	2.0	4000.0	7100.0	2.0
Ethylbenzene	ND	1800.0	1.0	ND	ND	None	ND	ND	-
Methylene chloride	ND	7.3	1.0	2.9	2800.0	5.0	ND	ND	-
Tetrachloroethene	ND	ND	None	ND	ND	None	ND	ND	-
Toluene	ND	15000.0	1.0	ND	18000.0	1.0	ND	24000.0	1.0
Trichloroethane,1,1,2-	ND	ND	None	ND	ND	None	ND	ND	-
Trichloroethene	6	830.0	3.0	ND	13000.0	1.0	ND	4300.0	1.0
Vinyl chloride	ND	190.0	1.0	ND	ND	None	ND	250.0	1.0
Xylene (total)	ND	9000.0	1.0	ND	ND	None	ND	ND	-
Oil & Grease	200	7000.0	10.0	300.0	11000.0	12.0	ND	9000.0	1.0
SEMI-VOLATILES:									
Acenaphthene	NE	NE	NE	NE	NE	NE	NE	NE	NE
bis(2-Ethylhexyl)phthalate									
Dibenzofuran									
Fluorene									
2-Methylnaphthalene									
2-Methylphenol									
Naphthalene									
INORGANICS:									
Aluminum	NE	NE	NE	NE	NE	NE	NE	NE	NE
Antimony									
Arsenic									
Barium									
Beryllium									
Calcium									
Chromium									
Cobalt									
Copper									
Iron									
Lead									
Magnesium									
Manganese									
Mercury									
Nickel									
Potassium									
Selenium									
Silver									
Sodium									
Thallium									
Vanadium									
Zinc									
PESTICIDES:									
Dieldrin	NE	NE	NE	NE	NE	NE	NE	NE	NE

continued

TABLE 5-2 (cont)
DATA SUMMARY FOR WELLS NORTHEAST OF CEDAR STREET

WELL NUMBER	MIN		MAX		FREQUENCY	AVG	GEOMETRIC	STANDARDS		NO. OF DETECTS GREATER THAN STANDARDS 1991 DATA ONLY	
UNIT	ug/L		ug/L		OF DETECTS	ug/L	MEAN	North Carolina* ug/L	Primary MCLs ug/L		
DATE SAMPLED	1/18/91		1/18/91		1/18/91	1/18/91	1/18/91			North Carolina	Primary MCLs
ORGANICS:											
Acetone	4.0	B	7.0	B	2/12	5.1	5.0	-	-	-	-
Benzene	3.0	J	7900.0		3/12	662.5	6.0	1	5	3/3	2/3
Carbon Disulfide	2.0	J	7.0		4/12	3.0	2.8	-	-	-	-
Dichloroethane,1,1-	ND		ND		-	-	-	-	-	-	-
Dichloroethane,1,2-	0.8	J	110.0	B	2/12	11.3	3.1	0.38	5	2/2	1/2
Dichloroethene,1,1-	ND		65.0		1/12	7.7	3.3	7	7	1/1	1/1
Dichloroethene (total),1,2-	0.8	J	42000.0	D	3/12	4233.8	10.1	-	-	-	-
Dichloroethene,trans-1,2-	NA		N/A		N/A	N/A	N/A	70	100	-	-
Ethylbenzene	0.9	J	1900.0	J	4/12	161.4	4.5	29	700	1/4	1/4
Methylene chloride	0.9		9.0		4/12	3.1	2.7	5	5 (1)	1/4	1/4
Tetrachloroethene	ND		2.0	J	1/12	2.5	2.5	0.7	5	1/1	-
Toluene	13.0	J	16000.0		3/12	337.4	6.8	1000	1000	1/3	1/3
Trichloroethane,1,1,2-	ND		3.0	J	1/12	2.5	2.5	-	5	-	-
Trichloroethene	0.7	J	3700.0		5/12	326.0	7.8	2.8	5	4/5	3/5
Vinyl chloride	ND		8.0	J	1/12	1046.5	10.0	0.015	2	1/1	1/1
Xylene (total)	5.0		9800.0		4/12	823.0	7.5	400	10000	1/4	-
Oil & Grease	NA		NA		NA	NA	N/A	-	-	-	-
SEMI-VOLATILES:											
Acenaphthene	3	J	6	J	2/12	4.9	4.9	-	-	-	-
bis(2-Ethylhexyl)phthalate	ND		3	J	1/12	4.8	4.8	-	-	-	-
Dibenzofuran	ND		2	J	1/12	4.8	4.6	-	-	-	-
Fluorene	ND		5	J	1/12	5.0	5.0	-	-	-	-
2-Methylnaphthalene	3	J	28		2/12	6.8	5.4	-	-	-	-
2-Methylphenol	ND		10	J	1/12	5.4	5.3	-	-	-	-
Naphthalene	130		230		2/12	34.2	8.9	-	-	-	-
INORGANICS:											
Aluminum	6840		587000		12/12	105230.4	11646.3	-	-	-	-
Antimony	20.9	B	24.6	B	4/12	11.9	10.2	-	10/5(2)	-	4/12
Arsenic	4.2	B	50.3		10/12	12.0	4.9	50	50	1/10	1/10
Barium	60.1	B	814		12/12	198.8	86.5	1000	2000	-	-
Beryllium	0.6	B	9.5		8/12	2.3	1.1	-	1 (1)	-	6/8
Calcium	2830	B	127000		12/12	46618.7	24531.3	-	-	-	-
Chromium	13		457		12/12	107.7	27.7	50	100	6/12	4/12
Cobalt	10.5	B	80.8		7/12	13.7	7.3	-	-	-	-
Copper	8.6	B	97.7		12/12	36.5	23.4	1000	1300(3)	-	-
Iron	10500		152000		12/12	38528.0	24016.8	300	-	12/12	-
Lead	8.6	B	307		12/12	51.1	25.8	50	15 (3)	3/12	11/12
Magnesium	1830	B	21200		12/12	7412.0	5621.2	-	-	-	-
Manganese	10.6	B	763		12/12	144.2	84.4	50	-	10/12	-
Mercury	0.13	B	0.5		3/12	0.1	0.1	1.1	2	-	-
Nickel	7.3	B	186		10/12	38.3	15.3	150	100	2/10	2/10
Potassium	2230	B	24000		12/12	6739.3	4481.7	-	-	-	-
Selenium	3.5	B	4.2	B	2/12	1.8	1.6	10	50	-	-
Silver	2.5	B	6.6	B	6/12	2.6	2.0	50	50 (4)	-	-
Sodium	4480	B	23500		12/12	9865.3	8763.4	-	-	-	-
Thallium	ND		1.4	B	1/12	1.9	1.8	-	2/1 (1)	-	1/1
Vanadium	19.8	B	518		12/12	138.9	50.3	-	-	-	-
Zinc	68.1		637		12/12	450.7	143.2	5000	-	-	-
PESTICIDES:											
Dieldrin	ND		0.11		1/12	0.06	0.05	-	-	-	-

continued

TABLE 5-2 (cont)
DATA SUMMARY FOR WELLS NORTHEAST OF CEDAR STREET

NOTES:
* - North Carolina water quality criteria for groundwater.
NA - Not analyzed
ND - Not detected
(-) - No standard set or no detects
1 - Proposed maximum contaminant level (MCL)
2 - Two proposed MCLs
3 - MCL is Action Level for Public Water Supply System.
4 - Silver currently has an MCL of 50 ug/L; as of 7/30/92 silver will no longer have a primary MCL, it's secondary MCL of 100 ug/L will become effective.

QUALIFIERS:
B - Analyte found in associated blank, organics
- Reported value is <Contract Required Detection Limit but > Instrument Detection Limit, inorganics

J - Value is estimated