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DRAFT FINAL

EFFLUENT STUDY
INSTALLATION RESTORATION AND UNDERGROUND STORAGE TANK SITES

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

CONTRACT TASK ORDER 0140

Prepared For:

DEPARTMENT OF THE NAVY
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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This report presents the results of a study that evaluates options and the estimated costs for providing and maintaining groundwater treatment systems for the Installation Restoration (IR) and Underground Storage Tank (UST) sites at Marine Corps Base (MCB), Camp Lejeune, North Carolina.

Four options for treating contaminated groundwater were considered:

Alternative 1 -	Construction of individual pump and treat systems for each IR and UST site.
Alternative 2 -	Construction of a central treatment plant and transmission system within each of the seven sanitary sewer outfall areas, solely for treatment of groundwater from the IR and UST sites in each area.
Alternative 3 -	Conversion of the existing Hadnot Point Sewage Treatment (STP) Plant and construction of a Base-wide transmission system, solely for treatment of groundwater from the IR and UST sites.
Alternative 4 -	Transmission and treatment of groundwater from all IR and UST sites at the planned Hadnot Point STP.

Section 2.0 presented the process used to develop the information needed to consider these alternatives. Available site-specific information was reviewed for 31 IR sites and 21 UST sites. Based on this review, it was determined that groundwater remediation may be necessary at 17 IR sites and 13 UST sites. In addition, in accordance with the Scope of Work, a total of 100 additional UST sites were projected to require groundwater remediation over the next seven years (1995 through 1999). Table ES-1 summarizes the distribution of these sites.

The principal contaminants of concern (COCs) identified in the review of the site-specific information included benzene, cadmium, chromium, 1,2-dichloroethylene, ethylbenzene, iron, lead, magnesium, mercury, toluene, total hydrocarbons, trichloroethylene, tetrachloroethylene, vinyl chloride, and xylene.

TABLE ES-1

SUMMARY OF IR AND UST SITES AT MCB CAMP LEJEUNE

Base Location (Outfall)	IR Sites		UST Sites		Projected Future UST Sites		Totals of Each Outfall	
	No.	Total Flow (gpm)	No.	Total Flow (gpm)	No.	Total Flow (gpm)	No.	Total Flow (gpm)
Camp Geiger	4	90	6	70	15	150	25	310
Hadnot Point(1)	8	705	4	30	70	350	82	1,085
Courthouse Bay	1	25	0	0	10	50	11	75
Montford Point	1	15	0	0	0	0	1	15
Onslow Beach	1	15	0	0	0	0	1	15
Rifle Range	2	30	1	5	0	0	3	35
Tarawa Terrace	0	0	2	20	5	25	7	45
Totals	**17**	**880**	**13**	**125**	**100**	**575**	**130**	**1,580**

(1) Includes Site 78 (Operable Unit No. 1).

Using the information assembled in Section 2.0, feasible treatment technology options for a groundwater remediation system were identified and evaluated. Section 3.0 presented this evaluation. Three primary treatment technologies were identified as applicable in a pump and treat system for the COCs: air stripping, liquid-phase carbon adsorption, and UV/chemical oxidation. Using a design flow of 25 gpm, a life-cycle cost analysis of the three alternatives determined that the air stripping system had the lowest five year life-cycle cost, at $715,000.

In Section 4.0, using the air stripping system as the primary treatment process, five different treatment scenarios were developed, depending on the anticipated COCs. These scenarios were matched with the IR and UST sites, and a range a flow capacities were determined for each treatment scenario. Then, capital and O&M costs were estimated for "typical" groundwater treatment plants with flow capacities matched to those projected for the sites. "Typical" groundwater treatment plants were sized for flow capacities of 5, 15, 25, 50, 100, 150, and 200 gpm. Capital costs for treatment systems with projected flow rates greater than 200 gpm were estimated based on USEPA costing tables from the "Handbook of Remedial Action at Waste Disposal Sites" (USEPA, 1985).

Capital and O&M cost estimates were also developed in Section 4.0 for groundwater extraction systems and a pumping or transmission system. The groundwater extraction systems considered were recovery trenches and shallow extraction wells. Recovery trenches were recommended for many of the UST sites in the site assessment reports. Shallow extraction wells were assumed to yield 4 gallons per minute.

Based on the cost estimates for the groundwater extraction, treatment, and transmission systems developed in Section 4.0, total capital and O&M costs were summarized for the four treatment alternatives. Detailed cost tables for these alternatives are provided in Section 5.0.

Section 6.0 describes the process used to develop the life-cycle cost analysis of the four treatment alternatives. The life-cycle costs include the capital costs and the annual operation and maintenance costs for the different alternatives. A summary of these costs is presented below.

Alternative	Total Capital Cost	O & M Costs (Years 0 - 10)	O & M Costs (Years 11 - 30)	Total Life Cycle Cost
1	$32,320,000	$9,900,000	$14,840,000	$142,000,000
2	$35,277,000	$2,960,000	$4,440,000	$68,000,000
3	$48,350,000	$6,980,000	$10,470,000	$126,000,000
4	$35,070,000	$3,800,000	$5,700,000	$77,000,000

As can be expected in a project of this type, there were a number of assumptions that were made to develop site data and cost estimates. These assumptions have been noted when necessary, as a footnote or comment, along with the reasoning that was used to make the assumption. However, it should be noted that, because of the number of assumptions made, the capital costs developed and the resulting life-cycle cost analysis, are preliminary and approximate. As additional site-specific information becomes available, the preliminary assumptions made for this study can be revised as necessary, and the resulting costs can be adjusted.

Based on the life-cycle cost analysis presented in Section 6.0, Alternative 2 - construction of regional treatment plants located throughout the Base, solely for treatment of groundwater from the IR and UST sites, has the lowest life-cycle, or present worth value, at $68,000,000. This alternative considers the construction of five regional groundwater plants located at the site of the existing sewage treatment plants located at Camp Geiger Courthouse Bay, Hadnot Point, Rifle Range, and Tarawa Terrace. The plants would range in size from 15 to 1,100 gallons per minute. The five existing sewage treatment plant sites could be used at the site for the groundwater treatment plant, thus taking advantage of the utilities and infrastructure already in place. It was determined that a regional treatment plant would not be required at Montford Point and at Onslow Beach, since each of these areas only have one site that is projected to require groundwater remediation.

Because of the many issues which have recently been raised regarding a discharge permit for the planned Hadnot Point Sewage Treatment Plant expansion, the issues of obtaining the necessary discharge permits for Alternatives 2, 3, and 4 need to be carefully considered. Permitting issues may dictate which alternatives are viable from a regulatory standpoint. Therefore, groundwater remediation systems that consider in-place treatment or reinjection of treated groundwater should be considered wherever possible. The use of these types of systems would decrease the amount of groundwater that would need to be discharged to a sanitary sewer or a watercourse. Systems with in-place treatment or reinjection of treated groundwater would decrease the costs associated with transmission of groundwater to a central treatment location.

Finally, the intent of this project is to provide LANTDIV and MCB Camp Lejeune with information that can be used to develop strategies for groundwater remediation at IR and UST sites. Therefore, Baker recommends that consideration be given to updating this report as additional information becomes available.

1.0 INTRODUCTION

This report presents an evaluation of the options and estimated costs for providing and maintaining groundwater treatment systems for the Installation Restoration (IR) and Underground Storage Tank (UST) sites located within Marine Corps Base (MCB), Camp Lejeune, North Carolina (Also referred to within this report as the "Base"). This report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy (DoN), Atlantic Division Naval Facilities Engineering Command (LANTDIV), CLEAN Program for Contract Task Order 0140.

The purpose of this report is to provide LANTDIV and MCB Camp Lejeune planners with a planning document that presents technologically acceptable and cost effective alternatives of providing treatment for the groundwater effluent from IR and UST sites at MCB Camp Lejeune.

1.1 Objectives of the Effluent Study

Seven objectives were identified in the Scope of Work prepared by LANTDIV for this project. These objectives are summarized below.

1. Identify which of the 31 IR sites and 21 UST sites will likely require some form of a groundwater pump and treat system for remediation, based on existing information provided to Baker from LANTDIV.

2. Develop a matrix that presents the following information for each IR and UST site:

    - The estimated extent of contamination at each site, including the identification of contaminants of concern.

    - The estimated groundwater flow rates and durations of remediation.

    - The projected start-up date for remediation at each site.

    - The location of each IR and UST site in relation to an existing or planned sewage treatment plant (STP), and to receiving streams.

3. Develop an evaluation matrix that identifies all the possible treatment alternatives for the sites, along with the economic and technological advantages or disadvantages.

4. Evaluate the following four alternatives for treating the contaminated groundwater from the sites:

   - Construction of individual pump and treat systems for each site or operable unit.

   - Construction of one or more regional treatment plants solely for treatment of groundwater from the IR and UST sites in that area.

   - Conversion of one or more of MCB Camp Lejeune's existing STPs solely for treatment of groundwater from the IR and UST sites.

   - Transmission and treatment of groundwater from all IR and UST sites at the planned Hadnot Point STP.

5. Evaluate the following:

   - The impact of using the existing STPs to treat contaminated groundwater from the IR and UST sites.

   - The capability of the equipment and systems at the STPs to treat the majority of the contaminants found at the IR and UST sites.

   - The impact of treating contaminated groundwater from the IR and UST sites on the proposed STP at Hadnot Point.

   - The differences, if any, of treating contaminated groundwater from IR sites versus UST sites.

   - The type of known or expected contaminants at the IR sites and whether quantities to be treated will be under RCRA (Resource Conservation and Recovery Act) provisions for listed waste solvent exclusion.

6. Provide cost estimates, and life-cycle cost analyses prepared in accordance with NAVFAC P-442 (Economic Analysis Handbook) for all feasible alternatives.

7. Provide recommendations for a strategy to treat the groundwater from the IR and UST sites based on cost and technological acceptability.

As is expected in this type of project, there is an enormous amount of information that is necessary to complete this type of analysis. In order to fill in information gaps or lack of specific information on the characteristics of particular sites, Baker has made assumptions, based on our technical knowledge, our experience with other projects, or our experience from working at the Base. As additional information becomes available, some of these assumptions can be evaluated and revised to reflect current conditions. In addition, it should be noted that, because of the number of assumptions made, the costs and life-cycle cost analysis to be developed are preliminary and approximate.

1.2 Description of the Base

MCB, Camp Lejeune is located in Onslow County, North Carolina (see Figure 1-1). There are six major Marine Corps and two Navy Commands at MCB, Camp Lejeune: The Marine Corps (USMC) owns all the real estate, operates entry-level formal training schools, and provides support and training for tenant commands; Headquarters Nucleus, II Marine Expeditionary Force (II MEF) coordinates operational planning for Fleet Marine Commands; 2d Marine Division (2d MAR DIV) is the ground combat element of the Force; 2d Force Service Support Group (2d FSSG) is the service and support element of the Force; 2d Surveillance, Reconnaissance and Intelligence Group (2d SRIG) obtains, produces, and releases information and intelligence during planning and execution of exercises and combat operations; 6th Marine Expeditionary Brigade (6th MEB) provides the planning staff for the Fleet Marine Force associated with Maritime Prepositioning Ships Squadron-I; the Naval Hospital and the Naval Dental Clinic provide primary medical and dental care to Marines and sailors stationed at MCB, Camp Lejeune and medical care to their families.

MCB, Camp Lejeune currently covers approximately 236 square miles and is bisected by the New River. The Atlantic Ocean forms the southeastern boundary of the Base. The City of Jacksonville is located immediately northwest of the Base. Within 15 miles are three large, publicly-owned tracts of land: Croation National Forest, Hoffman Forest, and Camp Davis Forest. The remaining land use surrounding the Base is agricultural. Estuaries along the

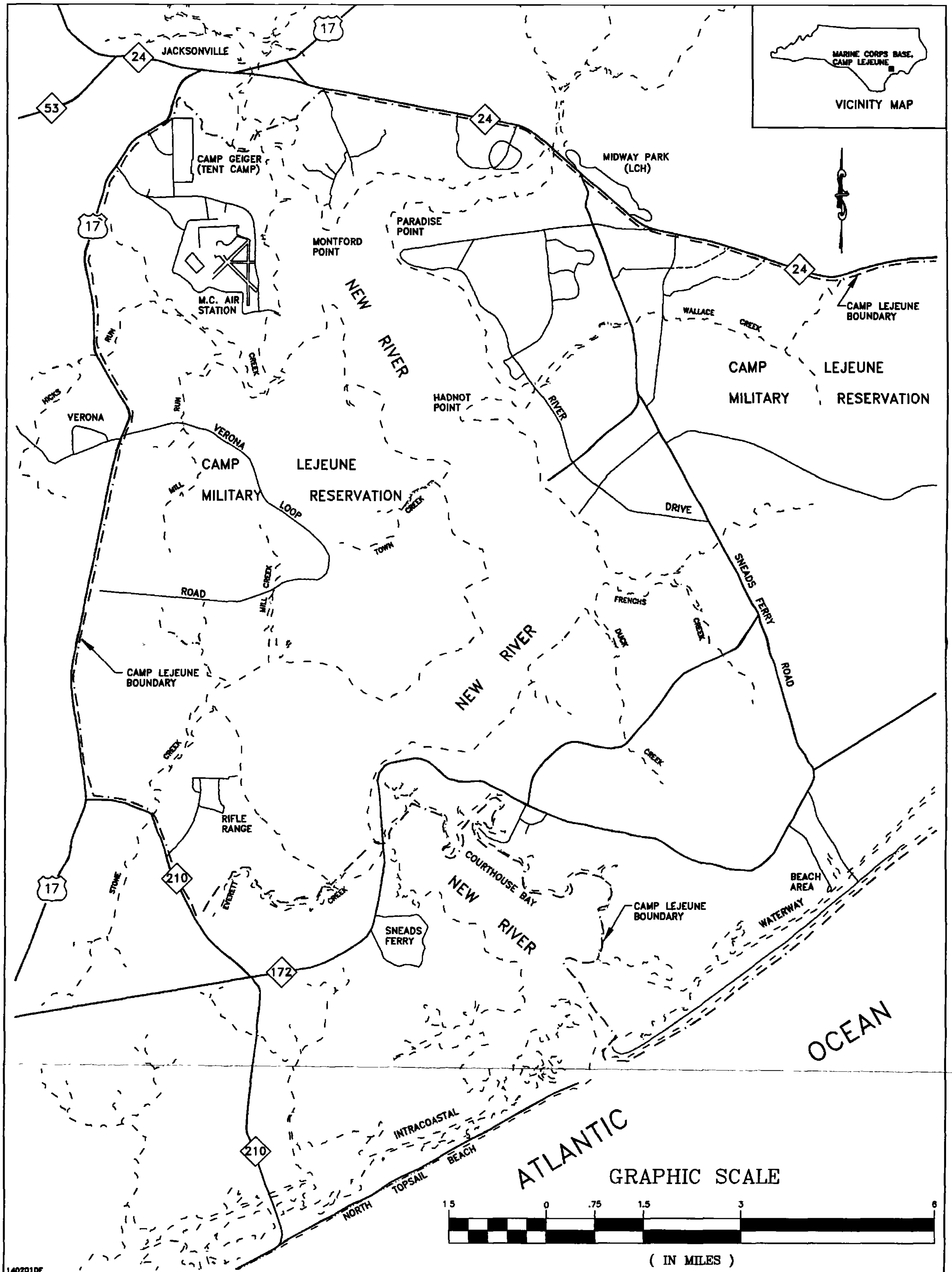

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FIGURE 1-1
LOCATION MAP

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: U.S.G.S. WATER-RESOURCES INVESTIGATIONS REPORT 89-4096 coast support commercial fishing. Tourism and residential resort areas have stimulated the regional economy. The Base is located in the Atlantic Coastal Plain on generally flat topography.

1.3 Format of the Effluent Study Report

This report consists of eight sections. Section 1.0 explains the purpose of the report, and presents a brief description of the Base. Section 2.0 explains how the IR and UST sites were evaluated, and a matrix developed with relevant information on each site. An identification and evaluation of the feasible technologies for treating the contaminated groundwater is presented in Section 3.0. Section 4.0 presents capital and operation and maintenance costs for the recommended groundwater treatment technology. Section 5.0 evaluates the four groundwater treatment alternatives considered for the Base. A life-cycle cost analysis of these four alternatives is presented in Section 6.0. Recommendations for a Base-wide groundwater treatment strategy are presented in Section 7.0. References are listed in Section 8.0.

2.0 IDENTIFICATION OF IR/UST SITES REQUIRING GROUNDWATER TREATMENT

The first objective identified in the Scope of Work characterized in Section 1.0 was to determine which of the 31 IR sites and 21 UST sites will require groundwater treatment. This section presents a summary of the process used by Baker to make this determination. It also discusses the methods and assumptions used to estimate the number and location of additional UST sites to be evaluated in the study. A brief description and specific information for each site is included in Appendix A. After evaluating site-specific information, Baker developed a site evaluation matrix (see Appendix B), which presents pertinent information for each of the sites. The locations of the IR and UST sites are shown on Figure 2, which is included in a map pocket at the end of this report.

2.1 Basis for Identifying Sites Requiring Groundwater Treatment

To order to identify the sites that will require groundwater treatment, Baker reviewed a number of documents including, but not limited to, IR site investigation reports, feasibility studies, and UST site assessment reports. Based on a review of site-specific background information, Baker made a preliminary determination of the sites that may require some degree of groundwater treatment.

2.1.1 Evaluation of Potential For Exclusion as Hazardous Waste under the Resource Conservation and Recovery Act (RCRA)

As an objective in the scope of work for this study, LANTDIV requested that Baker evaluate the type of known or expected contaminants at the IR sites and whether quantities to be treated would fall under a listed waste solvent exclusion under RCRA. Based on Baker's knowledge of RCRA, and a subsequent phone conservation with a regulatory specialist at the RCRA hotline, it appears that LANTDIV was referring to an exclusion listed under 40 CFR Section 261.3 (a)(2)(iv)(A).

Specifically, this exclusion indicates that a solid waste, as defined in section 261.2, is a hazardous waste if it is a mixture of solid waste and one or more hazardous wastes listed in subpart D and has not been excluded under section 260.20 and 260.22; however, a mixture of solid wastes and hazardous wastes listed in subpart D are not hazardous wastes (except as defined under 261.3 (a)(2)(i) or (ii) if the generator can demonstrate that the mixture consists of wastewater (the discharge of which is subject to regulation under either section 402 or section 307(b) of the Clean Water Act (including wastewater at facilities which have eliminated the discharge of wastewater)) and one or more of the spent solvents listed in section 261.31; provided that the maximum total weekly usage of these solvents (other than the amounts that can be demonstrated not to be discharged to wastewater) divided by the average weekly flow of wastewater into the headworks of the facility's wastewater treatment or pretreatment system does not exceed 1 part per million.

Basically, this exclusion applies to facilities in operation, that are currently regulated under section 402 or section 307(b) of the Clean Water Act (i.e. discharge under NPDES), and currently discharge small quantities of spent solvents in the wastewater stream. According to the regulatory specialist at the RCRA hotline, this exclusion was developed to allow exemption from the mixture rule, which requires that any mixture of hazardous waste with solid waste creates what is considered to be and regulated as a hazardous waste. Under this exemption, facilities can discharge small quantities of spent solvents, under regulation of the Clean Water Act, without triggering the requirements of RCRA.

Sites potentially requiring groundwater extraction and treatment systems at MCB Camp Lejeune would not be considered "facilities in operation", as facilities would be considered under RCRA, because the groundwater cleanup action is being carried out under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act. Therefore, it anticipated that the exclusion, as defined under section 261.3 of RCRA, would not be applicable to groundwater treatment systems constructed for the sole purpose of remediating contaminated groundwater; however, it should be understood that while not implicitly stated in the regulations, it was implied by the regulatory specialist at the RCRA hotline that this waste solvent exclusion is limited to facilities in operation.

2.1.2 IR Sites

The Scope of Work for this project listed 33 IR sites that were to be considered for groundwater remediation. However, two of these sites, Site 22, the Hadnot Point Fuel Farm, and Site 35, the Camp Geiger Fuel Farm, are considered UST sites. As a result; 31 IR sites were evaluated for this study.

For the purpose of this study, based on available data, groundwater remediation was recommended for 17 of the IR sites. Groundwater remediation was determined not to be needed at 14 sites. A groundwater remediation action is already planned at one IR site, Site 78.

The first step in the site background evaluation phase was the identification, collection, and preliminary review of documents that could provide background information or site data. The following references were reviewed for the IR sites:

- Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina (Water and Air Research, 1983)

- Site Summary Report Marine Corps Base Camp Lejeune, North Carolina (Environmental Science & Engineering, 1990)

- Preliminary Draft Report Wellhead Monitoring, Engineering Study 92-34, Marine Corps Base Camp Lejeune, North Carolina (Greenhorne & O'Mara, 1992)

- Wellhead Management Program, Engineering Study 91-36 (Geophex, 1991)

- Preliminary Draft Site Inspection Report, Initial Assessment Study Site 3: Old Creosote Plant (NUS, 1991)

- Preliminary Draft Site Inspection Report, Initial Assessment Study Site 7; Tarawa Terrace Landfill (NUS, 1991)

- Preliminary Draft Site Inspection Report, Initial Assessment Study Site 54; Crash Crew Training Burn Pit (NUS, 1991)

- Preliminary Draft Site Inspection Report, Initial Assessment Study Site 80; Paradise Point Golf Course (NUS, 1991)

- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina (U.S. Geological Survey, 1989)

- Draft Site Inspection Report Site 43, Agan Area Dump (Baker, 1992)

- Draft Final Site Inspection Report Site 44, Jones Street Dump (Baker, 1993)

- Draft Site Inspection Report Site 48, MCAS Mercury Dump (Baker, 1993)
- Draft Site Inspection Report Site 63, Verona Loop Dump (Baker, 1992)
- Draft Site Inspection Report Site 65, Engineer Area Dump (Baker, 1992)
- Draft Remedial Investigation/Feasibility Study Work Plan for Sites 2 and 74 (Baker, 1992)
- Remedial Investigation for Operable Unit No. 2 (Sites 6, 9, and 82) Marine Corps Base Camp Lejeune, North Carolina (Baker, 1993)
- Draft Final Interim Remedial Action Feasibility Study for the Shallow Aquifer at the Hadnot Point Industrial Area Operable Unit #1 (Baker, 1993)
- Final Fiscal Year 1994 Site Management Plan for Marine Corps Base Camp Lejeune, North Carolina (Baker, 1993)
- Feasibility Study for Operable Unit No. 2 (Sites 6, 9, and 82) Marine Corps Base Camp Lejeune, North Carolina (Baker, 1993)
- Final Proposed Remedial Action Plan for Operable Unit No. 2 (Sites 6, 9, and 82) Marine Corps Base Camp Lejeune, North Carolina (Baker, 1993)

After a preliminary review of these documents was completed, applicable site-specific background information, data, and maximum contaminant levels (MCLs) for the contaminants of concern (COCs) for each site were summarized. This summary is included in Appendix A. This information and data were evaluated and a recommendation made concerning each site's probable need for groundwater remediation. Table 2-1 presents a summary of the 31 IR sites that were evaluated.

For 29 sites of the 31 sites evaluated the existing data and background information provided in the Initial Assessment Study (IAS), Site Summary Report (SSR), SI Reports, and RI/FS Reports were adequate to assess the potential need for groundwater treatment. However, information and data on two sites, Site 85, Camp Johnson Battery Dump, and Site 12,

TABLE 2-1

SUMMARY OF IR SITES
SUMMARY OF GROUNDWATER REMEDIATION

Site Number/Name	Remediation Status	Basis for Determining Presence of Groundwater Contamination	Potential for Groundwater Remediati (Yes/No)
#1, French Creek Liquids Disposal Area	RI/FS	Evaluation of SSR data (4)	Yes
#2, Former Nursery/Day-Care Center	RI/FS	Baker Prposed Remedial Action Plan	No
#3, Old Creosote Plant	RI/FS (8)	Halliburton NUS SI Report (7)	Yes
#6, Storage Lots 203 and 201	Design	Baker ROD	Yes
#7, Tarrawa Terrace Landfill	RI/FS (8)	Halliburton NUS SI Report (7)	No
#9, Fire Fighting Training Pit	Delisted	Baker ROD (12)	No
#12, Explosive Ordnance Disposal	SI	No data, assumed contaminated (6)	Yes
#16, Montford Point Burn Dump	RI/FS	Evaluation of ISA information (5)	Yes
#21, Transformer Storage Lot 140	RI/FS	Baker RI/FS (2)	No(10)
#22, Industrial Area Tank Farm	This site was considered in the UST section.		
#24, Industrial Fly Ash Dump	RI/FS	Baker RI/FS (2)	Yes
#28, Hadnot Point Burn Dump	RI/FS	Evaluation of SSR data (4)	Yes
#30, Sneads Ferry Road Fuel Tank Sludge Area	RI/FS	Evaluation of SSR data (4)	No
#35, Camp Geiger Fuel Farm	This site was evaluated as a UST site.		Yes
#36, Camp Geiger Dump Near STP	RI/FS	Evaluation of SSR data (4)	Yes
#41, Camp Geiger Dump Near Trailer Park	RI/FS	Evaluation of SSR data (4)	Yes
#43, Agan Street Dump	RI/FS (8)	Baker SI Report (1)	Yes
#44 Jones Street Dump	RI/FS (8)	Baker SI Report (1)	Yes
#48, MCAS Mercury Dump	Delisted	Baker ROD (12)	No
#54, Crash Crew Training Burn Pit	RI/FS (8)	Halliburton NUS SI Report (7), (9)	No
#63, Verona Loop Dump	RI/FS (8)	Baker SI Report (1), (9)	No
#65, Engineer Area Dump	RI/FS (8)	Baker SI Report (1), (9)	No
#68, Rifle Range Dump	SI	Evaluation of SSR data (4)	Yes
#69, Rifle Range Chemical Dump	RI/FS	Evaluation of SSR data (4)	Yes
#73, Courthouse Bay Liquids Disposal Area	RI/FS	Evaluation of SSR data (4)	Yes
#74. Mess Hall Grease Pit Area	RI/FS	Evaluation of SSR data (4)	No
#75, MCAS Basketball Court Site	SI	Evaluation of SSR data (4)	No
#76, MCAS Curtis Road Site	SI	Evaluation of SSR data (4)	No
#78, Operable Unit #1	RI/FS	Baker Interim ROD	Yes(11)
#80, Paradise Point Golf Course Peticide Area	RI/FS (8)	Halliburton NUS SI Report (7)	Yes
#82, Piney Green Road VOC Area	Design	Baker ROD	Yes
#85, Camp Johnson Battery Dump	SI	Site visit and engineering judgement	No
A, MCAS (H) Officer's Housing Area	SI	Evaluation of SSR data (4)	No

(1) The need for groundwater remediation at this site was based on a Baker Site Investigation Report.
(2) The need for groundwater remediation at this site was based on a Baker RI/FS Report.
(3) The need for groundwater remediation at this site was based on an evaluation of information/data presented in the Initial Site Assessment (Water and Air, 1983).
(4) The need for groundwater remediation at this site was based on an evaluation of data/background information presented in the Site Summary Report (ESE, 1990).
(5) The need for groundwater remediation at this site was based on an evaluation of background information presented in the Initial Site Assessment (Water and Air, 1983).
(6) No site data was available, groundwater was assumed to be contaminated and need remediation.
(7) The need for groundwater remediation was based on an evaluation of data presented in a Halliburton NUS SI Report.
(8) The 1994 Fiscal Year Site Management Plan fo MCB Camp LeJeune has included these sites in the RI/FS phase. At the time Attachment C of the contract d
(9) It is anticipated the RI/FS will support a No Action alternative.
(10) Recovery wells may be placed at this site to capture a contaminant plume originating at Site 78.
(11) Site 78 is currently under remediation.
(12) No action is planned for this site based on the Record of Decision (ROD).

Explosive Ordnance Disposal Area, were extremely limited or nonexistent. At these sites the need for groundwater remediation was primarily based on engineering judgment.

2.1.3 UST Sites

Initially, under the Scope of Work identified for this CTO, 17 UST sites were identified for inclusion in this study. However, after identifying the available Site Assessment Reports, four additional UST sites were added to the list of potential UST sites requiring groundwater remediation, thus requiring an evaluation of a total of 21 UST sites.

The following references were identified, collected and reviewed to develop site-specific background information for each UST site:

- Final Report, Underground Fuel Investigation Comprehensive Site Assessment, Volume I, Camp Geiger Fuel Farm (Law Engineering, February 8, 1992)

- Final Site Assessment, Gottschalk Marina Building 728 (Versar, Inc., April 7, 1992)

- Final Report, Corrective Action Plan For Gottschalk Marina (Versar, Inc., October 23, 1992)

- Site Assessment (Tanks AS419-AS421 Marine Corps Air Station) (O'Brien & Gere, June 1992)

- Corrective Action Plan (JP-5 Line Area Marine Corps Air Station) (O'Brien & Gere, June 1991)

- Underground Storage Tank (UST) Site Check Investigation Report, Berkley Manor X Change Service Station Tank 820-2 (ATEC Associates, February 18, 1992)

- Draft Leaking Underground Storage Tank Site Assessment Report, Volume 1, Building 45, Equipment and Maintenance Shop UST S-941-2) (Law Engineering, April 2, 1993)

- Draft Leaking Underground Storage Tank Site Assessment Report, Volume 1, Camp Geiger Mini C Store Service Station, Building 912) (Law Engineering, March 4, 1993)

- Final Site Assessment Report, The Campbell Street Fuel Farm and UST System AS-143 (Baker Environmental, Inc., August 12, 1992)

- Draft Site Assessment Report, Additional Assessment Activities at the Campbell Street Fuel Farm and UST System AS-143 (Baker Environmental, Inc., February 1993)

- Draft Site Assessment Report, Additional Assessment Activities at The Rifle Range MCX Service Station, Underground Storage Tank System RR-72 (Baker Environmental, Inc., March 1993)

- Draft Site Assessment Investigation, Building AS-4151, the Steam Generating Plant (Baker Environmental Inc., July 1992)

- Final Site Assessment Investigation, Building AS-4151, the Steam Generating Plant (Baker Environmental, Inc., March 1993)

- Final Site Assessment Report, Building 21 Wastewater Treatment Plant, UST System 21.1 (Baker Environmental, Inc., January 8, 1993)

- Site Assessment Tanks M232-M236 Camp Johnson (O'Brien & Gere, January 1992)

- Addendum Site Assessment Tanks M232-M236 (O'Brien & Gere, February 1993)

- Site Assessment Tank S781 Midway Park (O'Brien & Gere, May 1992)

- Site Assessment Holcomb Boulevard Tanks S889-S891 (O'Brien & Gere, April 1992)

- Site Assessments STT61-STT66, Tarawa Terrace (O'Brien & Gere, April 1992)

- Addendum Site Assessment, Tanks STT61-STT66 (O'Brien & Gere, January 1993)

- Final Site Assessment Report, The Campbell Street JP-5 Pipeline (Baker Environmental, Inc., August 12, 1992)

- Final Site Assessment Report, Underground Storage Tank System H-28 at Building H-28 Housing Area (Baker Environmental, December 18, 1992)

- Final Site Assessment Report, Building A-47 Amphibious Vehicle Maintenance Facility, Underground Storage Tank System SA-21 (Baker Environmental, Inc., October 12, 1992)

- Final Site Assessment Report, AS-527 and the South End of the Aircraft Direct Refueling Area (Baker Environmental, Inc., January 1993)

The above referenced documents were reviewed and site-specific information was identified that could be used in determining the need for groundwater remediation at each of the 21 UST sites. Although site assessments had been conducted at two of these sites, namely Hadnot Point Fuel Farm and Tarawa Terrace Service Station (Abandoned Station), Site Assessment reports documenting the results were not available at the time of this study. However, groundwater pump and treat systems are in place at both of these sites, with the system on-line at Hadnot Point and a system in place at the Tarawa Terrace Service Station (Abandoned Station) with a proposed start-up date of February 1, 1994.

Because site checks and/or site assessments were conducted at all of the UST sites, there was a significant amount of site-specific information provided in the available documents. In general, these documents contained a description of the site check/assessment activities conducted at the site, results of previous investigations, if any, general hydrogeologic conditions, results of sampling activities, and conclusions and recommendations regarding the site. Site-specific background information summarized for each UST site is contained in Appendix A.

In most cases, because a site check or assessment was conducted, a recommendation was made as to whether or not groundwater remediation was necessary for a particular site. If a specific recommendation was made in the site check or assessment document(s) indicating the need for groundwater remediation at a particular site, then the site was identified in this study as requiring groundwater remediation. On the other hand, if the recommendation was made that a site not require groundwater remediation, then the site was identified as a site not anticipated to require remediation of groundwater. In a few instances, the site assessment recommended further investigation to determine the lateral and vertical extent of contamination in groundwater, but did not specifically recommend the need for groundwater remediation. As a conservative assumption, these sites were identified as requiring groundwater remediation.

Table 2-2 presents a summary of the UST sites evaluated in this study, and justification for determining that groundwater treatment was necessary. In most all cases, based on a review of analytical sampling data, it was apparent that sites identified in the Site Assessment Documents as requiring groundwater remediation were those where sampling results indicated constituents present at levels exceeding North Carolina Water Quality Standards or Federal Maximum Contaminant Levels (MCLs). However, there were some UST sites where constituents were present at concentrations exceeding these criteria, but the concentrations were minimal, and it was suggested that passive remediation would be sufficient to reduce groundwater contaminant concentrations to acceptable levels.

2.2 Identification of Pertinent Site Design Data

Once the IR and UST sites to be included in the evaluation of groundwater treatment alternatives were identified, Baker developed a site evaluation matrix which summarizes the following information:

- The estimated extent of groundwater contamination at each site, including the identification of COCs.
- The estimated groundwater flow rates and durations of remediation.
- The projected start-up date for remediation at each site.
- The location of each IR and UST site in relation to an existing or planned STP, and to receiving streams.

The methodology and assumptions Baker used to develop this matrix are presented and discussed below. The Site Evaluation Matrix is included in Appendix B.

2.2.1 Extent of Contamination at Each Site

In order to estimate the extent of groundwater contamination at sites identified as requiring remediation, if sufficient data was available, analytical results from groundwater sampling

TABLE 2-2

SUMMARY OF UST SITES
RECOMMENDATIONS FOR GROUNDWATER REMEDIATION

UST SITES POTENTIALLY REQUIRING REMEDIATION

Site Name	Basis for Determining Presence of Groundwater Contamination	Recommendation on Groundwater Remedi Yes/No
Camp Geiger Fuel Farm	Site Assessment Recommendation - Constituents detected > state max. allowable concentrations	Yes
Gottschalk Marina (Building 728)	Site Assessment Recommendation in vicinity Bldg. 729 (Paint Locker)	Yes
Tanks AS419-AS421 Marine Corps Air Station	Site Assessment & Engineering Judgement Constituents det. > State Water Quality Stds.	Yes
JP-5 Line Area Site (Marine Corps Air Station) *	Pump and Treat System is in place	Yes
Berkley Manor X Change Service Station Tank 820-2	Site Check & Engineering Judgement Constituents det. > State Water Quality Stds.	Yes
Building 45, UST S-941-2	Site Assessment Recommendation Constituents det. > State Water Quality Stds.	Yes
Camp Geiger Mini C Store Service Station (Bldg. 912)	Site Assessment Recommendation Constituents det. > State Water Quality Stds.	Yes
Campbell Street Fuel Farm	Site Assessment Recommendation Constituents det. > State Water Quality Stds.	Yes
Rifle Range at MCX Service Station (UST System RR-72)	Site Assessment Recommendation Verified contamination during site assessment	Yes
Steam Generating Plant - Building AS-4151	Site Assessment Recommendation Identified 2 isolated plumes of benzene contam.	Yes
Building 21, River Road (UST 21.1)	Site Assessment Recommendation Identified 2 isolated contaminant plumes	Yes
Hadnot Point Fuel Farm **	Pump and Treat on-line	Yes
Tarawa Terrace Service Station *	Pump and Treat System is in place	Yes
Tank S781 - Building No. 45 (Midway Park)	Site Assessment Recommendation Lack of significant groundwater contamination	No
Waste Oil Storage Tanks S889-S891 (Holcomb Boulevard	Site Assessment Recommendation No evidence of subsurface TPH leaching to GW	No
Tarawa Terrace Tanks STT61-STT66	Site Assessment Recommendation Natural biodegradation/attenuation - GW Monitoring	No
Campbell Street JP-5 Pipeline	Site Assessment Recommendation - Remediate Soils as source, passive groundwater remediation	No
Rapid Refueler (JP-5 Pipeline and South End of Aircraft	Site Assessment Recommendation - Concentrations not significant, remediate soils to remove source	No
Amphibious Vehicle Maintenance Area (UST SA-21)	Site Assessment Recommendation - Remove cont. soils, natural biodegradation GW/Monitoring Progra	No
UST H-28 (Building H-28)	Site Assessment Recommendation - Remediate soils as source, no active GW remediation necessary	No
Buildings M232-M236 (USTs at Camp Johnson)	Site Assessment Recommendation - GW remediation not warranted, consituents not exceed criteria	No

NOTES:
* - Indicates that a groundwater pump and treat system is in place, but not yet on-line.
** - Indicates that a groundwater pump and treat system is in place and on-line.

events were evaluated and compared to North Carolina Water Quality Standards (Class GA and GSA) for Federal MCLs. For each site, contaminated wells (wells with documented groundwater concentrations above state or federal criteria) were identified as well as clean wells (concentrations below criteria). Based on engineering judgment, and the relative locations of contaminated and clean wells and their boundaries, the potential lateral extent of contamination was identified, using available site drawings, and an areal extent estimated in square feet. As far as the depth of contamination, in general, for both IR and UST sites, with the exception of Site 6, groundwater contamination appears to be limited to the shallow aquifer. Site 6 was identified as requiring remediation of both the shallow and deep aquifer.

Maximum concentrations of each constituent detected were identified for each site. These concentrations were compared to both MCLs and North Carolina Water Quality Standards. Contaminants which were present above either of these criteria were identified as potential COCs, for consideration in groundwater treatment scenarios. Detected constituents with no MCLs or North Carolina Water Quality Standard were identified at maximum concentration levels.

2.2.2 Estimated Flow Rates and Durations of Remediation

Estimated groundwater flow rates and anticipated durations of pumping or extraction at each site are presented below for both IR and UST sites.

2.2.2.1 IR Sites

In order to estimate groundwater production from a contaminated aquifer it is necessary to make assumptions regarding well configuration, spacing, and productivity. Typically, prior to the design of an extraction system, an extensive site characterization is performed to determine site specific stratigraphy, transmissivity, water table data, hydraulic gradient, groundwater velocity and direction, and optimal pumping rates. This information and data is used to determine well spacing, configuration, and well field productivity. However, this level of data was not available for each site. As a result, broad-based assumptions were used to estimate groundwater production on a site-by-site basis.

Well Configuration

A number of well configurations could be effectively implemented at a site to recover contaminated groundwater. For this study, at sites with known groundwater direction, wells were configured in a line perpendicular to the flow of groundwater, downgradient of the contamination source. This type of configuration has been shown to be effective in capturing and containing a contaminant plume.

The direction of groundwater flow is known at 17 sites. However, at two sites (12 and 85) no site characterization or investigation had been performed and the direction of groundwater flow was unknown. To provide a rough estimate of the number of wells needed for an uncharacterized site, the area of contamination was assumed to fit into a square. The diagonal of this square was assumed to be perpendicular to groundwater flow. Wells would be placed along this diagonal to capture the contaminant plume.

Well Spacing

The capture zone that each well can generate will determine well spacing and the total number of wells needed at a site to capture a contaminant plume. An empirical determination of the capture zones of wells at each of the sites requiring groundwater remediation would require site-specific hydrological and hydrogeological data. Based on data from previous pump tests conducted at the Base, a conservative spacing of 250 feet was selected for well spacing. This is within a range of 150 feet to 300 feet reported for fine sand (USEPA Leachate Plume Management, 1985).

Well Productivity

Estimated yields from shallow recovery wells at 14 IR sites with limited data were based on historical data. Typically, optimal yields from wells drawing from the shallow aquifer at the Base range between 3 and 5 gallons per minute (gpm). However, yields can vary from this range, depending on site-specific conditions. For this study a yield of 4 gpm was assumed for shallow recovery wells at the sites with limited site specific data. It was assumed that no deep recovery wells would be needed at these sites.

More extensive site-specific data was available for Sites 6 and 82 from the Final Feasibility Study for Operable Unit No. 2 (Sites 6, 9, and 82) (Baker, 1993) and the Proposed Final

Remediation Plan for Operable Unit No. 2 (Sites 6, 9, and 82) (Baker, 1993). The Remedial Action Alternatives (RAA) for groundwater discussed in these documents, used yields of 5 gpm for shallow recovery wells and 150 gpm for deep recovery wells. These yields will be used in this study for Sites 6 and 82.

Pumping Duration

Because of limited site-specific data, it is difficult to empirically determine the volume of groundwater at each site that will need to be extracted in order to achieve the remediation goals. Therefore, Baker assumed that pumping durations for each site could range from 10 to 30 years.

2.2.2.2 <u>UST Sites</u>

Site-specific data was available for most of the UST sites identified as requiring groundwater remediation, as site assessments or investigations were conducted at these sites. Hydrogeological data generated during these assessments include, but are not limited to depth to groundwater, hydraulic conductivity, hydraulic gradient, groundwater flow direction, and site geology. In addition, where pump tests are conducted, additional data include transmissivity and storativity values for the aquifer.

Typically, this type of data is used to develop detailed estimates of well configuration, spacing, productivity, and pumping duration required to meet remediation goals. For the scope of this study, detailed estimates could not be made for every site. Rather, if data was available, theoretical equations were used to estimate trench or extraction well flow rates. If sufficient data was not available, the same assumptions used for IR sites were applied to UST sites.

Interceptor Trench Flow Rate Estimates and Placement

Trenches were recommended in Site Assessment Reports as the groundwater extraction technology for 5 UST sites, as identified in the Site Evaluation Matrix (Appendix B). In order to estimate a flow production from a typical groundwater collection trench, theoretical equations were used to calculate both a lower bound and upper bound flow.

The lower bound flow estimate was calculated assuming Darcy's Law as follows:

$$Q = K \times i \times A$$

where: Q = flow through area A per unit time (CF/MIN)

K = permeability of previous stratum in direction of flow (ft/sec)

i = hydraulic gradient producing flow (ft/ft)

A = cross-sectional area of element (stratum) through which flow proceeds

This equation assumes zero induced head, average hydraulic conductivity values, and average hydraulic gradients. An upper bound flow estimate was calculated using the following equation:

$$Q = K*x/(2*L)*(H\hat{}2\text{-}he\hat{}2)$$

where: Q = flow through area A per unit time (CF/MIN)

K = permeability of previous stratum in direction of flow (ft/sec)

x = length of trench (ft)

L = distance from trench location to end of zone of influence (ft)

H = elevation head and total head (ft)

he = seepage elevation (ft)

This equation assumes flow to a fully penetrating slot from a single line source (unconfined flow), a one-sided trench with geomembrane on back and ends, equilibrium conditions occur after drawdown, infinite trench length (relatively small zone of influence per pump test), the Dupuit-Forcheimer Assumption that the hydraulic gradient is constant at any vertical line below the drawdown curve or free water surface. Trench length (x) was estimated based on the estimated areal extent of contamination, to cover the extent of contamination (Note: Estimation of trench length is dependent on the accuracy of the scale of drawings available from Site Assessment Reports). It was assumed that seepage elevation (he) would equal zero, as the trench would not be pumped to its depth, and that an artificial head (H) would be induced within the trench. The parameter (L) was estimated as a nominal radius of influence of a pumping well (from pump test data). Flow rate (Q) was estimated for a range of H equal to 1 to 4 feet.

Site-specific data was evaluated (including hydraulic conductivity, gradient, etc.) and flow estimates were generated for the lower and upper bound. These estimates were compared, along with production rates achieved in pump tests (if performed) and the higher flow rate, or some reasonable rate in between, based on engineering judgment, was assumed to be a conservative estimate of potential flow production for a trench system at each of the 5 UST sites. In all cases, it was assumed that the groundwater extraction trench would be placed downgradient of the area of contamination identified, based on groundwater flow direction. Flow rates for the 5 UST sites where trenches are the recommended extraction technology are summarized in the Site Evaluation Matrix, attached as Appendix B.

Extraction Wells

Similar to the methodology for trenches, a lower and upper bound flow estimate was developed for UST sites where extraction wells were the assumed groundwater extraction technology. For a lower bound estimate, the same assumption utilized for well productivity at IR sites was utilized for UST sites. This assumption concluded that optimal yields for wells drawing from the shallow aquifer range between 3 and 5 gpm, with an average of 4 gpm. Because hydrogeological data was available for a majority of the UST sites, an upper bound flow estimate was generated utilizing the following theoretical equation:

$$H\hat{}2\text{-}hw\hat{}2 = (Q/pi \times K) \times \ln(Ro/rw)$$

or

$$Q = H\hat{}2\text{-}hw\hat{}2/\ln(Ro/rw) \times pi \times K$$

where: H = saturated aquifer thickness, (ft)
hw = height of water at well (ft), measured from bottom of aquifer
Q = pumping rate, (CF/Day)
K = hydraulic Conductivity (ft/day)
Ro = radius of influence of cone of depression (ft)
rw = radius of well (ft)

This equation represents the basic formula for equilibrium radial flow to a well, in an unconfined aquifer, developed by "Theim and Forcheimer" (USEPA, 1985). Available site-specific data was evaluated and upper bound flow estimates were calculated for each of the eight UST sites identified as requiring remediation (not identified as a site where a extraction trench should be used). The lower and upper bound flow estimates were compared and a representative flow for each of the eight UST sites was identified based on engineering judgment.

It should be understood that with the application of any theoretical or empirical formula without detailed parameter definition and documented applicability, there is the potential for error in flow estimates due to the number of assumptions made to define parameter values, and a field pump test would be required to determine the optimal well configuration, spacing, and productivity.

The number of extraction wells to be used at each site was determined on a site-by-site basis. In some instances, localized plumes were identified, and assuming a nominal radius of influence of 250 feet, only one extraction well was deemed necessary. In these scenarios, the well was assumed to be placed downgradient of the highest level of contamination. In other scenarios, based on the areal extent of contamination identified, several wells were required, and assumed to be placed in a line perpendicular to the groundwater flow direction and downgradient and at the leading edge of the estimated contaminant plume.

Flow rates for the remaining 8 of 13 UST sites requiring groundwater remediation where extraction wells are the assumed extraction technology are summarized in the Site Evaluation Matrix attached as Appendix B.

Existing Pump and Treat Systems at UST Sites

As mentioned previously, there are pump and treat systems in place at three UST sites. These include Hadnot Point Fuel Farm, where the system is on-line and has been operational for several years, and Tarawa Terrace Service Station and JP-5 Line Area Site, where systems are in-place, but not yet on-line. Extraction well flow rates for these sites was estimated based on available information. Since the Hadnot Point system was on-line, operational data was available from quarterly monitoring reports. Based on the report for the period October 1 through December 31, 1992, an average was developed for the amount of groundwater treated per day over the three month period. This flow was estimated at an average of 3 gpm and a conservative flow of 5 gpm for the Hadnot Point Fuel Farm. In addition, influent concentrations for analytical samples obtained were averaged to develop average groundwater concentrations of 7800 ppb benzene, 9600 ppb toluene, 680 ppb ethylbenzene, and 4000 ppb xylenes (total).

Since there was no data available, flow production for both the JP-5 Line Area site and Tarawa Terrace Service Station Pump and Treat Systems was assumed to be 8 gpm (4 gpm from two wells). Contaminant levels for JP-5 Line Area site were obtained from the Site Assessment Report prepared for the site. Because a Site Assessment Report was not available for Tarawa Terrace Service Station, the same assumption was made that two extraction wells would produce a total of 8 gpm. Constituents of concern were assumed to be benzene, toluene, ethylbenzene, and xylenes, at an average of concentrations detected for all UST sites located in the Tarawa Terrace outfall area.

Addition of New UST Sites To Require Groundwater Remediation

In accordance with LANTDIV's Scope of Work, Baker was to assume that 20 hypothetical UST sites requiring groundwater remediation would be added per year from Fiscal Year 1995 through Fiscal Year 1999. Baker assumed that the number of hypothetical UST sites assigned to an outfall would be approximately proportional to the number of USTs listed in the POL Inventories of the Final Spill Prevention and Countermeasures (SPCC) Plan, MCB Camp Lejeune, North Carolina (Baker, 1993). Table 2-3 is a breakdown, by outfall, of the existing 174 USTs inventoried in the SPCC Plan and the hypothetical UST sites.

In order to develop anticipated flow rates to be treated per each new UST site, the following assumptions were made:

- Camp Geiger Area (10 gpm - the average low flow calculated for existing UST sites was 1.5 gpm and average high flow was 10 gpm)

- Hadnot Point Industrial Area (5 gpm - the average low flow for existing UST sites was 1.5 gpm and average high flow was 7 gpm)

- Other Areas (5 gpm - as a conservative assumption)

Anticipated influent concentrations for the UST sites to be added per year were based on a range of concentrations detected above an MCL or North Carolina Water Quality Standard at the 13 UST sites currently identified as requiring groundwater remediation.

Table 2-4 presents a summary of "Hypothetical UST Sites" to be added per year as requiring groundwater remediation, for Fiscal Year 1995 through Fiscal Year 1999. The sites were

TABLE 2-3

TREND ANALYSIS OF USTS FROM SPCC PLAN

OUTFALL	AREA OF OUTFALL	No. Tanks IN SPCC	% OF INVENTORI USTs BY OUTFAL	% OF HYPOTHETICAL USTs BY OUTFA	# OF ANNUAL HYPOTHETICAL USTs BY OUTFAL
Hadnot Point	French Creek	31			
Hadnot Point	Paradise Point	4			
Hadnot Point	Naval Hospital	8			
Hadnot Point	Berkely Manor	8			
Hadnot Point	Midway Park	5			
Hadnot Point	HPIA	65			
Total Hadnot Point Outfall		121	69.54	70	14
Camp Geiger	MCA Air Station	21			
Camp Geiger	Camp Geiger	4			
Total Camp Geiger Outfall		25	14.37	15	3
Courthouse Bay	Amphibian Troops	4			
Courthouse Bay	Courthouse Bay	12			
Total Courthouse Bay Outfall		16	9.20	10	2
Terrawa Terrace	Terrawa Terrace	10			
Total Terrawa Terrace Outfall		10	5.75	5	1
Rifle Range	Rifle Range *	0			
Total Rifle Range Outfall		0	0.00	0	0
Onslow Beach	Onslow Beach	1			
Total Onslow Beach Outfall		1	0.57	0	0
Montford Point	Camp Johnson	1			
Total Montford Point Outfall		1	0.57	0	0
Totals		174	100.00	100	20

* This does not include the UST at Building 72

TABLE 2 - 4
CAMP LEJEUNE CTO #140
IR/UST SITES EFFLUENT STUDY

SUMMARY OF UST SITES TO ADD PER YEAR FOR GROUNDWATER REMEDIATION
FISCAL YEARS 1995 THROUGH 1999

FISCAL YEAR	(1) ADDED NO. SITES PER YEAR	UST SITE LOCATION (OUTFALL)	(2) % SITES	NO. UST SITES PER YEAR PER OUTFALL	HYPOTHETICAL UST SITE NAME
1995	20				
		Hadnot Point	70	14	
					1995-HP1
					1995-HP2
					1995-HP3
					1995-HP4
					1995-HP5
					1995-HP6
					1995-HP7
					1995-HP8
					1995-HP9
					1995-HP10
					1995-HP11
					1995-HP12
					1995-HP13
					1995-HP14
		Camp Geiger	15	3	
					1995-CG1
					1995-CG2
					1995-CG3
		Courthouse Bay	10	2	
					1995-CB1
					1995-CB2
		Tarawa Terrace	5	1	
					1995-TT1
		Montford Point	0	0	
		Onslow Beach	0	0	
		Rifle Range	0	0	
1996	20				
		Hadnot Point	70	14	
					1996-HP1
					1996-HP2
					1996-HP3
					1996-HP4
					1996-HP5
					1996-HP6
					1996-HP7
					1996-HP8
					1996-HP9
					1996-HP10
					1996-HP11
					1996-HP12
					1996-HP13
					1996-HP14
		Camp Geiger	15	3	
					1996-CG1
					1996-CG2
					1996-CG3
		Courthouse Bay	10	2	
					1996-CB1
					1996-CB2
		Tarawa Terrace	5	1	
					1996-TT1
		Montford Point	0	0	
		Onslow Beach	0	0	
		Rifle Range	0	0	

TABLE 2 - 4
CAMP LEJEUNE CTO #140
IR/UST SITES EFFLUENT STUDY

SUMMARY OF UST SITES TO ADD PER YEAR FOR GROUNDWATER REMEDIATION
FISCAL YEARS 1995 THROUGH 1999

FISCAL YEAR	(1) ADDED NO. SITES PER YEAR	UST SITE LOCATION (OUTFALL)	(2) % SITES	NO. UST SITES PER YEAR PER OUTFALL	HYPOTHETICAL UST SITE NAME
1997	20				
		Hadnot Point	70	14	
					1997-HP1
					1997-HP2
					1997-HP3
					1997-HP4
					1997-HP5
					1997-HP6
					1997-HP7
					1997-HP8
					1997-HP9
					1997-HP10
					1997-HP11
					1997-HP12
					1997-HP13
					1997-HP14
		Camp Geiger	15	3	
					1997-CG1
					1997-CG2
					1997-CG3
		Courthouse Bay	10	2	
					1997-CB1
					1997-CB2
		Tarawa Terrace	5	1	
					1997-TT1
		Montford Point	0	0	
		Onslow Beach	0	0	
		Rifle Range	0	0	
1998	20				
		Hadnot Point	70	14	
					1998-HP1
					1998-HP2
					1998-HP3
					1998-HP4
					1998-HP5
					1998-HP6
					1998-HP7
					1998-HP8
					1998-HP9
					1998-HP10
					1998-HP11
					1998-HP13
					1998-HP14
		Camp Geiger	15	3	
					1998-CG1
					1998-CG2
					1998-CG3
		Courthouse Bay	10	2	
					1998-CB1
					1998-CB2
		Tarawa Terrace	5	1	
					1998-TT1
		Montford Point	0	0	
		Onslow Beach	0	0	
		Rifle Range	0	0	

TABLE 2 - 4
CAMP LEJEUNE CTO #140
IR/UST SITES EFFLUENT STUDY

SUMMARY OF UST SITES TO ADD PER YEAR FOR GROUNDWATER REMEDIATION
FISCAL YEARS 1995 THROUGH 1999

FISCAL YEAR	(1) ADDED NO. SITES PER YEAR	UST SITE LOCATION (OUTFALL)	(2) % SITES	NO. UST SITES PER YEAR PER OUTFALL	HYPOTHETICAL UST SITE NAME
1999	20				
		Hadnot Point	70	14	
					1999-HP1
					1999-HP2
					1999-HP3
					1999-HP4
					1999-HP5
					1999-HP6
					1999-HP7
					1999-HP8
					1999-HP9
					1999-HP10
					1999-HP11
					1999-HP12
					1999-HP13
					1999-HP14
		Camp Geiger	15	3	
					1999-CG1
					1999-CG2
					1999-CG3
		Courthouse Bay	10	2	
					1999-CB1
					1999-CB2
		Tarawa Terrace	5	1	
					1999-TT1
		Montford Point	0	0	
		Onslow Beach	0	0	
		Rifle Range	0	0	

(1) Contractor is to assume 20 sites will be added per year requiring groundwater remediation from Fiscal Year 1995-1999.
(2) Based on an evaluation of the number of USTs inventoried in the SPCC Plan the following trend was indicated:

121/174 Hadnot Point
25/174 Camp Geiger
16/174 Courthouse Bay
10/174 Tarawa Terrace
1/174 Onslow Beach
1/174 Montford Point
0 Rifle Range

Therefore, assume the following percentage breakdown of new UST Sites per Outfall Locations:

Hadnot Point 70%
Camp Geiger 15%
Courthouse Bay 10%
Terrawa Terrace 5%
Remaining sites are assumed to have no new USTs

(3) For anticipated flowrates to be treated per each new UST site, assume the following:
Camp Geiger - 10 gpm (conservative as average low calculated for existing UST sites was 1.5 gpm and average high was 10 gpm).
Hadnot Point - 5 gpm (conservative as average low calculated for existing UST sites was 1.5 gpm and average high was 7 gpm)
All other Areas - 5 gpm (to be conservative)

(4) For anticipated influent concentrations, assume the following:

(Concentrations in ug/L)	Camp Geiger	Hadnot Point	Other Areas
Benzene	1200	15000	200
Ethylbenzene	400	1500	600
Toluene	400	22000	50
Xylenes	3000	8000	900
Trichloroethylene	500	-	-
Tetrachloroethylene	100	-	-
Total Hydrocarbons	400000	200	-

Note: These concentrations are based on a range of concentrations detected above an MCL or North Carolina Water Quality Standard at the 13 UST sites anticipated to require groundwater remediation. These 13 sites were identified from the initial evaluation of the 17 UST sites cited in the Contract Task Order (CTO 140) Scope of Work, and 4 UST sites added where recent site investigations have been performed.

identified as "hypothetical sites" for purposes of evaluating the impact of adding additional UST sites per year for groundwater remediation. In accordance with the Scope of Work, 20 hypothetical UST sites were added per year, for a total of 100 hypothetical UST sites.

Groundwater Remediation Duration

Because of the scope of this study, and the information available, an empirical determination was not made for each and every UST site requiring groundwater remediation. Rather, for purposes of evaluating life cycle costs for treatment alternatives, it is assumed that typical groundwater remediation will range from 10 to 30 years in duration. Although groundwater extraction and treatment typically occur over shorter time periods where trenches are chosen as the extraction technology, treatment alternatives cost analysis will still be performed assuming 10 and 30 year treatment periods, in accordance with this CTO.

2.2.3 Projected Start-Up Dates for Remediation at Each Site

Start-up dates for groundwater remediation at the IR sties was based on information in Tables 4-1 through 4-13 in the Fiscal Year 1994 Site Management Plan (SMP) Marine Corps Base Camp Lejeune, North Carolina (Baker, 1993). Table 2-5 summarizes these proposed start-up dates, which are also included in the Site Evaluation Matrix (Appendix B).

Start-up dates for groundwater remediation of 14 of the IR sites (Sites 1, 3, 6, 16, 24, 28, 36, 41, 43, 44, 69, 73, 80, and 82) was assumed to be approximately the same as the start dates for remedial action noted in the SMP. Start-up dates for groundwater remediation at 2 IR sites (Sites 12 and 68) had not been established in the SMP. For these sites it was assumed that construction would begin 60 months from the date the Final Site Investigation Project Plans are to be submitted to LANTDIV. This 60-month assumption can be broken down as follows.

- Six months to complete all SI activities
- Twelve months between the submission of Final SI Report and the commencement of RI/FS activities
- Forty-two months between commencement of RI/FS activities and the commencement of remedial action

TABLE 2-5

PROPOSED START-UP DATES FOR REMEDIATION OF IR SITES

Site Number/Name	Current Status	Estimated Fiscal Year 1994 SMP SMP Dates for the Start-Up of Remedial Action
#1, French Creek Liquids Disposal Area	RI/FS	August 1996 (6)
#2, Former Nursery/Day-Care Center	RI/FS	November 1995 (4)
#3, Old Creosote Plant	RI/FS	December 1996 (11)
#6, Storage Lots 203 and 201	Design	May 1995 (2)
#12, Explosive Ordnance Disposal	SI	July 1999 (12)
#16, Montford Point Burn Dump	RI/FS	June 1997 (7)
#24, Industrial Fly Ash Dump	RI/FS	October 1995 (1)
#28, Hadnot Point Burn Dump	RI/FS	August 1996 (6)
#35, Camp Geiger Fuel Farm	RI/FS	September 1996 (9)
#36, Camp Geiger Dump Near STP	RI/FS	April 1997 (5)
#41, Camp Geiger Dump Near Trailer Park	RI/FS	August 1996 (3)
#43, Agan Street Dump	RI/FS	April 1997 (5)
#44 Jones Street Dump	RI/FS	April 1997 (5)
#68, Rifle Range Dump	SI	July 1999 (12)
#69, Rifle Range Chemical Dump	RI/FS	August 1996 (3)
#73, Courthouse Bay Liquids Disposal Area	RI/FS	April 1997 (8)
#80, Paradise Pt. Golf Course Peticide Area	RI/FS	December 1996 (10)
#82, Piney Green Road VOC Area	Design	May 1995 (2)

(1) The source of this information is Table 4-1 of the 1994 Site Management Plan For MCB Camp LeJeune (SMP).
(2) The source of this information is Table 4-2 of the SMP.
(3) The source of this information is Table 4-3 of the SMP
(4) The source of this information is Table 4-4 of the SMP.
(5) The source of this information is Table 4-5 of the SMP.
(6) The source of this information is Table 4-6 of the SMP.
(7) The source of this information is Table 4-7 of the SMP.
(8) The source of this information is Table 4-8 of the SMP.
(9) The source of this information is Table 4-9 of the SMP.
(10) The source of this information is Table 4-11 of the SMP.
(11) The source of this information is Table 4-12 of the SMP.
(12) The source of this information is Table 4-13 of the SMP. This estimated date is 60 months from the submission of Final Site Investigation Project Plans.

Projected start-up dates for remediation of groundwater at each of the 13 UST sites were assumed to be those pump and treat start dates summarized in the Scope of Work for this CTO. The start-up dates range from the 1st quarter of 1994 through the 4th quarter of 1994 for all UST sites, with the exception of Hadnot Point Fuel Farm, which has been on-line since the 2nd quarter of 1992. The Tarawa Terrace Service Station and JP-5 Line Area Site have in-place pump and treat systems scheduled to start-up in early 1994. Specific estimated pump and treat start-up dates for each of the 13 UST sites identified as requiring groundwater remediation are summarized in the Site Evaluation Matrix, contained in Appendix B.

2.2.4 The Location of Each Site with Respect to STPs and Receiving Streams

One of the alternatives identified for evaluation in the scope of work involved the construction of one or more treatment plants solely for groundwater generated at IR and UST sites. To develop costs for this alternative, IR and UST sits were grouped into one of the seven existing sanitary sewer service (outfall) areas. The existing seven STPs were located so the adjacent collection system could operate primarily under gravity flow. New regional plants were located at existing sites in order to take advantage of gravity flow and existing utilities. The location of individual sites with respect to STP service areas (UST and IR sites) and Operable Units (IR sites) are noted in Table 2-6.

Receiving streams for each STP service is identified as follows:

STP Service (Outfall) Area	Receiving Stream
Camp Geiger	New River
Montford Point	Northeast Creek
Tarawa Terrace	Northeast Creek
Hadnot Point	New River
Rifle Range	Stone Bay
Courthouse Bay	Northeast Creek
Onslow Beach	Intracoastal Waterway

TABLE 2-6

LOCATION OF IR AND UST SITES WITH RESPECT TO TREATMENT PLANTS

Hadnot Point Industrial Area Sewage Treatment Plant

IR Sites	UST Sites
Site 1, French Creek Liquids Disposal Area	River Road Building 21
Site 3, Old Creosote Plant	Gottshalk Marina
Site 6, Storage Lots 203 and 201	Berkly Manor
Site 24, Industrial Fly Ash	HPIA Fuel Farm
Site 28, Hadnot Point Burn Dump	Hypothetical Tank Sites (14 sites per year)
Site 78, Hadnot Point Industrial Area	
Site 80, Paradise Pt. Golf Course	
Site 82, Piney Green Road VOC Area	

Tarrawa Terrace Area Sewage Treatment Plant

IR Sites	UST Sites
	Building 45
	Hypothetical Tank Sites (1 per year)

Montford Point Sewage Treatment Plant

IR Sites	UST Sites
Site 16, Montford Point Burn Dump	

Camp Geiger Sewage Treatment Plant

IR Sites	UST Sites
Site 41, Camp Geiger Dump Near Trailer Park	Camp Geiger Service Station
Site 36, Camp Geiger Dump Near STP	MCAS JP-5
Site 43, Agan Street Dump	Building 4151, Steam Generator
Site 44, Jones Street Dump	Camp Geiger Fuel Farm (Site 35)
	Hypothetical Tank Sites (3 per year)

Rifle Range Sewage Treatment Plant

IR Sites	UST Sites
Site 68, Rifle Range Dump	RR Building 72
Site 69, Rifle Range Chemical Dump	

Courthouse Bay Sewage Treatment Plant

IR Sites	UST Sites
Site 73, Courthouse Bay LDA	Hypothetical Tank Sites (2 per year)

Onslow Beach Sewage Treatment Plant

IR Sites	UST Sites
Site 12, Explosive Ordnance Disposal	

3.0 IDENTIFICATION AND EVALUATION OF FEASIBLE TECHNOLOGY OPTIONS FOR GROUNDWATER REMEDIATION AND DISCHARGE

This Section outlines an appropriate range of treatment technologies that are potentially applicable for groundwater remediation and discharge at sites within MCB, Camp Lejeune. These technologies were identified based on a review of available site background information, contaminants of concern (COCs), and engineering judgment. Feasible technologies could potentially be assembled as components of an overall groundwater treatment system for the following four alternatives:

- Alternative 1 - Construction of Individual Pump and Treat Systems for each IR and UST Site

- Alternative 2 - Construction of Regional Treatment Plants Within Each of Seven STP Outfall Areas

- Alternative 3 - Conversion of Existing STP to a Central Groundwater Treatment Plant

- Alternative 4 - Treatment at Planned Hadnot Point Sewage Treatment Plant

The technologies are identified and evaluated in the following sections. The evaluation is intended to identify the most appropriate and cost effective technology to be incorporated as the primary component of a groundwater treatment system. Additional pretreatment technologies will be included as part of the treatment system where applicable. Finally, alternative methods of discharging treated groundwater were considered.

3.1 Identification of Potentially Applicable Technologies

Based on a review of background information available for the sites included in the scope of this study, and the Site Evaluation Matrix prepared and presented in Section 2.0, the primary COCs detected in the groundwater at MCB, Camp Lejeune sites include volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals. Additionally, there are scattered occurrences of pesticides and explosives (ordnances). Due to the number of sites included in this study, technologies identified and evaluated were limited to conventional and demonstrated technologies with specific application to the COCs in groundwater. The technologies are described in further detail in the following sections, along with their applicability and limitations.

3.1.1 Aerobic Biological Treatment

Aerobic Biological treatment technologies are effective in the degradation/removal of primarily non-halogenated organic COCs including benzene, methylene chloride, toluene. Under controlled conditions successful removal of halogenated compounds such as trichloroethylene, and vinyl chloride may also be achieved (Rich, 1986). Actual removal efficiencies for these compounds can be determined during pilot testing. Heavy metals, such as lead, are typically not removed through biological treatment, and may even be inhibitory to biological populations at concentrations greater than 10 mg/L. Similarly, organic chemicals may also be inhibitory at elevated concentrations (ESE, 1988).

3.1.1.1 In-Situ Treatment

In-situ treatment involves the treatment of groundwater in place without the need for collection prior to treatment. In-situ treatment processes are generally divided into three categories: biological, chemical, and physical. In-situ biological treatment is based on the concept of enhancing subsurface nutrient and oxygen conditions to stimulate a microbial population to degrade contaminants. In-situ chemical treatment involves the injection of a specific chemical or chemicals into the subsurface in order to degrade, immobilize, or flush contaminants (USEPA, 1985). Physical in-situ treatment refers primarily to methods of temperature manipulation (heating and freezing). In-situ treatment methods can be used to restore both soil and groundwater quality.

3.1.1.2 Subsurface Biological Treatment

Biological treatment refers to techniques whereby contaminant removal is achieved via microbial metabolization. In-situ biological treatment utilizes microbial processes (primarily aerobic, but, in limited cases anaerobic) in which environmental conditions that promote biological activity are optimized. This is typically achieved by supplying an oxygen source and, in some cases, delivering nutrients to the subsurface via an injection wells, infiltration galleries, or other physical means.

The feasibility of implementing in-situ biological treatment as a remedial technique is dependent on waste and site characteristics, including the relative biodegradability of the organic COCs, environmental factors which affect microbial activity, and site hydrogeology. Biological treatment will only reduce the concentration of organic compounds which are amenable to biological degradation. These are compounds that are either substrates for microbial growth and metabolism, or are cometabolically broken down as the microorganism uses another primary substrate as its carbon and energy source (USEPA, 1985).

Most VOCs and SVOCs are considered to be relatively biodegradable, based on a ratio of biological oxygen demand (BOD_5) to chemical oxygen demand; however some VOCs, including multi-chlorinated compounds such as trichloroethylene considered less amenable to biological degradation.

The availability of a compound to the microbial population in the subsurface will also affect its biodegradability. Environmental factors which affect microbial activity and population size and determine the rate and extent of biodegradation include appropriate levels of organic and inorganic nutrient trace elements, oxygen concentration, pH, degree of water saturation, hydraulic conductivity of the soil, temperature, and the presence of toxins and growth inhibitors, such as heavy metals. Concentrations of contaminants at high levels can be toxic to microbial populations. Conversely, concentrations at low levels may not adequately stimulate the microbial population to promote the degradation of the contaminants (USEPA, 1985).

3.1.1.3 Ex-Situ Biological Treatment

Technologies addressed in this evaluation which utilize ex-situ biological processes for treatment of contaminated groundwater include aerobic activated sludge, aerobic-aerated lagoon, and a fixed-film, aerobic, trickling filter. These technologies are described below:

Aerobic Activated Sludge

The activated sludge process is an aerobic biological treatment technology that employs microorganisms to degrade a wide variety of organic constituents in aqueous waste streams. Typically, aqueous waste flows into an aeration basin or tank where microbial oxidation and assimilation (treatment) occur. Organic components of the aqueous waste stream serve as the carbon and energy sources required for microbial growth. Organic matter is converted to microbial cell tissue and carbon dioxide. Sludge generated from the process 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 commonly utilized biological wastewater treatment process. The effectiveness of the process depends primarily on organic loading, sludge retention time, mixed liquor suspended solids concentration, hydraulic retention time, and oxygen supply. It is possible that VOCs may be removed to a certain extent during the aeration process, and metals, if not removed during a pretreatment step, could settle out in the sludge.

Aerated Lagoon

Aerated lagoons operate on the same premise as completely mixed biological reactors, with the exception that there is no recycle of biomass. The lagoon is 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 major differences between an aerated lagoon and activated sludge system is that microorganisms in the lagoon are grown in a disperse state rather than a flocculent mass, and biomass is not recycled from the sedimentation step to the aeration step. The performance of aerated lagoons is dependent on detention time, temperature, and nature of the waste (USEPA, 1990). Two of the existing STPs, Camp Geiger and Hadnot Point, have aeration lagoons as part of the sewage treatment process.

Trickling Filter

The trickling filter process is an aerobic biological treatment process in which soluble organic compounds are removed from wastewaters. The process is based upon the principle in which a biological growth, attached to a nonmoving media, converts soluble organics present in wastewater streams into carbon dioxide, water, and bacterial solids. This aerobic biological process differs from the activated sludge process in that the microorganisms are attached to media fixed within a reactor, rather than suspended within a reactor. Efficient operation of a trickling filter can only be accomplished for wastewater streams that contain an adequate amount of soluble organics to support a viable mass of microorganisms. All seven of the STPs at MCB, Camp Lejeune employ trickling filters as part of the secondary treatment process.

3.1.2 Physical Separation Treatment (Ex-Situ)

Physical separation technologies typically applicable for the groundwater COCs include air stripping, carbon adsorption, filtration, oil/water separation, and sedimentation. These technologies are typically applied to groundwater that is made available for treatment above the ground surface after being extracted from the subsurface. When applied above the ground surface, these technologies are referred as ex-situ technologies. These technologies are described below.

3.1.2.1 Air Stripping

Air stripping is a physical separation process based on the equilibrium partitioning of a volatile compound between the aqueous and gas phases. There are a variety of process configurations available for air stripping, with the two most popular being conventional packed towers and low-profile air stripping units (for groundwater treatment). In a packed tower configuration, air is driven upwards through the tower, while contaminated water flows down through the tower, over inert packing material. On the other hand, typical low-profile air stripping units use adjustable trays, where water cascades down through the unit, and is contacted with a clean air stream. In either case, the contaminated water stream comes in contact with air, to promote mass transfer of volatile compounds from the aqueous to gas phase. Depending on the specific regulatory requirements of the state in which the process is operating, treatment of the discharged (contaminated) air stream may be required.

Equilibrium partitioning is dictated by a compound's Henry's Law Constant. Henry's Law Constant is the ratio of the gas phase concentration to liquid phase concentration, at equilibrium conditions. The greater the value of Henry's Law Constant, the greater the tendency for the compound to transfer from the water phase (groundwater stream) to the gas phase (air). Other factors which affect the effectiveness of air stripping besides Henry's Law Constant include air-to-liquid ratio, temperature, pH, and process equipment.

3.1.2.2 Carbon Adsorption

Carbon adsorption is a physical adsorption process in which soluble organic compounds are adsorbed to activated carbon within a reactor. Activated carbon is a highly porous solid which provides an extremely large active surface area for adsorption. For aqueous and vapor streams, the primary driving forces for adsorption include a combination of the hydrophobic nature of the contaminant and the affinity of the contaminant for the carbon. Adsorption of specific compounds is dependent on the properties of the carbon, physical and chemical characteristics and concentration of the compounds, characteristics of the aqueous phase, and the residence or contact time of the reactor. Carbon adsorption systems are typically designed as a dual bed series system, to provide a flexible carbon changing schedule and high effluent quality. Carbon adsorption can be used as a primary treatment step or a secondary (polishing) step of an overall treatment system. Carbon will require periodic change out and regeneration or replacement which is dependent on the concentrations of contaminants within the waste stream being treated.

3.1.2.3 Filtration

Filtration is a physical separation process used to remove suspended solids and biological floc from aqueous streams. 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. In typical cases, especially if dissolved metals are present, filtration is proceeded by chemical technologies such as neutralization and precipitation/coagulation. Pretreatment to remove oil and grease is required to prevent fouling of the filtration media. Backwashing of the filtration unit(s) is required whenever solids are detected in the effluent, or when the head loss of the media becomes significant. Backwash water is usually returned to the head end of the treatment plant, for subsequent treatment. The efficiency of a filtration unit is dependent upon several factors including influent flow rate, filter media type, media pore size, and characteristics of the aqueous waste stream to be filtered.

3.1.2.4 Oil/Water Separation

Oil/water separation is a physical separation technique used primarily to treat two-phased aqueous waste streams such as oil and water mixtures. The efficiency of the oil/water separation process requires that the nonaqueous phase have a significantly less specific gravity than water and should occur as a nonemulsified substance. If oils are emulsified in water, emulsion breaking chemicals can be added to allow separation into two phases. A removal system is designed as part of the separator for floated and settled material. Oil/water separation can be accomplished using a variety of process configurations including gravity separators, dissolved air flotation, residual oil flotation, coalesces, or ultrafiltration. Gravity separators are typically used in groundwater treatment systems. Recent advances in the technology of gravity separators have introduced units with plate packs that reduce the space requirements for settling because of the magnitude of increased surface area.

3.1.2.5 Sedimentation

Sedimentation is a physical separation process which relies on gravity to remove suspended solids from an aqueous waste stream. Sedimentation can be achieved in batch or continuous process modes in lined impoundments, conventional settling basins, clarifiers, tanks, and high rate gravity settlers. In low flow groundwater treatment systems (<10 gpm), sedimentation can be accomplished in a round tank with a conical bottom. A floating skimmer device can be employed to draw off supernatant, as the level of solids (sludge) changes in the tank. Pretreatment, including neutralization, and precipitation/coagulation is typically required before sedimentation is employed (depending on if solids are suspended or dissolved). Sludge produced as a result of the sedimentation process will require proper handling for disposal.

3.1.3 Chemical Treatment (Ex-Situ)

Chemical treatment technologies identified as potentially applicable for sites at Camp Lejeune include neutralization, precipitation/flocculation, and UV/chemical oxidation. These technologies are described in further detail below.

3.1.3.1 Neutralization

Neutralization involves the interaction of an acid with a base (or vice versa), to adjust the pH of an aqueous waste stream to approximately 7.0 standard units. This technology is one of the common types of chemical treatment used by industrial wastewater treatment facilities. Neutralization is suitable for the treatment of aqueous streams with high or low pH levels. In general, equalization basins or multiple neutralization units are used when the desired accuracy of the effluent pH is critical. Neutralization can be carried out as either a continuous or batch process. Batch processes allow for greatest control since the pH can be monitored and discharge delayed until proper pH is obtained; however, because of storage requirements, batch processes are typically limited to streams with low flows. Continuous neutralization processes require more elaborate control and feed equipment. The choice of a neutralizing agent is not only dependent on economics, but more so on compatibility of the agent with the waste stream and process equipment. One of the major limitations of neutralization is that it is subject to the influence of temperature and the resulting heat effects common to most chemical reactions (USEPA, 1990).

3.1.3.2 Precipitation/Flocculation

Precipitation is a physiochemical process where substances/compounds dissolved in solution are transformed into a solid phase for subsequent removal. Removal of metals as hydroxides or sulfides is the most common precipitation application in wastewater/groundwater treatment.

Flocculation is a process by which small, unsettleable particles suspended in a liquid medium are coaxed to agglomerate into larger, more settleable particles. Mechanisms which create flocculation include surface chemistry and particle charge phenomena. Specifically, two sequential mechanisms make up the flocculation process: (1) chemically induced destabilization of the requisite surface-related forces, allowing particles to stick together when they touch, and (2) chemical bridging and physical enmeshment between nonrepelling particles, allowing for formation of larger, more easily settleable particles. Flocculation involves three basic steps, including (1) addition of flocculating agent to waste stream, (2) rapid mixing to disperse flocculating agent, and (3) slow and gentle mixing to allow for contact between small particles (USEPA, 1985). Typical chemicals used to cause flocculation include alum, lime, various iron salts, and organic flocculating agents (polyelectrolytes).

After the precipitation/flocculation process is complete, and dissolved substances have been suspended, and flocculated into larger particles, sedimentation typically follows to remove suspended solids from the liquid, via gravity.

3.1.3.3 UV/Chemical Oxidation

UV/chemical oxidation is a chemical oxidation process which occurs in the presence of ultraviolet (UV) light, typically using either hydrogen peroxide (H_2O_2) or ozone (O_3) as the oxidants. While hydrogen peroxide solution can be purchased commercially, ozone, because of it's unstable nature, must be generated on site. During the process, compounds are exposed to UV radiation and oxidizing agent(s) in a reaction chamber. The UV radiation photolyzes both oxidant and compound to produce reactive free radical species, which participate in a series of oxidation reactions that lead to final products. Chemical oxidation can transform a variety of compounds (both inorganics and organics) into more stable, less toxic forms. The specific chemical reactions which occur are dependent on the particular contaminants, particular chemical oxidant, and solution pH. Theoretical considerations and treatability results are used to establish the process specific oxidant(s), oxidant dosage(s), and retention time(s) needed to properly treat the aqueous waste stream. This technology is applicable for groundwater and industrial wastewater contaminated with VOCs, SVOCs, and PCBs/pesticides.

3.1.4 Treated Groundwater Discharge Options

A common method of discharging treated groundwater from the IR and UST sites currently undergoing groundwater remediation at the Base is to discharge to a sanitary sewer. Typically, the treated groundwater is piped or pumped to the nearest sanitary sewer, and ultimately becomes part of the influent to one of the existing STPs. For the purpose of this study, discharge to a sanitary sewer is still considered as a viable alternative, especially for sites located in or near an area served by sanitary sewers. However, it is evident, based on discussions with Base planning personnel and LANTDIV, that a future scenario that projects a large volume of groundwater being sent to a STP, may not be acceptable, and may not be viable from a STP permitting standpoint. Therefore, alternative methods for discharge of treated groundwater have been considered. If these discharge methods are used at applicable IR and UST sites, the amount of groundwater that would be discharged to a STP would be decreased.

Alternative methods for the discharge of treated groundwater potentially applicable for the IR and UST sites include discharge to an infiltration gallery, injection well, or nonpotable reuse. These methods would be used to discharge treated groundwater following treatment for the removal of the COCs. A brief description of these discharge methods are presented below.

3.1.4.1 Discharge to a Sanitary Sewer

To date, the groundwater treatment systems that have been installed or designed for the Base have discharged treated groundwater to the sanitary sewer system. In some cases, because of site considerations, this alternative may prove to be the most cost effect discharge method. Therefore, this discharge alternative should still be considered when evaluating a site.

3.1.4.2 Infiltration Gallery

An infiltration gallery is a system of perforated piping that is installed in shallow trenches. The gallery is most often arranged with a header pipe that distributes the treated groundwater to a series of parallel pipes. Each of the distribution pipes have small openings along the length of the pipe, that allow the liquid to drain into the surrounding soil. As its name implies, the infiltration gallery is designed to allow the treated groundwater to infiltrate into the soil, so that the treated groundwater ultimately recharges the aquifer.

The infiltration gallery is an adaptation of the septic tank tile field. In a groundwater treatment system, the gallery is typically located upgradient of the contaminated area, which helps to flush the contaminates towards the extraction trenches or wells.

3.1.4.3 Injection Well

An injection well is another method for discharging treated groundwater back into the aquifer. The injection well is similar is design to an extraction well, and is used to inject groundwater back into the aquifer. The designer of the injection well must insure that the well design and selected pumping equipment is capable of overcoming the pressure head exerted by the aquifer.

In a groundwater treatment system injection wells are usually placed in one of two arrangements. The injection wells can be placed upgradient of the extraction wells, in an alignment that is perpendicular to the hydraulic gradient, or they can be placed in a circular arrangement, centered around an extraction well.

3.1.4.4 Nonpotable Reuse

Nonpotable reuse is a term used to describe the reuse of treated water for a beneficial purpose. The term is most often applied to the reuse of treated municipal or industrial wastewater, where the treated effluent is used for a beneficial purpose. However, nonpotable reuse may also have an application in a groundwater treatment and discharge system. Nonpotable reuse options include spray irrigation, fire protection, evaporative cooling, and boiler feed. For the purposes of this study, only spray irrigation will be evaluated as a nonpotable reuse option. While these other reuse systems may be applicable at specific sites, the evaluation of these options is beyond the scope of this project.

Where sites conditions permit, treated groundwater could be sprayed over a vegetated area as a means of discharge. In a spray irrigation system, a system of sprinklers is used to deliver groundwater to an dedicated irrigation area. Typically, there are restrictions on the location of the spray field, relative to other buildings and facilities. In some cases, the spray field would have to have access restrictions to prevent exposure to humans when the system is operating. At MCB Camp Lejeune, a spray system would be designed based on a site specific maximum application rate (1.75 inches per week in North Carolina), and would have to meet other State requirements in accordance with Chapter 15A of the North Carolina Administrative Code (NCAC) 2H .0200. Therefore, the size and design of the spray field would be based on the amount of groundwater to be discharged.

3.2 Evaluation of Potentially Applicable Technologies

In order to simplify the evaluation of the four groundwater treatment and discharge alternatives, the extent of technology evaluation must be reasonably limited in scope. This is primarily due to the number of sites included in this study. The primary objective of this study is to recommend a strategy for managing groundwater remediation at MCB, Camp Lejeune. This objective could be successfully accomplished by identifying the most appropriate and cost effective treatment and discharge technologies to act as the primary components for a groundwater treatment and discharge system on a site-wide basis, and evaluating this technology in each of the four treatment alternative scenarios.

The most appropriate and cost effective primary treatment and discharge technology will be identified based on an identifiable site-wide trend of groundwater remediation requirements at MCB, Camp Lejeune (i.e. comparable flows, COCs, etc.). Sites not corresponding to the site-wide trend will require "specialized" treatment systems, for which the primary technology can be applied from the other appropriate technologies retained during the following technology evaluation.

3.2.1 Treatment Technology Evaluation

Table 3-1 presents a summary evaluation of the applications, limitations, advantages, and disadvantages for each technology/process option identified in Section 3.1. A brief description of the rationalism for the technologies selected for further evaluation is provided herein.

TABLE 3 - 1
CAMP LEJEUNE IR/UST SITES EFFLUENT STUDY
TECHNOLOGY/PROCESS OPTION EVALUATION SUMMARY

TECHNOLOGY/PROCESS OPTION (1)	APPLICATIONS	LIMITATIONS	ADVANTAGES	DISADVANTAGES	TECHNOLOGY RETAINED FOR FURTHER EVALUATION	
					YES	NO
IN SITU TREATMENT (AEROBIC - BIOLOGICAL)						
Bioreclamation	* Soils/Groundwater where organic contamination source exists * Contaminants of Concern are relatively biodegradable Most suitable organic groups include: Aromatics and Halogenated aromatics Polyaromatic Hydrocarbons Phenols, Halophenols Biphenyls, Organophosphates Pesticides, Herbicides	* Biodegradability of organic contaminants * Poor Environmental Factors (i.e. low hydraulic conductivity of soil, lack of organic and inorganic nutrients trace elements, * Heavy metals in groundwater/sorbed on soil can oxidize as result of oxidizing subsurface, precipitate iron and manganese hydroxides, nutrient/oxygen/chemical delivery system could potentially be plugged * High concentrations of inorganic and/or organic contaminants can be toxic to microbial populations; conversely, concentrations too low can deprive microbial population of food source * Competition for food source by predators	* Capable of degrading organics sorbed to soils * Treats contaminated soil in subsurface without need for excavation and removal	* Implementation/Treatment Period longer than excavation and removal of contaminated soils * Subject to fluctuations in subsurface environment	X (2)	
EX SITU TREATMENT (AEROBIC - BIOLOGICAL)						
Activated Sludge	* Aqueous waste streams containing conventional pollutants, phenolics, oil & grease, polynuclear aromatic hydrocarbons, volatile organics, biodegradable inorganics * Conventional treatment applicable to low strength wastes * Proven effective treatment for a wide range of organic compounds	* Activated sludge process subject to shock loads * Pretreatment required for suspended solids, oil & grease and metals * Efficient operation of process requires aqueous stream with sufficient soluble organics to support a viable mass of microorganisms * Biological treatment inhibited by heavy metals	* Aerobic systems can treat wide range of organic waste in fairly short retention time, potentially remove 95% organics in aqueous streams (US EPA, 1990) * Moderate capital cost compared to other treatment systems	* Process adversely affected by shock loads of toxics * Start-up time can be slow for acclimation of organisms to wastes * Detention time can be long for complex wastes * Sludge produced during biological process may be a hazardous waste and require disposal in a RCRA-approved manner * At many Camp Lejeune sites, metals and suspended solids removal would be necessary. Also, carbon adsorption or another treatment technology may be needed to remove non degradable contaminants * VOC emissions may require treatment * Because of sensitive nature of process, will require more operator attention than other systems * This treatment may be cost prohibitive at sites with low groundwater flows		X
Aerated Lagoon	* Aqueous waste streams containing conventional pollutants, phenolics, oil & grease, polynuclear aromatic hydrocarbons, volatile organics, biodegradable inorganics * Conventional treatment applicable to low strength wastes * Proven effective treatment for a wide range of organic compounds * Established treatment technology for domestic and certain industrial wastewaters	* Biological process in aerated lagoon subject to shock loads * Pretreatment required for suspended solids, oil & grease and metals * Efficient operation of process requires aqueous stream with sufficient soluble organics to support a viable mass of microorganisms * Biological treatment inhibited by heavy metals	* Aerobic systems can treat wide range of organic waste in fairly short retention time, potentially remove 95% organics in aqueous streams (US EPA, 1990) * Moderate capital cost compared to other treatment systems * Aerated lagoons have been demonstated to be effective in removing benzene, toluene, and trichloroethane * Aerated lagoons can tolerate considerable variations in organic and hydraulic loading and are less vulnerable to process upsets compared to other biological treatment methods * Aerated lagoons exist at Hadnot Point and Camp Geiger STPs	* Start-up time may be slow if organisms require acclimation * Detention time may be high for complex waste streams * At many Camp Lejeune sites, metals and suspended solids removal would be necessary. Also, carbon adsorption or another treatment technology may be needed to remove non degradable contaminants * An aerobic system may require a supplemental food source to maintain a constant supply for the microbial population, if the food supply in the water being treated is inadequate or fluctuates significantly * VOC emissions may require treatment * Because of sensitive nature of process, will require more operator attention than other systems * This treatment may be cost prohibitive at sites with low groundwater flows * Aerated lagoons are subject to algae blooms as flow increases	X (3)	
Trickling Filter	* Aqueous waste streams containing conventional pollutants, phenolics, oil & grease, polynuclear aromatic hydrocarbons, volatile organics, biodegradable inorganics * Conventional treatment applicable to low strength wastes * Proven effective treatment for a wide range of organic compounds	* Biological process subject to shock loads * Pretreatment required for suspended solids, oil & grease and metals * Efficient operation of process requires aqueous stream with sufficient soluble organics to support a viable mass of microorganisms * More effective for removal of colloidal and suspended BOD, used primarily as a roughing filter * Biological treatment inhibited by heavy metals	* Aerobic systems can treat wide range of organic waste in fairly short retention time, potentially remove 95% organics in aqueous streams (US EPA, 1990) * Moderate capital cost compared to other treatment systems * Trickling filter demonstrated to be effective in removing benzene and trichloroethylene * All of the existing STPs at Camp Lejeune have trickling filters as part of the secondary sewage treatment process	* Process adversely affected by shock loads of toxics * Start-up time can be slow for acclimation of organisms to wastes * Detention time can be long for complex wastes * At many Camp Lejeune sites, metals and suspended solids removal would be necessary. Also, carbon adsorption or another treatment technology may be needed to remove non degradable contaminants * VOC emissions may require treatment * Because of sensitive nature of process, will require more operator attention than other systems * This treatment may be cost prohibitive at sites with low groundwater flows		X

TABLE 3 - 1
CAMP LEJEUNE IR/UST SITES EFFLUENT STUDY
TECHNOLOGY/PROCESS OPTION EVALUATION SUMMARY

TECHNOLOGY/PROCESS OPTION (1)	APPLICATIONS	LIMITATIONS	ADVANTAGES	DISADVANTAGES	TECHNOLOGY RETAINED FOR FURTHER EVALUATION	
EX SITU TREATMENT (PHYSICAL SEPARATION)						
Air Stripping	* Removal of volatile organic compounds from aqueous waste streams * Generally applicable for compounds with Henry's Law Constants greater than 0.003	* Feed stream must be low in suspended solids to prevent fouling and plugging of air stripping unit * Feed stream may require pH adjustment to reduce solubility and improve transfer to gas phase * Air stripping only remove VOCs, if SVOCs and other constituents are present, will require an additional treatment step for removal	* Air stripping combined with another technology, such as carbon adsorption, has been documented as an effective method of removing contaminants from groundwater * If combined with carbon adsorption, air stripping removes VOCs and reduces loading on carbon, thus reducing frequency and expense of carbon regeneration * Recent technology advancement in development of low profile air stripping units that require less space and are less conspicuous than conventional packed tower air stripper * Cost-effective treatment for low concentrations of volatiles * Equipment required for air stripping relatively simple * Process not sensitive to fluctuations in groundwater flow/quality, as with biological treatment * Ease of installation/operation with modular equipment * Moderate capital costs, low O&M compared to other treatment techniques	* Technology is not appropriate for compounds with a low Henry's Law Constant * Air stripping not effective in removing methylene chloride, and SVOCs, which are constituents of concern at Camp Lejeune (i.e. will require additional treatment step in process) * Depending on air pollution regulations in State of North Carolina, off-gas from air stripping process may require collection and treatment, which can drive up O&M costs * At many Camp Lejeune sites, metals , oil & grease and suspended solids would be necessary to prevent fouling of the air stripping unit. Additionally, an additional treatment step such as carbon adsorption will likely be required to remove some VOCs and SVOCs that are not amenable to removal via air stripping * Colder temperatures decrease the efficiency of an air stripper	X	
Carbon Adsorption (liquid phase)	* Adsorption of soluble organic compounds (not oil & grease or colloids) * Adsorptive capacity of carbon increases as: ** Molecular weight increases ** Structural complexity increases ** Boiling Point Increases ** Refractive Index Increases ** Solubility Decreases * Ease of integration into more complex treatment systems	* Suspended solids in feed stream can interfere and reduce effectiveness * Not applicable for removing inorganic compounds (i.e. requires additional treatment step) * Highest concentration of solute in influent stream that has been documented to have been treated on a continuous basis is 10,000 ppm total organic carbon (TOC), and a 1 % solution is considered as the upper limit * It is recommended that influent oil & grease be reduced to less than 5 mg/L and suspended solids to less than 10 mg/L	* Well developed and demonstrated technology for removal of mixed organics in aqueous waste streams * Activated carbon systems have an increased tolerance for concentration and flow variations * Prefabricated units are readily available * Technology effective even if particular application has low flowrate * Capital costs are moderate, and O&M costs can be high, but reduced if a pretreatment step is employed to reduce loading * Carbon regeneration costs can be reduced significantly if a pretreatment step is employed prior to carbon adsorption, such as air stripping. Air stripping will reduce the VOC loading, and thereby reduce the respective loading on the carbon units * Downflow carbon adsorption systems can handle much higher solids loadings than upflow systems * Flexibility in process, units can be arranged in series to increase service life between regeneration, or in parallel, to achieve maximum hydraulic capacity	* Contaminants with lower molecular weights, high solubility, or high polarity are not effectively removed by activated carbon * Suspended solids can impact operation of system, therefore pretreatment will likely be required at a majority of the Camp Lejeune sites * Iron may host slime producing bacteria which can foul and clog the carbon * High concentrations of contaminants in the influent can exhaust the carbon in a relatively short period of time * Spent carbon requires regeneration or disposal and replacement The number of facilities accepting spent carbon classified as hazardous waste are limited, disposal can present a major operating cost	X	
Filtration	* Physical process applicable for removing suspended solids and biological floc from aqueous streams * Granular media filters capable of producing a filtered effluent with suspended solids of 1 to 10 mg/L	* Generally applicable for aqueous streams containing less than 100 to 200 mg/L suspended solids (depending on effluent requirements) * Large flow fluctuations have deleterious effect on effluent quality	* Well established technology for removal of suspended solids from aqueous waste streams * Filtration equipment is standard, readily available in wide range of sizes to accomodate design flows * Easily integrated with other treatment equipment * Small space requirements * Simple to operate and control * Capital costs moderate, O & M relatively low	* Oil and Grease should be removed prior to filtration to prevent fouling of filtration media * Requires backwash to remove particles lodged in filtration media, which is an obvious maintenance consideration * Colloidal size particles and dissolved solids will not be filtered out * High concentration of suspended solids can clog filtration media and inhibit filtration process * Filtration process produces a sludge that will require subsequent handling, if hazardous, will require specialized handling for disposal	X	

TABLE 3 - 1
CAMP LEJEUNE IR/UST SITES EFFLUENT STUDY
TECHNOLOGY/PROCESS OPTION EVALUATION SUMMARY

TECHNOLOGY/PROCESS OPTION (1)	APPLICATIONS	LIMITATIONS	ADVANTAGES	DISADVANTAGES	TECHNOLOGY RETAINED FOR FURTHER EVALUATION	
Oil/Water Separation	* Physical/chemical separation technology to remove free phase oils and suspended solids from aqueous waste streams	* Efficiency of process relies on difference in specific gravity of aqueous phase and nonaqueous phase for gravity separation * Emulsified oils must be treated with chemicals to allow separation from aqueous phase	* Well established technology for removal of oil & grease and suspended solids * Oil/Water separators are available in a wide variety of designs to suit specific applications (from API separators to those that use corrugated plate packs) * Prepackaged oil/water separators can be easily installed in the field * Operation requires minimum operator supervision as compared to other treatment technologies * Capital and O&M Costs are relatively low compared to	* May require pretreatment to break emulsions or precipitate other compounds targeted for removal (i.e. dissolved metals), polymer addition to develop smaller oil particles into "flocs" which have improved separation characteristics * Recovered oil must be handled in a manner consistent with regulatory requirements * Solids that settle out/precipitated out will form a sludge in bottom of oil/water separator that will require proper handling and disposal * Depending on air pollution regulations in North Carolina, emissions from oil/water separator unit may require collection and treatment	X	
Sedimentation	* Gravity separation process used to separate suspended solids from aqueous waste streams * Typically required as a pretreatment step prior to chemical processes including carbon adsorption, ion exchange, stripping, reverse osmosis, and filtration	* Suspended solids must be heavier than water * Suspended oil droplets or oil-soaked particles may not settle out and may have to be removed by another method * Sedimentation affected by turbulence and bottom scour	* Most clarifiers have capability of removing 90 to 99 percent of suspended solids * Process employs readily available equipment * Operation is relatively simple * Versatile process, can be applied to almost any liquid waste stream containing suspended solids * When employed in conjunction with precipitation/ flocculation, can be used to remove metals * Capital and O&M Costs relatively low compared to other technologies	* Sedimentation processes produces a large volume of sludge that requires subsequent handling and disposal * Design based primarily on flow and requried detention time, which when high, could result in problems with space requirements	X	
EX SITU TREATMENT (CHEMICAL TREATMENT)						
Neutralization	* Chemical treatment technology used to adjust the pH of an aqueous stream for further treatment, to a pH of approximately 7.0, via addition of an acid or base * Generally used as part of an overall pretreatment stage of aqueous stream treatment * Process can be continuous or batch * Generally applicable to aqueous waste streams containing metals and general inorganics	* Requires process control (simple) to monitor addition of pH altering chemicals * Medium to high flow streams require a continuous pH adjustment system, which requires more elaborate control and feed equipment * Due to corrosive nature of chemicals used to adjust pH, compatibility of chemicals and process equipment must be given careful consideration * Subject to influence of temperature and resulting heat effects common to most chemical reactions	* Well established technology incorporated in many wastewater treatment systems * Equipment for neutralization readily available * Equipment can be easily integrated into an overall treatment system * Total soluble metals can be decreased by up to 80%	* Pretreatment may be required to remove oil & grease and suspended solids * Neutralization is an exothermic reaction and will give off heat, could present an explosion hazard	X	
EX SITU TREATMENT (CHEMICAL TREATMENT)						
Precipitation/ Flocculation	* Precipitation is a physiochemical process where chemical equilibrium relationships which affect solubility of inorganic species are altered to transform substance in solution into solid phase * Removal of metals as hydroxides or sulfides is the most common precipitation application in wastewater treatment * Applicable for removal of most metals from aqueous waste stream, including zinc, cadmium, copper, lead, and manganese * Flocculation is a process used to agglomerate small, unsetteable particles in an aqueous steam into larger, more setteable particles * Flocculation involves three basic steps: ** Addition of flocculating agent to waste stream ** Rapid mixing to disperse flocculating agent ** Slow/gentle mixing to allow for contact between smaller particles * Once flocculated into larger particles, suspended particles are typically removed via sedimentation	* Precipitation of inorganics (metals) governed by species solubility * Requires accurate control of precipitant dosages, especially when working with aqueous waste streams where there is a wide variation in flow rates and quantities of metals in stream * Cyanide and other ions can complex with metals, reducing efficiency of precipitation process * High viscous waste streams will inhibit settling of solids * No concentration limit for precipitation and flocculation	* Precipitation and flocculation are well established technologies * Operating parameters well defined * Equipment simple, readily available, easy to operate * Precipitation and flocculation can be eaily integrated into other treatment systems * Moderate capital costs, low O&M costs	* Precipitation and flocculation generate a large volume of sludge which will require handling and disposal * Minimal safety and health hazards associated with operation * Laboratory tests required to determine proper addition of chemicals * Chemical addition must be monitored, along with settling characteristics of waste stream , and adjustments made where necessary	X	

TABLE 3 - 1
CAMP LEJEUNE IR/UST SITES EFFLUENT STUDY
TECHNOLOGY/PROCESS OPTION EVALUATION SUMMARY

TECHNOLOGY/PROCESS OPTION (1)	APPLICATIONS	LIMITATIONS	ADVANTAGES	DISADVANTAGES	TECHNOLOGY RETAINED FOR FURTHER EVALUATION	
UV/Chemical Oxidation	* Technology applicable to groundwater and industrial wastewater contaminated with VOCs, semivolatiles, and PCBs/pesticides	* Potential exists that incomplete oxidation may occur which would result in the potential for formation of more toxic oxidation products * Some oxidants can be decomposed before reaction completed because of interaction with high concentrations of organic solvents * Highly concentrated waste streams will require large doses of oxidant(s) in order to treat target compounds (due to non-selective nature of oxidizing agents) * Some oxidizing agents react violently in presence of significant quantities of readily oxidizable materials (reagents must be added in small quantities)	* Chemical Oxidation process offers on-site destruction of organic wastes, thereby producing no byproducts that will require further handling/treatment (i.e. sludge, vapor, etc...) * Equipment readily available for this process	* High energy consumption, high operating costs * Process mechanisms not well understood/track record not established as for air stripping or carbon adsorption * Potential for incomplete oxidation, formation of more toxic products * Laboratory/pilot-scale testing required to determine appropriate oxidant feed rates and reactor retention times * Potential hazards involved with handling of oxidants * Requires more instrumentation to monitor process compared to other technologies	X (4)	

NOTES:

(1) Technologies/Process Options included in this initial technology evaluation were selected based on site-specific characteristics of IR/RI-FS/SI sites and UST sites at Camp Lejeune. Specific characteristics considered when identifying the technologies included the type and magnitude of groundwater contamination (i.e. constituents of concern and concentrations) and anticipated flows of groundwater to be treated. Because of the magnitude of the scope of sites included in this study, only conventional technologies typically applied in similar groundwater remediation scenarios were evaluated.

(2) Based on a comparison of relative advantages and disadvantages, in situ bioreclamation was retained as a potential technology; however, because this technology is typically applied as part of a soil/subsurface remediation project, and only groundwater is being addressed in the scope of this study, its application will only be considered for implementation as part of an overall groundwater treatment system at a site where there a specific source(s) of groundwater contamination has been identified (i.e. May be effective at some sites to set up an infiltration gallery upgradient of identified contamination source, extract groundwater downgradient, treat in aboveground treatment system, and reintroduce treated effluent to subsurface)

(3) Aeration lagoon was retained as a possible treatment technology. Although a review of available background information for IR/RI-FS/SI and UST sites indicates that VOCs and SVOCs are the major contaminants besides metals, there are a few IR/RI-FS/SI sites that may be better suited to biological treatment. Because there are two STPs that have aerated lagoons, this technology was retained as a potential treatment technique.

(4) Based on knowledge of air stripping, carbon adsorption, and UV/Chemical oxidation processes, it is anticipated that an economic analysis of the three technologies would indicate that UV/Chemical oxidation is the most costly system to install and operate; however, this technology is applicable for treating pesticides, which are present at several IR/RI-FS/SI sites. Therefore, this technology was retained as a potentially feasible technology for a limited number of sites.

3.2.1.1 In-Situ Biological Treatment

Although this technology is typically applied as part of a soil/subsurface remediation project, and only groundwater is being addressed in the scope of this study, it will be retained as a technology for application at sites where a specific source(s) of groundwater contamination has been identified.

3.2.1.2 Activated Sludge

Activated sludge will not be retained for further consideration because many of the sites requiring remediation have relatively low flows, and even if activated sludge were to be implemented at a centralized treatment plant with higher flows (Alternative 2, 3, or 4), the process is very sensitive to fluctuations in flow and organic loading, which is often the case with remediation of contaminated groundwater.

3.2.1.3 Aerated Lagoon

This technology will be retained for further consideration for incorporation into treatment alternatives, specifically for sites that are in close proximity to either the Camp Geiger or Hadnot Point STP, as both of these locations have aerated lagoons as part of the current sewage treatment process. Although this technology is not one of the more conventional groundwater treatment technologies for the COCs identified for sites at MCB, Camp Lejeune, its potential as a component of an overall treatment system should be considered, especially for Alternatives 2, 3, and 4.

3.2.1.4 Trickling Filter

Trickling filter will not be retained for further consideration as a primary treatment technology for reasons similar to that indicated for activated sludge. Although each STP at Camp Lejeune has trickling filter(s) as part of the sewage treatment process, the process is adversely affected by shock loads of toxics, and will require more operator attention, similar to activated sludge, because of the sensitive nature of the process. In addition, because some of the COCs, including ethylbenzene, xylenes and chlorinated solvents (TCE, PCE) are relatively undegradable.

3.2.1.5 Air Stripping

Air stripping will be retained as a potential primary treatment technology because it is a demonstrated technology for treatment of contaminated groundwater with VOCs, a major contaminant of concern at MCB, Camp Lejeune. Unlike biological processes, air stripping is not sensitive to fluctuations in groundwater flow and quality. Air stripping systems can be designed for a low flow of 5 gpm, up to systems designed for millions of gallons per day. Moreover, when combined with another technology such as carbon adsorption, this technology would treat the entire range of organic COCs. Pretreatment will be required as part of any treatment system for removal of metals, suspended solids, and oil and grease. The major drawback to air stripping is that it merely transfers contaminants from the aqueous to gas phase. Air pollution regulations in North Carolina will dictate whether collection and treatment of air stripper off-gas is required, and the extent.

3.2.1.6 Carbon Adsorption

Carbon adsorption will be retained as a potential primary treatment technology as well as a secondary (post treatment) technology. Carbon adsorption is a well developed and demonstrated technology for removal of mixed organics in aqueous waste streams. Similar to air stripping, activated carbon units have an increased tolerance for concentration and flow variations. Carbon regeneration/replacement can significantly increase the operation and maintenance costs for this technology; however, if a pretreatment step is incorporated to reduce organic loading, carbon changeout frequency can be significantly reduced.

3.2.1.7 Filtration

Filtration will be retained as a feasible technology for incorporation as either a pretreatment or post treatment step of an overall groundwater treatment process. Based on knowledge of groundwater characteristics at this point, it is not clear whether filtration will be required, because data is not available as to the total solids content of groundwater at the sites within MCB, Camp Lejeune. However, for purposes of developing cost estimates, a cost may be allowed for a filtration unit, in order to be conservative. Filtration equipment requires minimal space, is easily integrated with other treatment components, and is available in a wide range of standard sizes to accommodate a range of design flows. Backwash capabilities are required in any filtration system, to provide a means to dislodge particles lodged in filtration media.

3.2.1.8 Oil/Water Separation

Based on background data for individual sites within Camp Lejeune, and the fact that oil/water separators have been incorporated into the existing groundwater pump and treat systems (UST sites), oil/water separation will be retained for consideration as a pretreatment technology for incorporation into groundwater treatment alternatives. Oil/water separation is a well established phase separation technology, and is typically required to remove oil and grease from aqueous streams prior to conventional treatment in air strippers, carbon absorbers, and UV/chemical oxidation units.

3.2.1.9 Sedimentation

Sedimentation is typically required as a component of any pretreatment process for removal of suspended solids prior to primary treatment. Metals have been detected at many of the sites identified as potentially requiring groundwater treatment. Data on total suspended solids was not available for a number of the sites. As a conservative assumption, if it is assumed a majority of the sites will require pretreatment for metals removal, and/or suspended solids, sedimentation will be required as part of the overall treatment system. Sedimentation processes typically generate a large volume of sludge, which requires subsequent handling and disposal.

3.2.1.10 Neutralization

Neutralization will be retained as a feasible technology for incorporation as a pretreatment technology. The actual decision as to whether neutralization will be required will be dependent on the characteristics of individual waste streams (groundwater). However, as a conservative assumption at this point, it will be assumed that neutralization would be necessary. Equipment for neutralization is readily available, and easily integrated into an overall treatment system. Neutralization is subject to the influence of temperature and resulting heat effects common to most chemical reactions.

3.2.1.11 Precipitation/Flocculation

Similar to the reasoning provided for filtration, sedimentation, and neutralization, precipitation/flocculation will be retained as a potential pretreatment technology for incorporation into a groundwater treatment system. Precipitation is required when dissolved substances such as metals, are present and require removal from the waste stream. Flocculation is a process which assists in the settling of solid particles. Laboratory testing is required to determine the proper dosages of chemicals.

3.2.1.12 UV/Chemical Oxidation

UV/chemical oxidation will be retained as a potential primary treatment technology for incorporation into groundwater treatment alternatives at MCB, Camp Lejeune. Although UV/chemical oxidation typically has high energy consumption and thus high operation and maintenance costs, this technology has a major advantage in that it results in complete destruction of organic wastes. A significant consideration is the potential for incomplete oxidation of wastes, and possible formation of more toxic products. Compared to air stripping and carbon adsorption which do not necessarily need treatability testing to determine design, laboratory testing is required for UV/chemical oxidation to determine appropriate oxidant feed rates and reactor detention times.

3.2.2 Treated Groundwater Discharge Technology Evaluation

Table 3-2 presents a summary evaluation of the applications, limitations, advantages, and disadvantages for each discharge option identified in Section 3.1.4. Based on this comparison, all of these discharge options should be evaluated for use at a site. The selection of the best discharge method needs to be considered on a site-by-site basis.

Therefore, for the purposes of this study, a determination was made of which discharge alternative appeared most suited to a site, based on a first review of the site conditions.

3.3 Technology Applicability on a Per Site Basis

In order to manage the scope of sites included in this study, and evaluate four groundwater treatment alternatives as specified in the Contract Task Order Scope of Work, three technologies were identified as being potential primary technologies for treatment of groundwater at the majority of sites within MCB, Camp Lejeune. These technologies include air stripping, carbon adsorption, and UV/chemical oxidation. Sites with COCs that distinguish them from the majority will be given separate consideration, and the most appropriate technology selected from the retained technologies.

TABLE 3 - 2
CAMP LEJEUNE IR/UST SITES EFFLUENT STUDY
TREATED GROUNDWATER DISCHARGE
TECHNOLOGY OPTION EVALUATION SUMMARY

TECHNOLOGY OPTION (1)	APPLICATIONS	LIMITATIONS	ADVANTAGES	DISADVANTAGES	TECHNOLOGY RETAINED FOR FURTHER EVALUATION	
					YES	NO
INFILTRATION GALLERY	* Sites with suitable area and soils * Remote sites not close to other utilities * Systems with low flow rates	* Must have suitable soils or ability to place suitable soils around piping * High flow rates may limit use of the technology	* No off-site discharge * Infiltrated groundwater can increase efficiency of aquifer restoration	* High flowrate systems may require large area for infiltration gallery	X	
INJECTION WELL	* Sites with suitable area and soils * Remote sites not close to other utilities	* Must have suitable subsurface geology * High flow rates may limit system, increase installation and operation costs	* No off-site discharge * Recharged groundwater can increase efficiency and shorten time for aquifer restoration	* Requires a separate pumping system to inject groundwater * Pumping system failure will shut-down system * Injection wells may clog over time	X	
NONPOTABLE REUSE	* Treated groundwater can be used as a water source for other uses, such as spray irrigation, fire protection, boiler feed	* Groundwater treatment system may require addition components to produce required effluent quality * Infrastructure needs to be in place or constructed	* Beneficial reuse of a water resource * May meet a water demand in a area where water is not readily available	* Requires a separate pumping and distribution system * Seasonal demand for reuse water may exclude some uses * Additional monitoring may be required	X	

Each of the three primary treatment technologies has advantages and disadvantages that can be compared on a qualitative basis, as presented in Table 3-1. Comparison of the technologies on an economic basis, when considered collectively with the technical advantages and disadvantages, will lead to selection of the most appropriate technology.

The technologies identified in Section 3.2.1, including primary and pretreatment technologies were evaluated on a per site basis, solely on their technical ability to treat groundwater with specific COCs. The results of this evaluation are summarized in Table 3-3, which shows that the significant majority of sites requiring groundwater treatment have VOCs as a primary COCs, which links the sites on a base-wide basis. Groundwater from all of these sites could be treated by the most cost-effective technology.

3.4 Cost Evaluation of Three Primary Treatment Technologies

In order to simplify the evaluation of the four alternatives required to be evaluated under the scope of this Contract Task Order, an economic comparison was performed on three primary treatment technologies, including air stripping, liquid-phase carbon adsorption, and UV/chemical oxidation, in order to identify the most cost-effective treatment technology. The capital and operation and maintenance costs were developed assuming a 25 gpm treatment system. Tables 3-4, 3-5, and 3-6 summarize the estimated capital and operation and maintenance costs for air stripping, liquid-phase carbon adsorption, and UV/chemical oxidation. Assumptions used to develop the cost estimates are summarized within each cost estimate.

Life-cycle cost, or Present Net Equivalent Value was calculated for each treatment system, in order to allow cost comparison on an equal basis. A period of five years was assumed, along with a discount rate of 10 percent. A summary of the life cycle costs are summarized in Table 3-7. As shown in Table 3-7, air stripping appears to be the most cost effective, with a life cycle cost of $715,000, as compared to liquid-phase carbon adsorption ($1,100,000) and UV/chemical oxidation ($1,168,000). Considering a comparison of the technical advantages and disadvantages of air stripping, along with its life cycle cost, it is apparent that air stripping (with secondary carbon adsorption for SVOCs, pesticides) will be the most technically and cost effective treatment option for incorporation into the majority of groundwater treatment alternatives considered for Camp Lejeune.

TABLE 3 - 3
SUMMARY OF TECHNOLOGY APPLICABILITY FOR GROUNDWATER TREATMENT ALTERNATIVES ON A PER SITE BASIS

APPLICABLE TECHNOLOGIES/PROCESS OPTIONS FOR INCORPORATION INTO TREATMENT ALTERNATIVES (1)				PRIMARY TREATMENT				PRETREATMENT (2)				
STP OUTFALL AREA	SITE IDENTIFICATION	SITE DESIGNATION	CONTAMINANTS OF CONCERN	AERATION LAGOON	AIR STRIPPING	CARBON ADSORPTION	UV CHEMICAL OXIDATION	NEUTRALIZATION	PRECIPITATION/ FLOCCULATION	OIL/WATER SEPARATION	SEDIMENTATION	FILTRATION
Camp Geiger												
	Campbell Street Fuel Farm	UST	VOCs	A (3)	A	A	A	NDA, MBR (4)	NA	NA	NA	NA
	Building AS-4151 (Steam Gen. Plant)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	Camp Geiger Fuel Farm	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA (5)	NA	NA	NA	NDA, MBR	A	NA	A	A
	Tanks AS419-AS421	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	JP-5 Line Area Site	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Petroleum Hydrocarbons	A	NA	A	A	NDA, MBR	NA	A	NDA, MBR	NDA, MBR
	Camp Geiger Mini C Store Service Station	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	NDA, MBR	A	NA	A	A
	All Hypothetical Sites (FY 1995 - FY 1999)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Petroleum Hydrocarbons	A	NA	NA	A	NDA, MBR	NA	A	NDA, MBR	NDA, MBR
	Camp Geiger Dump, STP	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
			Oil & Grease	NA	NA	NA	NA	NDA, MBR	A	A	NA	NA
	Camp Geiger Dump, Trailer Park	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Explosives (Ordnance)	NA	NA	A?	A?	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Pesticides	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
			Oil & Grease	NA	NA	NA	NA	NDA, MBR	A	A	NA	NA
	Agan Street Dump	SI	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Jones Street Dump	SI	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
			Oil & Grease	NA	NA	NA	NA	NDA, MBR	A	A	NA	NA
Montford Point (Camp Johnson)												
	Montford Point Burn Dump	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A

TABLE 3 - 3
SUMMARY OF TECHNOLOGY APPLICABILITY FOR GROUNDWATER
TREATMENT ALTERNATIVES ON A PER SITE BASIS

APPLICABLE TECHNOLOGIES/PROCESS OPTIONS FOR INCORPORATION INTO TREATMENT ALTERNATIVES (1)				PRIMARY TREATMENT				PRETREATMENT (2)				
STP OUTFALL AREA	SITE IDENTIFICATION	SITE DESIGNATION	CONTAMINANTS OF CONCERN	AERATION LAGOON	AIR STRIPPING	CARBON ADSORPTION	UV CHEMICAL OXIDATION	NEUTRALIZATION	PRECIPITATION/ FLOCCULATION	OIL/WATER SEPARATION	SEDIMENTATION	FILTRATION
Tarawa Terrace												
	Building 45, UST S-941-2	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Tarawa Terrace Service Station (Pump & Treat in-place but not on-line)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	All Hypothetical Sites (FY 1995 - FY 1999)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
Hadnot Point												
	Building 21, River Road (UST System 21.1)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	Gottschalk Marina	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Berkley Manor X Change Service Station (Tank 820-2)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Petroleum Hydrocarbons	A	NA	NA	A	NDA, MBR	NA	A	NDA, MBR	NDA, MBR
	Hadnot Point Fuel Farm (Pump & Treat on-line)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	All Hypothetical Sites (FY 1995 - FY 1999)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Petroleum Hydrocarbons	A	NA	NA	A	NDA, MBR	NA	A	NDA, MBR	NDA, MBR
	French Creek LDA	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Former Daycare/Nursery	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Old Creosote Plant	RI/FS (6)	SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
	Storage Lots 203/201	RI/FS (6)										
	Shallow Aquifer & Deep Aquifers		VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Industrial Fly Ash Dump	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	HP Burn Dump	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Pesticides	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
			Oil & Grease	NA	NA	NA	NA	NDA, MBR	A	A	NA	NA
	Operable Unit 1 (Site 78)	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Paradise Point Gulf Course	SI	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Pesticides	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A

TABLE 3 - 3
SUMMARY OF TECHNOLOGY APPLICABILITY FOR GROUNDWATER TREATMENT ALTERNATIVES ON A PER SITE BASIS

APPLICABLE TECHNOLOGIES/PROCESS OPTIONS FOR INCORPORATION INTO TREATMENT ALTERNATIVES (1)				PRIMARY TREATMENT				PRETREATMENT (2)				
STP OUTFALL AREA	SITE IDENTIFICATION	SITE DESIGNATION	CONTAMINANTS OF CONCERN	AERATION LAGOON	AIR STRIPPING	CARBON ADSORPTION	UV CHEMICAL OXIDATION	NEUTRALIZATION	PRECIPITATION/ FLOCCULATION	OIL/WATER SEPARATION	SEDIMENTATION	FILTRATION
Rifle Range												
	Rifle Range, Bldg. 72 (Former MCX Gas Station)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	Rifle Range Dump	SI	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
	Rifle Range Chemical Dump	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			Pesticides	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
Courthouse Bay												
	All Hypothetical Sites (FY 1993 - FY 1999)	UST	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
	Courthouse Bay LDA	RI/FS	VOCs	A	A	A	A	NDA, MBR	NA	NA	NA	NA
			SVOCs	A	NA	A	A	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A
			Oil & Grease	NA	NA	NA	NA	NDA, MBR	A	A	NA	NA
Onslow Beach												
	Explosive Ordnance Disposal	SI	Explosives (Ordnances)	NA	NA	A?	A?	NDA, MBR	NA	NA	NA	NA
			Metals	NA	NA	NA	NA	A	A	NA	A	A

NOTES:

(1) The following technologies/process options were retained from the initial evaluation (See Table 3-3)
In Situ Bioreclamation
Aerated Lagoon
Air Stripping
Carbon Adsorption (Liquid Phase)
Precipitation/Flocculation
UV/Chemical Oxidation
(2) Pretreatment including all or some of these technologies may be required depending on the primary treatment and groundwater characteristics (i.e. total solids, etc...).
(3) A = Technology applicable to contaminant of concern.
(4) NDA = Technology not directly applicable, MBR = may be required as part of an overall groundwater treatment system at a particular site.
(5) NA = Technology not specifically applicable to contaminant of concern.
(6) The 1994 Site Management Plan has included this site in the RI/FS phase.

TABLE 3 - 4

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR AIR STRIPPING TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	25,000.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (4)	12,000.00
Effluent Transfer Pumps/Level Controls/Motor Starter (4)	2,000.00
Post Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (2000# units) (5)	15,000.00
Backwash System (6)	22,000.00
Purchased Equipment (Subtotal)	116,000.00
Installation (assume 40 % purchased equipment cost)	46,000.00
Total Direct Capital Cost	162,000.00
INDIRECT CAPITAL COSTS	
Engineering & Design (6% Total Direct Cost)	10,000.00
Design & Construction Administration (10% Total Direct Cost)	16,000.00
Health & Safety (5% Total Direct Cost)	8,000.00
Contingency Allowance (25% Total Direct Cost)	41,000.00
Other Direct Costs	
Legal (5% Total Direct Cost)	8,000.00
License/Permit Costs (15% Total Direct Cost)	24,000.00
Start-up/Shakedown (10% Total Direct Cost)	16,000.00
Total Indirect Capital Cost	123,000.00
Total Capital Cost (Treatment System Only)	285,000.00

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($)
Electricity (7)	
Pretreatment (Mixers, Pumps)	2,400.00
Treatment	
Air stripper blower, transfer pump	4,200.00
Post Treatment (Backwash Pump)	100.00
Materials (pH chemicals, polymer) (8)	17,000.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (9)	1,500.00
Operating Labor (10)	30,000.00
Maintenance Labor (10)	3,000.00
Sampling Labor (10)	3,000.00
Analytical (Samples) (10)	29,000.00
Administration (20% labor/25% materials)	11,000.00
Total Operation & Maintenance	101,000.00

TABLE 3 - 4 cont.

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR AIR STRIPPING TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 2000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 2000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Electricity costs based on estimated rated horsepower of air stripper blower, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr.

(8) Material costs for pH adjustment chemicals and polymers based on estimate of one 55gal drum per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(9) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 3.0 lb/day, for "low" organic stream (<.2 ppm) at 25 gpm. Based on this estimate, and 2,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period, however, to be more conservative, assume replacement once per year, with 20% carbon replacement (new) required, at $.85/pound.

(10) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TC (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance for carbon changeouts, @ 7 changeouts per year, 2 men, 8 hours per changeout at $29.10 per hour.

TABLE 3 - 5

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR LIQUID PHASE CARBON ADSORPTION TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	25,000.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Treatment Equipment (VOCs, SVOCs, Pesticides)	
Liquid-Phase Carbon Adsorption (Two-Stage System) (4)	90,000.00
Backwash System (5)	28,000.00
Purchased Equipment (Subtotal)	183,000.00
Installation (assume 40 % purchased equipment cost)	73,000.00
Total Direct Capital Cost	256,000.00
INDIRECT CAPITAL COSTS	
Engineering & Design (6% Total Direct Cost)	15,000.00
Design & Construction Administration (10% Total Direct Cost)	26,000.00
Health & Safety (5% Total Direct Cost)	13,000.00
Contingency Allowance (25% Total Direct Cost)	64,000.00
Other Direct Costs	
Legal (5% Total Direct Cost)	13,000.00
License/Permit Costs (15% Total Direct Cost)	38,000.00
Start-up/Shakedown (10% Total Direct Cost)	26,000.00
Total Indirect Capital Cost	195,000.00
Total Capital Cost (Treatment System Only)	451,000.00

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($)
Electricity (6)	
Pretreatment (Mixers,Pumps)	2,400.00
Treatment	
Post Treatment (Backwash Pump)	100.00
Materials (pH chemicals, polymer) (7)	17,000.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (8)	56,000.00
Operating Labor (9)	30,000.00
Maintenance Labor (9)	3,000.00
Sampling Labor (9)	3,000.00
Analytical (Samples) (9)	29,000.00
Administration (20% labor/25% materials)	11,000.00
Total Operation & Maintenance	152,000.00

TABLE 3 - 5 cont.

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR LIQUID PHASE CARBON ADSORPTION TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental - See Summary of Costs for Oil/Water Separators attached to this cost estimate)

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary (see supplementary calculations)

(4) Cost for liquid-phase carbon adsorption system based on two (2) 10,000 # carbon units operated in series. Cost estimate based on estimate provided by Encotech Activated Carbon Products and Systems. Units provided with appropriate connections for influent feed, backwash, etc. Pounds carbon per unit based on assumption that carbon adsorbers will have to remove "high" organic concentration of 33 ppm, and 30 minute empty bed contact time.

(5) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle and JC Cleaners).

(6) Electricity costs based on estimated rated horsepower of pumps, mixers assuming 24 hour per day, 365 day per year at $0.0675/kw*h

(7) Material costs for pH adjustment chemicals and polymers based on estimate of one 55gal drum per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(8) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $0.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 200 lb/day, for "high" organic stream (33 ppm) at 25 gpm. Based on this estimate, and 10,000 lb carbon unit, carbon would be anticipated to require change-out every 50 days. In addition to reactivation, assume 20% loss of carbon during reactivation will require replacement with new carbon, @ $.85/#.

(9) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TC (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance for carbon changeouts, @ 7 changeouts per year, 2 men, 8 hours per changeout at $29.10 per hour.

TABLE 3 - 6

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR UV/CHEMICAL OXIDATION TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	25,000.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Treatment Equipment (VOCs, SVOCs, Pesticides)	
UV/Chemical Oxidation System (4)	200,000.00
Purchased Equipment (Subtotal)	265,000.00
Installation (assume 40 % purchased equipment cost)	106,000.00
Total Direct Capital Cost	371,000.00
INDIRECT CAPITAL COSTS	
Engineering & Design (6% Total Direct Cost)	22,000.00
Design & Construction Administration (10% Total Direct Cost)	37,000.00
Health & Safety (5% Total Direct Cost)	19,000.00
Contingency Allowance (25% Total Direct Cost)	93,000.00
Other Direct Costs	
Legal (5% Total Direct Cost)	19,000.00
License/Permit Costs (15% Total Direct Cost)	56,000.00
Start-up/Shakedown (10% Total Direct Cost)	37,000.00
Total Indirect Capital Cost	283,000.00
Total Capital Cost (Treatment System Only)	654,000.00

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($)
Electricity (5)	
Pretreatment (Mixers,Pumps)	2,400.00
Treatment (UV/Oxidation System)	13,100.00
Materials (pH chemicals, polymer) (6)	17,000.00
Operating Labor (7)	30,000.00
Maintenance Labor (7)	1,400.00
Sampling Labor (7)	3,000.00
Analytical (Samples) (7)	29,000.00
Administration (20% labor/25% materials)	11,000.00
Total Operation & Maintenance	107,000.00

TABLE 3 - 6 cont.

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES

CAPITAL AND O AND M COST ESTIMATE FOR UV/CHEMICAL OXIDATION TREATMENT SYSTEM

Basis:
Flow = 25 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental - See Summary of Costs for Oil/Water Separators attached to this cost estimate)

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary (see supplementary calculations)

(4) Cost for UV/Chemical Oxidation Treatment System based on range of typical capital costs for UV/oxidation system as provided in EPA/540/A5-89/012 [Ultrox International Radiation/Oxidation Technology - Applications Analysis Report]. System includes UV radiation/oxidation treatment tank (reactor - including UV lamps), and oxidation source (ozone generator with air preparation system or hydrogen peroxide feed system).

(5) Electricity costs for pretreatment equipment is base on estimated rated horsepower of pumps, mixers assuming 24 hours per day, 365 day per year at $0.0675/kw*hr. Operating costs for UV/oxidation system based on estimated direct O&M cost range developed based on case studies of actual system installations - Ultrox system [EPA/540/A5-89/012 - Ultrox International Radiation/Oxidation Technology - Applications Analysis Report]. Cost assumes $1.00/1000 gallons water treated.

(6) Material costs for pH adjustment chemicals and polymers based on estimate of one 55gal drum per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(7) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TC (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance Labor assumes labor will be less intensive than that required for systems that require carbon changeout, assume 4 hours per month, 1 man, @ $29.10 per hour.

TABLE 3 - 7

ECONOMIC COMPARISON OF THREE CONVENTIONAL TREATMENT TECHNOLOGIES LIFE CYCLE COST ANALYSIS OF THREE ALTERNATIVE GROUNDWATER TREATMENT SYSTEMS

ALTERNATIVE A: GROUNDWATER TREATMENT WITH AIR STRIPPING (25 GPM SYSTEM)							
FIVE YEAR LIFE CYCLE COST ANALYSIS (BASED ON 1993 DOLLARS)	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	LIFE CYCLE COST
1. Capital Cost of Treatment System (2)	$332,000	$0	$0	$0	$0	$0	
2. Annual Operation & Maintenance Cost (2)	$0	$101,000	$101,000	$101,000	$101,000	$101,000	
3. Annual Expenditures (Based on 1993 dollars) - "A" (3)	$332,000	$101,000	$101,000	$101,000	$101,000	$101,000	
4. Cash Flow Factor (Future Worth of Equal Annual Expenditures) - (F/A) (4)	1.0000	1.0000	2.1000	3.3100	4.6410	6.1051	
5. Future Worth of Equal Annual Expenditures " F "	$332,000	$101,000	$212,100	$334,310	$468,741	$616,615	
6. Cash Flow Factor (Present Worth of Future Amount of Annual Expenditures " F ")	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	
7. Present Worth of Future Amount of Annual Expenditures " P "	$332,000	$91,819	$175,279	$251,167	$320,150	$382,856	$715,000

ALTERNATIVE B: GROUNDWATER TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION (25 GPM SYSTEM)							
FIVE YEAR LIFE CYCLE COST ANALYSIS (BASED ON 1993 DOLLARS)	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	LIFE CYCLE COST
1. Capital Cost of Treatment System	$525,000	$0	$0	$0	$0	$0	
2. Annual Operation & Maintenance Cost	$0	$152,000	$152,000	$152,000	$152,000	$152,000	
3. Annual Expenditures (Based on 1993 dollars) - "A"	$525,000	$152,000	$152,000	$152,000	$152,000	$152,000	
4. Cash Flow Factor (Future Worth of Equal Annual Expenditures) - (F/A)	1.0000	1.0000	2.1000	3.3100	4.6410	6.1051	
5. Future Worth of Equal Annual Expenditures " F "	$525,000	$152,000	$319,200	$503,120	$705,432	$927,975	
6. Cash Flow Factor (Present Worth of Future Amount of Annual Expenditures " F ")	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	
7. Present Worth of Future Amount of Annual Expenditures " P "	$525,000	$138,183	$263,787	$377,994	$481,810	$576,180	$1,101,000

ALTERNATIVE C: GROUNDWATER TREATMENT WITH UV/CHEMICAL OXIDATION (25 GPM SYSTEM)							
FIVE YEAR LIFE CYCLE COST ANALYSIS (BASED ON 1993 DOLLARS)	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	LIFE CYCLE COST
1. Capital Cost of Treatment System	$762,000	$0	$0	$0	$0	$0	
2. Annual Operation & Maintenance Cost	$0	$107,000	$107,000	$107,000	$107,000	$107,000	
3. Annual Expenditures (Based on 1993 dollars) - "A"	$762,000	$107,000	$107,000	$107,000	$107,000	$107,000	
4. Cash Flow Factor (Future Worth of Equal Annual Expenditures) - (F/A)	1.0000	1.0000	2.1000	3.3100	4.6410	6.1051	
5. Future Worth of Equal Annual Expenditures " F "	$762,000	$107,000	$224,700	$354,170	$496,587	$653,246	
6. Cash Flow Factor (Present Worth of Future Amount of Annual Expenditures " F ")	1.0000	0.9091	0.8264	0.7513	0.6830	0.6209	
7. Present Worth of Future Amount of Annual Expenditures " P "	$762,000	$97,274	$185,692	$266,088	$339,169	$405,600	$1,168,000

NOTES:

(1) Life Cycle Cost, or Present Net Equivalent Value equals Capital Expenditure (n=0) + Present Worth of Future Amount of Annual Expenditures (n=5).
(2) Capital Cost of Treatment System and Annual Operation & Maintenance Cost taken from cost estimates (Tables 3-3 through 3-5).
(3) Annual expenditures are assumed to be equal over a 5 year period, and occur at the end of each of years 1 - 5.
(4) Cash Flow Factors taken from "Expanded Interest Tables for the Engineer-In-Training and Professional Engineering Examinations, Third Edition, 1983.
(5) Discount rate of 10% assumed for analysis.

A total of 130 sites at MCB, Camp Lejeune were identified during the evaluation of site background information as requiring groundwater remediation (Fiscal Years 1995 through 1999). Of these sites, approximately 96 percent have VOCs as primary COCs, and would be amenable to primary treatment by air stripping, with secondary treatment by carbon adsorption to remove additional organics. The remaining 4 percent of sites would not be effectively treated by air stripping because the COCs are strictly semivolatiles, pesticides, or a combination of the two. In these scattered instances, liquid-phase carbon adsorption will probably be the best treatment option, as it has a lower life-cycle cost (when compared to UV/chemical oxidation), and can effectively adsorb semivolatiles, pesticides, and other organic compounds.

4.0 DEVELOPMENT OF CAPITAL AND OPERATION AND MAINTENANCE COSTS FOR GROUNDWATER TREATMENT ALTERNATIVES

This section presents the methodology used and the cost estimates developed for the major components of the groundwater treatment alternatives, which include groundwater extraction systems, pumping and transmission systems, and groundwater treatment and discharge systems. These systems and their associated costs are discussed in further detail in the following sections.

4.1 Groundwater Extraction Systems

Groundwater extraction technologies evaluated during the course of this study included recovery trenches, for a limited number of UST sites, and extraction wells, for the majority of UST sites and all of the IR sites. Capital and operation and maintenance cost estimates for site-specific extraction systems were developed for each IR and UST site identified as requiring groundwater remediation.

4.1.1 Recovery (Drainage) Trenches

The number of recovery trenches required at a particular site and the corresponding trench length was defined during the development of the Site Evaluation Matrix. The trench was assumed to be a biopolymer drainage trench. Similar to typical slurry wall construction, a trench is excavated and a biodegradable slurry is used to hydraulically shore the trench. The slurry excavation is subsequently backfilled with permeable materials (i.e., stone, gravel) and the slurry treated with additives to convert it to water and a small quantity of natural carbohydrate (Baker, 1992). Horizontal drainpipe and/or vertical extraction wells are installed to collect groundwater. In addition, filter fabrics may be placed in the trench to resist clogging of the drainage materials or removal systems by infiltration of fines from surrounding soils (Baker, 1992).

Benefits of the biopolymer method of drainage trench construction include installation up to 70 feet without extensive excavation, flexibility in design components and configurations, expedient construction schedule, minimal generation of trench spoil materials, minimal worker safety concerns, proven performance in remedial applications, cost effectiveness, and long-term performance (Baker, 1992).

The basic components of the biopolymer drainage trench were identified to include gravel fill, geotextile, collection pipes, trench wells, submersible pumps, outflow pipes, and electrical conduit. A conservative estimate was made that submersible pumps would be located at intervals of approximately 1 pump per 200 LF of trench. Capital costs for installing a biopolymer collection trench were estimated as follows:

Capital Cost Component	Unit Cost ($)
BP Trench (Excavation and Installation)	675/LF
Geotextile Fabric	15/LF
Submersible Pumps	1800/each
Pump Control Panel (1 per pump)	1500/each
Master Control Panel (1 for total sys.)	2000/each

These costs were estimated based on a biopolymer collection trench conceptual design Baker developed for another project, where chlorinated solvents (PCE, TCE) were contaminants in groundwater. The cost components included in the estimate are the major components for a biopolymer collection trench. Several vendors were contacted in the initial development of these unit costs.

Operation and maintenance costs were estimated based on engineering judgment, for the major components that would comprise the operation/maintenance of a biopolymer collection trench. The following unit costs were assumed for operation and maintenance of a drainage trench:

Operation and Maintenance Cost Component	Unit Cost ($)
Electricity (Trench Pump (s))	150/pump/year
Maintenance Labor	
General (52 hours per year)	29.10/hour/year
Annual Inspection (40 hr per year)	29.10/hour/year
Maintenance Materials	4,000/year
Trench Maintenance	2,000/year

These costs do not include equipment replacement (pumps, etc.), administration, or decommissioning. The main purpose of these cost estimates is to provide a means for comparing the economic effectiveness of the four groundwater treatment alternatives.

4.1.2 Extraction Wells

The assumptions used in determining the number of extraction wells to be used at each IR and UST site where extraction wells are the identified groundwater extraction technology were discussed in Section 2.0 of this report. From a conceptual standpoint, each extraction well is envisioned to consist of the following components:

- Six-inch diameter steel casing
- Ten- to 20-foot screens
- Washed coarse graded sand and gravel pack
- Bentonite seal
- Protective well casing
- Steel well vault
- Submersible low flow pump and controller
- Outflow piping
- Electrical conduit

The cost for installing an extraction well was based on the cost for installing a 6-inch recovery well for a pump test at the HPIA Operable Unit at MCB, Camp Lejeune. The cost for this one well was approximately $6,000. Thus, as a conservative estimate, because most sites would require the installation of more than one extraction well, a cost of $5,000 per well was assumed. It is assumed that this cost includes all materials, labor, and mobilization required to install an extraction well. The estimated cost for extraction well discharge piping was developed assuming that each well will require a minimum of 200 feet of discharge piping at a cost of $16.00/LF. Miscellaneous well appurtenances was assumed at $2,000 per well, and would include items such as valves, electrical conduit, etc. The unit costs assumed for estimating capital costs for extraction wells are summarized as follows:

Capital Cost Component	Unit Cost ($)
Install 6-inch diameter extraction well	5,000/well
Extraction Well Discharge piping	4,000/well
Submersible Pump	1,800/well
Miscellaneous Well Appurtenances	2,000/well
Pump Control Panel (1 per pump)	1,500/well
Master Control Panel (1 for total system)	2,000/well
Total Capital Cost per Well	$16,300/well

Operation and maintenance costs for operating and maintaining extraction (recovery) wells were estimated as follows:

Operation and Maintenance Cost Component	Unit Cost ($)
Electricity (Submersible Well Pump)	150/well/year
Maintenance Labor	
General	1,400/well/year
Maintenance Materials	1,000/well/year
Total Annual O&M Cost	$2,550/well/year

Similar to costs identified for drainage trenches, these costs do not include equipment replacement (pumps, etc.), administration, or decommissioning.

Table 4-1 presents a summary of the estimated capital and operation and maintenance costs for groundwater extraction systems, for all IR and UST sites defined as requiring groundwater remediation. A detailed breakdown of the development of these costs is included in Appendix C of this report.

4.2 Groundwater Transmission Systems

A substantial portion of capital costs for Alternatives 2 and 3 were for the design and construction of new collection systems, separate from the existing sanitary sewer systems, to transport contaminated groundwater to the treatment plants. For Alternative 2, the costs for groundwater collection systems were developed for service areas defined by the existing sanitary sewer service areas. These service areas, or outfalls, include Camp Geiger, Rifle Range, Courthouse Bay, Hadnot Point, and Tarawa Terrace. Because the Montford Ponit and Onslow Beach areas each have only one site, these two areas would not need a central groundwater treatment plant or the associated transmission system. The cost for a transmission system for Alternative 3 includes separate costs developed for each outfall, and a base-wide system that collects contaminated groundwater from each of the outfalls and transports it to the existing Hadnot Point STP site. The cost for a collection and transmission system for Alternative 4 includes costs to extend the existing sanitary sewer system to each site and upgrade the proposed base-wide sanitary sewer system to accommodate the additional flows generated by groundwater remediation.

TABLE 4-1

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER EXTRACTION SYSTEMS

CAMP GEIGER OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Campbell Street Fuel Farm	$425,900	1994	$461,200	$9,200
Building AS-4151 (Steam Gen. Plant)	$201,800	1994	$218,500	$9,000
Camp Geiger Fuel Farm	$567,200	1994	$614,300	$9,300
Tanks AS419-AS421 (Air Station)	$30,600	1994	$33,100	$5,100
JP-5 Line Area Site	$0	1993	$0	$5,100
Camp Geiger Mini C Store Service Station	$30,600	1994	$30,600	$5,100
Hypothetical Sites ($30,600 per Site, Total of 15 Sites - FY 1995-FY1999)	$765,000	N/A	$1,016,800	$76,500
#36, Camp Geiger Dump, STP	$30,600	1997	$40,800	$5,100
#41, Camp Geiger Dump, Park	$59,200	1996	$78,900	$10,200
#43, Agan Street Dump	$73,500	1997	$91,800	$12,800
#44, Jones Street Dump	$73,500	1997	$91,800	$12,800
TOTALS	$2,260,000		$2,680,000	$160,200

TABLE 4-1 (CONTINUED)

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER EXTRACTION SYSTEMS

HADNOT POINT OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Building 21, River Road (UST System 21.1)	$50,000	1994	$54,200	$9,000
Gottschalk Marina	$16,300	1994	$17,700	$2,600
Berkley Manor X Change Ser. Sta. Tank 820-2	$44,900	1994	$48,600	$7,700
Hadnot Point Fuel Farm	$0	1992	$0	$10,200
Hypothetical Sites ($30,600 per Site, Total of 70 Sites - FY 1995 - FY 1999)	$2,140,000	N/A	$2,850,000	$357,000
#1, French Creek LDA	$116,400	1996	$145,400	$20,400
#2, Former Daycare/Nursery	$0	N/A	$0	$0
#3, Old Creosote Plant	$73,500	1996	$91,800	$12,800
#6, Storage Lots 203/201 Shallow Aquifer	$44,900	1995	$52,300	$7,650
#6, Storage Lots 203/201 Deep Aquifer	$55,000	1995	$64,100	$30,600
#24, Industrial Fly Ash Dump	$173,600	1995	$202,200	$30,600
#28, HP Burn Dump	$159,300	1996	$199,000	$28,100
#78, Operable Unit 1	$161,300	1994	$174,700	$28,050
#80, Paradise Pt. Golf Course	$30,600	1996	$38,200	$5,100
TOTALS	$3,070,000		$3,940,000	$550,000

TABLE 4-1 (CONTINUED)

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER EXTRACTION SYSTEMS

MONTFORD POINT OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
#16, Montford Point Burn Dump	$30,600	1997	$40,800	$5,100
TOTALS	$30,000		$40,000	$5,100

TARAWA TERRACE OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993$	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Building 45, UST S-941-2	$30,600	1994	$33,100	$5,100
Tarawa Terrace Service Station	$0	1993	$0	$5,100
Hypothetical Sites ($30,600 per Site, Total of 5 Sites - FY 1995 - FY 1999)	$153,000	N/A	$203,400	$25,500
TOTALS	$180,000		$240,000	$35,700

TABLE 4-1 (CONTINUED)

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS
FOR GROUNDWATER EXTRACTION SYSTEMS

RIFLE RANGE OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATE STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Rifle Range Bldg. 72 (Former MCX Gas Station)	$39,800	1994	$43,100	$8,900
#68, Rifle Range Dump	$30,600	1999	$38,200	$5,100
#69, Rifle Range Chemical Dump	$30,600	1996	$38,200	$5,100
TOTALS	$100,000		$120,000	$20,000

COURTHOUSE BAY OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATE STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Hypothetical Sites ($30,600 per Site, Total of 10 Sites - FY 1995 - FY 1999)	$306,000	N/A	$396,600	$51,000
#73, Courthouse Bay LDA	$73,500	1997	$97,900	$12,800
TOTALS	$380,000		$490,000	$60,000

ONSLOW BEACH OUTFALL AREA SITES

SITE NAME	ESTIMATED CAPITAL COST 1993 $	ESTIMATE STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
#12, Explosive Ordnance Disposal	$44,900	1999	$59,800	$7,700
TOTALS	$45,000		$60,000	$8,000

The first step in estimating pumping and transmission costs for Alternatives 2 and 3 included the development of the conceptual design of the systems supporting these alternatives. The conceptual design for the Alternative 4 collection system was taken from the Wastewater Treatment Master Plan, Phase I (Greenhorne and O'Mara, 1991). The key assumptions and items that were considered in the conceptual design of these system are noted below.

4.2.1 Treatment Plant Location Assumptions

The location of treatment plants was a major factor in estimating transmission and pumping costs for Alternatives 2, 3 and 4. The locations will impact the costs of pipeline construction and pumping requirements.

Alternative 2

Alternative 2 assumed that the most cost effective locations for new groundwater treatment plants that would serve sites in the existing STP outfalls, would be the sites of existing STPs. Although existing plants are not adequate to treat contaminated groundwater, existing piping and utilities could be used to in order to reduce costs. In addition, these locations typically facilitate the use of a gravity flow collection system.

Alternative 3

The location of a base-wide groundwater treatment facility for Alternative 3 was assumed to be the existing Hadnot Point STP.

Alternative 4

In accordance with the Scope of Work, the location of the groundwater treatment plant for Alternative 4 is the planned Hadnot Point STP.

4.2.2 System Assumptions

It was assumed that the construction of the collection systems would occur in phases to minimize the impact of high capital costs. The scope required Baker to consider IR and UST sites that would be remediated between 1995 and 1999. From this time period two approximately equal phases were created, Phase I (1995-1996) and Phase II (1997-1999).

Flows from IR and UST sites were included in a phase, based on when remedial activity was due to commence.

Alternatives 2 and 3

Pipe sizes for Alternatives 2 and 3 were estimated for Phase I and Phase II flows. These pipe sizes were then compared. If required the diameters varied 4 inches or more, construction of parallel lines was recommended. The smaller pipe would be installed during Phase I and the larger pipe installed during Phase II. If the required diameters varied only 2 inches the larger pipe was installed at the appropriate time.

To select pumps, Phase I and II flows were calculated at each node. Pumps were selected to accommodate Phase I and additional pumps or a single replacement were then selected to accommodate Phase II flows.

Alternative 4

A new system was not redesigned for this alternative. An explanation of the cost estimate for this alternatives included in Section 4.2.3.

Flows

Alternatives 2 and 3

Pipe sizes and pumps for collection systems were selected based on estimated flows from the 16 IR and 13 UST sites determined to need groundwater remediation in Section 2.0 and 100 hypothetical UST sites that would require groundwater treatment between 1995 and 1999 (20 sites per year as requested in the Scope of Work).

System Configurations

Alternative 2

The configurations of the Alternative 2 collection systems were based on the location of each site with respect to a proposed regional treatment facility. Where ever possible, alignments for each proposed link were located adjacent to existing roadways. Table 4-2 summarizes the components of the transmission system for Alternative 2.

Alternative 3

The Alternative 3 configuration, links the collection systems developed in Alternative 2 (with the exception of the Hadnot Point system) and transports the contaminated groundwater to the site of the existing Hadnot Point treatment plant. The configuration of the Hadnot Point collection systems for Alternative 2 and Alternative 3 are different because the location of the treatment facility is changed. Table 4-3 summarizes the components of the transmission system for Alternative 3.

Alternative 4

The proposed alignment for this alternative was taken from the Wastewater Treatment Master Plan, Phase I (Greenhorne and O'Mara, 1991). Costs for extending the existing sewer system to serve contaminated sites was included in the extraction system cost for each site.

General Design

Concrete-lined ductile iron pipe was selected as the piping material for the system. Available pipe sizes were selected for each system using the Hazen-Williams equation and the American Pipe Manual, a ductile iron pipe applications and design manual. Selections were made to minimize head loss where ever possible.

$$Q = .006756\,C\,D^{2.63}\,H^{0.54}$$

where: Q = flow (gallons per minute)
C = coefficient of friction for concrete lined DIP (140)
D = inside diameter of pipe (inches)
H = loss of head per 1,000 feet of length (feet)

TABLE 4-2

SUMMARY OF TRANSPORTATION COSTS FOR ALTERNATIVE 2

Hadnot Point Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	99,450	$2,127,935	
Vendor Pumps	15	$153,975	
Pump Stations	3	$832,563	
Contengencies		$622,895	
Indirect Costs		$1,027,776	
Outfall Total		$4,765,143	$476,514

Hadnot Point Outfall Phase II			
	Units	Capital Costs	Annual O&M
Piping	43,950	$2,127,935	
Vendor Pumps	0	$0	
Pump Stations	0	$0	
Contengencies	0	$425,587	
Indirect Costs		$702,219	
Outfall Total		$3,255,741	$325,574

Hadnot Point Outfall Totals			
	Units	Capital Costs	Annual O&M
Piping	143,400	$4,255,870	
Vendor Pumps	15	$153,975	
Pump Stations	3	$832,563	
Contengencies	0	$1,048,482	
Indirect Costs		$1,729,994	
Outfall Total		$8,020,883	$802,088

Camp Geiger Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	43,700	$806,380	
Vendor Pumps	16	$166,260	
Pump Stations	1	$51,500	
Contengencies		$204,828	
Indirect Costs		$337,966	
Outfall Total		$1,566,934	$156,693

Camp Geiger Phase II			
	Units	Capital Costs	Annual O&M
Piping	33,500	$594,070	
Vendor Pumps	0	$0	
Pump Stations	5	$480,813	
Contengencies		$214,977	
Indirect Costs		$354,711	
Outfall Total		$1,644,570	$164,457

Camp Geiger Outfall Totals			
	Units	Capital Costs	Annual O&M
Piping	77,200	$1,400,450	
Vendor Pumps	16	$166,260	
Pump Stations	6	$532,313	
Contengencies		$419,805	
Indirect Costs		$692,677	
Outfall Total		$3,211,504	$321,150

Tarawa Terrace Outfall Phase I Only			
	Units	Capital Costs	Annual O&M
Piping	9,100	$116,750	
Vendor Pumps	6	$60,510	
Pump Stations	0	$0	
Contengencies		$35,452	
Indirect Costs		$58,496	
Outfall Total		$271,208	$27,121

Tarawa Terrace Outfall Totals Phase I Only			
	Units	Capital Costs	Annual O&M
Piping	9,100	$116,750	
Vendor Pumps	6	$60,510	
Pump Stations	0	$0	
Contengencies		$35,452	
Indirect Costs		$58,496	
Outfall Total		$271,208	$27,121

TABLE 4-2
(CONTINUED)

SUMMARY OF TRANSPORTATION COSTS FOR ALTERNATIVE 2

Courthouse Bay Outfall Phase I	Units	Capital Costs	Annual O&M
Piping	24,000	$406,730	
Vendor Pumps	4	$40,740	
Pump Stations	0	$0	
Contengencies		$89,494	
Indirect Costs		$270,719	
Outfall Total		$807,683	$80,768

Courthouse Bay Outfall Phase II	Units	Capital Costs	Annual O&M
Piping	7,000	$123,340	
Vendor Pumps	0	0	
Pump Stations	0	0	
Contengencies		$24,668	
Indirect Costs		$74,621	
Outfall Total		$222,629	$22,263

Courthouse Bay Outfall Totals	Units	Capital Costs	Annual O&M
Piping	31,000	$530,070	
Vendor Pumps	4	$40,740	
Pump Stations	0	$0	
Contengencies		$114,162	
Indirect Costs		$345,340	
Outfall Total		$1,030,312	$103,031

Rifle Range Outfall Phase I	Units	Capital Costs	Annual O&M
Piping	13,500	$196,846	
Vendor Pumps	3	$29,855	
Pump Stations	0	$0	
Contengencies		$45,340	
Indirect Costs		$74,811	
Outfall Total		$346,853	$34,685

Rifle Range Outfall Phase II	Units	Capital Costs	Annual O&M
Piping	3,500	$56,350	
Vendor Pumps	2	$19,970	
Pump Stations	0	$0	
Contengencies		$15,264	
Indirect Costs		$25,186	
Outfall Total		$116,770	$11,677

Rifle Range Outfall Phase Totals	Units	Capital Costs	Annual O&M
Piping	17,000	$253,196	
Vendor Pumps	5	$49,825	
Pump Stations	0	$0	
Contengencies		$60,604	
Indirect Costs		$99,997	
Outfall Total		$463,622	$46,362

Alternative 2 Totals Phase I	Units	Capital Costs	Annual O&M
Piping	189,750	3654641	
Vendor Pumps	44	451340	
Pump Stations	4	884062.5	
Contengencies		$998,009	
Indirect Costs		$1,769,769	
Outfall Total		$7,757,821	$775,782

Alternative 2 Totals Phase II	Units	Capital Costs	Annual O&M
Piping	87,950	$2,901,695	
Vendor Pumps	2	$19,970	
Pump Stations	5	$480,813	
Contengencies		$680,496	
Indirect Costs		$1,156,736	
Outfall Total		$5,239,709	$523,971

Alternative 2, Grand Totals	Units	Capital Costs	Annual O&M
Piping	277,700	$6,556,336	
Vendor Pumps	46	$471,310	
Pump Stations	9	$1,364,875	
Contengencies		$1,678,504	
Indirect Costs		$2,926,505	
Outfall Total		$12,997,530	$1,299,753

TABLE 4-3

SUMMARY OF TRANSPORTATION COSTS FOR ALTERNATIVE 3

Hadnot Point Outfall and Trunk System (Phase I only)			
	Units	Capital Costs	Annual O&M
Piping	344,700	$8,854,580	
Vendor Pumps	17	$175,545	
Pump Stations	11	$981,188	
Contengencies		$2,002,263	
Indirect Costs		$550,622	
Outfall Total		$12,564,197	$1,256,420

Hadnot Point Outfall and Trunk System Totals (Phase I only)			
	Units	Capital Costs	Annual O&M
Piping	344,700	$8,854,580	
Vendor Pumps	17	$175,545	
Pump Stations	11	$981,188	
Contengencies		$2,002,263	
Indirect Costs		$550,622	
Outfall Total		$12,564,197	$1,256,420

Camp Geiger Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	43,700	$806,380	
Vendor Pumps	16	$166,260	
Pump Stations	1	$51,500	
Contengencies		$204,828	
Indirect Costs		$337,966	
Outfall Total		$1,566,934	$156,693

Camp Geiger Phase II			
	Units	Capital Costs	Annual O&M
Piping	33,500	$594,070	
Vendor Pumps	0	$0	
Pump Stations	5	$480,813	
Contengencies		$214,977	
Indirect Costs		$354,711	
Outfall Total		$1,644,570	$164,457

Camp Geiger Phase Totals			
	Units	Capital Costs	Annual O&M
Piping	77,200	$1,400,450	
Vendor Pumps	16	$166,260	
Pump Stations	6	$532,313	
Contengencies		$419,805	
Indirect Costs		$692,677	
Outfall Total		$3,211,504	$321,150

Tarawa Terrace Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	9,100	$116,750	
Vendor Pumps	6	$60,510	
Pump Stations	0	$0	
Contengencies		$35,452	
Indirect Costs		$58,496	
Outfall Total		$271,208	$27,121

Tarawa Terrace Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	9,100	$116,750	
Vendor Pumps	6	$60,510	
Pump Stations	0	$0	
Contengencies		$35,452	
Indirect Costs		$58,496	
Outfall Total		$271,208	$27,121

TABLE 4-3
(CONTINUED)

SUMMARY OF TRANSPORTATION COSTS FOR ALTERNATIVE 3

Courthouse Bay Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	24,000	$406,730	
Vendor Pumps	4	$40,740	
Pump Stations	0	$0	
Contengencies		$89,494	
Indirect Costs		$270,719	
Outfall Total		$807,683	$80,768

Courthouse Bay Outfall Phase II			
	Units	Capital Costs	Annual O&M
Piping	7,000	$123,340	
Vendor Pumps	0	0	
Pump Stations	0	0	
Contengencies		$24,668	
Indirect Costs		$74,621	
Outfall Total		$222,629	$22,263

Courthouse Bay Outfall Totals			
	Units	Capital Costs	Annual O&M
Piping	31,000	$530,070	
Vendor Pumps	4	$40,740	
Pump Stations	0	$0	
Contengencies		$114,162	
Indirect Costs		$345,340	
Outfall Total		$1,030,312	$103,031

Rifle Range Outfall Phase I			
	Units	Capital Costs	Annual O&M
Piping	13,500	$196,846	
Vendor Pumps	3	$29,855	
Pump Stations	0	$0	
Contengencies		$45,340	
Indirect Costs		$74,811	
Outfall Total		$346,853	$34,685

Rifle Range Outfall Phase II			
	Units	Capital Costs	Annual O&M
Piping	3,500	$56,350	
Vendor Pumps	2	$19,970	
Pump Stations	0	$0	
Contengencies		$15,264	
Indirect Costs		$25,186	
Outfall Total		$116,770	$11,677

Rifle Range Outfall Phase Totals			
	Units	Capital Costs	Annual O&M
Piping	17,000	$253,196	
Vendor Pumps	5	$49,825	
Pump Stations	0	$0	
Contengencies		$60,604	
Indirect Costs		$99,997	
Outfall Total		$463,622	$46,362

Alternative 3 Totals Phase I			
	Units	Capital Costs	Annual O&M
Piping	435,000	10381286	
Vendor Pumps	46	472910	
Pump Stations	12	1032687.5	
Contengencies		$2,377,377	
Indirect Costs		$1,292,615	
Outfall Total		$15,556,875	$1,555,688

Alternative 3 Totals Phase II			
	Units	Capital Costs	Annual O&M
Piping	44,000	$773,760	
Vendor Pumps	2	$19,970	
Pump Stations	5	$480,813	
Contengencies		$254,909	
Indirect Costs		$454,518	
Outfall Total		$1,983,969	$198,397

Alternative 3, Grand Totals			
	Units	Capital Costs	Annual O&M
Piping	479,000	$11,155,046	
Vendor Pumps	48	$492,880	
Pump Stations	17	$1,513,500	
Contengencies		$2,632,285	
Indirect Costs		$1,747,132	
Outfall Total		$17,540,844	$1,754,084

It was assumed that all links would be force mains and pump stations would be constructed where links intersected.

4.2.3 Costs Assumptions

Alternatives 2 and 3

Costs were developed for the installation of a range of pipe and pump sizes using vendor quotes and catalogs, Means Site Work and Landscape Cost Data, 1993. Table 4-4 summarizes unit costs for the installation of 2-inch ductile iron pipe, and 4-inch, 6-inch, 8-inch, 10-inch, 12-inch, 14-inch, 18-inch, and 24-inch concrete-lined ductile iron pipe. Table 4-5 summarizes unit costs for 10, 20, 50, 100, 150, 200, 300, 400, 1000, and 2600 gpm pumps.

Operation and maintenance costs were assumed to be 10 percent of capital costs of the pumping equipment and force main system.

Alternative 4

Costs for this alternative were not based on a redesign of a new sanitary sewer system that would accommodate sanitary and groundwater flows. The cost for the construction and operation of a base-wide sanitary sewer collection system was developed in the Wastewater Treatment Master Plan, Phase I (Greenhorne and O'Mara, 1991). Capital costs to expand this system to accommodate the additional groundwater flow were based on a comparison of the estimated sanitary sewage flows, as estimated by Greenhorne and O'Mara, to the estimated groundwater flows from the various service areas in the base. The estimated capital costs were increased to take into account the increased size of the pumping systems in order to handle the estimated groundwater flows.

Costs for extending the existing sewer system to serve contaminated sites were included in the extraction system cost for each site.

4.3 Groundwater Treatment Systems

The results of the technology screening and life-cycle cost analysis conducted in Section 3.0 indicate that air stripping is the most cost-effective treatment technology, when compared to

TABLE 4-4

UNIT COSTS OF TRANSMISSION PIPE

Pipe Size	Unit Cost of Pipe Installed (per LF)	Unit Cost for Excavation (per LF)	Unit Cost for Backfill (per LF)	Total Unit Cost (per LF)
2" Diameter PVC, Class 160, SDR 26	$4.28	$1.25	$1.25	$6.78
4" Diameter, DI, Cement lined	$13.60	$1.25	$1.25	$16.10
6" Diameter, DI, Cement lined	$15.50	$1.25	$1.25	$18.00
8" Diameter, DI, Cement lined	$22.00	$1.50	$1.50	$25.00
10" Diameter, DI, Cement lined	$33.00	$1.50	$1.50	$36.00
12" Diameter, DI, Cement lined	$35.00	$2.00	$2.00	$39.00
14" Diameter, DI, Cement lined	$45.50	$2.00	$2.00	$49.50
18" Diameter, DI, Cement lined	$63.00	$2.00	$2.00	$67.00
24" Diameter, DI, Cement lined	$83.00	$4.20	$2.00	$89.20

TABLE 4-5

PUMPING SYSTEM UNIT COSTS

Item/Source	Unit	Unit/Cost	Source
10 gpm pump	Each	$4,000	Vendor
20 gpm pump	Each	$4,100	Vendor
50 gpm pump	Each	$4,300	Vendor
100 gpm pump	Each	$4,600	Vendor
150 gpm pump	Each	$4,900	Vendor
200 gpm pumping station	Each	$51,500	Means[2]
300 gpm pumping station	Each	$57,250	Means[2]
400 gpm pumping station	Each	$63,000	Means[2]
1000 gpm pumping station	Each	$97,500	Means[2]
Precast wet well	Each	$1,885	Means[2]
Excavation for vendor pumps	Crew Day	$2,000	Engineering Judgment/Means[2]
Excavation and Installation for pumping station	LS	75% of equipment costs	Engineering Judgment/Means[2]

(1) 25 horsepower pump station will accommodate 2,400 gpm to 3,700 gpm flows.
(2) Means. 1993. Site Work and Landscape Cost Data.

primary treatment with liquid-phase carbon adsorption and UV/chemical oxidation, for treating groundwater containing oil and grease, inorganics (heavy metals), VOCs, SVOCs, and pesticides. However, all of these contaminants are not necessarily present in groundwater at all sites.

In order to cover site-specific groundwater treatment requirements for all IR and UST sites, five treatment scenarios were developed for purposes of tailoring treatment systems to site-specific contaminants. These scenarios are identified as follows:

Scenario "A"

Assumes COCs are VOCs and oil and grease. A treatment system for this scenario would include pretreatment with oil/water separation, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.

Scenario "B"

Assumes COCs are inorganics (heavy metals) and oil and grease. A treatment system for this scenario would include primary treatment with oil/water separation and metals removal.

Scenario "C"

Assumes COCs are SVOCs, oil and grease, inorganics (heavy metals), and pesticides. A treatment system for this scenario would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.

Scenario "D"

Assumes COCs are VOCs, SVOCs, inorganics (heavy metals), oil and grease, and pesticides. A treatment system for this scenario would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption. This would be considered as the "worst case scenario."

Scenario "E"

Assumes COCs are oil and grease, SVOCs, and pesticides. A treatment system for this scenario would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

Typically, due to the nature of substances stored in UST systems without secondary containment (i.e., fuel oil, heating oil, liquified petroleum gas, etc.), constituents present in environmental media (i.e. soils, groundwater) resulting from spills or past practices commonly include benzene, toluene, xylenes, ethylbenzene (BTEX), total petroleum hydrocarbons (TPH), lead, and petroleum product (dissolved or floating). BTEX can be effectively reduced by air stripping because of volatile nature of the constituents. As long as lead is not a problem, groundwater at the majority of UST sites may be effectively treated using treatment scenario "A", which includes pretreatment with oil/water separation and product recovery, primary treatment with air stripping to reduce VOCs, and limited secondary treatment with liquid-phase carbon adsorption to "polish" the effluent.

Conversely, COCs at IR sites may impose a wide range of treatment needs, because of the variety of constituents that may be present, including VOCs, SVOCs, inorganics (metals), pesticides, and oil and grease. Thus, treatment at these sites can range from simple pretreatment systems to reduce oil and grease and metals levels (treatment scenario "B"), to more complex treatment trains that include pretreatment for oils and grease and metals, primary treatment for VOCs, and secondary treatment to remove SVOCs and pesticides (treatment scenario "D").

The most applicable treatment scenario was identified for each IR and UST site, based on site-specific contaminants anticipated to be present. Because a wide range of flows are anticipated to require treatment at the IR and UST sites, the following "typical" treatment plant flow capacities were identified: 5, 15, 25, 50, 100, 150, and 200 gpm.

Groundwater flow estimates developed for each IR and UST site were compared to these capacities, and rounded up or down to the nearest treatment plant capacity, for purposes of developing capital and operation and maintenance cost estimates for comparing groundwater treatment alternatives. Cost estimates were developed for the following treatment scenarios at the following flow capacities:

- Scenario "A" [5, 15 gpm]
- Scenario "B" [15, 25 gpm]
- Scenario "C" [15, 25, 50 gpm]
- Scenario "D" [5, 15, 25, 50, 100, 150, and 200 gpm]
- Scenario "E" [15, 25 gpm]

In addition, for locations where the estimated flows exceed 200 gpm, cost estimates for the groundwater treatment systems were developed based on cost scales from the USEPA "Handbook of Remedial Action at Waste Disposal Sites" for the major components of the treatment system.

In general, the capital costs include both direct and indirect costs. Direct capital costs include, but are not limited to equipment, piping, electrical, instrumentation, installation, and costs for a treatment building. Indirect capital costs include design services, engineering services, supervision, inspection and overhead, health and safety, and legal. Operation and maintenance costs include electricity consumption (equipment and treatment building), materials, material handling (i.e., carbon, sludge), labor, analytical samples, and administration. These detailed cost estimates, along with the assumptions made in their development, are included in Appendix D of this report.

5.0 EVALUATION OF FOUR GROUNDWATER TREATMENT ALTERNATIVES

Using the information developed in Sections 3.0 and 4.0, Baker evaluated the costs of four different alternatives for treating groundwater from the IR and UST sites. The four alternatives considered are as follows:

- Alternative No. 1 Construction of individual pump and treat systems for each site or operable unit.
- Alternative No. 2 Construction of one or more regional treatment plants solely for treatment of groundwater from the IR and UST sites in that area or operable unit.
- Alternative No. 3 Conversion of one or more of Camp Lejeune's existing STPs solely for treatment of groundwater from the IR and UST sites.
- Alternative No. 4 Transmission and treatment of groundwater from all IR and UST sites at the planned Hadnot Point STP.

A description of each of these alternatives is presented in this section. Total capital and operation and maintenance cost estimates were developed for groundwater extraction, transmission, and treatment. These cost estimates are required as a prerequisite to the evaluation of life-cycle costs, which will be presented in Section 6.0.

5.1 Alternative No.1 - Construction of Individual Pump and Treat Systems

Alternative No. 1 assumes that individual extraction and treatment systems will be constructed at each IR and/or UST site identified as requiring groundwater remediation. A total of 17 IR sites and 113 UST sites (13 current, and 100 hypothetical future sites to be added) were identified as sites that would require some extent of groundwater treatment. Thus, implementation of Alternative No. 1 would involve the construction and operation of approximately 130 individual groundwater treatment systems. The major components required for this alternative include a groundwater extraction and treatment system.

5.1.1 Groundwater Extraction and Treatment Systems

As discussed in Section 4.0, each IR site was identified as requiring one of five treatment scenarios, based on the site-specific COCs. The basic treatment system assumed for each scenario is discussed in Section 4.0. Capital and operation and maintenance costs were developed for a flow range covering five selected treatment plant capacities (i.e. 5, 15, 25, 50, 100, 150, and 200 gpm). In addition, cost estimates were also developed for groundwater treatment systems with flows greater than 200 gpm, specifically for Camp Geiger and Hadnot Point. Accordingly, each site was paired with the most appropriate treatment plant capacity.

Initial capital costs for the site-specific groundwater extraction system and treatment system were developed assuming a base year of 1993. Based on the estimated start-up date for groundwater treatment at each site, the capital cost was adjusted by applying MILCON escalation indices obtained from NAVFAC P-442, Economic Analysis Handbook (Naval Facilities Engineering Command, June 1986), to represent the projected capital cost that would be incurred in the start-up year for the treatment system.

In order to address the total cost for groundwater treatment at the "hypothetical" UST sites (potentially to be added Fiscal Year 1995 through Fiscal Year 1999), the estimated capital cost (Base Year 1995) and operation and maintenance costs were multiplied by the anticipated total number of "hypothetical" UST sites for the above referenced period and shown as a total capital and operation and maintenance cost, respectively.

Tables 5-1, 5-2, 5-3, and 5-4 provide a summary of the estimated capital and operation and maintenance costs for Alternative No. 1, as applied to all IR and UST sites within Camp Geiger; Hadnot Point, Montford Point, and Tarawa Terrace; and Rifle Range, Courthouse Bay, and Onslow Beach outfall (service) areas, respectively. The total capital cost for providing groundwater treatment systems for Alternative No. 1 is approximately $32 million.

TABLE 5-1

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS
FOR GROUNDWATER TREATMENT SYSTEM

ALTERNATIVE 1
CAMP GEIGER OUTFALL AREA SITES

SITE NAME	ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	ASSUMED TREATMENT PLANT CAPACITY (GPM)	TREATMENT SCENARIO (A,B,C,D,E)	ESTIMATED CAPITAL COST 1993$	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL CO IN STARTUP YEAR	ESTIMATED O&M COST
Campbell Street Fuel Farm	2.5	5	A	$106,300	1994	$115,123	$60,000
Building AS-4151 (Steam Gen. Plant)	0.5	5	A	$106,300	1994	$115,123	$60,000
Camp Geiger Fuel Farm	15	15	A	$209,300	1994	$226,672	$63,000
Tanks AS419-AS421 (Air Station)	8	15	A	$209,300	1994	$226,672	$63,000
JP-5 Line Area Site	8	15	A	$0	1993	$0	$63,000
Camp Geiger Mini C Store Service Station	12	15	D	$322,100	1994	$348,834	$107,000
Hypothetical Sites ($106,300 per Site, Total of 15 Sites - FY 1995 - FY 1999)	5	5	A	$1,590,000	N/A	$2,120,000	$900,000
#36, Camp Geiger Dump, STP	8	15	D	$322,100	1997	$429,037	$107,000
#41, Camp Geiger Dump, Park	16	25	D	$377,000	1997	$502,164	$119,000
#43, Agan Street Dump	20	25	B	$209,000	1996	$261,041	$85,000
#44, Jones Street Dump	20	25	C	$342,000	1996	$427,158	$110,000
			TOTALS	$3,790,000		$4,770,000	$1,740,000

NOTES:

(1) Treatment system scenarios were developed, based on site-specific contaminants of concern. The scenarios are identified as follows:
Scenario A = Assumes contaminants of concern are VOCs, and oil&grease. Treatment system would include pretreatment with oil/water separation, Primary Treatment with Air Stripping, and Secondary Treatment with Liquid-Phase Carbon Adsorption.
Scenario B = Assumes contaminants of concern are inorganics (metals) and oil&grease. Treatment system would include primary treatment with oil/water separation and metals removal.
Scenario C = Assumes contaminants of concern are SVOCs, Oil&Grease, Inorganics (metals), and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.
Scenario D = Assumes the "worst case scenario" in that contaminants of concern are VOCs, SVOCs, Inorganics (metals), Oil&Grease, and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.
Scenario E = Assumes contaminants of concern are oil&grease, SVOCs, and pesticides. Treatment system would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

Camp Lejeune
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TABLE 5-2

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER TREATMENT SYSTEM

ALTERNATIVE 1
HADNOT POINT OUTFALL AREA SITES

SITE NAME	ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	ASSUMED TREATMENT PLANT CAPACITY (GPM)	TREATMENT SCENARIO (A,B,C,D,E) (1)	ESTIMATED CAPITAL COST 1993 $	STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COST
Bldg. 21 River Rd (UST System 21.1)	1	5	A	$106,300	1994	$115,123	$60,000
Gottschalk Marina	4	5	D	$145,300	1994	$157,360	$95,000
Berkley Manor X Change Service Station (Tank 820-2)	12	15	A	$209,300	1994	$226,672	$63,000
Hadnot Point Fuel Farm (In service)	5	5	A	$0	1992	$0	$60,000
Hypothetical Sites ($106,300 per Site, Total of 70 Sites - FY 1995 - FY 1999)	5	5	A	$7,440,000	N/A	$9,890,000	$4,200,000
#1, French Creek LDA	32	50	D	$724,000	1996	$904,276	$123,000
#2, Former Daycare/Nursery	0	N/A		$0	1996	$0	$0
#3, Old Creosote Plant	20	25	E	$202,900	1996	$253,422	$76,000
#6, Storage Lots 203/201 Shallow Aquifer	15	15	D	$209,300	1995	$243,835	$63,000
#6, Storage Lots 203/201 Deep Aquifer	300	300	D	$1,500,000	1995	$1,747,500	$470,000
#24, Industrial Fly Ash Dump	48	50	C	$664,000	1995	$773,560	$111,000
#28, HP Burn Dump	44	50	D	$724,000	1996	$904,276	$123,000
#78, Hadnot Point Industrial Area	160	160	D	$0	1994	$0	$144,000
#80, Paradise Pt. Golf Course	8	15	D	$322,100	1996	$402,303	$107,000
			TOTALS	$12,250,000		$15,620,000	$5,700,000

NOTES:
(1) Treatment system scenarios were developed, based on site-specific contaminants of concern. The scenarios are identified as follows:
Scenario A = Assumes contaminants of concern are VOCs, and oil&grease. Treatment system would include pretreatment with oil/water separation, Primary Treatment with Air Stripping, and Secondary Treatment with Liquid-Phase Carbon Adsorption.
Scenario B = Assumes contaminants of concern are inorganics (metals) and oil&grease. Treatment system would include primary treatment with oil/water separation and metals removal.
Scenario C = Assumes contaminants of concern are SVOCs, Oil&Grease, Inorganics (metals), and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.
Scenario D = Assumes the "worst case scenario" in that contaminants of concern are VOCs, SVOCs, Inorganics (metals), Oil&Grease, and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.
Scenario E = Assumes contaminants of concern are oil&grease, SVOCs, and pesticides. Treatment system would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

TABLE 5-3

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER TREATMENT SYSTEM

ALTERNATIVE 1
MONTFORD POINT AND TARAWA TERRACE OUTFALL AREA SITES

SITE NAME	ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	ASSUMED TREATMENT PLANT CAPACITY (GPM)	TREATMENT SCENARIO (A,B,C,D,E) (1)	ESTIMATED CAPITAL COST 1993$	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED O&M COST
MONTFORD POINT OUTFALL AREA SITES							
#16, Montford Point Burn Dump	8	15	D	$322,100	1997	$429,037	$107,000
			TOTALS	$320,000		$430,000	$110,000
TARAWA TERRACE OUTFALL AREA SITES							
Building 45, UST S-941-2	5	5	D	$145,300	1994	$193,540	$95,000
Tarawa Terrace Service Station	8	15	A	$0	1993	$0	$63,000
Hypothetical Sites ($106,300 per Site, Total of 5 Sites - FY 1995 - FY 1999)	5	5	A	$530,000	N/A	$710,000	$300,000
			TOTALS	$680,000		$900,000	$460,000

NOTES:
(1) Treatment system scenarios were developed, based on site-specific contaminants of concern. The scenarios are identified as follows:
Scenario A = Assumes contaminants of concern are VOCs, and oil&grease. Treatment system would include pretreatment with oil/water separation, Primary Treatment with Air Stripping, and Secondary Treatment with Liquid-Phase Carbon Adsorption.
Scenario B = Assumes contaminants of concern are inorganics (metals) and oil&grease. Treatment system would include primary treatment with oil/water separation and metals removal.
Scenario C = Assumes contaminants of concern are SVOCs, Oil&Grease, Inorganics (metals), and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.
Scenario D = Assumes the "worst case scenario" in that contaminants of concern are VOCs, SVOCs, Inorganics (metals), Oil&Grease, and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.
Scenario E = Assumes contaminants of concern are oil&grease, SVOCs, and pesticides. Treatment system would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

TABLE 5-4

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS
FOR GROUNDWATER TREATMENT SYSTEM

ALTERNATIVE 1
RIFLE RANGE, COURTHOUSE BAY AND ONSLOW BEACH OUTFALL AREA SITES

SITE NAME	ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	ASSUMED TREATMENT PLANT CAPACITY (GPM)	TREATMENT SCENARIO (A,B,C,D,E) (1)	ESTIMATED CAPITAL COST 1993$	ESTIMATED STARTUP DATE	ESTIMATED CAPITAL COST IN STARTUP YEAR	ESTIMATED ANNUAL O&M COSTS
RIFLE RANGE OUTFALL AREA SITES							
Rifle Range Bldg. 72 (Former MCX Gas St	1.5	5	A	$106,300	1994	$115,123	$60,000
#68, Rifle Range Dump	8	15	D	$322,100	1996	$402,303	$107,000
#69, Rifle Range Chemical Dump	8	15	A	$209,300	1996	$261,416	$63,000
			TOTALS	$640,000		$780,000	$230,000
COURTHOUSE BAY OUTFALL AREA SITES							
Hypothetical Sites ($106,300 per Site, Total of 10 Sites - FY 1995 - FY 1999)	5	5	A	$1,060,000	N/A	$1,410,000	$600,000
#73, Courthouse Bay LDA	20	25	D	$377,000	1997	$502,164	$119,000
			TOTALS	$1,440,000		$1,910,000	$720,000
ONSLOW BEACH OUTFALL AREA SITES							
#12, Explosive Ordnance Disposal	12	15	C	$255,400	1997	$340,193	$96,000
			TOTALS	$260,000		$340,000	$100,000

NOTES:
(1) Treatment system scenarios were developed, based on site-specific contaminants of concern. The scenarios are identified as follows:
Scenario A = Assumes contaminants of concern are VOCs, and oil&grease. Treatment system would include pretreatment with oil/water separation, Primary Treatment with Air Stripping, and Secondary Treatment with Liquid-Phase Carbon Adsorption.
Scenario B = Assumes contaminants of concern are inorganics (metals) and oil&grease. Treatment system would include primary treatment with oil/water separation and metals removal.
Scenario C = Assumes contaminants of concern are SVOCs, Oil&Grease, Inorganics (metals), and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.
Scenario D = Assumes the "worst case scenario" in that contaminants of concern are VOCs, SVOCs, Inorganics (metals), Oil&Grease, and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.
Scenario E = Assumes contaminants of concern are oil&grease, SVOCs, and pesticides. Treatment system would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

5.2 Alternative No. 2 - Construction of Regional Treatment Plants

Alternative No. 2 assumes that one regional treatment plant will be constructed within each of the seven STP service (outfall) areas for treatment of groundwater from the IR and UST sites. In order to develop a strategy for the concept of treating groundwater at regional plant locations, it was assumed that IR and UST sites would be assembled for treatment according to their location with respect to the adjacent outfall area. The Site Evaluation Matrix (Appendix B) groups the sites based on the location of their respective outfall areas. For clarification purposes, these outfall areas include: (1) Camp Geiger, (2) Montford Point, (3) Tarawa Terrace, (4) Hadnot Point, (5) Rifle Range, (6) Courthouse Bay, and (7) Onslow Beach. As shown in the Site Evaluation Matrix, the majority of sites requiring groundwater treatment are located within the Camp Geiger and Hadnot Point outfall areas.

Based on the individual groundwater flow rates estimated for each IR and UST sites, the following cumulative flows would require treatment at the seven central treatment plants:

Regional Treatment Plant	Cumulative Groundwater Extraction Rate (gpm)	Assumed Plant Capacity (gpm)
Camp Geiger	310	300
Montford Point	15	15
Tarawa Terrace	45	50
Hadnot Point	1,050	1,100
Rifle Range	35	50
Courthouse Bay	75	75
Onslow Beach	15	15

It should be noted that because the Montford Point and Onslow Beach areas each have only one site, these two areas would not need a regional groundwater treatment plant or the associated transmission system.

The assumed plant capacity for the remaining five outfall areas represents the cumulative estimated groundwater flow within each area, adjusted to represent a nominal plant capacity, for the purpose of developing capital and operation and maintenance costs for extraction, transmission, and treatment. Major components of Alternative No. 2 include a groundwater extraction system, transmission system, and treatment system. Each of these components is further discussed in the following sections, and the capital and operation and maintenance costs developed are presented for evaluation.

5.2.1 Groundwater Extraction System

Similar to Alternative No. 1, a groundwater extraction system would be required at each IR and UST site requiring groundwater remediation, with the exception of the UST sites where current pump and treat systems are already constructed in place (Hadnot Point Fuel Farm, Tarawa Terrace Service Station, and JP-5 Line Site). Capital and operation and maintenance costs were developed for site-specific groundwater extraction systems and presented in Section 4.0. Individual site extraction system costs were added together to develop a cumulative cost for sites within each outfall area. These costs will be used in the evaluation of life-cycle costs, which will be developed for comparison of Alternative No. 2 to Alternatives No. 1, 3, and 4.

5.2.2 Groundwater Transmission System

To transport groundwater from the IR and UST sites in each area to the five regional treatment plants, a total of approximately 278,000 feet of force main and 46 pump stations would need to be constructed. The total estimated capital cost to install this transmission system is approximately $16,000,000. Table 5-5 presents the estimated capital cost and operation and maintenance costs for transmission systems developed for Alternative 2.

5.2.3 Groundwater Treatment System

Due to the fact that groundwater will be combined for treatment from a number of sites for centralized treatment, treatment scenario D was assumed as the basis for developing capital and operation and maintenance costs for the treatment component of Alternative No. 2. Treatment scenario D assumes a worst case scenario, where the primary COCs include oil and grease, VOCs, SVOCs, inorganics (metals), and pesticides.

Detailed capital and operation and maintenance costs were developed over a range of five flow rates for scenario D (5, 15, 25, 50, 100, 150, and 200 gpm). According to the cumulative projected flows for each outfall area, three of the five regional treatment plants would require a capacity less than 100 gpm. Capital and operation and maintenance costs developed for groundwater treatment systems in Section 4.0 for 15, 50, and 100 gpm systems (Scenario D) will be applied to the applicable plants, with the exception of Camp Geiger and Hadnot Point.

TABLE 5-5

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER TRANSMISSION SYSTEMS

ALTERNATIVE 2

SITE NAME	TOTAL ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	TOTAL ESTIMATED QUANTITY OF PIPE (LINEAR FEET)	TOTAL ESTIMATED QUANTITY OF PUMPS/	ESTIMATED CAPITAL COST	ESTIMATED O&M COST
CAMP GEIGER OUTFALL AREA SITES (Camp Geiger Central Groundwater Treatment Plant)	310	77,200	16	$4,150,000	$415,000
MONTFORD POINT OUTFALL AREA SITES * (Site 16, Montford Point Burn Dump)	15	0	0	$0	$0
TARAWA TERRACE OUTFALL AREA SITES (Tarawa Terrace Central Groundwater Treatment Plant)	45	9,100	1	$320,000	$32,000
HADNOT POINT OUTFALL AREA SITES (Hadnot Point Central Groundwater Treatment Plant)	1100	143,400	15	$10,150,000	$1,015,000
RIFLE RANGE OUTFALL AREA SITES (Rifle Range Central Groundwater Treatment Plant)	35	17,000	5	$570,000	$57,000
COURTHOUSE BAY OUTFALL AREA SITES (Courthouse Bay Central Groundwater Treatment Plant)	75	31,000	4	$1,260,000	$126,000
ONSLOW BEACH OUTFALL AREA SITES * (Site 12, Explosive Ordnance Disposal)	15	0	0	$0	$0
TOTALS	1,595	277,700	41	$16,450,000	$1,645,000

NOTE:
* These areas have only one site requiring groundwater treatment, therefore no transmission system is required.

Due to the magnitude of flow anticipated for central treatment plants at Camp Geiger and Hadnot Point, the same cost basis could not be assumed, because the treatment equipment required would be similar in scale to the equipment required at a municipal water treatment plant. To estimate costs for a groundwater treatment plant to treat 300 gpm from Camp Geiger [0.43 million gallons per day (mgd)] and 1,100 gpm from Hadnot Point (1.6 mgd), cost scales for the major components of the treatment system, including oil/water separation, metals precipitation/removal, air stripping, and carbon adsorption were used from the USEPA "Handbook of Remedial Action at Waste Disposal Sites."

Table 5-6 provides a summary of the capital and operation and maintenance costs developed for the groundwater treatment system component of Alternative No. 2. The total estimated capital cost for providing the groundwater extraction, transmission, and treatment systems for this alternative is approximately $35,000,000 million. These costs will be combined with the costs developed for groundwater extraction and transmission, and evaluated and compared to Alternatives No. 1, 3, and 4, in Section 6.0.

TABLE 5-6

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER TREATMENT SYSTEM

ALTERNATIVE 2

SITE NAME	TOTAL ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	ASSUMED TREATMENT PLANT CAPACITY (GPM)	TREATMENT SCENARIO (A,B,C,D,E) (1)	ESTIMATED CAPITAL COST	ESTIMATED O&M COST
CAMP GEIGER OUTFALL AREA SITES					
(Camp Geiger Central Groundwater Treatment Plant)	310	300	D	$1,801,800	$187,200
MONTFORD POINT OUTFALL AREA SITES					
(Montford Point Central Groundwater Treatment Plant)	15	15	D	$430,000	$107,000
TARAWA TERRACE OUTFALL AREA SITES					
(Tarawa Terrace Central Groundwater Treatment Plant)	45	50	D	$960,000	$123,000
HADNOT POINT OUTFALL AREA SITES					
(Hadnot Point Central Groundwater Treatment Plant)	1090	1100	D	$5,405,400	$561,600
RIFLE RANGE OUTFALL AREA SITES					
(Rifle Range Central Groundwater Treatment Plant)	35	50	D	$960,000	$123,000
COURTHOUSE BAY OUTFALL AREA SITES					
(Courthouse Bay Central Groundwater Treatment Plant)	75	100	D	$1,270,000	$125,000
ONSLOW BEACH OUTFALL AREA SITES					
(Onslow Beach Central Groundwater Treatment Plant)	15	15	D	$430,000	$107,000

NOTES:
(1) Treatment system scenarios were developed, based on site-specific contaminants of concern. The scenarios are identified as follows:
Scenario A = Assumes contaminants of concern are VOCs, and oil&grease. Treatment system would include pretreatment with oil/water separation, Primary Treatment with Air Stripping, and Secondary Treatment with Liquid-Phase Carbon Adsorption.
Scenario B = Assumes contaminants of concern are inorganics (metals) and oil&grease. Treatment system would include primary treatment with oil/water separation and metals removal.
Scenario C = Assumes contaminants of concern are SVOCs, Oil&Grease, Inorganics (metals), and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, and primary treatment with liquid-phase carbon adsorption.
Scenario D = Assumes the "worst case scenario" in that contaminants of concern are VOCs, SVOCs, Inorganics (metals), Oil&Grease, and Pesticides. Treatment system would include pretreatment with oil/water separation and metals removal, primary treatment with air stripping, and secondary treatment with liquid-phase carbon adsorption.
Scenario E = Assumes contaminants of concern are oil&grease, SVOCs, and pesticides. Treatment system would include pretreatment with oil/water separation and primary treatment with liquid-phase carbon adsorption.

5.3 Alternative No. 3 - Treatment at One Central Plant

Alternative No. 3 considers a treatment scenario where groundwater from all the sites at the Base is extracted and pumped to an existing STP. This alternative assumes that the STP is converted to a plant dedicated to treat contaminated groundwater.

The total estimated flows that could be generated from the IR and UST sites are estimated at approximately 2.3 mgd. Of this amount, 1.6 mgd is estimated from Hadnot Point and Sites 6 and 82. The existing Hadnot Point STP has a capacity of 8 mgd. Therefore, for the purposes of this study, Baker assumed that the Hadnot Point STP would be converted to a groundwater treatment plant.

5.3.1 Groundwater Transmission System

To estimate capital costs for this alternative, Baker first developed preliminary costs for a groundwater transmission system and a series of pump stations that would be required to pump extracted groundwater from the IR and UST sites to the Hadnot Point Plant. To develop this system of pump stations and force mains, Baker reviewed the Wastewater Treatment Plant Master Plan developed for the planned Hadnot Point STP (Greenhorne and O'Mara, 1991). Using this plan as a guide, preliminary routes of the force mains were determined.

To transport groundwater from the IR and UST sites in each area to a central treatment plant, approximately 480,000 feet of force main and 48 pump stations would need to be installed. The total estimated capital cost to install this transmission system is approximately $21,000,000. Table 5-7 presents the estimated capital and operation and maintenance costs for the transmission system for this alternative.

5.3.2 Upgrading the Hadnot Point STP

To develop estimated costs to convert the existing Hadnot Point STP to a groundwater treatment plant capable of serving the entire Base, Baker made the following assumptions:

- The existing STP structural facilities (primary and secondary settling tanks, pumping facilities, anaerobic digesters) would be retrofitted with new equipment or converted to serve a new function.

TABLE 5-7

SUMMARY OF CAPITAL AND OPERATION & MAINTENANCE COSTS FOR GROUNDWATER TRANSMISSION SYSTEMS

ALTERNATIVE 3
CENTRAL TREATMENT PLANT AT EXISTING HADNOT POINT STP

SITE NAME	TOTAL ESTIMATED GROUNDWATER EXTRACTION RATE (GPM)	TOTAL ESTIMATED QUANTITY OF PIPE (LINEAR FEET)	TOTAL ESTIMATED QUANTITY OF PUMPS/ PUMPING STATIO	ESTIMATED CAPITAL COST	ESTIMATED O&M COST
CAMP GEIGER OUTFALL AREA SITES	310	77,200	16	$4,150,000	$415,000
MONTFORD POINT OUTFALL AREA SITES	15	0	0	$0	$0
TARAWA TERRACE OUTFALL AREA SITES	45	9,100	6	$320,000	$32,000
TRUNK SYSTEM AND HADNOT POINT OUTFALL AREA SITES (Hadnot Point Central Groundwater Treatment Plant)	1090	344,700	17	$14,640,000	$1,464,000
RIFLE RANGE OUTFALL AREA SITES	35	17,000	5	$570,000	$57,000
COURTHOUSE BAY OUTFALL AREA SITES	75	31,000	4	$1,260,000	$126,000
ONSLOW BEACH OUTFALL AREA SITES	15	0	0	$0	$0
TOTALS	1,570	479,000	48	$20,940,000	$2,094,000

- A new chemical feed system would be installed prior to the primary settling tanks for metals removal.

- The existing primary settling tanks would be retrofitted with new equipment to provided for suspended solids and metals removal.

- A new fine bubble type aeration system would be installed to provide air stripping capabilities.

- The existing secondary settling tanks would be retrofitted with new equipment.

- A liquid phase carbon adsorption system would be installed to provide a final treatment process for VOC removal.

- The existing anaerobic digesters would be converted to solids thickening tanks.

- A new solids handling system would be installed to dewater solids generated during the treatment process.

- A new administration building and laboratory would be constructed.

To determine the estimated costs for converting the existing Hadnot Point STP, Baker considered the costs estimated by Greenhorne and O'Mara for an upgrade of the STP to a 10 mgd advanced secondary treatment plant (Task 4, Alternative 2). Using these costs as a basis, Baker made adjustments to take into account that the existing plant capacity of 8 mgd would not be increased. With this adjustment, the estimated cost to convert the Hadnot Point STP to a central groundwater treatment plant is approximately $14,900,000 in 1993 dollars or $19,800,000 if the plant was built in 1997. Table 5-8 presents a breakdown of the estimated costs for Alternative No.3.

5.3.3 Annual Operation and Maintenance Costs

Annual operation and maintenance costs are estimated from EPA cost curves for advanced wastewater treatment plants. For a plant capacity of approximately 5.8 mgd, the annual operation and maintenance costs are estimated to be $4,050,000.

TABLE 5-8

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

ALTERNATIVE NO.3

REGIONAL GROUNDWATER TREATMENT PLANT AT HADNOT POINT

Basis:
Flow = 3 mgd
Contaminants of Concern: VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Upgrade to Hadnot Point STP	
1. Upgrade Existing Influent Pump Station	$190,000
2. Install Chemical Feed System	$160,000
3. Upgrade Existing Primary Settling Tanks	$520,000
4. Install Fine Bubble Aeration System	$1,700,000
5. Upgrade Existing Secondary Settling Tanks	$520,000
6. Upgrade Return Sludge Pumping	$70,000
7. Install Carbon Adsorption System	$2,000,000
8. Upgrade Solids Handling System	$1,700,000
9. Convert Anaerobic Digesters to Solids Thickening Tanks	$80,000
10. Construct Administration Building and Laboratory	$700,000
11. Site Work	$1,300,000
12. Emergency Power	$950,000
Subtotal Direct Capital Costs	$9,890,000
Construction Contingency (20% Subtotal Direct Capital Costs)	$1,978,000
TOTAL DIRECT CAPITAL COST	$11,868,000
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	$712,000
Engineering Services (10% Total Direct Capital Cost)	$1,187,000
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	$653,000
Health and Safety (3% Total Direct Capital Cost)	$356,000
Legal (1% Total Direct Capital Cost)	$119,000
TOTAL INDIRECT CAPITAL COST	$3,027,000
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY) 1993$	$14,895,000
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY) 1997$	$19,840,000

ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS	
Annual O&M Costs per EPA Cost Curve (Adjusted for Age of Facility)	$4,050,000

5.4 Alternative No. 4 - Treatment at the Proposed Hadnot Point STP

The final alternative considered estimated costs to treat all groundwater from the IR and UST sites at the planned Hadnot Point STP. To evaluate this alternative the following assumptions were made:

- Groundwater extraction costs are assumed to be the same as those developed for Alternatives 1 through 3, with a total estimated capital cost of $7,500,000.

- The extracted groundwater is discharged to existing sanitary sewers and transported to the new STP. The estimated capital costs to construct the additional pumping capacity and force mains are based on costs in the Wastewater Treatment Plant Master Plan (Greenhorne & O'Mara, 1991). These costs were adjusted to reflect the additional costs that would be required to increase the size of the pump stations at Camp Geiger, Tarawa Terrace, Rifle Range, and Courthouse Bay to handle the groundwater flows.

- The pump station at Montford Point is assumed to be large enough to handle the projected groundwater flows from this area.

- The planned Hadnot Point STP capacity is increased approximately 3 mgd, from 15 mgd to 18 mgd, to handle the estimated maximum flows of sanitary sewage and contaminated groundwater.

To determine the estimated costs for constructing additional treatment processes at the planned Hadnot Point STP, Baker reviewed the costs estimated by Greenhorne and O'Mara for building a 15 mgd advanced secondary treatment plant (Task 4, Alternative 3). These costs were adjusted to take into account the additional equipment would be required to provide groundwater treatment systems.

The estimated cost to add groundwater treatment systems to the planned Hadnot Point STP is approximately $9,500,000 in 1993 dollars or approximately $12,700,00 if the plant was built in 1997.

The total estimated capital cost for Alternative No.4 is as follows:

Groundwater Extraction System:	$7,570,000
Groundwater Transmission System:	14,800,000
Groundwater Treatment System:	12,700,000
Total Estimated Capital Cost	$35,000,000

5.4.1 Annual Operation and Maintenance Costs

Annual operation and maintenance costs are estimated from EPA cost curves for advanced wastewater treatment plants. For the portion of the planned Hadnot Point STP attributed to groundwater treatment (approximately 2.3 mgd), the annual operation and maintenance costs are estimated to be $3,800,000.

6.0 LIFE-CYCLE COST ANALYSIS OF GROUNDWATER TREATMENT ALTERNATIVES

This section presents a life-cycle cost analysis of the four groundwater treatment alternatives considered in this report.

Using the cost estimates developed in Sections 4.0 and 5.0, life-cycle, or Net Present Value (NPV) costs for the alternatives have been calculated based on the guidance presented in the Navy's Economic Analysis Handbook, NAVFAC P-442 (Naval Facilities Engineering Command, June 1986).

The life-cycle cost analysis is an economic analysis method that allows different alternatives to be compared with each other, based on the total cost incurred by each alternative over its useful life. The analysis considers both one time capital cost expenditures and the present worth of reoccurring, or annual operation and maintenance costs. In accordance the Scope of Work, annual operation and maintenance costs were calculated for two different time periods, 0 to 10 years, and 11 to 30 years. For the analysis, Baker assumed that the operation and maintenance costs increased 50 percent in years 11 through 30, to take into account equipment replacement costs. As required by NAVFAC P-442, a 10 percent interest rate was used in the analysis.

The life-cycle, or NPV, cost for each alternative is the sum of:

- Total capital costs for groundwater extraction, transmission, and treatment costs, plus

- Annual operation and maintenance costs for years 0 through 10, adjusted by the discount factor of 6.145, plus

- Annual operation and maintenance costs for years 11 through 30, adjusted by the discount factor of 9.427

Therefore, the following equation was used to determine the life-cycle cost for each alternative:

Total Capital Cost
+ Annual O&M Costs (Yrs 1-10) x 6.145
+ Annual O&M Costs (Yrs 11-30) x 9.427
= Life-cycle cost

Table 6-1 shows the capital costs, annual operation and maintenance costs, and life-cycle costs for alternatives 1 through 4. The resulting life-cycle costs are summarized below.

LIFE-CYCLE COST ANALYSIS SUMMARY
ALTERNATIVES 1 THROUGH 4

No.	Alternative Description	Total Life-Cycle Cost
1	Individual Treatment Systems at Each Site	$142,000,000
2	Regional Treatment Systems at Each Outfall	$68,000,000
3	Conversion of STP to Groundwater Treatment Plant	$126,000,000
4	Treatment at Planned Hadnot Point STP	$77,000,000

TABLE 6-1

LIFE CYCLE COST ANALYSIS SUMMARY

ALTERNATIVES 1 THROUGH 4

ALTERNATIVE 1 - INDIVIDUAL GROUNDWATER TREATMENT PLANTS

OUTFALL AREA	EXTRACTION CAPITAL COST	TREATMENT CAPITAL COST	TRANSMISSION CAPITAL COST	TOTAL CAPITAL COST	ANNUAL O&M (Yrs 1-10)	ANNUAL O&M (Yrs 11-30)	PRESENT WORTH (1993 $)
Camp Geiger	$2,680,000	$4,770,000	$0	$7,450,000	$1,900,200	$2,850,300	$28,500,000
Montford Point	$40,000	$430,000	$0	$470,000	$115,100	$170,000	$1,700,000
Tarawa Terrace	$240,000	$900,000	$0	$1,140,000	$495,700	$740,000	$6,600,000
Hadnot Point	$3,940,000	$15,620,000	$0	$19,560,000	$6,250,000	$9,375,000	$88,700,000
Rifle Range	$120,000	$780,000	$0	$900,000	$250,000	$375,000	$3,700,000
Courthouse Bay	$490,000	$1,910,000	$0	$2,400,000	$780,000	$1,170,000	$11,000,000
Onslow Beach	$60,000	$340,000	$0	$400,000	$108,000	$162,000	$1,600,000
TOTALS	$7,570,000	$24,750,000	$0	$32,320,000	$9,900,000	$14,840,000	$141,800,000

ALTERNATIVE 2 - SEVEN REGIONAL GROUNDWATER TREATMENT PLANTS

OUTFALL AREA	EXTRACTION CAPITAL COST	TREATMENT CAPITAL COST	TRANSMISSION CAPITAL COST	TOTAL CAPITAL COST	ANNUAL O&M (Yrs 1-10)	ANNUAL O&M (Yrs 11-30)	PRESENT WORTH (1993 $)
Camp Geiger	$2,680,000	$1,801,800	$4,150,000	$8,631,800	$788,400	$1,180,000	$17,300,000
Montford Point	$40,000	$430,000	$0	$470,000	$159,100	$240,000	$2,200,000
Tarawa Terrace	$240,000	$960,000	$320,000	$1,520,000	$188,700	$280,000	$3,600,000
Hadnot Point	$3,940,000	$5,405,400	$10,150,000	$19,495,400	$1,216,600	$1,820,000	$32,900,000
Rifle Range	$120,000	$960,000	$570,000	$1,650,000	$215,000	$320,000	$4,000,000
Courthouse Bay	$490,000	$1,270,000	$1,260,000	$3,020,000	$250,000	$380,000	$5,800,000
Onslow Beach	$60,000	$430,000	$0	$490,000	$144,000	$220,000	$2,100,000
TOTALS	$7,570,000	$11,257,200	$16,450,000	$35,277,200	$2,960,000	$4,440,000	$68,000,000

ALTERNATIVE 3 - CENTRAL GROUNDWATER TREATMENT PLANT

OUTFALL AREA	EXTRACTION CAPITAL COST	TREATMENT CAPITAL COST	TRANSMISSION CAPITAL COST	TOTAL CAPITAL COST	ANNUAL O&M (Yrs 1-10)	ANNUAL O&M (Yrs 11-30)	PRESENT WORTH (1993 $)
Total Base	$7,570,000	$19,840,000	$20,940,000	$48,350,000	$6,980,000	$10,470,000	$125,600,000

ALTERNATIVE 4 - TREATMENT AT PLANNED HADNOT POINT STP

OUTFALL AREA	EXTRACTION CAPITAL COST	TREATMENT CAPITAL COST	TRANSMISSION CAPITAL COST	TOTAL CAPITAL COST	ANNUAL O&M (Yrs 1-10)	ANNUAL O&M (Yrs 11-30)	PRESENT WORTH (1993 $)
Total Base	$7,570,000	$12,700,000	$14,800,000	$35,070,000	$3,820,000	$5,730,000	$77,400,000

7.0 CONCLUSIONS AND RECOMMENDATIONS

This report presents an evaluation of the options and estimated costs for providing and maintaining groundwater treatment systems for the IR and UST sites located within MCB, Camp Lejeune, North Carolina.

The primary objectives of this study were to identify which of the IR sites and UST sites will likely require some form of a groundwater pump and treat system for remediation, estimate the groundwater flow rates from these sites, and the COCs; evaluate groundwater treatment technologies that are applicable to the sites; and develop cost estimates, and life-cycle cost analyses for four different alternatives.

7.1 Conclusions

Based the life-cycle cost analysis presented in Section 6.0, the ranking of alternatives from the lowest life-cycle cost to the highest is:

Alternative 2	\$68,000,000
Alternative 4	\$77,000,000
Alternative 3	\$126,000,000
Alternative 1	\$142,000,000

Alternative 2 involves the construction of regional treatment plants solely for treating groundwater from the IR and UST sites in each area. This alternative would require the construction of seven treatment plants, one in each of the seven sanitary service areas.

Costs for this Alternative 2 were based on the following assumptions:

- Five groundwater treatment plant would be located at the site of the existing STP, and would use the infrastructure in place at each site.

- Capital costs for each of the five groundwater treatment plants were based on installing new treatment processes to remove VOCs, SVOCs, inorganics (metals), oil and grease, and pesticides from the contaminated groundwater.

The total capital cost for Alternative 2, estimated at approximately $35,000,000. Alternative 4 also has an estimated total capital cost of $35,000,000, and has the second lowest life-cycle cost, at approximately $77,000,000.

Estimated annual operation and maintenance costs for Alternative 2 are approximately $2,900,000 per year for the first 10 years, and approximately $4,400,000 per year for years 11 through 30.

7.2 Recommendations

The results of this study are intended to provide LANTDIV and MCB, Camp Lejeune with information to be used in planning and developing future strategies for groundwater remediation. Based on the the information generated during this study, the following recommendations are made:

Consideration should be given to developing regional groundwater treatment plants in five of the seven STP services areas.

The groundwater treatment plants could be located at the sites of the existing of the existing STPs. Portions of these plants are scheduled to be taken out of service when the planned Base-wide sewage pumping system is constructed. Some of the existing STP facilities could be used for the central groundwater treatment plants.

LANTDIV and the Base should consider the performance of one or more pilot studies at selected UST and IR sites to evaluate on-site, or in-situ treatment systems. The use of these systems, which would treat groundwater in-place, or reinject treated groundwater at the site, would decrease the impact from the discharge of groundwater to the Base STPs.

8.0 REFERENCES

Note: These references are in addition to those already cited in Section 2.0 of this report:

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Appendix A
IR and UST Site Background Information

APPENDIX A - IR SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/USR SITE EFFLUENT STUDY

Site 1, French Creek Liquids Disposal Area

History: This site was active between the mid 1940's through the mid 1970's. Liquid wastes from vehicle maintenance were poured on the ground. It is estimated that 5,000-20,000 gallons of waste petroleum and 1,000-10,000 gallons of battery acid were disposed of at this site.

Description: The area of concern is approximately 7-8 acres and is located in the HPIA WWTP outfall. (If shaded areas are scaled the site consists of two areas of concern, one 7 acres and the other about 4 acres.)

Characterization: Six shallow monitoring wells were installed at this site and sampled in July 1984 and in November 1986. Supply well #636 was also sampled in July 1984. A total of 13 samples were collected and analyzed.

Chemicals of concern include cadmium, chromium, hexavalent chromium, lead, antimony, oil & grease, VOC's, total phenols, xylene, methylethyl ketone, methyl isobutyl ketone, and ethylene dibromide.

Groundwater flow is in a westerly direction. Low levels of VOC's were detected during both sampling events. Cadmium (3/13), lead (2/13) and chromium (4/13) were detected above the applicable standards. These contaminants showed the tendency to decrease over time.

Recommendations and Conclusions: From the evaluation of the SSR data, Baker has concluded the shallow groundwater aquifer is potentially contaminated. However, contaminants do not appear to have migrated vertically.

Groundwater (shallow aquifer) should be remediated.

APPENDIX A - IR SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/USR SITE EFFLUENT STUDY

Site 2, Former Nursery Daycare Center

History: Between 1945-1958 this building was used to store, handle, and mix pesticides. Pesticide equipment was also washed at this location.

Description: The area of concern is estimated to be approximately 220,000 square feet and is located in the HPIA WWTP outfall. Two potential source areas exist at this site, Building 712 and the Former Storage Area.

Characterization: During 1984, 5 shallow wells were installed and sampled in July. In addition, four supply wells were sampled. The shallow wells were resampled in December 1986 and March 1987. .

In 1992, 3 shallow wells were sampled by Baker personnel as part of a scoping effort.

Chemicals of concern are DDD, DDE, DDP ethlybenzene,naphthalene, xylene, and toluene.

During the ESE investigation pesticides were detected in the shallow groundwater. Supply wells (1,000 ft from the site) were unaffected. Ethlybenzene, and toluene exceeded North Carolina Standards for Groundwater (NCSGW) in a single well located approximately 500 feet from the site.

During the Baker investigation ethyl benzene, toluene, and naphthalene were detected. Arsenic, cadmium and lead were detected at unacceptable levels.

An RI field investigation was completed by Baker in 1993. The preliminary Feasibility Study indicated that the shalow aquifer haad been impacted by VOC contamination. However, the proposed Remedial Action Plan (PRAP) developed by Baker supported the no action alternative. Groundwater contamination was not extensive and levels of contamination were not substantially above MCls.

Recommendations and Conclusions: For the purposes of this study (based on the PRAP) Baker will assume that groundwater remediation will not be required.

Groundwater (shallow aquifer) should be not remediated.

Site 3, Old Creosote Plant

History: The plant was operable from 1951 to 1952. Logs were cut and pressured treated with hot creosote. No records of creosote disposal at this site exist. Facility was dismantled and sold . All that remains are the concrete pads and boiler chimney.

Description: The site is approximately 5 acres and is located in the HPIA WWTP outfall.

Characterization: In 1991 a Site Inspection was performed by Halliburton NUS. Semivolitiles were detected in one well out of three. Chemicals of Concern detected in this well included, acenapthene (1,500 micrograms per liter), anthracene (260 micrograms per liter), chrysene (96 micrograms per liter), fluoranthene (640 micrograms per liter), fluorene (890 micrograms per liter), 2-methylnapthalene (1,500 micrograms per liter), napthalene (2 wells 9-4,400 micrograms per liter), phenanthrene (1,600 micrograms per liter), pyrene (460 micrograms per liter), and dibezofuran (1,100 micrograms per liter). The risk assessment indicated that groundwater contamination at this did not currently present a health risk because no receptors were present. However, the report acknowledged these levels of contaminants would present a potential risk if the site was developed as part of a residential area.

Recommendations and Conclusions: Based on analysis of data in the Halliburton NUS SI report it can be concluded the potential need for groundwater remediation exists.

Groundwater (shallow aquifer) should be remediated.

Site 6, Storage Lots 201 and 203

History: This facility has been operational from the mid 1940s through the present. It has been most recently used as a hazardous waste storage facility to store transformers contaminated with PCBs. In the 1940s it was used as a disposal site. A wooded area north of Lot 203 is believed to have been a VOC disposal site.

Description: Lot 203 is approximately 46 acres and lot 201 is approximately 25 acres. The VOC site is approximately 50-55 acres.

Characterization: Between 1986 and 1987, 8 shallow monitoring wells were installed and sampled in two rounds. Benzene, 1,1,2,2-tetrachloroethane, and chloromethane, were detected.

In 1992 Baker began an RI field investigation and installed 19 shallow wells and 6 deep wells and collected approximately 33 ground water samples.

The chemicals of concern were VOCs, SVOCs, pesticides, PCBs and metals. 12 VOCs were detected from the 35 shallow monitoring wells. These VOCs include trichloroethene, chlorobenzene, tetrachloroethene, DCE, 1,1,2-tetrachloroethane, chloroform, vinyl chloride, total xylenes, bromochloroethane, 1,2,-dichloroethane, 1,1,2-trichloroethane, and 1,1,1-trichloroethane. TCE(1/35), tetrachloroethene (4/35), chloroform (1/35), vinyl chloride(1/35) and 1,2,-dichloroethane.

SVOCs were detected in samples collected from shallow wells but believed to be the result of laboratory contamination. The 16 shallow wells exhibited concentrations of metals above acceptable standards. These contaminants are chromium,lead, manganese, and arsenic.

VOC contamination was detected in deep wells These VOCs include trichloroethene, tetrachloroethene, DCE, methylene chloride, and, ethyl benzene. Trichloroethene, tetrachloroethene, DCE, and methylene chloride were detected above acceptable limits.

PCBs were not detected in the deep wells. Metals were detected but all were within acceptable limits.

An RI field investigation was completed in 1993. The Study concluded that plumes of VOCs that substantially exceeded Federal MCL's existed in the deep and shallow aquifer associated with sites 6 and 82.

Recommendations and Conclusions: The Record of Decision that was produced by Baker for these site indicated that groundwater had been impacted as a result of activities in the area of concern. The shallow and deep aquifers contains unacceptable levels of VOCs.OCs.

Groundwater (shallow and deep aquifers) should be remediated.

Site 7, Tarawa Terrace Landfill

History: The start-up date of facility is unknown. However it was closed in 1972. It is believed that no hazardous materials were deposed of at this facility. Construction debris, sewage treatment plant filter media, and household trash are known to have been disposed of at this site.

Description: The site is approximately 5 acres and is located in the Tarawa Terrace WWTP outfall.

Characterization: The Initial Assessment Study indicated the potential quantity of waste at this site is insignificant whether hazardous or not. Halliburton NUS conducted an SI. The results supported the IAS.

Recommendations and Conclusions: The potential for groundwater contamination is very limited. For the purpose of this study Baker has concluded that groundwater at this site is not contaminated.

Groundwater remediation is not recommended.

Site 9, Fire Fighting Training Pit

History: This site was used for fire fighting training exercises from the 1960s through the present. The pit was originally unlined but a liner has been constructed. Oils, and solvents, were burned in the pit. An oil-water separator has been installed as a means of pollution control.

Description: The site is a 2 acre site and is located in the HPIA WWTP outfall. The area of concern (pit area) is approximately 4,000 square feet.

Characterization: Three shallow wells were installed and sampled along with a nearby supply well between 1984 and 1987. Chromium lead and phenols were detected above acceptable limits in the shallow wells, but, not in the supply wells.

The compounds of concern were TCL VOCs and SVOCs, and TAL metals.

In 1992 Baker initiated a field investigation program as part of an RI/FS. As part of this effort, 1 deep and 5 shallow wells were installed and a total of 9 samples were collected. Trace levels of VOCs, 2-chloroethylvinyl ether (1/9), total xylenes (1/9) were detected in two shallow wells. Trace levels of SVOCs, phenol(1/9), dimethyl phthalate (1/9) , bis (2-ethylhexyl) phthalate (3/9) were detected in a deep well. 2-chloroethylvinyl ether (1/9), dimethyl phthalate , bis (2-ethylhexyl) phthalate are possibly laboratory contaminants. These were never stored or used at this site.

Metals(total) were detected in all monitoring wells sampled. Chromium (2/9), lead (2/9), manganese (2/9), and mercury(1/9) were detected above acceptable standards only in the shallow wells.

The RI field investigation was completed in 1993. The Study concluded groundwater at this site had not been impacted by previous activities.

Recommendations and Conclusions: The Record of Decision that was produced by Baker for this site in September 1993 indicated that groundwater had not been impacted as a result of activities in the area of concern and acepted the no action alternative.

Groundwater remediation is not recommended.

Site 12 Explosive Ordinance Disposal

History: During the early 1960's ordnance was disposed of by burning or exploding when it was found to be inert, defective, or unserviceable. Materials disposed of at this site included ordnance, colored smokes and white phosphorous. Typically undestroyed residues were less than 1 pound.

Description: The site is approximately 30 acres and is not located in a WWTP outfall. However, Onslow Beach WWTP is the closest.

Characterization: No site characterization has been performed.

Chemicals of concern could potentially be lead, white phosphorous, other metals, HDX, RDX, TNT and any derivatives of these.

Recommendations and Conclusions: The Baker Site Management Plan (SMP) recommended an SI be conducted in FY 1993. To date no investigation has been performed. The Baker SMP indicated the potential for groundwater contamination exists. Due to the lack of data, Baker has assumed the groundwater at this site is contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 16 Montford Point Burn Dump

History: This site was opened in 1948 and closed in 1972. However, additional unauthorized dumping did occur. The site contains building debris, garbage, tires, and waste oils. Approximate quantities are not known. Only a small amount of oil is suspected.

Description: The site is approximately 4 acres and is located in the Montford Point WWTP outfall.

Characterization: Asbestos insulation has been dumped on the surface but has been removed. No site characterization has been performed.

Chemicals of concern could include BTEX, O&G, metals and asbestos.

Recommendations and Conclusions: The Baker Site Management Plan recommends an RI/FS be conducted in FY 1994. Due to the lack of data, Baker has assumed the groundwater at this site is contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 21 Transformer Storage Lot 140

History: From 1958 to 1977 this site was used as a pesticide mixing and cleaning area. Approximately, 350 gallons per week of rinsate was discharged overland.

A pit was used to drain transformer oil over a one year period (1950-1951).

Description: The lot the site is located on is approximately 196,000 square feet. Drawings indicate the area where operation may have occurred is considerably smaller. The pit was approximately 30 feet by 6 feet by 8 feet. This site is in the HPIA WWTP outfall.

Characterization: One monitoring well was installed. It was sampled in 1984 and 1987. However, only 2,4-d was detected in 1987. Soil borings indicated vertical migration could potentially occur. Pesticides were detected in the soil at a depth of 5 feet.

Chemicals used at the site include Diazinon, Chlordane, DDT, Lindane, Silvex, Dalpon, and Dursban. Other chemicals of concern included VOCs, PCBs, tetrachlorodioxin, xylene, Methyl Ethyl ketone, methyl isobutyl ketone, ethylene dibromide PCBs are also believed top be present.

An RI field investigation performed by Baker indicated that contamination was limited.

Recommendations and Conclusions: Trace amounts of a single herbicide was detected in the 1987 round of sampling (none were detected in the first). Although groundwater data is limited, it appears the vertical migration of contaminants at this site is limited. Based on this data and Baker RI results it can be assumed the groundwater at this site is not contaminated.

Groundwater remediation is not recommended.

Site 24, Industrial Area Fly Ash Dump
History: This facility was active from the 1940s through 1980. The site was used for the disposal of solvents, waste stripping compounds, sewage sludge, and water treatment sludge.

Description: The site is approximately 20-25 acres and is located in the HPIA WWTP outfall.

Characterization: 5 monitoring wells were installed in 1984 and 2 in 1986. A total of 14 samples were collected between 1984-1986.

The chemicals of concern were metals and VOCs.

Benzene, chloroform and methyl chloride were detected. Only benzene(1/14) and chloroform (1/14) were detected above acceptable standards in 1984.

Metals were detected at low levels. However, only chromium (4/14) was detected above acceptable standards. Hexavalent chromium was also detected.

The results of a Baker RI field effort also indicated the presence of metals in groundwater above acceptable standards.

Recommendations and Conclusions: Based on the evaluation of the ISA and RI data Baker has concluded the groundwater at this site may potentially require remediation.

Groundwater (shallow aquifer) should be remediated.

Site 28 Hadnot Point Burn Dump

History: This facility operated between 1946 and 1971. A variety of industrial wastes, trash, garbage, oil-based paint was deposited then burned. It is estimated the volume of the fill is approximately 185,000-379,000 cubic yards. Due to the fact that the material was burned no estimate of specific compounds can be made.

Description: The site covers approximately 23 acres and is currently used as a recreational area with a stocked fishing pond. This site is in the HPIA WWTP outfall.

Characterization: Four wells were installed and 8 samples were collected in three rounds between 1984 and 1987.

The chemicals of concern were metals, hexavalent chrome, organochlorine pesticides, PCBs, O&G, VOCs, Tetrachlorodioxin, xylene, Methyl Ethyl Ketone, Methyl Isobutyl ketone.

Pesticides were detected in the down gradient wells in 1984. However these levels had decreased by 1986. Trichloroethene and Vinyl Chloride was found above acceptable standards during both sampling events at a down gradient well. Unacceptable levels of lead were found in single samples at two locations (one downgradient).

Unacceptable levels of chromium were also found at two locations. Three of the four samples collected at this location between 1984 and 1987 exceeded the applicable standard. hexavalent chrome was found in a single sample a single location

Arsenic, mercury and zinc were also detected.

Recommendations and Conclusions: Based on this data Baker concluded the groundwater at this site is contaminated. into Cogdels Creek.

Groundwater (shallow aquifer) should be remediated.

Site 30, Sneads Ferry Fuel Tank Sludge Area

History: In 1970 sludge from fuel storage tanks was disposed of here along with tank washout waters. Approximately, 600 gallons of tank bottoms were deposited at the site. This waste material contained tetraethyl lead and related compounds.

Description: Exact location is not known. This site is not located in any WWTP outfall, but is close to Onslow Beach WWTP.

Characterization: Two monitoring wells were installed and sampled twice between 1984 and 1987.

The chemicals of concern included lead, VOCs, Oil & Grease, xylene, Methyl Ethyl Ketone, and Methyl Isobutyl ketone.

Initial sampling indicate lead was present. One well exceeded the applicable standards. Chloroform was initially below detection limits at the down gradient locations but was detected above the applicable standards later in time. Methylene Chloride was initially detected in the upgradient well.

Recommendations and Conclusions: The Initial Assessment Study (IAS) indicated the site had the potential, for adverse impact. However, due to the limited volume of contamination it is anticipated that groundwater remediation will not be required.

Groundwater (shallow aquifer) should not be remediated.

Site 35, Camp Geiger Fuel Area Fuel Farm

History: This facility was as a fuel storage and pumping area in 1957 and 1958. A leak occurred in an underground fuel line. No precise estimate of amount of fuel that leaked out, was made. However, it was in the magnitude of thousands of gallons. Fuel from this spill leaked into Brinson Creek.

Description: Area of concern is approximately 2,500 square feet. This site is in the Camp Geiger WWTP outfall.

Characterization: In 1984, three water samples were collected from soil borings and analyzed. In 1986-1987, 3 monitoring wells were installed and sampled.

The chemicals of concern were primarily O&G, lead, DCE, TCE, benzene, xylene, and ethylene dibromide.

Lead was detected above the applicable standard in all of the three initial samples. TCE (2/6), DCE (3/6), and benzene (3/6) were detected in the six samples taken from the monitoring wells. These detections were primarily downgradient of the site. Levels of benzene in three groundwater samples exceeded groundwater quality standards.

Recommendations and Conclusions: Based on this data Baker concluded the shallow aquifer is contaminated with low level fuel related VOCs. The contamination may have migrated from the fuel spill or another source. Vertical contamination migration cannot be confirmed with this data (Site Summary Report, ESE,1990).

This site was evaluated as a UST site.

Groundwater (shallow aquifer) should be remediated.

Site 36 Camp Geiger Dump Near Sewage Treatment Plant

History: This site was active between the late 1940s and late 1950s. This site was used for the disposal of garbage, waste oils, solvents, and hydraulic fluids. Most of the material was burned prior to burial. It is estimated that 10,000 -14,000 gallons of waste oils and solvents were disposed of and burned here.

Description: This site is approximately 25,000 square feet and rises about 10-12 feet above grade. The estimated volume of the site is 14,000 cubic yards. This site is located in the Camp Geiger WWTP outfall.

Characterization: Three monitoring wells were installed in 1984 and sampled between 1984 and 1989.

Chemicals of concern were lead, cadmium, chromium, hexavalent chromium, VOCs, oil & grease, xylene, total phenol, methyl ethyl ketone, and methyl isobutyl ketone.

Out of 8 samples that were analyzed for cadmium, lead, and chromium, 7 samples had levels above acceptable limits. Phenols were detected in all samples.

Recommendations and Conclusions: Based on this data Baker concluded that groundwater at this is site contaminated. The Baker SMP recommended that a RI/FS be performed in FY 1994.

Groundwater (shallow aquifer) should be remediated.

Site 41, Camp Geiger Dump Near Trailer Park

History: The site was operated between 1940 and 1970. Background information indicates construction debris, waste oil and solvents, asphalt, batteries, Mirex, and ordnance were of at this site . It is estimated 10,000 to 15,000 gallons of waste oil was deposited and burned, along with thousands of mortar shells. A limited amount of drum waste believed to contain chloroacetophenone (tear gas) and possibly chemical agent test kits.

Description: The size of the facility is 30 acres. It had a volume of 110,000 cubic yards. This site is in the Camp Geiger WWTP outfall.

Characterization: Five shallow monitoring wells were installed between 1984 and 1985. These were sampled in 1984 and 1985. 10 samples were collected.

Chemicals of concern were lead, cadmium, chromium, hexavalent chromium, VOCs, oil & grease, xylene, pesticides, total phenols, ordnance compounds, tetrachlorodioxin, methyl ethyl ketone, and methyl isobutyl ketone.

Benzene, Dichlorodifluoromethane, TCE, and Vinyl Chloride were detected in one of four samples taken in 1984. Vinyl chloride and dichlorodifluoromethane levels were above acceptable standards. At the same location in 1987 methylene chloride was detected above acceptable standards. However previously detected VOCs were not detected. This well is at the southern perimeter of the facility.

Phenols were detected in 7 of 10 samples.

Pesticides were detected in 2 of 5 samples taken in 1987. None were detected in 1984.

Cadmium (2/10), chromium (9/10) and lead (4/10) were detected. Chromium (3/10) and lead (4/10), were detected at levels above acceptable limits. Metals contamination decreased over time. The majority of metal detections were lateral or downgradient of the facility.

Ordnance compounds were detected in one sample.

Site 41, Camp Geiger Dump Near Trailer Park (Continued)

Recommendations and Conclusions: The Baker SMP recommended an RI/FS be conducted in FY 95. Based on an evaluation of this information and data Baker concluded groundwater along the perimeter of the facility is contaminated. Groundwater flow is toward the surface water network and contaminant migration is likely.

Groundwater (shallow aquifer) should be remediated.

Site 43, Agan Street Dump

History: The period of operation is unknown. Trash, construction debris, and wastewater treatment plant sludge were disposed of on the ground surface.

Description: The site is approximately 5 acres and is the Camp Geiger WWTP outfall.

Characterization: As part of a Baker Site Investigation effort three shallow monitoring wells were installed and 4 samples were collected.

The chemicals of concern were Target Compound List, VOCs, SVOCs, PCBs and pesticides, and Target Analyte List, metals (unfiltered) and cyanide.

Only carbon disulfide was detected in one of four groundwater samples collected. No other VOCs, SVOCs, or pesticides were detected in the groundwater.

Numerous metals were detected. Beryllium (1/4), cadmium (1/4), chromium (4/4), iron (4/4), and manganese (4/4), were detected at levels above acceptable standards. These elevated levels may be due to the unfiltered solids content of the groundwater.

Recommendations and Conclusions: It should be noted that due to the elevated level of beryllium the groundwater does pose a potential risk to health.

Although contamination appears limited, for the purposes of this study, Baker has assumed that groundwater at this site is contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 44, Jones Street Dump

History: This facility was operational in the 1950s and received general debris. Small quantities of hazardous material may have been deposited.

Description: The site is approximately 5 acres and is in the Camp Geiger WWTP outfall. The exact type and quantity of waste is not known.

Characterization: As part of a Baker Site Investigation effort three shallow monitoring wells were installed and four samples were collected.

The chemicals of concern included TCL (organics) and TAL inorganics and cyanide.

VOCs ,carbon disulfide, toluene, and ethylbenzene were detected in 2 of four samples at low levels.

Low levels of PAH (<.1ppm) were detected in one well.

Metal were detected in all wells. Arsenic (1/4), barium (3/4) , beryllium (1/4), cadmium (2/4), chromium (4/4), copper (1/4),iron (4/4) lead (3/4),manganese (3/4),mercury (1/4), nickel (3/4), and thallium (1/4) were detected above acceptable limits.

Recommendations and Conclusions: The shallow aquifer in the survey area has a low level of contamination. The particular PHAs detected in the groundwater range from immobile to low mobility in ground water. The semi volatiles in the ground water range from low to moderately immobile. It should be noted that volatiles that were very mobile were detected in some of the soil sample. As a result the potential for contaminant migration through groundwater exists. The presence of inorganics in the groundwater poses a risk to health and the environment. For the purposes of this study Baker concluded groundwater at this site is contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 48, MCAS Mercury Dump

History: between 1955 and 1966 mercury was drained from the delay lines of radar units. Small amounts of mercury were hand carried and dumped or buried at random locations. approximately 1 pound per year was disposed of at this location.

Description: The site is approximately 4 acres. However, there are two suspected disposal areas that total approximately 8,000 square feet. This area is in the outfall of the Camp Geiger WWTP.

Characterization: As part of a remedial investigation Baker installed and sampled 3 shallow monitoring wells.

The primary chemical of concern was mercury. Although samples were tested for a range of VOCs, SVOCs, pesticides, and metals. Very limited trace amounts of organics were found and elevated levels of aluminum, iron and manganese. However, no mercury was found

Recommendations and Conclusions: Based on this data no source areas of contamination have been identified. The Draft Remedial Action Plan and Record of Decision supported the no action alternative.

Groundwater remediation is not recommended.

Site 54, Crash Crew Training Burn Pit Unit at Air Station

History: This site was used as a fire training area from the mid 1950s until the present as a fire training site. Approximately 15,000 gallons of POL are year are burned per year. Leaded fuels and solvents may also have been used. It is estimated that approximately .5 million gallons have been used at this site. The burn pit was lined in 1975.

Description: The total site is approximately 1.5 acres in size. The burn pit appears from photos and scale drawings to be approximately 100-150 feet in diameter. This area is in the outfall of the Camp Geiger WWTP.

Characterization: Three shallow (20'-30 ft wells) were installed and groundwater sampled between 1984 and 1987. During this period 7 ground water samples were analyzed.

The chemicals of concern at that time were cadmium, chromium, hexavalent chrome, lead, oil and grease, total phenols and ethylene dibromide. Soil borings 200-800 feet SE of the pit indicate that POL underlies the site.

Groundwater flows in a southeasterly direction. Between 300-400 feet downgradient of the burn pit total O&G, phenols, and lead were detected. Lead levels were below the applicable standards.
Water Supply Well # 5009 is nearby. However, the SSR indicated no contamination was detected in this well.

Recommendations and Conclusions: The SSR indicated that the possibility for the deep aquifer exists. Although no contamination had been found, the Baker Site Management Plan indicates the potential for groundwater contamination is present. Based on this information and data Baker concluded the groundwater at this site is contaminated.

Groundwater remediation (shallow aquifer) is recommended.

Site 63, Verona Loop Dump

History: The dates of operation for this facility are unknown. It is believed that only "bivouac wastes" were disposed of here. No known disposal of hazardous waste occurred

Description: The site is approximately 3 to 4 acres and is not located in any WWTP outfall. It is close to Camp Geiger WWTP.

Characterization: During a Site Investigation performed by Baker conducted in 1991, 3 shallow monitoring wells were installed and sampled.

The chemicals of concern were Target Compound List, VOCs, SVOCs, PCBs and pesticides, and Target Analyte List, metals (unfiltered) and cyanide.

Organic contamination was limited to low levels of benzoic acid and (2-ethylhexyl) phthalate and carbon disulfide in two wells. Aluminum (3/3), barium (2/3), Chromium (2/3), lead (1/3), manganese(3/3) and iron (3/3) levels exceeded the applicable standards.

Recommendations and Conclusions: Groundwater data is limited. For the purposes of this study Baker concluded groundwater at this site is contaminated.

Groundwater remediation (shallow aquifer) is recommended.

Site 65 Engineer Area Dump

History: This facility operated between 1958 and 1972. Wastes disposed of included construction debris, lubricants, and batteries. Much of this waste was burned

Description: The size of the facility is approximately 4-5 acres and located in the Courthouse Bay WWTP outfall. The exact quantity of wastes disposed of here is uncertain.

Characterization: As part of a Baker Site Investigation effort, three shallow monitoring wells were installed and sampled. Samples were tested for Target Compound List (TCL) organics and Target Analyte Metals (TAL)

4,4-DDD was detected in 1 of 3 samples. Arsenic(1/3), beryllium (1/4), chromium (3/3) , copper, lead (2/3), and manganese (2/3) were detected above acceptable limits.

Recommendations and Conclusions: Pesticides were detected in trace amounts and metals were detected above acceptable levels. Although contamination is limited, the presence of metals at these levels may be a health hazard. Based on this data, Baker concluded that groundwater at this site is a contaminated

Groundwater (shallow aquifer) should be remediated.

Site 68, Rifle Range Dump

History: This facility was a dump that was active between 1942 and 1972. Types of wastes include garbage, Waste Treatment plant Sludge, building debris, and a small amount of cleaning solvents used for small arms. The capacity of the facility is approximately, 100,000 cubic yards. Approximately 1,000-2,000 gallons of cleaning solvents were disposed of.

Description: The actual dump site appears to have covered approximately 20 to 30 acres. This facility is in the Rifle Range WWTP outfall.

Characterization of the Site: Nearby supply wells (1,500 feet from the dump) were sampled in 1981. Three shallow monitoring wells were installed around the facility in 1984 and sampled between 1984 and 1986.

In general, the chemicals of concern have been Volatile Organic Compounds. In 1981 Methylene Chloride, chloroform, trichloroethylene were detected in Supply wells RR-45 and RR-97. It should be noted that these wells are located upgradient from the facility. During the 1984-1986 sampling efforts no VOC were detected in the monitoring wells or the supply wells.

Recommendations and Conclusions: The SSR indicates contamination migration to the deep or shallow has not occurred. The data from the 1980's sampling efforts, appears incongruent with historical records. Baker Site Management Plan indicates the potential for groundwater contamination is present. Based on evaluation of this information Baker recommended that groundwater is contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 69, Rifle Range Chemical Dump

History: This facility was operable from the early 1950s until 1976. It was used as used as a chemical dump for all types of chemical wastes that were generated on the base. The list of materials disposed of at the site includes pentachlorophenol, DDT, TCE, malathion, diazinon, lindane, gas cylinders, HTH, drums containing chloroacetophenone, and chemical agent test kits.

Characterization: 8 groundwater wells were installed and sampled between 1984 and 1986. 16 samples were collected.

The chemicals of concern were pentachlorophenol, pesticides, PCBs, mercury, residual chlorine, xylene, tetrachlorodioxin, methyl ethyl ketone, methyl isobutyl ketone and ethylene dibromide.

VOCs were detected in 7 of 18 samples. These VOCs include benzene,chlorobenzene, trichloroethene, chlorobenzene, chloroform, 1,2,-dichloroethane, 1,1-dichloroethylene, TCE, methylene chloride tetrachloroethene, 1,1,2-tetrachloroethane, tetrachloroethene, 1,1,2-trichloroethane, trichloroethene, toluene, and vinyl chloride. Benzene (2/18), chloroform (2/18), 1,2,-dichloroethane (2/18), TCE (6/18), methylene chloride (1/18) and vinyl chloride(4/18).

Mercury was detected in 8 wells and pesticides were detected in 1 well.

Recommendations and Conclusions: The shallow groundwater in the area of concern is clearly contaminated with VOCs and presents a clear and present danger to the environment and human health. (Site Summary Report, ESE, 1990).

Groundwater (shallow aquifer) should be remediated.

Site 73 Courthouse Bay Liquids Disposal Area

History: This site was to dispose of used battery acid and waste oil. Batteries were carried to a specific area and disposed of in hand shoveled holes. Vehicles were driven into the general area and oil was allowed to drain onto the ground. These practices occurred for approximately 27-32 years.

It is estimated that 10,000-20,000 gallons of used battery acid, and 400,000 gallons of waste oil were deposited.

Description: The total size of the site is 13 acres. The acid disposal site is approximately 200 feet from Courthouse Bay and is 1 acre in size (POL was also deposited here). POL was deposited exclusive over 12 acres. This facility is in the Courthouse Bay WWTP outfall.

Characterization of the Site: Five shallow wells were installed (3 approximately 20 feet)and 10 samples were taken (in 2 rounds 1984-1987). 1984 levels are higher than 1987 levels and indicate the contamination is migrating. In 1984 a supply well upgradient of the source was sampled and found to be contaminated with chloroform,

The chemicals of concern are cadmium, chromium, lead, antimony, zinc, oil&grease, total phenols, xylene, methyl ethyl ketone, methyl isobutyl ketone, ethylene dibromide, hexavalent chrome,

Recommendations and Conclusions: Shallow groundwater is contaminated and contaminants are migrating (Site Summary Report, ESE, 1990)

Groundwater (shallow aquifer) should be remediated.

Site 74, Mess Hall Grease Pit

History: Available information suggests that the site was active from the early 1950s through the 1960. The site consists of a grease pit where waste food and grease were disposed of, and a disposal trench where drums and pesticide soaked bags were disposed of. A former pesticide control area is also located at this site. An actively pumping supply well is at this site.

Description: The area of concern is approximately 700,000 square feet and is in the Hadnot HPIA WWTP outfall.

Characterization: 3 shallow wells were installed and sampled between 1984 and 1987. 7 samples were collected including one from an active supply well. The chemicals of concern were pesticides, herbicides, PCBs, VOCs. Only trace levels of pesticides and herbicides were detected.

As part of a scoping effort, a limited number of samples were collected by Baker personnel. The results confirmed earlier analytical results.

Recommendations and Conclusions: The groundwater does not appear to be substantially impacted by site activity (Site Summary Report, ESE, 1990).

Groundwater remediation is not recommended.

Site 75 MCAS Basketball Court

History: During the 1950's approximately 100, 55 gallon drums were buried at this site. These drums contained chloroacetophenone (tear gas), chloropicrin, chloroform, carbon tetrachloride,and benzene.

Description: From drawings it is estimated that the site is approximately 2000 square feet. It is located approximately 300 feet from on-base housing and 800 feet from a supply well. This facility is in the WWTP outfall.

Characterization of the Site: Three shallow monitoring wells were installed in 1984. These along with 3 supply wells were sampled in 1984 and 1987. The initial round was analyzed for VOC's and the second round for VOC's chloropicrin, and tetrachlorodioxin. None of the analytes were detected during either sampling event.

A geophysical survey was performed and failed to detect the presence of metal objects.

The chemicals of concern were chloroacetophenone (tear gas), chloropicrin, chloroform, carbon tetrachloride, and benzene.

Recommendations and Conclusions: No evidence of contamination was found (Site Summary Report, ESE, 1990).

Groundwater remediation is not recommended.

Site 76, MCAS Curtis Road Site

History: It is believed that a total of 25 to 75 drums of chloracetophenone were disposed of at this location on two occasions in 1949.

Description: The exact location of the site is unknown. It is estimated to be 1/4 of an acre.

Characterization: Two shallow wells were installed and sampled in 1984 and resampled in 1987 and a geophysical survey were performed.

The chemicals of concern included chloroform, carbon tetrachloride, benzene, chloropicrin, tetrachlorodioxin, chloroacetophone, and VOCs.

No contaminants or metal objects were detected.

Recommendations and Conclusions: The suspected disposal is not contributing contaminants to area surveyed (Site Summary Report, ESE, 1990).

Groundwater remediation is not recommended.

Site 80, Paradise Point Golf Course

History: No information exists that would indicate how long any potential disposal occurred. Pesticides and herbicides were mixed here and limited vehicle maintenance was performed here. Potentially, waste oil, excess herbicides and pesticides, and washwater used to clean sprayers have been disposed of at this site.

Description: This site consists of a 1 acre area at the back of the machine shop and the truck wash area at the Paradise Point Golf Course. This facility is in the HPIA WWTP outfall.

Characterization: In 1991 NUS performed a Site Investigation. Three wells were installed and sampled. Tolulene, ethylbenzene, xylenes, and carbon disulfide were detected in a sample from one well. these levels were below regulatory limits. Additional data should be gathered to fully characterize the site.

However, areas of dead vegetation were note during a Baker visual inspection.

Chemicals of concern could potentially include BTEX, herbicides, and pesticides.

Recommendations and Conclusions: The Baker Site Management Plan (SMP) recommended an SI be conducted at this site. To date no investigation has been performed. The Baker SMP also indicated the potential for groundwater contamination exists. Based on this and due to limited data, the groundwater at this site is assumed to be contaminated.

Groundwater (shallow aquifer) should be remediated.

Site 82, Piney Green Road VOC Area

History:
An RI field investigation was by Baker for Site 6, 9, and 82 in 1993. The Study concluded that plumes of VOCs that substantially exceeded Federal MCL's existed in the deep and shallow aquifer associated with sites 6 and 82.

Recommendations and Conclusions: The Record of Decision that was produced by Baker for these sites in September 1993 indicated that groundwater had been impacted as a result of activities in the area of concern. The shallow and deep aquifers contain unacceptable levels of VOCs.

Groundwater (shallow and deep aquifers) should be remediated.

Site # 85, Camp Johnson Battery Dump

History: A limited amount of decomposed batteries and old charcoal gas canisters from the Korean War era were unearthed during construction activities.

Description: The canisters and batteries were observed in random piles over 2-3 acres. This site is in the Montford Point WWTP outfall.

Characterization: Site characterization has not been performed at this location.

Recommendations and Conclusions: Although a site characterization has not been performed Baker anticipates that due to the limited amount of contamination at the site, groundwater quality will not be impacted.

Groundwater remediation is not recommended.

Site A, MCAS Officers' Housing Area

History: During 1986 hospital waste was identified in an eroding bank of the New River.

Description: No information was available regarding the volume or mode of disposal. This location is in the Camp Geiger WWTP outfall.

Characterization: Two shallow monitoring wells were installed and sampled in 1986 and 1987.

The chemicals of concern included VOCs, free chlorine, and O & G.

None of the target analytes were detected.

Recommendations and Conclusions: No significant contamination was noted in the area and the waste materials identified were not hazardous (Site Summary Report, ESE, 1990).

The Baker SMP indicated the potential for groundwater contamination exists. However. ESE recommended no further action be taken. Based on this information Baker concluded that groundwater at this site was not contaminated.

Groundwater remediation is not recommended.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Camp Geiger Fuel Farm

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by Law Engineering (Raleigh, NC)

Site Assessment (August 5, 1991 to August 31, 1991)

* Installation of 21 hydropunches
* Groundwater sampling for analysis
* Installation of 18 soil borings, subsequently used for installation of 18 monitoring wells
* Monitoring wells "paired" in 17 of 18 boreholes, each with a "shallow" screened interval and a "deep" screened interval (MW-20 only has "shallow screened interval")
* Groundwater Monitoring Wells (installed in this investigation, MW-8, MW-9, MW-10,.... MW-25)
* Hydropunch Installations (HP-1, HP-2, ...HP-21)
* Performed soil-gas survey and tracer testing of underground fuel lines

PREVIOUS INVESTIGATIONS

* When initially constructed, tanks at fuel farm used to store No. 6 fuel oil, tanks later converted for storage of other petroleum products
* Ice House, Gasoline filling station, and Mess Hall were former sites that have been demolished, Mess Hall had a UST, which was fed by an underground fuel distribution line, extending from the fuel farm to the UST (UST stored No. 6 fuel oil when boiler was in operation)
* Leaking underground line reportedly discovered at Camp Geiger Fuel Farm (1957-1958)
    ** Camp Lejeune Fire Department estimated thousands of gallons of fuel released, spill migrated to east and northeast into Brinson Creek
    ** Trenches dug and fuel ignited and burned
* ESE performed confirmation study at fuel farm between 1984 and 1987
    ** Three hand-auger borings advanced and groundwater and soil samples collected and analyzed
    ** 1986, ESE collected sediment and surface water samples from Brinson Creek, installed 3 MWs upgradient and downgradient of fuel farm (Groundwater found to be contaminated with VOCs)
* NUS performed investigation in area north of fuel farm in 1990
    ** Fuel observed in stormwater drainage ditch, earthen dam constructed in drainage ditch to contain fuel, storm drainage rerouted to south
    ** Four MWs installed, three in vicinity of ponded stormwater and one in upgradient position;

Analytics on samples indicated groundwater in one well contaminated with petroleum-fuel constituents (No free product observed in wells)

** Representative of IR Division of EMD indicated that a 5-foot thickness of free product on surface of ponded water

* Civilian-in-charge of fuel dispensing at fuel farm reported that an incident, involving release of fuel from gasoline line (line carried gas from pump house to dispensing island). Line sealed off and replaced. Subsurface investigation not undertaken at time of possible release.

* Current site operation involves five ASTs used to dispense gasoline, diesel and kerosene to government vehicles and supply USTs in use at Camp Geiger and the Air Station. Six underground lines used to distribute fuel within fuel farm.
* Three USTs identified in and around fuel farm include Building No. 480, Former Mess Hall, and Building No. 474. Only UST at Bldg. 480 remains in active use.

<u>GENERAL HYDROGEOLOGIC CONDITIONS</u>

* Depth to groundwater typically less than 10 ft. bls
* Petroleum product (free product) not detected in any MWs
* Groundwater in surficial aquifer generally flows across project site to east, towards Brinson Creek
* Groundwater in surficial aquifer generally moves laterally across project site with no significant vertical gradient
* Hydraulic Conductivity of unconsolidated sands within surficial aquifer to be approx. 28 feet/day
* Based on soil and stratigraphic borings, three distinctive units identified as follows:
    ** First Unit - fine to medium-grained, unconsolidated sand, thickness of unit ranges from 15 to 30 feet
    ** Second Unit - oolitic, fossiliferous limestone ranging in thickness from 6.5 to 20 feet (matrix consists of fine-grained sand, fine-grained phosphate grains and lime mud
    ** Third Unit - unconsolidated, dark gray to black silty, clayey sand (may be a confining unit separating surficial and Castle Hayne aquifers

<u>CONCLUSIONS/RECOMMENDATIONS</u>

* Three areas of soil contamination which correlate to areas of known or suspected USTs or transmission lines:

- ** Near location of UST adjacent to site of former mess hall (vincinity of boring no. B-4)
- ** Vicinity of UST behind Bldg. No. 480 and extending to NE towards ponded stormwater
- ** AST and fuel-dispensing area of Fuel Farm

* Pattern of soil contamination corresponds with direction of groundwater flow (appears petroleum fuel released at source locations, subsequently migrated through soil towards Brinson Creek, partly as free-phase liquid hydrocarbon prior to dispersion, adsorption and dissolution into groundwater)

* Documented groundwater contamination both in upper portion of surficial aquifer and, to a lesser extent, at depths 10 to 15 feet below the water table

* From a public health/welfare standpoint, groundwater remediation not necessary because present exposure to groundwater contaminants in vicinity of Camp Geiger Fuel Farm unlikely because water-supply wells at Camp Geiger supply water from Castle Hayne aquifer and are located west (upgradient) of documented contamination. Additionally, an apparent confining unit separates the contaminated surficial aquifer from the Castle Hayne aquifer

* Based on regulatory requirements (i.e. North Carolina Environmental Management Commission maximum allowable concentrations for contaminant constituents in groundwater), groundwater remediation will be necessary because a number of constituents were detected at levels above the maximum allowable concentrations

* Site Assessment report recommends enhanced bioreclamation technology (Extract groundwater from recovery wells and/or trenches, treat, and discharge through an infiltration gallery to create a closed loop system.

- ** Conventional pump and treat discharge systems may not be effective in completely restoring aquifer and will not directly address residual soil contamination in the capillary fringe area

- ** Site has good physical characteristics to implement technology (relatively coarse-grained soils, secure areas for construction of infiltration systems, moderately thick vadose zone upgradient of contaminant plumes)

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Campbell Street Fuel Farm and Associated Pipeline

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Phase I Site Assessment (December 9, 1991 to January 17, 1992)

* Installation of 15 penetrometers (hydropunches)
* Groundwater sampling for analysis
* Installation of 7 shallow and 3 deep groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs

* Groundwater Monitoring Wells - Shallow (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7)

* Hydropunch Installations (HP-1, HP-2, HP-3,..... HP-15)

* Groundwater Monitoring Wells - Deep (DW-1, DW-2, DW-3)

Phase II Site Assessment (November 16, 1992 to December 7, 1992)

* Groundwater sampling for analysis

* Installation of 18 shallow, 3 deep groundwater monitoring wells, and 1 recovery well

* Hydraulic conductivity tests conducted on select MWs

* Groundwater Monitoring Wells - Shallow (MW-8, MW-9, MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-21, MW-22, MW-23, MW-24, MW-25)

* Groundwater Monitoring Wells - Deep (DW-4, DW-5, DW-6)

* Recovery Well - RW-1

* Aquifer Drawdown/Recovery Test performed in recovery well RW-1

* Free product (approximately .02 feet thick) encountered in MW-13

PREVIOUS INVESTIGATIONS

* CSFF consists of 4 ASTs (installed in 1985 to replace 7 USTs and associated piping systems)

* 4 groundwater monitoring wells from a previous hydrogeologic assessment (in vicinity of CSFF and UST AS-143)

* ASTs store JP-5 aviation fuel

* 6/8 former USTs stored JP-5 fuel

* Free product identified in vicinity of Bldgs. AS-4141 and AS-4146 (area where known release of JP-5 aviation fuel occurred). An interim recovery system began continuous operation in 1986. (See fig. 2-2 of Site Assessment)

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater typically 6 to 7 ft. bls (shallow/deep)

* Petroleum (free) product detected in MW-13 on 12/30/92 (Thickness approx. 0.02 feet)

* Direction of shallow groundwater flow is estimated to be southeast across the site

* Direction of groundwater flow in deeper portion of acquifer is west to east

* Average hydraulic conductivity for site is 8.18E-2 ft/day

* Geologic material underlying the site is undifferentiated layers of sediments consisting of clays and sands

* pH range of groundwater samples:
  shallow MWs (4.88 - 7.62)
  deep MWs (6.45 - 12.11)

* Aquifer characterization tests (drawdown & recovery) performed in recovery well RW-1 (12/5/92)

  ** step-drawdown test performed to evaluate max flow rate of well RW-1

  ** 1 gpm selected for constant-rate test based on data collected from step-drawdown test

  ** Average Transmissivity T (7.1E-2 sq.ft./day (MW-18 and MW-21)

  ** Average Storativity S (2.1E-2, MW-18 and MW-21)

* Estimated aquifer thickness equals 15 feet

* Average hydraulic conductivity equals 6.3 feet/day

CONCLUSIONS/RECOMMENDATIONS

* Plume in vicinity of MW-4, DW-2, and MW-16 and HP-10 estimated to begin at base of soil mound and extend southeast (downgradient)

* It appears that contamination has not migrated from the surficial, water-bearing layer into the deeper aquifer

* Groundwater contamination appears to have several possible sources: tanker loading operations, UST @ AS-143, and soil mound in fuel farm

* Recommended that an interceptor trench be installed along Campbell Street, south of tanker loading area

APPENDIX A - UST SITES (SITE BACKGROUND INFORMTION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Tarawa Terrace Tanks STT61-STT66

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Site Assessment (December 12, 1991 thru January 11, 1992)
* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of Seven Nested Well Pairs [shallow MWs 1,3,5,7,...(approx. 12 to 15 ft bls) and deep MWs 2,4,6,8...(approx. 28 to 30 ft bls)]
* Four soil borings completed
* Groundwater Sampling completed
* Groundwater samples collected from 10 hydropunch locations and from 14 monitoring wells analyzed for VOCs (EPA 8010 and 8020), three samples for PAHs (EPA 8100), and one for full scan TCLP

PREVIOUS INVESTIGATION/SITE HISTORY

* Site located within fenced area between a railroad (approx. 75' to south) and Highway 24 (approx. 75' to north)
* Tank compound contains pump house, six ASTs (capacity approx. 30,000 gallons) and associated piping
* Six ASTs were installed 1942 for liquid petroleum storage, in 1980, tanks converted to waste oil storage
* Currently, Tanks STT61-STT65 are empty, and Tank STT66 remains in service and contains variable amounts of waste oil
* According to Tom Morris (EMD), tank STT66 had a pipe freeze and break which occurred in approximately 1988
* Preliminary site investigation conducted in 1990 by Dewberry & Davis, including hand augering and soil boring sampling in area of tanks
    ** Data from investigation indicated some TPH contamination in soils, as well as BTEX, styrene, and 1,1,1-trichloroethane

GENERAL HYDROGEOLOGIC CONDITIONS

* Site geology encountered sands/silty sands
* In situ permeability tests conducted on all 14 MWs (MW1-MW14)
* Average Hydraulic conductivity calculated to be 24 gpd/sf
* Depth to groundwater 4 to 8 feet below grade
* Groundwater flow in overall southerly direction
* Hydraulic gradient estimated to be 0.001 ft/ft
* Groundwater flow velocity calculated to be 3 ft/yr
* No free product detected in any of the 14 MWs

CONCLUSIONS/RECOMMENDATIONS

* Groundwater sampling results: TCLP and PAH results less than detection limits, and BTEX detected in some samples above method detection limits
  ** Benzene detected in excess of North Carolina WQS and Federal MCL in two wells and three hydropunches
* Based on risk assessment, concluded that there is no potential for exposure to groundwater, and that there is no significant risk related to groundwater exposure pathway
* Based on extemely low hydraulic gradient producing a very slow flow rate, it is not expected that groundwater will readily provide transportation for benzene migration
* Recommended additional site assessment work at STT61-STT66 to identify lateral and vertical extent of contamination to the west and south of site (install additional MWs and hydropunches to delineate extent of benzene plume in groundwater)

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Tarawa Terrace Tanks STT61-STT66

****ADDENDUM SITE ASSESSMENT*******************************

Addendum Field Investigation (December 1992)

* Installation of 6 hydropunches (H-11...H-16)
* Installation of three nested Well Pairs [shallow MWs 15,17,19 (approx. 15 ft bls) and deep MWs 16 18,20 (approx. 30 ft bls)]
* Installation of a test well and completion of an 8 hour pump test (test well installed to depth of 20 ft. bls)
* Soil sampling from construction of addt. MWs
* Groundwater Sampling completed
* Following installation of each well and hydropunch, samples collected and analyzed for volatile organics by 601/602 method

PREVIOUS INVESTIGATION/SITE HISTORY

* Results of initial site investigation conducted by O'Brien and Gere indicated that additional field activities were warranted to better define subsurface contamination identified in the vicinity of MW13 and MW14

GENERAL HYDROGEOLOGIC CONDITIONS

* Site geology encountered sands/silty sands (consistent with initial investigation)
* Grain size analysis of soil sample obtained from unconfined aquifer encountered during installation of test well (9 to 11 ft. bls) revealed sediments ranging from fine-to-medium, sandy-clay to fine-to-medium clayey-sand
* In situ permeability tests conducted on all 14 MWs (MW1-MW14)
* Average Hydraulic conductivity calculated to be 24 gpd/sf
* Pump test conducted at a constant discharge rate of 5.5 gpm for duration of 8 hours
    ** Water levels in test well and two nearby well clusters (MW3&MW4 and MW9 & MW10) measured and recorded, evaluation of data from MW9/MW10 indicated that distance from well cluster to test well may have been too great for data to be utilized (MW10 not demonstrate enough drawdown to be considered effective)

- ** Transmissivity, storativity and hydraulic conductivity values determined for test well, MW3, MW9 and MW4
- ** Based on average 2000 gpd/sf transmissivity, radius of influence calculated to be approx. 2200 ft.

* Depth to groundwater 4 to 8 feet below grade
* Groundwater flow in overall southerly direction
* Hydraulic gradient estimated to be 0.001 ft/ft
* Groundwater flow velocity calculated to be 3 ft/yr
* No free product detected in any of the additional MWs
* Possible re-charge boundary in shallow groundwater system suggested by variances in GW elevations north of railroad tracks (created by railroad tracks and compacted path around tank area)

CONCLUSIONS/RECOMMENDATIONS

* BTEX, trichlorofluoromethane, 1,1-dichloroethane, 1,1,1-trichloroethane, PCE and chloroform detected above MDLs in some groundwater samples
  - ** Benzene (0.001 mg/L to 0.042 mg/L) at six locations
  - ** Toluene, ethylbenzene, xylene detected at three MWs above MDLs, but below NC WQS
  - ** Benzene and tetrachloroethene at concentrations above NC WQS, other organic compounds detected were within regulatory limits
* Results of risk assessment conducted for site indicate that there is no significant risk related to the groundwater exposure pathway
* Concentrations of benzene decrease with distance from site, groundwater quality 350 feet downgradient (MW20) meet North Carolina standards. It is anticipated that natural processes of biodegradation, attenuation and dispersion account for the decreased concentrations. Also, no identifiable source (free product or TPH laden soils) has been detected in the groundwater system. Because risk assessment identified no risk as a result of benzene in groundwater, it appears that the most appropriate course of action would be to initiate a groundwater sampling and monitoring program (O'Brien & Gere, January 1993).
  - ** Recommend semi-annual sampling for minimum of five years, due to low hydraulic gradients and subsequent slow groundwater flow velocity at site.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Campbell Street JP-5 Pipeline

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Site Assessment (December 9, 1991 to February 6, 1992)

* Installation of 20 penetrometers (hydropunches)
* Groundwater sampling for analysis
* Installation of 7 shallow and 4 deep groundwater monitoring wells

* Hydraulic conductivity tests conducted on select MWs

* Groundwater Monitoring Wells - Shallow (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7)

* Hydropunch Installations (HP-1, HP-2, HP-3,..... HP-20)

* Groundwater Monitoring Wells - Deep (DW-1, DW-2, DW-3, DW-4)

* Pipeline used to transfer JP-5 aviation fuel from Campbell Street Fuel Farm to aircraft direct refueling area

PREVIOUS INVESTIGATIONS

* Known release of JP-5 aviation fuel occurred from Campbell Street JP-5 pipeline (associated with operation of now-abandoned pipeline)

* 3 groundwater monitoring wells from a previous hydrogeologic assessment (in vicinity of the Campbell Street JP-5 Pipeline)

* No free product detected in the two wells checked

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater typically 4 to 10 ft. bls (shallow/deep)

* No free product detected in any MWs

* Direction of shallow groundwater flow is estimated to be southeast across the site

* Direction of groundwater flow in deeper portion of aquifer is southwest

* Average hydraulic conductivity for site is 1.6E-2 ft/day

* Geologic material underlying the site is undifferentiated layers of sediments consisting of clays and sands

* pH range of groundwater samples:
  shallow MWs (4.63 - 12.27)
  deep MWs (10.15 - 12.60)

CONCLUSIONS/RECOMMENDATIONS

* Primary areas of concern wrt groundwater contamination are the southern portion of the pipeline (vicinity of aircraft direct refueling station) and northern end of pipeline (vicinity of steam-generating facility)

* Groundwater contamination detected in vicinity of MWs MW-1 and DW-1 appears to be northern limit of petroleum contamination in JP-5 pipeline

* Soil boring for MW-3 did have significant levels of TPH present, thus affecting the groundwater conditions

* Deeper portions of aquifers have relatively low concentrations of organic compounds

* Remediation of soils in vicinity of Bldg. AS-4151 and aircraft rapid refueling station recommended, remediate soils and condition of shallow aquifer improve w/o performing active groundwater remediation (periodic monitoring of MWs recommended after soil removal completed)

* Recommended that abandoned pipeline be flushed to confirm that it is no longer a source of contamination

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: **Tanks AS419-AS421 Marine Corps Air Station**

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Site Assessment (January 21 1992 through January 29, 1992)
* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of Seven Nested Well Pairs [shallow MWs 1,3,5,7,...(approx. 15 ft bls) and deep MWs 2,4,6,8...(approx. 30 ft bls)]
* Four soil borings completed
* Groundwater Sampling completed
* Groundwater samples collected from 10 hydropunch locations and from 14 monitoring wells analyzed for VOCs (EPA 8010 and 8020), three samples for PAHs (EPA 8100), and one for full scan TCLP

PREVIOUS INVESTIGATION/SITE HISTORY

* Site located at Marine Corps Air Station, on southwest corner of Foster Street and Campbell Street
* Three (25,000 gal) tanks installed 1954 for storage of #6 fuel oil, in use til 1979
* During period 1979 to 1988, tanks used for waste oil storage
* Tanks emptied 1988, currently remain empty except for 2 to 3 inches residual in bottom of each tank
* Spill occurred in tank area according to Mr. Tom Morris (MCB, EMD), date, quantity, details unknown
* Preliminary site investigation conducted 1990 by Dewberry & Davis, including soil borings in area of tanks
    ** Soil samples analyzed for TPH (California GC method and EPA IR method 418.1) and for VOCs (8010/8020)
    ** Two samples, near valves on west and east sides of tanks (0.5 - 2 ft. bls), 211 ppm diesel (GC) and 7000 ppm total (IR); and 70 ppm diesel (GC), 7500 total (IR), respectively
    ** VOCs chloroform, methylene chloride, 1,1,1-trichloroethane, 1,1,2-trichlorotrifluoroethane detected in soil samples
    ** Dewberry & Davis conclude that based on locations and concentrations of detected compounds, results are likely related to localized surface spills
* ASTs have been removed (based on site visit 4/21/93)

GENERAL HYDROGEOLOGIC CONDITIONS

* Site geology encountered sands/silty sands
    ** sandy topsoil (grade to 2 ft.)
    ** silty clays, sandy clays, clayey sands (2 to 9 ft. below grade)
    ** course gray sand (9 to 15 ft. below grade)
    ** greenish gray sand deeper than 15 ft., and dark green sand towards 26 ft. below grade
* In situ permeability tests conducted on all 14 MWs (MW1-MW14)
* Average Hydraulic conductivity calculated to be 6.6 gpd/sf
* Depth to groundwater 7 to 10 feet below grade
* Groundwater flow radial pattern skewing east, with deeper wells flow northeast direction
* Hydraulic gradient estimated to be 0.002 ft/ft
* Groundwater flow velocity calculated to be 1.58 ft/yr
* No free product detected in any of the 14 MWs

CONCLUSIONS/RECOMMENDATIONS

* Five wells contained constituent concentrations above North Carolina Water Quality Standards (MW3, MW4, MW6, MW10, and MW12)
    ** Constituents include PCE (0.004 ppm to 0.210 ppm) TCE (0.004 ppm to 0.280 ppm), benzene in one well (0.006 ppm)
    ** Additional constituents detected above MDL but not regulated by NC include 1,2-Dichloroethylene, 1,1-Dichloroethylene, and chloroethane
* Results of risk assessment indicate no potential for exposure, no significant risk related to groundwater exposure pathway
* Site Assessment recommended further investigation and sampling to determine the lateral and vertical extent of chlorinated compounds in groundwater. Remediation of groundwater could be implemented effectively using recovery wells and air stripping.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Hadnot Point Fuel Farm

PREVIOUS INVESTIGATION/SITE HISTORY

* Specific data not available as Site Assessment reports could not be located by the Environmental Management Division (IR/UST) of MCB, Camp Lejeune
* Hadnot Point Industrial Area is an IR site, includes the Hadnot Point Operable Unit (northern and southern groundwater contaminant plumes)
* Hadnot Point Fuel Farm is a former fuel farm, where the USTs have been excavated and removed, and a groundwater pump and treat system is in place and operating
  ** Pump and treat system consists of recovery wells, and treatment by oil/water separator, product recovery, packed tower air stripper, carbon adsorbers, and effluent discharged to sanitary sewer

GENERAL HYDROGEOLOGIC CONDITIONS

* Specific data not available as Site Assessment reports were not able to be located by EMD

CONCLUSIONS/RECOMMENDATIONS

* Groundwater pump and treat system is in operation at the Hadnot Point Fuel Farm.

* Review product recovery data and system operations summary reports provided by EMD to determine how successful the system is operating. Determine if need pump groundwater to a different location (other options of pump to a centralized groundwater treatment plant, pump to sewage treatment plant converted to groundwater treatment plant, or to new planned Hadnot Point STP), or if operation of on-site pump and treat should continue.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Tarawa Terrace Service Station

PREVIOUS INVESTIGATION/SITE HISTORY

* Specific data not available as Site Assessment reports could not be located by the Environmental Management Division (IR/UST) of MCB, Camp Lejeune
* Areas referred to by Tarawa Terrace Service Station include the following (according to Mr. Tom Morris of MCB AC/S EMD):

  ** TT2453 - this is oldest service station, where a pump and treat system is currently in place and in operation. Consists of recovery wells, and treatment by oil/water separator, product recovery, packed tower air stripper, carbon adsorbers, and effluent discharged to sanitary sewer

  ** TT2478 - This is the newest station, a MCX station, where a site check has been prepared, no assessment yet, reportedly observed 2' product in six monitoring wells

  ** No Bldg. ID - This is a building in between TT2453 and TT2478, which has been renovated. No investigation has been conducted to date.

GENERAL HYDROGEOLOGIC CONDITIONS

* Specific data not available as Site Assessment reports were not able to be located by EMD

CONCLUSIONS/RECOMMENDATIONS

* Groundwater pump and treat system is in currently in place, but not yet on-line at location of former service station, TT2453.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: JP-5 Line Site (Marine Corps Air Station)

GENERAL DATA FROM Corrective Action Plan

Field Investigations performed by O'Brien & Gere (Raleigh, NC)

Field Investigations performed in 1989************

* Installation of six monitoring wells in JP-5 line area (OBG-1 thru OBG-6) (constructed to depth of 15 ft. bls)
* Wells surveyed to id horizontal position and elevation (above MSL)
* Presence of free product layer depress water table due to hydrostatic pressure
* Groundwater samples collected from (OBG-1, OBG-3, OBG-4, OBG-6, and W-1 and analyzed for BTEX and total hydrocarbons (EPA method 503.1)

PREVIOUS INVESTIGATION/SITE HISTORY

* Site is a portion of the Marine Corps Air Station called the JP-5 Line Site, is approximately 600 ft. by 600 ft., comprised of several parking lots, an airplane hanger, and in close proximity to Bldgs. AS-4141 and AS-4146 along White Street
* Free product was identified in area and an interim recovery system was installed and started up in 1986
* Previous to OBG's involvement, free product was measured in 5 additional wells by Richard Catlin & Associates, 1987
  ** Specialized Marine installed and maintained a recovery system which removed approx. 4000 gallons of free product up to December 1987. As recovery system was an obstacle to construction of a new hanger, it was dismantled and wells abandoned in Dec. 1987
* Wells monitored by O'Brien & Gere, free product detected in MW W-10 (0.80 ft. free product) on 30 Sept. 1989

GENERAL HYDROGEOLOGIC CONDITIONS

* Subsurface site geology characterized by sand, silt and clay
  ** Clay (first 15 ft. below grade)
  ** fine to medium gray sand (below 15 ft. below grade)
* September 1989, 8 hour pump test attempted on OBG-3, initial pumping rate of 15 gpm attempted but not

sustainable. Retried at 5 gpm, aquifer could not sustain a pumping rate of 5 gpm (although drawdown was at slower rate)

* In-situ permeability tests performed on OBG-1 and OBG-3
* Calculated hydraulic conductivity of 11.0 gpd/sf (OBG-1) and 3.8 gpd/sf (OBG-3), average of 7.4 gpd/sf
* Depth to groundwater approx. 6 to 8 ft. bls
* Groundwater flow east
* Hydraulic gradient estimated to be 0.02 ft/ft
* Groundwater flow velocity calculated to be 18 ft/yr

<u>CONCLUSIONS/RECOMMENDATIONS</u>

* BTEX below detection limits with exception of OBG-3, where Benzene and Ethylbenzene were > MDL Benzene (0.13 mg/L), Ethylbenzene (0.049 mg/L)
* Toluene (OBG-6 at 0.002 mg/L)
* Xylene (OBG-3 at 0.220 mg/L), (OBG-6 at 0.002 mg/L), and (W-1 at 0.490 mg/L)
* Total hydrocarbons (range BDL to 890 mg/L (W-1))
* Because field investigation revealed measurable amounts of free phased and dissolved phase petroleum hydrocarbons in monitoring wells, O'Brien & Gere recommended a recovery system be installed and operated
  ** System to consist of 2 recovery wells and product treatment system (recovery wells extend to 25 ft. below grade, and each well have 2 pneumatic pumps: 1 drawdown and 1 product ejector pump). Product treatment system to consist of oil/water separator, AST product recovery tank, air stripper tower and carbon contactors. Discharge effluent to sanitary sewer.
* Pretreatment requirement of 2 mg/L Total Toxic Organics before discharge to sanitary sewer. Recovered groundwater to be sampled and analyzed for EPA 602 parameters upon start-up and then monthly.
* Recovery system to operate until no free product present in any of the recovery wells for a period of 6 months. Following system shutdown, monitoring wells to be gauged for free product monthly for 6 months, and then discontinued if no product identified

* Recovery system in-place and in operation.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Rapid Refueler (JP-5 pipeline and south end of Aircraft Direct Refueling Area

GENERAL DATA FROM SITE ASSESSMENT
Assessment (June 15 1992 to June 24 1992)

* Installation of 10 penetrometers
* Groundwater sampling for analysis
* Installation of 7 shallow and 2 deep groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs

  Groundwater Monitoring Wells - Shallow
  (MW-8, MW-9, MW-10, MW-11, MW-12, MW-13, MW-14)

  Hydropunch Installations
  (HP-21, HP-22, HP-23, HP-24, HP-25, HP-26, HP-27, HP-28, HP-29, HP-30, HP-31)

  Groundwater Monitoring Wells - Deep (DW-5, DW-6)

PREVIOUS INVESTIGATIONS
12/91 Site assessment performed for entire JP-5 pipeline

* Included installation of 3 soil borings, 6 hydropunches, one deep MW and three shallow MWs, installed along southern end of pipeline in vicinity of AS-527

1992 SITE ASSESSMENT

* Depth to groundwater typically 4 to 8 ft. bls (shallow/deep)

* Petroleum (free) product detected in MW-10 (estimated s.g. = 0.82 (JP-5 jet fuel))

* Direction of shallow groundwater flow is estimated to be N-NE across the site

* Average hydraulic conductivity for shallow water-bearing zone estimated at 6.18E-2 feet/day (2.18E-5 cm/sec)

* Average groundwater flow velocity for shallow water-bearing zone estimated at 2.3E-3 feet/day or 8.3E-1 feet/year

* Geologic material underlying the site is described as "very sandy"

* pH range of groundwater samples:

shallow MWs (5.0 - 6.0)
deep MWs (5.0 - 7.99)

RECOMMENDATIONS

* Levels of VOCs for certain constituents did exceed North Carolina Water Quality Standards, but levels were not considered to be significant.

* Recommend remediation of soils in northern portion of refueling area and along the removed JP-5 pipeline.

* Periodic monitoring of monitoring wells to evaluate groundwater conditions, if soils are remediated, it is anticipated that the condition of the shallow water-bearing zone will improve without groundwater remediation.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Building 45, UST S-941-2

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by Law Engineering, Raleigh, NC)

Site Assessment (December 11, 1992 thru December 16, 1992)

* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of 7 groundwater MWs and 1 ext. test well
* Twelve soil borings completed
* Groundwater Sampling completed
* Hydropunch samples analyzed for purgeable aromatic compounds, including total xylenes and MTBE (method 602),; also HP-1, HP-3, HP-4, HP-6, HP-7 analyzed for total lead; HP-1, HP-4, and HP-6 analyzed for purgeable halocarbons (Method 601)
* Groundwater samples from MWs analyzed for purgeable aromatic compounds, including total xylenes and MTBE (Method 602); MW-4, MW-7, MW-8 and MW-9 analyzed also for total lead; MW-7 and MW-9 also analyzed for purgeable aromatic compounds (Method 601)

PREVIOUS INVESTIGATION/SITE HISTORY

* Site located adjacent to Bldg. 780 near Highway 24
* UST system at site consisted of 2 USTs; Tank S-941-2 (550 gal steel tank) installed 1941, contained gasoline and Tank S-941-1 (6000 gal. steel tank) installed 1941, contained diesel fuel
* UST Tank S-941-2 failed leak detection test June 1990
* ATEC conducted subsurface investigation in August 1991, results indicated that groundwater contamination by petroleum-fuel related hydrocarbons was present in vicinity of subject site (three MWs shallow MW-1,MW-2, and MW-3 were installed)
* USTs removed in October 1992 by Jones and Frank
* Closure samples collected below Tank S-941-2 confirmed soil contamination with TPH range 52.3 ppm to 525 ppm Free product was observed in excavation for UST S-941-1, no soil samples were collected

GENERAL HYDROGEOLOGIC CONDITIONS

* Near surface soil fine sand
* Results of grain size distribution test on representative sample collected at depth of 7 to 7.5 ft. bls indicate sample contained 82.6% sand and 17.4% silty clay
* Moist soil conditions at 4 to 6 ft. bls
  Soil at 9 to 14 ft. bls classified in field as dark grey to dark brown clay (approx. 5 to 10 ft. thick)

Dense sandy soils below clay layer to depth of approx. 51 ft. bls

* Eight hour pump test conducted at PW-1 Jan. 1993 at a constant pumping rate of approximately 1.4 gpm. Flowrate maintained and drawdown in MW-3, MW-7 and MW-10, as well as MW-9 measured and recorded
    * Approx. aquifer thickness of 50 feet
    * Average hydraulic conductivity estimated to be 1.6 ft/day (MW-3), 2.7 ft/day (MW-7), 2.1 ft/day (MW-10), and 1.2 ft/day (MW-9): avg 1.48 ft/day
* In situ permeability tests conducted on MW-4, MW-5, MW-7, MW-8, and MW-10
    * Hydraulic conductivity estimates of .29 ft/day (MW-4), 0.11 ft/day (MW-5), 0.5 ft/day (MW-7), 0.17 ft/day (MW-8), and .33 ft/day (MW-10)
    * Based on effective porosity 15% to 25% for fine sand, and hydraulic conductivity estimates, average linear velocity of surificial aquifer expected to range from 0.04 ft/day to 3.32 ft/day
* Depth to groundwater 3 to 6 feet bls
* Groundwater flow in surficial aquifer generally flows across project site in a north/northwesterly direction
* Groundwater in surficial aquifer appears to be moving vertically downward (as measured by two well clusters MW-7 S/MW-9 D and MW-6 S/MW-8 D)
* Free product thicknesses measured in ATEC wells MW-2 (2.40 feet) and MW-3 (0.56 feet)

<u>CONCLUSIONS/RECOMMENDATIONS</u>

* Based on results of analysis on soil samples, concentrations of contamination typically greatest at depths (3 to 6 ft. bls) near saturated soil zone
* Based on headspace sampling, emissions of VOCs detected in samples collected from 9 of 12 boreholes from which soil samples collected
* Laboratory testing indicated TPH in only one boring (SB-3), TPH 890 mg/kg [700 mg/kg gasoline, 190 mg/kg diesel)
* Suspected source of soil contamination include both former tanks and product transmission lines
* Petroleum contamination originates in vicinity of former UST site and extends to the north/northwest
* Based on groundwater analytical results, apparent that groundwater beneath former UST system contaminated by petroleum fuel related hydrocarbons including benzene, toluene, ethylbenzene, xylenes, and MTBE
* Hydrocarbon contamination in groundwater appears to originate from area of former UST systems, and migrate in the predominant groundwater flow direction, which is north/northwesterly
* Consistent pattern of elevated lead concentrations does not exist at site

* Groundwater samples collected from well clusters MW-7/MW-9 and MW-8/MW-6 (installed to monitor groundwater at multiple depths and delineate vertical extent of gw contamination) did not exhibit petroleum related hydrocarbon concentrations in excess of laboratory detection limits
* Assuming only sorption-desorption of contaminant constituents and avg linear flow velocity of 0.269 ft/day, benzene movement estimated at 0.0598 ft/day, and ethylbenzene at 0.0054 ft/day
* Based on Law Engr. Site activities, they indicate there is a spatial distribution of petroleum-hydrocarbon contamination in soil (adsorbed phase) and presence of free product (liquid phase) and water samples (dissolved phase)
* Present exposure to groundwater contaminants in vicinity of project site considered unlikely, but concentrations of contaminants in gw are present above NC maximum allowable concentrations

* Adsorbed phase (soil contamination) and liquid-phase (free product) hydrocarbons represent on-going source of dissolved phase contamination. Pumping systems can result in further spreading of liquid-phase hydrocarbons if not properly designed. Recommended that free product removal be performed and substantially completed prior to implementation of groundwater remediation efforts. May be feasible to begin groundwater restoration efforts in hydraulically downgradient areas to retard further dissolved-phase plume migration. Also, soil remediation efforts should be completed prior to commencing groundwater remediation efforts.

* Recommend air stripping as most cost effective means of groundwater treatment for the site, because of heavier semi-volatile compounds related to diesel fuel, polishing of effluent with GAC may be required to meet effluent standards

** Recommend following be completed (as of 4/93):

  * Define spatial extent of measureable free product accumulation hydraulically downgradient of former UST system
  * Install and sample additional monitoring wells and/or hydropunches downgradient of former UST system and south of MW-1 to define horizontal and vertical extent of dissolved petroleum-hydrocarbon contamination (analyze for purgeable halocarbon compounds, purgeable aromatics, and semi-volatile compounds)

* Suspected source of soil contamination include both former tanks and product transmission lines
* Comparison of analytical results with ATEC (Aug. 91) assessment, and UST closure sample results (Environmental & Regulatory Consultants), indicates horizontal extent of petroleum contamination limited to area of UST excavation and vicinity of former dispenser island; additionally, soil contamination is present at eastern edge of Bldg. 912, and may be present under bldg.
* Based on groundwater analytical results, apparent that groundwater beneath former UST system contaminated by petroleum fuel related hydrocarbons including benzene, toluene, ethylbenzene, xylenes, MTBE, and lead
* Hydrocarbon contamination in groundwater appears to originate from area of former UST system, and migrate in the predominant groundwater flow direction, which is north/northeasterly
* Although lead concentration in vicinity of HP-1S is elevated (210 ug/L), near former UST system, a consistent pattern of elevated lead concentrations does not exist at site
* Groundwater samples collected from well clusters MW-6D/ MW-3S and MW-7D/MW-9S (installed to monitor groundwater at multiple depths and delineate vertical extent of gw contamination) did not exhibit petroleum related hydrocarbon concentrations in excess of laboratory detection limits
* Based on analytical results, appears that contamination in vicinity of former UST system is confined to surficial aquifer, above clay layer, found at approx. 13 ft. bls
* Assuming only sorption-desorption of contaminant constituents and avg linear flow velocity of 0.238 ft/day, benzene movement estimated at 0.044 ft/day, and ethylbenzene at 0.004 ft/day
* Based on Law Engr. Site activities, they indicate there is a spatial distribution of petroleum-hydrocarbon contamination in soil (adsorbed phase) and water samples (dissolved phase)
* Present exposure to groundwater contaminants in vicinity of project site considered unlikely, but concentrations of contaminants in gw are present above NC maximum allowable concentrations
* Adsorbed phase (soil contamination) hydrocarbons represent on-going source of dissolved phase contamination. Soil remediation efforts should be completed prior to commencing groundwater remediation efforts.
* Law Engineering has documented levels of benzene, ethylbenzene, MTBE, and lead above NC maximum allowable concentrations; also, ATEC groundwater assessment activities indicated toluene and total xylenes concentrations in excess of reg. standards in Aug. 1991

* Develop design plans for implementation of a free product recovery system upon definition of spatial extent of liquid hydrocarbon plume

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: **Berkley Manor X Change Service Station Tank 820-2**

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Check performed by ATEC Associates)

Site Check (August 1991)

* ATEC installed 3 MWs around UST 820-2
* MWs sampled on Aug. 29, 1991, collected at depth of one foot below water table. Samples analyzed for TPH (Method 8015 - California Modified) and BTEX (Method 624)
* Aug. 27, 1991, while drilling MW-1, gas line from 820-2 UST to super unleaded fuel pump broken at depth of 4 ft. bls by drill bit and auger
    * Product bailed from borehole, fire dept. estimated 60 gallons gas contained in supply line, much of product bailed or absorbed by absorbent pads
* Contractor hired by MCE to excavate area, repair break in line, it is believed that contaminated soils were placed back in excavation once line repaired
* ATEC concluded that release did not effect reported soil and groundwater contamination results, because gw samples were obtained 2 days after line break occurred, and gas contamination would not drain immediately through 9 ft. of unsaturated soil into groundwater

PREVIOUS INVESTIGATION/SITE HISTORY

* UST 820-2 located adjacent to Building 820, the Berkley Manor Exchange Service Station
* Site check to comply with US EPA and North Carolina UST regulations
* UST 820-2 is a 10,000 gallon UST, contains gasoline, tank was installed in 1984. Three other 10,000 gal gasoline USTs (820-1, 820-3, 820-4) are also present at site
* June 1990, UST 820-2 failed leak detection test (leak rate 3.86 gal/hr). Leak repaired at pump and UST retested. UST failed again with leak rate of 0.08 gal/hr

GENERAL HYDROGEOLOGIC CONDITIONS

* Water table encountered at approx. 13 feet BLS
* Groundwater flow to southeast
* Free product measured 0.2 feet in MW-2 (free phase gasoline)
* Hydraulic gradient estimated at 0.0239 ft/ft

* Hydraulic conductivity assumed 0.28 ft/day for fine sand aquifer
* Porosity assumed to be 30 percent
* Groundwater velocity calculated to be 8 ft/yr, which is relatively swift, mostly due to relatively steep water table gradient at site

CONCLUSIONS/RECOMMENDATIONS

* Significant TPH concentrations detected in samples (range 26 to 310 ppm)
* North Carolina EHNR has not set limit for TPH in groundwater
* High concentrations BTEX detected in groundwater samples at levels exceeding NC WQS
  Benzene (6800 to 31000 ppb)
  Toluene (11000 to 42000 ppb)
  Ethylbenzene (1100 to 2900 ppb)
  Total Xylenes (5100 to 15000 ppb)
* ATEC recommended that UST 820-2 be taken out of service and repaired, or removed along with associated lines ASAP.
  ** Additional MWs be installed to determine extent of free phase, dissolved phase, vapor phase, and adsorbed phase contamination
  ** Risk and remediation assessments should be conducted at site to assess associated risk and determine remediation alternatives

*** Based on site visit conducted 4/20/93, it appears that a soil gas survey was conducted since site check, as probe locations were observed

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Building 21, River Road (UST 21.1)

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Phase I Site Assessment (May 11, 1992 to May 22, 1992)

* UST stored gasoline for an auxiliary generator located in Building 21
* Installation of 1 penetrometer (hydropunch)
* Groundwater sampling for analysis
* Installation of 7 shallow and 4 deep groundwater monitoring wells, and 1 recovery well
* Hydraulic conductivity tests conducted on select MWs
* Aquifer (drawdown and recovery) tests performed
* Groundwater Monitoring Wells - Shallow (MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9)
* Hydropunch Installation (HP-1)
* Groundwater Monitoring Wells - Deep (DW-1, DW-2, DW-3, DW-4)

Phase II Site Assessment (February 2, 1993 to February 13, 1993)

* Groundwater sampling for analysis
* Installation of 7 shallow groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs
* Groundwater Monitoring Wells - Shallow (MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16)
* Resampling of MW-3, MW-4, and MW-9

PREVIOUS INVESTIGATIONS

* Site check performed on UST 21.1 by ATEC Environmental Consultants:
    ** Two soil borings converted into two MWs (MW-1, MW-2)
    ** Groundwater samples collected and analyzed for TPH (EPA Method 8015) and BTEX (EPA Method 8240)

** BTEX and TPH were detected in GW samples; North Carolina WQS exceeded for benzene at MW-1, MW-2, MW-3, MW-4, and MW-9, also toluene and ethylbenzene limits exceeded in MW-1

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater typically 3 to 9 ft. bls (shallow wells) and 5 to 8 ft. bls (deep wells)

* No detection of petroleum (free) product in any new or existing wells

* Direction of shallow groundwater flow is estimated to be north @ approx. 70 feet/yr

* Direction of groundwater flow in deeper portion of acquifer is estimated to be north @ approx. 2329 feet/yr

* Based on slug tests, average hydraulic conductivity for shallow water-bearing zone = 8.78E-2 ft/day and 3.44 ft/day for the deep water-bearing zone

* Based on aquifer characterization tests, average hydraulic conductivity for shallow water-bearing zone = 3.12 ft/day and 1.04E2 ft/day for the deep water-bearing zone

* Geologic material underlying site is described as silty sands (shallow water-bearing zone) and fine to medium-grained sands (deep water-bearing zone)

* pH range of groundwater samples:
  shallow MWs (5.69 to 6.49)
  deep MWs (6.40 to 11.02)

* Aquifer characterization tests (drawdown & recovery) performed in recovery well RW-1 (May 22, 1992)

  ** step-drawdown test performed to evaluate max flow rate of well RW-1

  ** 3 gpm selected for constant-rate test based on data collected from step-drawdown test

  ** Shallow Water-Bearing Zone (Transmissivity Storativity, and Hydraulic Conductivity Values)

  Transmissivity T = 1.56E2 sq.ft./day
  Storativity S = invalid
  Approx. Aquifer Thickness = 50 feet
  Hydraulic Conductivity = 3.12 ft/day
  Avg. Groundwater flow velocity = 1.91E-1 ft/day

** Deep Water-Bearing Zone (Transmissivity and Storativity Values)

Transmissivity T = 5.19E3 sq.ft./day
Storativity S = 2.42E-2
Approx. Aquifer Thickness = 50 feet
Hydraulic Conductivity = 1.04E2 ft/day
Avg. groundwater flow velocity = 6.38 ft/day

CONCLUSIONS/RECOMMENDATIONS

* Phase I assessment recommended additional field work be performed to further identify lateral limits of GW contamination

* Groundwater will require remediation in the immediate vicinity of the former UST 21.1, at Bldg. 21

* Phase I assessment identified 2 isolated contaminant plumes, one within immediate vicinity of UST 21.1 (MW-1 and MW-2) and the other approx. 65 feet downgradient (NE) from system (MW-9)

* Potential sources for contamination are UST 21.1 and/or the two ASTs

* Contamination in shallow water-bearing zone relatively high (MW-1, MW-2, and MW-9), and relatively low in deep water-bearing zone

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: **Camp Geiger Mini C Store Service Station (Bldg 912)**

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by Law Engineering, Raleigh, NC)

Site Assessment (November 1992)
* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of 7 groundwater MWs and 1 ext. test well
* Twelve soil borings completed
* Groundwater Sampling completed
* Hydropunch samples analyzed for purgeable aromatic compounds (method 602), also HP-1S, HP-2S, HP-3S, HP-1D, and HP-2D analyzed for total lead; also HP-1S, HP-2S, and HP-3S samples analyzed for purgeable halocarbons (method 601)
* Groundwater samples from MWs analyzed for purgeable aromatic compounds (method 602) and purgeable halocarbons (method 601); also samples from MW-9S, MW-10S, and MW-11S analyzed for total lead

PREVIOUS INVESTIGATION/SITE HISTORY

* Site located on A Street, bounded to east by enlisted men's club and barracks
* UST systems at Mini C Store Service Station installed 1964, consisting of 5 USTs; 1 (4000 gal) gasoline UST, 2 (6000 gal) gasoline USTs, 1 (550 gal) diesel UST, and 1 (550 gal) used oil UST
* Tank Removal Report prepared Sept. 1992 for UST TC-912-1, indicated a 6000 gal reg. gas UST failed tank system check performed 6/28/90
* Petroleum USTs deactivated 1990, excavated and removed June 1992, appears that used oil UST, located western side of service station, has not been removed from site
* ATEC conducted subsurface investigation August, 1991, results investigation indicated that soil and groundwater contamination by petroleum-fuel related hydrocarbons is present in vicinity of, and hydraulically downgradient from site
    ** 5 shallow MWs installed (MW-1S thru MW-5S)

GENERAL HYDROGEOLOGIC CONDITIONS
* Near surface soil - fine to medium sand, some areas containing slightly silty sands
* Results of grain size distribution test on representative sample collected at depth of 14.5 to 16.0 ft. bls indicate sample contained 0.1% gravel, 78.5% sand, and 21.4% silt/clay

* Moist soil conditions at 6 to 10 ft. bls
  Soil at 13 ft. bls classified in field as dark grey to greenish gray sandy clay (approx. 7 to 10 ft. thick)
  Sandy soils with shell fragments encountered below clay layer to depth of approx. 35 ft. bls, where limestone encountered
* Eight hour pump test conducted at PW-8 November 19 1992 at a constant pumping rate of approximately 6.4 gpm. Flowrate maintained and drawdown in MW-1S, MW-2S, MW-4S, and MW-5S measured and recorded
  * Approx. aquifer thickness of 40 feet assumed
  * Average hydraulic conductivity estimated to be 24 ft/day (MW-1S), 45 ft/day (MW-2S), 39 ft/day (MW-4S), and 16 ft/day (MW-5S): avg 30 ft/day
* In situ permeability tests attempted on 5 shallow monitoring wells, initial attempts unsuccessful due to highly permeable soils at site [groundwater removal rates approximating 6 gpm not feasible w/o pumping the wells]
  ** In lieu of recovery tests, saturated soil sample collected from MW-6D, analyzed for grain size gradation of saturated soils
  ** Hydraulic conductivity could not be determined due to excessive fines in the sample
* Using est. effective porosity 15% to 25% for fine sand, hydraulic conductivity estimates from pumping test data, and assumed aquifer thickness, average linear velocity calculated to range from .178 ft/day to .297 ft/day
* Depth to groundwater 3 to 6 feet bls
* Groundwater flow in surficial aquifer generally flows across project site in a north/northeasterly direction towards Edwards Creek
* Groundwater in surficial aquifer appears to be moving vertically downward (as measured by two well clusters MW-3S/MW-6D and MW-9S/MW-7D)
  ** vertical gradient determined to be +0.04 (at MW-9S/MW-7D) (+ means gw moving vertically downward)
* No free product measured in any of the on-site MWs

<u>CONCLUSIONS/RECOMMENDATIONS</u>

* Based on results of analysis on soil samples, concentrations of contamination typically greatest at depths (4.5 to 10.0 ft. bls) near saturated soil zone
* Based on headspace sampling, emissions of VOCs detected in samples collected from 9 of 11 boreholes from which soil samples collected
* Soil samples analyzed for TPH (method 5030 (volatile fraction) and (method 3550 (semivolatile fraction)); additional 8 sample analyzed for lead, 6 for ignitability, 3 for TCLP lead, and 6 for pH
* Laboratory testing indicated TPH in only three borings (B-1A), TPH 359 mg/kg; (B-1B), TPH 245 mg/kg

* Based on nature of contaminants, Law suggests that packed tower air stripping or air diffusion may be most cost-effective method for groundwater remediation. May also want to consider enhanced bioreclamation because physical characteristics of site (i.e. coarse-grained soils, large,open areas for construction of infiltration systems, and thick vadose zone to allow adequate percolation of treated water) may be well suited for technology
* Law recommended implementing a monitoring program for MCB Camp Geiger drinking water wells (TC-600 and TC-700) as a precautionary measure (sample and analyze for BTEX, MTBE, and lead)

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Rifle Range at MCX Service Station
UST System RR-72

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Phase I Site Assessment (April 27, 1992 to May 5, 1992)

* UST System RR-72 consist of 3 USTs (RR72-1, RR72-2, & RR72-3), associated fuel distribution supply line, and a fuel dispenser island

* Groundwater sampling for analysis
* Installation of 7 shallow groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs
* Groundwater Monitoring Wells - Existing Shallow (MW-1, MW-2, MW-3, MW-4, & MW-5)
* New Monitoring Wells - Shallow (MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, MW-12)

Phase II Site Assessment (January 10, 1992 to February 10, 1993)

* Groundwater sampling for analysis

* Installation of 5 shallow groundwater monitoring wells and 1 recovery well

* Installation of 5 hydropunches (HP-1, HP-2, HP-3, HP-4, HP-5)

* Hydraulic conductivity tests conducted on select MWs

* Groundwater Monitoring Wells - Shallow (MW-13, MW-14, MW-15, MW-16, MW-17)

* Recovery Well (RW-1)

* Aquifer Drawdown/Recovery Test performed in recovery well RW-1

* No free product encountered in MWs

PREVIOUS INVESTIGATIONS

* May 1991, UST RR72-1 removed & 3 shallow soil samples collected and analyzed for TPH (EPA Method 5030)

* 1/3 soil samples TPH concentration equal 100 ppm

* Free phase product not observed during excavation

* August 1991, ATEC Environmental Consultants performed site check of UST system RR-72. Five soil borings advanced and converted to monitoring wells (MW-1 through MW-5)

    * Soil and groundwater samples collected and analyzed for TPH and BTEX

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater at approx. 4 to 6 ft. bls.

* No detection of petroleum (free) product in any new or existing wells

* Direction of shallow groundwater flow is estimated to be southwest across site @ approx. 225 feet/yr

* Based on slug tests, average hydraulic conductivity for site = 9.7 feet/day (3.43E-3 cm/s)

* Geologic material underlying site is described as silty fine sands (shallow water-bearing zone)

* pH range of groundwater samples: shallow MWs (5.43 to 6.79)

* Aquifer characterization tests (drawdown & recovery) performed in recovery well RW-1 (2/3/93)

    ** Step-drawdown test performed to evaluate the maximum flow rate of well RW-1

    ** .5 gpm selected for constant-rate test based on data collected from step-drawdown test

    ** Average Transmissivity T (656 gallons/day-ft)

    ** Average Storativity S (1.03E-2)

* Estimated aquifer thickness equals 15 feet

* Sandy clay underlies site @ approx. 10 to 15 feet

CONCLUSIONS/RECOMMENDATIONS

* Groundwater impacted with dissolved-phase hydrocarbons to southwest of UST RR-72-1, consistent with gasoline compounds

* Properly close and remove USTs RR-72-2 and RR-72-3, excavate interceptor trench downgradient of plume for

3of3

collection of groundwater, install an infiltration gallery upgradient for recharge, treatment of groundwater by carbon adsorption

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Steam Generating Plant - Bldg. AS-4151

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Site Assessment (First Phase - June 15, 1992 to June 25, 1992 and Second Phase - January 11, 1993 to February 10, 1993)

* Steam-Generating Plant, Bldg. AS-4151, operates 3 ASTs (store No. 6 fuel oil) and 1 UST (stores No. 2 fuel oil)
* Groundwater sampling for analysis
* Installation of 14 shallow groundwater monitoring wells and 2 deep groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs
* Groundwater Monitoring Wells - Shallow (122MW-1 thru 122MW-14)
* Groundwater Monitoring Wells - Deep (122DW-1, 122DW-2)
* Installation of Recovery/pumping well (122RW-1)
* Attempted to perform aquifer drawdown/recovery test in recovery well 122RW-1, but test abandoned because well pumped dry @ .25 gpm
* JP-5 fuel line damaged during initial assessment activities (June 15 to 25), product released but contained

PREVIOUS INVESTIGATIONS

* Site Assessment performed on JP-5 fuel line (passes beneath eastern portion of Bldg. AS-4151 site), report submitted 7/9/92

    * Investigation included installation of several MWs and hydropunches, collection & analysis of groundwater samples

    * Analytical results indicated that contamination is present within soils at AS-4151, and that groundwater contamination is present at the site

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater at approx. 3 to 4 ft. bls (shallow wells) and 4 to 5 ft. bls (deep wells)

* Petroleum product (free product) detected in 122MW-9 @ thickness equal to 0.19 feet

* Direction of shallow groundwater flow is estimated to be east across site @ approx. 3 feet/yr

* Based on slug tests, average hydraulic conductivity for shallow water-bearing zone equals 1.92E-2 ft/day

* Geologic material underlying site is described as silty fine sands (shallow water-bearing zone)

* pH range of groundwater samples:
shallow MWs (3.67 to 7.36)

CONCLUSIONS/RECOMMENDATIONS

* Weathered free product observed in 122MW-9 and on water collected in excavation for fuel line repair

* Two isolated plumes of benzene contamination (northeast and southwest of Bldg. AS-4151)

* Majority of groundwater contamination appears to be upper fourteen feet (shallow water-bearing zone) with exception of contamination detected in 13DW-1

* Potential sources contamination are abandoned fuel line or pesticides used to control various insect populations at site

* Abandoned fuel line and adjacent soils should be excavated and removed

* Active Free Product/Groundwater Interceptor Trench recommended for groundwater remediation at AS-4151, recovery wells should be installed w/pumps for removal of free product and groundwater. Capture recovered free product with oil/water separator and transport off site by a licensed waste hauler. Treat groundwater by an appropriate technology such as air stripping or carbon adsorption.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Amphibious Vehicle Maintenance Area
UST SA-21

GENERAL DATA FROM SITE ASSESSMENTS (relative to groundwater)

Phase I Site Assessment (April 27, 1992 to May 6, 1992)

* UST system consist of 30,000-gallon tank, fuel distribution line, oil/water separator, and fuel dispensing area
* UST SA-21 used to store diesel fuel, contained gasoline until mid-1970s
* UST SA-21 excavated and removed from service May 1991
* Groundwater sampling for analysis
* Installation of 7 shallow groundwater monitoring wells and 2 deep groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs
* Groundwater Monitoring Wells - Existing Shallow (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7, & MW-8)
* New Monitoring Wells - Shallow (MW-9, MW-10, MW-11, MW-12, MW-13, MW-14, & MW-15)
* New Monitoring Wells - Deep (DW-1, DW-2)
* Installation of 10 hydropunches

Phase II Site Assessment (January 15, 1993 to February 10, 1993)

* Groundwater sampling for analysis
* Conversion of soil borings to shallow monitoring wells (MW-16, MW-17, MW-18)
* Conversion of soil borings to deep monitoring wells (DW-3, DW-4)
* Installation of 5 hydropunches (HP-1, HP-2, HP-3, HP-4, HP-5)
* Hydraulic conductivity tests conducted on select MWs
* Recovery Well (RW-1)
* Aquifer Drawdown/Recovery Test performed in recovery well RW-1
* No free product encountered in MWs

PREVIOUS INVESTIGATIONS

* May 1991 - Excavation and removal of UST SA-21
  3 shallow soil samples collected and analyzed for TPH (EPA Methods 3550/5030)

* August 1991, ATEC Environmental Consultants performed a site check for UST system SA-21; 8 soil borings advanced and converted into shallow MWs (MW-1 through MW-8), in the vicinity of UST SA-21

* Groundwater samples collected from MWs and analyzed for TPH and BTEX

  * BTEX and TPH detected in several GW samples, benzene exceeded at MW-3 and MW-7

* Free phase product not observed during excavation

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater at approx. 4 to 8 ft. bls (shallow wells) and 12 to 18 ft. (deep wells)

* No detection of petroleum (free) product in any new or existing wells

* Direction of shallow groundwater flow is estimated to be northeast across site @ approx. 3 feet/yr

* Based on slug tests, average hydraulic conductivity for shallow water-bearing zone equals 4.61E-1 ft/day and 2.8 ft/day for deep water-bearing zone

* Geologic material underlying site is described as silty fine sands (shallow water-bearing zone)

* pH range of groundwater samples:
  shallow MWs (6.13 to 6.76)
  deep MWs (10.86 to 11.01)

* Aquifer characterization tests (drawdown & recovery) performed in recovery well RW-1 (2/5/93)

  ** Step-drawdown test performed to evaluate the maximum flow rate of well RW-1

  ** 3 gpm selected for constant-rate test based on data collected from step-drawdown test

  ** Average Transmissivity T (895 gallons/day-ft)

  ** Average Storativity S (.0092)

* Estimated aquifer thickness equals 15 feet
* Sandy clay underlies site @ approx. 16 to 20 feet
* Based on pump test data, hydraulic conductivity for site estimated to be 8 ft/day, and avg. groundwater flow velocity = 63 ft/yr

CONCLUSIONS/RECOMMENDATIONS

* Groundwater samples collected during additional site assessment and analyzed for polynuclear aromatic

hydrocarbons (EPA Method 610) were not detected in MW-16, MW-17, MW-18, DW-3, DW-4 and RW-1

* Based on analysis of samples from DW-1, DW-2, dissolved-phase hydrocarbons have not infiltrated the deeper portion of the water table

* Soil mound created from excavation of UST SA-21 should be analytically characterized, removed and properly disposed of from the site

* No off-site appear to contribute to the groundwater contamination detected at the site

* After removal of contaminated soils (TPH>100ppm), natural biodegradation should be utilized in conjunction with a groundwater monitoring program

* Existing recovery well RW-1 could be used to remedy localized contamination at MW-15

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: UST H-28 (Bldg. H-28)

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)

Site Assessment (May 12, 1992 to May 20, 1992)

* UST consist of a single 550-gallon tank, used to store fuel oil for heating
* UST H-28 excavated and removed from service May 1990
* Groundwater sampling for analysis
* Installation of 7 shallow groundwater monitoring wells
* Hydraulic conductivity tests conducted on select MWs
* Groundwater Monitoring Wells - Existing Shallow (MW-8, MW-9, & MW-10)
* New Monitoring Wells - Shallow (MW-1, MW-2, MW-3, MW-4, MW-5, & MW-6)

PREVIOUS INVESTIGATIONS

* May 1990 - Excavation and removal of UST H-28
  1 shallow soil sample collected and analyzed for TPH (EPA Methods 3550/5030)

* September 1991, ATEC Environmental Consultants performed a site check for UST system H-28; 3 soil borings advanced and converted into shallow MWs (MW-8, MW-9, & MW-10), in the vicinity of UST H-28

* Groundwater samples collected from MWs and analyzed for TPH and BTEX

  * TPH not detected, BTEX detected at three MWs (benzene exceed MCL and NC WQS @ MW-8 and MW-9)

* Free phase product not observed during excavation

GENERAL HYDROGEOLOGIC CONDITIONS

* Depth to groundwater at approx. 8.5 to 10 ft. bls.

* No detection of petroleum (free) product in any new or existing wells

* Direction of shallow groundwater flow is estimated to be northwest and west across site @ approx. 1.1 feet/yr

* Based on slug tests, average hydraulic conductivity for site is 7.1E-1 ft/day

* Geologic material underlying site is described as silty fine sands

CONCLUSIONS/RECOMMENDATIONS

* Concentrations of purgeable halocarbons not detected in any groundwater samples

* BNAs detected in two MWs (MW-4, MW-6)

* 1,2-dichloroethane only constituent detected using TCLP full scan analysis

* Remediate soils in immediate vicinity of former UST tank pit and in direct vicinity of SB-1, removal of source should result in improvement of shallow aquifer without performing active groundwater remediation

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: **Buildings M232-M236 (USTs)**
Camp Johnson

<u>GENERAL DATA FROM SITE ASSESSMENT</u> (relative to groundwater)
Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Site Assessment (November 4, 1991 thru November 14, 1991)
* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of Seven Nested Well Pairs [shallow MWs 1,3,5,7,...(approx. 15 ft bls) and deep MWs 2,4,6,8...(approx. 30 ft bls)]
* Four soil borings completed (B1-B4)
* Groundwater Sampling completed
* Groundwater samples collected from 10 hydropunch locations and from 14 monitoring wells analyzed for VOCs (EPA 8010 and 8020), three samples for PAHs (EPA 8100), and one for full scan TCLP

<u>PREVIOUS INVESTIGATION/SITE HISTORY</u>

* Site located at Camp Johnson, consists of 5 rectangular buildings used as living quarters
* Between 1942 and 1990, each bldg. had an UST, located at NE corner, used for heating oil
* May 1990, USTs exhumed by UTTS Environmental, reported to be corroded
* Soil samples collected at time of USTs removal indicated elevated levels of TPH, range from 120 ppm to 6900 ppm

<u>GENERAL HYDROGEOLOGIC CONDITIONS</u>

* Site geology encountered sand, silt and clays
    ** Gray/orange silts and clays, with varying amounts of very fine to medium grained sand (upper 9 feet)
    ** Sediments deeper than 9 ft. bls very fine gray sand grading to poorly sorted, subangular, very coarse gray and orange-brown sands towards 19 ft. bls
    ** Medium to very coarse sands (19 to 30 ft. bls)
* In situ permeability tests conducted on all 14 MWs (MW1-MW14)
* Average Hydraulic conductivity calculated to be 11 gpd/sf (shallow wells) and 20 gpd/sf (deep wells); all wells average 15 gpd/sf
* Depth to groundwater 8 to 12 feet below grade
* Groundwater flow localized, is northeast in tank area, and overall, in southeasterly direction
* Hydraulic gradient estimated to be 0.006 ft/ft

* At effective porosity of 40%, groundwater flow velocity calculated to be 7 ft/yr
* No free product detected in any of the 14 MWs

CONCLUSIONS/RECOMMENDATIONS

* With exception of 2 samples, no parameter analyzed was above NC regulatory standard for drinking water. Dichloromethane detected above reg. limit in H3, but was present in reagent blank, indicating contamination by laboratory. MW12 had chloroform at 0.004 mg/l, above reg. limit, but chloroform is not constituent of heating oil, and is unlikely that site provided source for this contaminant.
* Toluene (up to 0.008 mg/L), ethylbenzene (0.002 mg/L), and xylene (0.015 mg/L) also detected, but below NC WQS. Although present below NC WQS, do indicate presence of petroleum hydrocarbons in groundwater near vicinity of removed tanks. Also verified by presence of visible sheen on HP2-HP-5, and MW3 groundwater samples.
* Results of risk assessment indicate no potential for exposure, no significant risk related to groundwater exposure pathway
* Recommended that excavations where tanks removed are opened, and limited quantities of contaminated soil should be removed, backfill excavations with clean soil.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Buildings M232-M236 (USTs)
Camp Johnson

GENERAL DATA FROM ADDENDUM SITE ASSESSMENT (relative to groundwater)
Addendum Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Addendum Field Investigation (December 1992)
* Installation of 8 hydropunches (H-1 ...H-8)
* Installation of 3 additional Monitoring Wells (MW-15 thru MW17) to depth of 15 ft. below grade
* Groundwater Sampling completed
* Groundwater samples collected from 8 hydropunch locations and from 3 monitoring wells analyzed for volatile organics by method 601/602

PREVIOUS INVESTIGATION/SITE HISTORY

* Site located at Camp Johnson, consists of 5 rectangular buildings used as living quarters
* Between 1942 and 1990, each bldg. had an UST, located at NE corner, used for heating oil
* May 1990, USTs exhumed by UTTS Environmental, reported to be corroded
* Soil samples collected at time of USTs removal indicated elevated levels of TPH, range from 120 ppm to 6900 ppm
* Initial site investigation conducted by O'Brien & Gere in November 1991

GENERAL HYDROGEOLOGIC CONDITIONS

* Site geology encountered sand, silt and clays
  ** Gray/orange silts and clays, with varying amounts of very fine to medium grained sand (upper 9 feet)
  ** Sediments deeper than 9 ft. bls very fine gray sand grading to poorly sorted, subangular, very coarse gray and orange-brown sands towards 19 ft. bls
  ** Medium to very coarse sands (19 to 30 ft. bls)
* In situ permeability tests conducted on all 17 MWs (MW1-MW17)
* Average Hydraulic conductivity calculated to be 11 gpd/sf (shallow wells) and 20 gpd/sf (deep wells); all wells average 14 gpd/sf
* Depth to groundwater 5 to 9 feet below grade
* Presence of immiscible layer observed in MW3, tends to depress water table due to hydrostatic pressure

* Groundwater flow localized, is northeast in tank area, and overall, in southeasterly direction
* Hydraulic gradient estimated to be 0.006 ft/ft
* At effective porosity of 40%, groundwater flow velocity calculated to be 7 ft/yr
* Monitoring efforts for free product in 1991 investigation did not detect presence of free product in any of the 14 MWs; however, in December 1992, free product was detected in MW3, with a thickness of 0.12 feet

CONCLUSIONS/RECOMMENDATIONS

* Benzene only detected constituent present above North Carolina Water Quality Standards, in H1 (newly installed) at 0.014 mg/L.
* Location of H1, and lack of detectable constituents at MW13, MW14, MW15, and H7 suggest an alternate source of benzene rather than former tanks for Bldgs. M232-M236.
* Risk assessment indicated there is no risk from groundwater exposure pathway
* Soil remediation not appear to be warranted, as all TPH values were below proposed State NC soil cleanup guidelines
* Free product quantity is limited, and does not appear to be contributing source of VOCs to groundwater, groundwater chemical data evaluation indicates that volatile organic constituents are not present at concentrations above detection limits or regulatory standards, and downgradient wells do not demonstrate presence of volatile organics in groundwater.
* Because of limited quantity of free product, its characteristics, and lack of VOCs in groundwater, groundwater remediation not warranted. But, appropriate measures should be taken to remove free product occurrence, maybe with a passive floating skimmer device, that could be installed at MW3 (allow cost effective capture of limited, localized free product plume)
* Monitor free product occurrence and groundwater quality for 5 year duration to confirm results of second investigation and maintain groundwater quality stability

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: GOTTSCHALK MARINA (BUILDING 728)

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by Versar, Inc. (Springfield, VA)

Site Assessment (November 5 to November 20, 1991)

* Installation of 10 hydropunches
* Groundwater sampling for analyses
* Installation of 14 soil borings, subsequently converted to monitoring wells
* Seven shallow groundwater monitoring well clusters, each of two wells
* Total of 95 soil and groundwater samples collected and analyzed for TPH, Lead (total), purgeable halocarbons, purgeable aromatics, polynuclear aromatic hydrocarbons, pH, and flashpoint
* Groundwater Monitoring Wells (installed GW-1S/1D, GW-2S/2D.....GW-7S/7D)
* Shallow well screened (5 to 15 ft. bls) and deeper well screened (15 to 25 ft. bls)
* Hydropunch Installations (HP-1....HP-10)
* 37 groundwater samples collected for analysis from hydropunches and monitoring wells during investigation
* 5 samples - purgeable halocarbons
  26 samples - purgeable aromatics
  3 samples - polynuclear aromatic hydrocarbons
  15 samples - total lead
* Hydraulic Conductivity (Slug tests) performed

BACKGROUND

* November 1989, 250 gal. UST (contain No. 2 fuel oil removed from area behind SW corner of Bldg. No. 728)
* Sheen of free product observed on surface of GW within excavation, along with visible staining
* Small paint locker (Bldg. No. 729) used for storage of solvents and paints, located SE of Bldg. No. 728
* Site contains 4 ASTs on S and SW side of site (2 contain kerosene (250gal), 3rd contains kerosene (500gal), 4th contains liquid petroleum gas, also a 550 gal UST contains waste oil (SE corner of Bldg. 728))

GENERAL HYDROGEOLOGIC CONDITIONS

* Average depth to groundwater:
  Shallow screened interval = 3.06 ft. bls
  Deeper screened interval = 7.21 ft. bls

* Site underlain by undifferentiated unconsolidated sediments of an assortment of sands, silts, and clays (depth ls to avg. depth 45 ft. bls)
* Uppermost water-bearing unit is surficial aquifer
* Groundwater flow direction of surficial aquifer toward north in direction of Wallace Creek
* No continuous clay layer reported to separate surficial aquifer from Castle Hayne aquifer (because of thin and discontinuous nature of layers, considerable vertical leakage of GW occurs through and around clay layers)
* Average Hydraulic Conductivity is 1.9 ft/day based on aquifer "slug" tests

CONCLUSIONS/RECOMMENDATIONS

* No evidence of groundwater contamination in vicinity of removed UST at Bldg. 728, thus for this area, no groundwater remediation
* Groundwater in vicinity of Bldg. 729 (Paint locker) contaminated with VOCs including benzene, ethylbenzene, and xylene (source anticipated to be paint and related materials stored in locker)
* Soil around paint locker anticipated to be contaminated by benzene, ethylbenzene, and xylene
* Recommend integrated closed-loop treatment system where groundwater pumped out (extraction north) and treated by carbon adsorption system, then treated groundwater injected upgradient (south) of Bldg. 729.

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: **Waste Oil Storage Tanks S889-S891**
Holcomb Boulevard

GENERAL DATA FROM SITE ASSESSMENT (relative to groundwater)
Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Site Assessment (November 20, 1991 thru November 26, 1991)
* Installation of 10 hydropunches (HP-1 ...HP-10)
* Installation of Seven Nested Well Pairs [7 shallow MWs MW-1S thru MW-7S (approx. 20 ft bls) and 7 deep MWs MW-1D thru MW-7D (approx. 34 ft bls)]
* Four soil borings completed
* Groundwater Sampling completed
* Groundwater samples collected from 10 hydropunch locations and from 14 monitoring wells analyzed for VOCs (EPA 8010 and 8020), three samples for PAHs (EPA 8100), one sample for full scan TCLP

PREVIOUS INVESTIGATION/SITE HISTORY

* Site contains 4 ASTs on concrete cradles approx. 10 ft. above grade (S889 thru S891)
* Concrete Secondary Containment recently installed to replace earthen berm
* ASTs used to contain liquid petroleum (butane and propane), but since 1980, have contained waste oil
* 1990, Dewberry & Davis conducted surface soil investigatory program as part of characterization of MCBs waste oil tank sites
  ** Six hand augers advanced to 2 to 4.5 ft. bls and soil samples collected
  ** Surface sample collected at outfall which drained bermed area to west of site
  ** Samples analyzed for TPH, one sample also for VOCs
  ** TPH detected in several of the samples (up to 5200 ppm), and sample analyzed for VOCs had detectable concentrations

GENERAL HYDROGEOLOGIC CONDITIONS

* Site geology encountered sands/silty sands
  ** medium grained sand (grade to 4 ft.)
  ** silty sand/sandy clay (sand to 20 ft.)
  ** organic and sand layer at 15 ft.
  ** medium to coarse grained sand under silty sand and sandy clays
* In situ permeability tests conducted on all 14 MWs
* Average Hydraulic conductivity calculated to be 6.81 gpd/sf

* Depth to groundwater typically measured at 13 to 16 ft. bls
* Groundwater flow to south]
* Hydraulic gradient calculated to be 0.007 ft/ft
* Groundwater flow velocity calculated to be 5.8 ft/yr
* No free product detected in any of the 14 MWs

CONCLUSIONS/RECOMMENDATIONS

* One GW sample (MW-6D) had 3 ug/L toluene (well below 1000 ug/L NC WQS for toluene, all other samples did not have detected concentrations of VOCs

* Results of risk assessment concluded there is no risk related to groundwater exposure

* Remediation assessment concluded that because there is no evidence of subsurface TPH concentrations leaching to groundwater and there is no risk related to presence of TPH in subsurface soils via soil exposure pathway, groundwater remediation is not justified

APPENDIX A - UST SITES (SITE BACKGROUND INFORMATION)

MCB CAMP LEJEUNE - IR/UST SITE EFFLUENT STUDY

UST SITE NAME: Tank S781 - Bldg. No. 45 (Midway Park)

<u>GENERAL DATA FROM SITE ASSESSMENT</u> (relative to groundwater)
Site Assessment performed by O'Brien & Gere (Raleigh, NC)

Site Assessment (December 4 through December 12, 1991)
* Installation of 10 hydropunches (H-1 ...H-10)
* Installation of Seven Nested Well Pairs [shallow MWs (approx. 12 to 20 ft bls) and deep MWs (approx. 27 to 30 ft bls)] (MW-1 through MW-14)
* Four soil borings completed
* Groundwater Sampling completed
* Groundwater samples collected from 10 hydropunch locations and from 14 monitoring wells analyzed for VOCs (EPA 8010 and 8020), three samples for PAHs (EPA 8100), and one for full scan TCLP

<u>PREVIOUS INVESTIGATION</u>/SITE HISTORY

* Bldg. 45 located at Midway Park, services large machinery for MCB
* Tank S781 is an AST with a capacity of 176,000 gal.
* Land formerly housed a power plant owned by Carolina Power & Lighting
* When owned by CP&L, the tank stored fuel oil, when MCB aquired property, tank was used to store waste oils
* Tank was emptied in 1988 (approx. 8 inches of thick sludge remains in bottom of tank
* Dewberry & Davis conducted a preliminary site investigation in Nov. 1990
    ** Five hand augers, five soil borings, and 2 monitoring wells completed
    ** Groundwater samples did not indicate contaminant levels above method detection limits
    ** Soil samples did have TPH > 10 mg/kg action level (greatest concentration 2200 ppm at suspected vicinity of underground piping from pump house toward main bldg.)

<u>GENERAL HYDROGEOLOGIC CONDITIONS</u>

* Site geology encountered sands/silty sands
    ** topsoil and medium to fine grained sand (grade to 4 ft.)
    ** silty sand/sandy clay (sand to 20 ft.)
    ** organic and sand layer at 15 ft.
    ** medium to coarse grained sand under silty sand and sandy clays
* In situ permeability tests conducted on 13 of the 14 MWs

* Average Hydraulic conductivity calculated to be 39.2 gpd/sf
* Depth to groundwater typically measured at 6 to 19 ft. bls
* Groundwater flow to north to northwest
* Hydraulic gradient calculated to be 0.0.002 ft/ft
* Groundwater flow velocity calculated to be 10 ft/yr
* Groundwater elevations, topography, and flow direction indicate that groundwater discharges to Northeast Creek
* No free product detected in any of the 14 MWs

CONCLUSIONS/RECOMMENDATIONS

* All groundwater samples analyzed for PAHs (EPA 8100) and TCLP had levels below method detection limits and constituents detected by EPA 8010 and 8020 had concentrations below the NC water quality criteria

* Results of risk assessment concluded there is no risk related to groundwater exposure pathway

* Lack of significant groundwater contamination indicates that remediation focus on soil containing residual petroleum product (subsurface TPH concentrations in soil considered unacceptable in State of North Carolina)

Appendix B
Site Evaluation Matrix

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year (millions of gallons)	15 Year (millions of gallons)	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Campbell Street Fuel Farm	UST	110,000	NA	600	Trench	NA	NA	1	5	1995	13	26	39	MTBE Benzene Toluene Ethyl Dibromide Ethylbenzene Xylenes,total 1,4-Dichlorobenzene	1490 73 782 782 681 5518 3080	Camp Geiger	New River
Bldg. AS-4151 (Steam Generating Plant)	UST	62,400	NA	280	Trench	NA	NA	1	5	1995	13	26	39	Benzene Ethyl Dibromide 1,4-Dichlorobenzene	11.9 0.9 3.33	Camp Geiger	New River
Camp Geiger Fuel Farm	UST	225000 157500 (2 plumes)	NA	800	Trench	NA	NA	1	15	1995	39	79	118	Benzene Ethylbenzene Xylenes (total) Lead Trans-1,2-Dichloroethene Trichloroethene Chloroform 1,2-Dichloroethane Tetrachloroethene Bromoform Vinyl Chloride	2300 590 1800 76 110 810 9 1 1 16 6	Camp Geiger	New River
Tanks AS419-AS421 (Air Station)	UST	2000 2000 (assuming plume contamination within 25' radius of MW3 and MW6/MW12)	NA NA	NA	Well	2	15	NA	NA	1995	24	47	71	Benzene 1,2-Dichloroethylene (tot) Trichloroethylene Perchloroethane	6 94 280 210	Camp Geiger	New River
JP-5 Line Area Site (Pump & Treat System Constructed, but not yet on-line)	UST	(Data not available to estimate)	NA	NA	Well	2	15	NA	NA	1995	24	47	71	Benzene Ethylbenzene Xylene Total Hydrocarbons	13 49 490 890,000	Camp Geiger	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Camp Geiger Mini C Store Service Station	UST	34,500	NA	NA	Well	2	15	NA	NA	1994	24	47	71	Benzene Ethylbenzene Methyl Tert. Butyl Ether Lead	140 68 290 240	Camp Geiger	New River
HYPOTHETICAL SITES																	
Hypothetical Site 1995-CG1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1995	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
Hypothetical Site 1995-CG2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1995	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
Hypothetical Site 1995-CG3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1995	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
Hypothetical Site 1996-CG1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1996	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 [illegible]	Camp Geiger	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year (millions of gallons)	15 Year (millions of gallons)	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1996-CG2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1996	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1996-CG3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1996	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1997-CG1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1997	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1997-CG2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1997	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1997-CG3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1997	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1998-CG1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1998	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1998-CG2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1998	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		
Hypothetical Site 1998-CG3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1998	16	32	47	Benzene	1200	Camp Geiger	New River
														Ethylbenzene	400		
														Toluene	400		
														Xylenes	3000		
														Trichloroethylene	500		
														Tetrachloroethylene	100		
														Total Hydrocarbons	400000		

Appendix B - Site Evaluation Matrix
Effluent Study for IR/RI-FS/SI and UST Sites
CTO - 19140
MCB Camp Lejeune, North Carolina

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1999-CG1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1999	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
Hypothetical Site 1999-CG2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1999	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
Hypothetical Site 1999-CG3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	10	NA	NA	1999	16	32	47	Benzene Ethylbenzene Toluene Xylenes Trichloroethylene Tetrachloroethylene Total Hydrocarbons	1200 400 400 3000 500 100 400000	Camp Geiger	New River
#36, Camp Geiger Dump, STP	RI/FS	43560	330	NA	Well	2	15	NA	NA	1997	24	47	71	T-1,2 Dichloroethene Methylene Chloride Phenol Cadmium Chromium Lead O&G	2 7 7 19 680 346 2000	Camp Geiger	New River

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
#41, Camp Geiger Dump, Park	RI/FS	1306800	818	NA	Well	4	25	NA	NA	1996	39	79	118	Methylene Chloride	10	Camp Geiger	New River
														Vinyl Chloride	1		
														RDX	1.28		
														Pentachlorphenol	11		
														Aldrin	0.017		
														Cadmium	7.1		
														Chromium	530		
														Lead	196.3		
														O&G	48000		
#43, Agan St. Dump	SI	217800	1080	NA	Well	5	25	NA	NA	1997	39	79	118	Carbon Disulfide	1.9	Camp Geiger	New River
														Beryllium	3.1		
														Cadmium	6.9		
														Chromium	249		
														Iron	134000		
														Magnesium	11800		
														Manganese	297		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year (millions of gallons)	15 Year (millions of gallons)	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#44, Jones St. Dump	SI	130680	1130	NA	Well	5	25	NA	NA	1997	39	79	118	Carbon Disulfide	6	Camp Geiger	New River
														2-Methylnaphthalene	14		
														Acenapthene	16		
														Dibenzofuran	8		
														Phenanthranene	24		
														Napthalene	62		
														Fluoroanthene	14		
														Anthracene	3		
														Benzo(a)anthracene	3		
														Pyrene	9		
														Barium	3180		
														Beryllium	36.6		
														Cadmium	32		
														Calcium	201000		
														Chromium	895		
														Iron	662000		
														Lead	508		
														Magnesium	35700		
														Mercury	1.1		
														Nickel	486		
														Thallium	2.7		

CAMP GEIGER

Subtotal Flows (GPM)	Wells	285	Trenches	25	Total Flow (GPM)	310

UST SITES
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IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
#16, Montford Pt. Burn Dump	RI/FS	174240	500	NA	Well	2	15	NA	NA	1997	24	47	71	Estimated quantities		Montford Point	Northeast Creek
														T-1,2-Dichloroethene	38		
														Trichloroethene	15		
														Vinyl Chloride	22		
														Beryllium	3.1		
														Cadmium	6.9		
														Chromium	249		
														Iron	134000		
														Magnesium	11800		
														Manganese	297		

MONTFORD POINT

Subtotal Flows (GPM)	Wells	15	Trenches	0	Total Flow (GPM)	15

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
Building 45, UST S-941-2	UST	11,000	NA	NA	Well	2	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Xylenes (Total) Lead	87 70 1900 84	Tarawa Terrace	Northeast Creek
Tarawa Terrace Service Station (Pump & Treat System Constructed, but not yet on-line)	UST	Data not available to estimate	NA	NA	Well	2	15	NA	NA	1994	24	47	71	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek
Hypothetical Site 1995-TT1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek
Hypothetical Site. 1996-TT1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek

Appendix B - Site Evaluation Matrix
Effluent Study for IR/RI-FS/SI and UST Sites
CTO - 19140
MCB Camp Lejeune, North Carolina

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1997-TT1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek
Hypothetical Site 1998-TT1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek
Hypothetical Site 1999-TT1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Tarawa Terrace	Northeast Creek

TARAWA TERRACE

Subtotal Flows (GPM)	Wells	45	Trenches	0	Total Flow (GPM)	45

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
Building 21, River Road (UST System 21.1)	UST	700 400 (2 separate plumes)	NA	35 25	Trench	NA	NA	2 Trench A Trench B	 5 5	1995	13 13	26 26	39 39	Benzene Toluene Ethyl Dibromide Ethylbenzene 1,4-Dichlorobenzene	2420 2740 3 146 2	Hadnot Point	New River
Gottschalk Marina	UST	400 (localized plume)	NA	NA	Well	1 (only)	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Xylene Lead	42 47 910 34.7	Hadnot Point	New River
Berkley Manor X Change Service Station Tank 820-2	UST	62,000	280	NA	Well	3	15	NA	NA	1995	24	47	71	Benzene Ethylbenzene Toluene Xylenes (total) Total Hydrocarbons	31,000 2900 42,000 15,000 310	Hadnot Point	New River
Hadnot Point Fuel Farm (Pump & Treat System Currently in Operation)	UST	Data not available to estimate	NA	NA	Well	4	5	NA	NA	1992	8	16	24	Benzene Ethylbenzene Toluene Xylenes (total)	7800 680 9600 4000	Hadnot Point	New River
Hypothetical Site 1995-HP1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
Hypothetical Site 1995-HP3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1995-HP4	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1995-HP5	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1995-HP6	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1995-HP7	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1995-HP8	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
Hypothetical Site 1995-HP9	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP10	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP11	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP12	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP13	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1995-HP14	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

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IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1996-HP1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP4	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP5	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP6	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1996-HP7	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP8	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	13	26	39	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP9	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP10	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP11	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP12	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology						Estimated Groundwater Volume for Treatment at Flow Durations			Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
					Well or Trench	Wells		Trenches		Estimated Start-up Date							
						Number of Wells	Estimated Flowrate	Number of Trenches	Estimated Flowrate		5 Year	10 Year	15 Year				
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
Hypothetical Site 1996-HP13	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	13	26	39	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1996-HP14	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP4	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	13	26	39	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s)	Max Cross Section Perpendicular to Gradient	Estimated Trench Length	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate	Trenches: Number of Trenches	Trenches: Estimated Flowrate	Estimated Start-up Date	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration	Treated Discharge Destination	Effluent Receiving Stream Identification
		(sq.ft.)	(ft.)	(ft.)			(GPM)		(GPM)	(Year)	(millions of gallons)				(ug/L)	(STP)	(STP Discharge)
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP5	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP6	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	13	26	39	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP7	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP8	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	13	26	39	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP9	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP10	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes	15000 1500 22000 8000	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP11	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	13	26	39	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP12	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP13	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
														Total Hydrocarbons	200		
Hypothetical Site 1997-HP14	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1998-HP1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1998-HP2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1998-HP3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP4	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP5	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP6	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP7	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP8	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1998-HP9	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP10	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP11	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP12	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP13	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1998-HP14	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year (millions of gallons)	15 Year (millions of gallons)	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1999-HP1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1999-HP2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1999-HP3	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1999-HP4	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1999-HP5	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		
Hypothetical Site 1999-HP6	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene	15000	Hadnot Point	New River
														Ethylbenzene	1500		
														Toluene	22000		
														Xylenes	8000		
														Total Hydrocarbons	200		

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1999-HP7	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP8	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP9	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP10	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP11	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP12	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1999-HP13	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
Hypothetical Site 1999-HP14	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes Total Hydrocarbons	15000 1500 22000 8000 200	Hadnot Point	New River
#1, French Creek LDA	RI/FS	348480	1800	NA	Well	8	50	NA	NA	1996	79	158	237	Benzene 1,1 Dichloroethane 1,1,2,2 Tetrachloroethane Tetrachloroethene Trichloroethene Phenols Cadmium Chromium Lead	4.4 6.7 4 6.8 5.2 4 10 160 136	Hadnot Point	New River
#3, Old Creosote Plant	SI	4356000	1050	NA	Well	5	25	NA	NA	1996	39	79	118	Napthalene Anthracene Chrysene Flouorene Phenanthranene Acenaphtene Fluoranthene Dibezofuran	10 10 10 10 10 10 10 10	Hadnot Point	New River

UST SITES
Draft: 12/15/93

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#6, Storage Lots 203/201 Shallow Aquifer	SI	1306800	2850	NA	Well	3	15	NA	NA	1995	24	47	71	Bromodichloromethane	0.6	Hadnot Point	New River
														Chlorobenzene	110		
														Chloroform	2.7		
														1,2 Dichloroethane	0.6		
														T-1,2-Dichloroethene	16		
														1,1,2,2 Tetrachloroethane	6.9		
														Tetrachloroethene	0.9		
														1,1,1-Trichloroethane	0.5		
														1,1,2-Trichloroethane	0.5		
														Trichloroethene	120		
														Vinyl Chloride	1.6		
														bis(2-Ethylhexyl)Phthalate	2		
														(Chlorophenol,2)	5		
														Phenols	1		
														Aluminum	1820		
														Antimony	20		
														Cadmium	3000		
														Calcium	58000		
														Iron	3280		
														Lead	2		
														Magnesium	4240		
														Manganese	127		
#6, Storage Lots 203/201 Deep Aquifer	SI	1306800	2850	NA	Well	2	300	NA	NA	1995	473	946	1,419	1,1- Dichloroethene	0.6	Hadnot Point	New River
														T-1,2-Dichloroethene	5800		
														Methylene Chloride	790		
														Tetrachloroethene	630		
														Trichloroethene	58000		
														Ethylbenzene	48		
														Bis(2-Ethylhexyl)phalate	22		
														Phenol	22		
														Calcium	97600		
														Potassium	70200		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#24, Industrial Fly Ash Dump	RI/FS	1089000	3000	NA	Well	12	50	NA	NA	1996	79	158	237	Benzene	3	Hadnot Point	New River
														Chloroform	1.6		
														Chromium	130		
														Hex Chrome	14.2		
														Lead	58		
#28, HP Burn Dump	RI/FS	1001880	2600	NA	Well	11	50	NA	NA	1996	79	158	237	T-1,2-Dichloroethene	38	Hadnot Point	New River
														Trichloroethene	15		
														Vinyl Chloride	22		
														DDD,PP'	0.22		
														DDDE,PP'	0.028		
														Dieldrin	0.003		
														Chromium	330		
														Hexavalent Chrome	46.4		
														Lead	336		
														O&G	9		
#78, Operable Unit 1	RI/FS	Not Estimated	Not Estimated	NA	Well	32	160	NA	NA	1994	252	505	757	Benzene	7900	Hadnot Point	New River
														T-1,2-Dichloroethene	42000		
														Trichloroethene	14000		
														Antimony	46.5		
														Arsenic	50.3		
														Beryllium	9.5		
														Iron	265000		
														Lead	307		
														Manganese	763		
														Mercury	1.4		
														Nickel	186		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#80, Paradise Pt. Golf Course	43560	SI	296	NA	Well	2	15	NA	NA	1996	24	47	71	Estimated quantities		Hadnot Point	New River
														Benzene	17		
														Chloroform	38		
														T-1,2-Dichloroethene	360		
														Methylene Chloride	12		
														Vinyl Chloride	74		
														Dibromochloromethane	10		
														Phenols	15		
														Bromodichloromethane	20		
														Chlordane	0.027		
														Endrin	0.2		
														Heptachlor	0.05		
														Lindane	0.05		
														Methoxychlor	0.5		
														Toxaphene	1		
														2-4-D	0.5		
														2,4,5-TP	0.1		
														DDD	0.7		
														DDT	0.6		
														DDE	0.1		
														Aldrin	0.01		
														Chlordane	0.05		
														Dieldrin	0.003		
														Cadmium	10		
														Chromium	95		
														Lead	109		

HADNOT POINT

Subtotal Flows (GPM)	Wells	1040	Trenches	10	Total Flow (GPM)	1050

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#68 Rifle Range Dump	SI	174240	480	NA	Well	2	15	NA	NA	1999	24	47	71	Bromodichloromethane	0.6	Rifle Range	Stone Bay
														Chlorobenzene	110		
														Chloroform	2.7		
														1,2 Dichloroethane	0.6		
														T-1,2-Dichloroethene	16		
														1,1,2,2 Tetrachloroethane	6.9		
														Tetrachloroethene	0.9		
														1,1,1-Trichloroethane	0.5		
														1,1,2-Trichloroethane	0.5		
														Trichloroethene	120		
														Vinyl Chloride	1.6		
														bis(2-Ethylhexyl)Phthalate	2		
														(Chlorophenol,2)	5		
														Phenols	1		
														Aluminum	1820		
														Antimony	20		
														Cadmium	3000		
														Calcium	58000		
														Iron	3280		
														Lead	2		
														Magnesium	4240		
														Manganese	127		

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year (millions of gallons)	15 Year (millions of gallons)	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#69 Rifle Range Chem. Dump	RI/FS	304920	345	NA	Well	2	15	NA	NA	1996	24	47	71	Benzene	4	Rifle Range	Stone Bay
														Chlorobenzene	55		
														Chloroform	14		
														1,2 Dichloroethane	5.9		
														T-1,2-Dichloroethene	37000		
														1,1,2,2 Tetrachloroethane	44		
														Tetrachloroethene	20		
														1,1,1-Trichloroethane	7.9		
														Trichloroethene	710		
														Vinyl Chloride	440		
														1,2 Dibromoethane	4.74		
														BHC,B	0.087		
														BHC,D	2.44		
Rifle Range, Bldg. 72 (Former MCX Gas Station)	UST	2,625	NA	50	Trench	NA	NA	1	5	1994	8	16	24	Benzene	357	Camp Geiger	New River
														Ethylbenzene	1090		
														Ethyl Dibromide	100		
														1,4-Dichlorobenzene	110		

RIFLE RANGE

Subtotal Flows (GPM)	Wells	30	Trenches	5	Total Flow (GPM)	35

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1995-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1995-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1995	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1996-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1996-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1996	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1997-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1997-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1997	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1998-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1998-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1999-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1999-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
#73, Courthouse Bay LDA	RI/FS	522720	1230	NA	Well	5	25	NA	NA	1997	39	79	118	Benzene Chloroform Methylene Chloride Vinyl Chloride Dibromochloromethane Phenols Bromodichloromethane Cadmium Chromium Lead O & G	17 38 12 74 10 15 20 10 95 109 2000	Courthouse Bay	New River

COURTHOUSE BAY

Subtotal Flows (GPM)	Wells	75	Trenches	0	Total Flow (GPM)	75

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations: 5 Year (millions of gallons)	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
#12, Explosive Ordnance Dis.	SI	217800	660	NA	Well	3	15	NA	NA	1997	24	47	71	Estimated quantities		Onslow Beach	Intracoastal Waterway
														RDX	2		
														HMX	0.6		
														Beryllium	36.6		
														Cadmium	32		
														Chromium	895		
														Iron	662000		
														Hexavalent Chrome	481		
														Lead	35700		
														Magnesium	1730		
														Mercury	486		
														Nickel	32500		
														Phosphorus	100		
														Silver	12600		
														Thallium	759		

ONSLOW BEACH

Subtotal Flows (GPM)	Wells	15	Trenches	0	Total Flow (GPM)	15

IR, RI/FS, SI or UST SITE	Site Designation (IR/RI-FS/SI or UST)	Estimated Extent of Contaminant Plume(s) (sq.ft.)	Max Cross Section Perpendicular to Gradient (ft.)	Estimated Trench Length (ft.)	Groundwater Extraction Technology: Well or Trench	Wells: Number of Wells	Wells: Estimated Flowrate (GPM)	Trenches: Number of Trenches	Trenches: Estimated Flowrate (GPM)	Estimated Start-up Date (Year)	Estimated Groundwater Volume for Treatment at Flow Durations (millions of gallons): 5 Year	10 Year	15 Year	Contaminants of Concern	Estimated Influent Concentration (ug/L)	Treated Discharge Destination (STP)	Effluent Receiving Stream Identification (STP Discharge)
Hypothetical Site 1998-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1998	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1999-CB1	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
Hypothetical Site 1999-CB2	UST	Future Hypothetical Site	Not Estimated	NA	Well	No Estimate	5	NA	NA	1999	8	16	24	Benzene Ethylbenzene Toluene Xylenes	200 600 50 900	Courthouse Bay	New River
#73, Courthouse Bay LDA	RI/FS	522720	1230	NA	Well	5	25	NA	NA	1997	39	79	118	Benzene Chloroform Methylene Chloride Vinyl Chloride Dibromochloromethane Phenols Bromodichloromethane Cadmium Chromium Lead O & G	17 38 12 74 10 15 20 10 95 109 2000	Courthouse Bay	New River

COURTHOUSE BAY

Subtotal Flows (GPM)	Wells	75	Trenches	0	Total Flow (GPM)	75

Appendix C
Detailed Cost Estimates for Groundwater Extraction Systems

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
CAMP GEIGER OUTFALL AREA SITES

SITE IDENTIFICATION	Campbell Street Fuel Farm	Building AS-4151 Steam Generating Plant	Camp Geiger Fuel Farm	Tanks AS419-AS421 (Air Station)
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED	Trench	Trench	Trench	Wells
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)	2.5	0.5	15	8
NUMBER OF EXTRACTION WELLS/TRENCHES	1	1	1	2
IF TRENCH, SPECIFY TRENCH LENGTH (LF)	600	280	800	NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)	3	1.4	4	NA
IF EXTRACTION WELL, # WELLS	NA	NA	NA	2

GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	600	$405,000.00	280	$189,000.00	800	$540,000.00	NA	$0.00
Geotextile Fabric	LF	$15.00	600	$9,000.00	280	$4,200.00	800	$12,000.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	3	$5,400.00	2	$3,600.00	4	$7,200.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	3	$4,500.00	2	$3,000.00	4	$6,000.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$425,900.00		$201,800.00		$567,200.00		$0.00
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	3	$450.00	2	$300.00	4	$600.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	52	$1,500.00	52	$1,500.00	52	$1,500.00	NA	$0.00
Annual Inspection	HOUR	$29.10	40	$1,200.00	40	$1,200.00	40	$1,200.00	NA	$0.00
Maintenance Materials	LS	-	-	$4,000.00	-	$4,000.00	-	$4,000.00	NA	$0.00
Trench Maintenance	LS	-	-	$2,000.00	-	$2,000.00	-	$2,000.00	NA	$0.00
SUBTOTAL - O&M COST				$9,150.00		$9,000.00		$9,300.00		$0.00

GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$10,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$8,000.00
Submersible Pump	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$3,600.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$4,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$3,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00		$30,600.00
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$300.00
Maintenance Labor										
General	WELL	$1,400.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$2,800.00
Maintenance Materials	WELL	$1,000.00	NA	$0.00	NA	$0.00	NA	$0.00	2	$2,000.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00		$5,100.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$425,900.00		$201,800.00		$567,200.00		$30,600.00
O&M (TOTAL)				$9,150.00		$9,000.00		$9,300.00		$5,100.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
CAMP GEIGER OUTFALL AREA SITES

SITE IDENTIFICATION			JP-5 Line Area Site		Camp Geiger Mini C Store Service Station		Hypothetical Site (typical for all hypothetical sites)		#36, Camp Geiger Dump, STP	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Wells		Wells		Wells		Wells
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				8		12		10		8
NUMBER OF EXTRACTION WELLS/TRENCHES				2		2		2		2
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA		NA
IF EXTRACTION WELL, # WELLS				2		2		2		2
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	2	$10,000.00	2	$10,000.00	2	$10,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	2	$8,000.00	2	$8,000.00	2	$8,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	2	$3,600.00	2	$3,600.00	2	$3,600.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	2	$4,000.00	2	$4,000.00	2	$4,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	2	$3,000.00	2	$3,000.00	2	$3,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$30,600.00		$30,600.00		$30,600.00
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	2	$300.00	2	$300.00	2	$300.00
Maintenance Labor										
General	WELL	$1,400.00	2	$2,800.00	2	$2,800.00	2	$2,800.00	2	$2,800.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	2	$2,000.00	2	$2,000.00	2	$2,000.00
SUBTOTAL - O&M COST				$5,100.00		$5,100.00		$5,100.00		$5,100.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$30,600.00		$30,600.00		$30,600.00		$30,600.00
O&M (TOTAL)				$5,100.00		$5,100.00		$5,100.00		$5,100.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
CAMP GEIGER OUTFALL AREA SITES

SITE IDENTIFICATION			#41, Camp Geiger Dump, Park		#43, Agan St. Dump		#44, Jones St. Dump		#54, Crash Train Pit MCAS		#63, Verona Loop Dump	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Wells		Wells		Wells		Wells		Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				16		20		20		12		8
NUMBER OF EXTRACTION WELLS/TRENCHES				4		5		5		3		2
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA		NA		NA
IF EXTRACTION WELL, # WELLS				4		5		5		3		2
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH												
CAPITAL COSTS												
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH												
O&M COSTS												
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor												
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL												
CAPITAL COSTS												
Install 6" dia. extraction well (mat'l, labor, mob.)	WELL	$5,000.00	4	$20,000.00	5	$25,000.00	5	$25,000.00	3	$15,000.00	2	$10,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	4	$16,000.00	5	$20,000.00	5	$20,000.00	3	$12,000.00	2	$8,000.00
Submersible Pump	EACH	$1,800.00	4	$7,200.00	5	$9,000.00	5	$9,000.00	3	$5,400.00	2	$3,600.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	4	$8,000.00	5	$10,000.00	5	$10,000.00	3	$6,000.00	2	$4,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	4	$6,000.00	5	$7,500.00	5	$7,500.00	3	$4,500.00	2	$3,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$59,200.00		$73,500.00		$73,500.00		$44,900.00		$30,600.00
EXTRACTION WELL												
O&M COSTS												
Electricity (Submersible Well Pump)	EACH	$150.00	4	$600.00	5	$750.00	5	$750.00	3	$450.00	2	$300.00
Maintenance Labor												
General	WELL	$1,400.00	4	$5,600.00	5	$7,000.00	5	$7,000.00	3	$4,200.00	2	$2,800.00
Maintenance Materials	WELL	$1,000.00	4	$4,000.00	5	$5,000.00	5	$5,000.00	3	$3,000.00	2	$2,000.00
SUBTOTAL - O&M COST				$10,200.00		$12,750.00		$12,750.00		$7,650.00		$5,100.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:												
CAPITAL (TOTAL)				$59,200.00		$73,500.00		$73,500.00		$44,900.00		$30,600.00
O&M (TOTAL)				$10,200.00		$12,750.00		$12,750.00		$7,650.00		$5,100.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
MONTFORD POINT OUTFALL AREA SITES

SITE IDENTIFICATION			Hypothetical Site (typical for all hypothetical sites)		#16, Montford Point Burn Dump		#85, Camp Johnson Battery Dump	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Well		Well		Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				5		8		12
NUMBER OF EXTRACTION WELLS/TRENCHES				2		2		3
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA
IF EXTRACTION WELL, # WELLS				2		2		3
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS								
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS								
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor								
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS								
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	2	$10,000.00	3	$15,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	2	$8,000.00	3	$12,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	2	$3,600.00	3	$5,400.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	2	$4,000.00	3	$6,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	2	$3,000.00	3	$4,500.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$30,600.00		$44,900.00
EXTRACTION WELL O&M COSTS								
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	2	$300.00	3	$450.00
Maintenance Labor								
General	WELL	$1,400.00	2	$2,800.00	2	$2,800.00	3	$4,200.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	2	$2,000.00	3	$3,000.00
SUBTOTAL - O&M COST				$5,100.00		$5,100.00		$7,650.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:								
CAPITAL (TOTAL)				$30,600.00		$30,600.00		$44,900.00
O&M (TOTAL)				$5,100.00		$5,100.00		$7,650.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
TARAWA TERRACE OUTFALL AREA SITES

SITE IDENTIFICATION	Building 45, UST S-941-2	Tarawa Terrace Service Station	Hypothetical Site (typical for all hypothetical sites)
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED	Well	Well	Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)	5	8	5
NUMBER OF EXTRACTION WELLS/TRENCHES	2	2	2
IF TRENCH, SPECIFY TRENCH LENGTH (LF)	NA	NA	NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)	NA	NA	NA
IF EXTRACTION WELL, # WELLS	2	2	2

GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS								
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS								
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor								
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00

GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS								
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	2	$10,000.00	2	$10,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	2	$8,000.00	2	$8,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	2	$3,600.00	2	$3,600.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	2	$4,000.00	2	$4,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	2	$3,000.00	2	$3,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$30,600.00		$30,600.00
EXTRACTION WELL O&M COSTS								
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	2	$300.00	2	$300.00
Maintenance Labor								
General	WELL	$1,400.00	2	$2,800.00	2	$2,800.00	2	$2,800.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	2	$2,000.00	2	$2,000.00
SUBTOTAL - O&M COST				$5,100.00		$5,100.00		$5,100.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:								
CAPITAL (TOTAL)				$30,600.00		$30,600.00		$30,600.00
O&M (TOTAL)				$5,100.00		$5,100.00		$5,100.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
HADNOT POINT OUTFALL AREA SITE

SITE IDENTIFICATION			Building 21, River Road (UST System 21.1)		Gottschalk Marina		Berkley Manor X Change Service Station Tank 820-2		Hadnot Point Fuel Farm	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Trench		Well		Well		Wells
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				1		4		12		5
NUMBER OF EXTRACTION WELLS/TRENCHES				2		1		3		4
IF TRENCH, SPECIFY TRENCH LENGTH (LF)			(combined)	60		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)			(1 pump per	2		NA		NA		NA
IF EXTRACTION WELL, # WELLS			trench)	NA		1		3		4
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	60	$40,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	60	$900.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	2	$3,600.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$50,000.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	2	$300.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	52	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	40	$1,200.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	-	$4,000.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	-	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$9,000.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	NA	$0.00	1	$5,000.00	3	$15,000.00	4	$20,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	NA	$0.00	1	$4,000.00	3	$12,000.00	4	$16,000.00
Submersible Pump	EACH	$1,800.00	NA	$0.00	1	$1,800.00	3	$5,400.00	4	$7,200.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	NA	$0.00	1	$2,000.00	3	$6,000.00	4	$8,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	1	$1,500.00	3	$4,500.00	4	$6,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$0.00		$16,300.00		$44,900.00		$59,200.00
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	NA	$0.00	1	$150.00	3	$450.00	4	$600.00
Maintenance Labor										
General	WELL	$1,400.00	NA	$0.00	1	$1,400.00	3	$4,200.00	4	$5,600.00
Maintenance Materials	WELL	$1,000.00	NA	$0.00	1	$1,000.00	3	$3,000.00	4	$4,000.00
SUBTOTAL - O&M COST				$0.00		$2,550.00		$7,650.00		$10,200.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$50,000.00		$16,300.00		$44,900.00		$59,200.00
O&M (TOTAL)				$9,000.00		$2,550.00		$7,650.00		$10,200.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
HADNOT POINT OUTFALL AREA SITE

SITE IDENTIFICATION			Hypothetical Site (typical for all hypothetical sites)		#1, French Creek LDA		#2, Former Daycare/Nursery		#3, Old Creosote Plant	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Wells		Wells		Wells		Wells
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				5		32		8		20
NUMBER OF EXTRACTION WELLS/TRENCHES				2		8		2		5
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA		NA
IF EXTRACTION WELL, # WELLS				2		8		2		5
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	8	$40,000.00	2	$10,000.00	5	$25,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	8	$32,000.00	2	$8,000.00	5	$20,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	8	$14,400.00	2	$3,600.00	5	$9,000.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	8	$16,000.00	2	$4,000.00	5	$10,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	8	$12,000.00	2	$3,000.00	5	$7,500.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$116,400.00		$30,600.00		$73,500.00
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	8	$1,200.00	2	$300.00	5	$750.00
Maintenance Labor										
General	WELL	$1,400.00	2	$2,800.00	8	$11,200.00	2	$2,800.00	5	$7,000.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	8	$8,000.00	2	$2,000.00	5	$5,000.00
SUBTOTAL - O&M COST				$5,100.00		$20,400.00		$5,100.00		$12,750.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$30,600.00		$116,400.00		$30,600.00		$73,500.00
O&M (TOTAL)				$5,100.00		$20,400.00		$5,100.00		$12,750.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
HADNOT POINT OUTFALL AREA SITE

SITE IDENTIFICATION			#6, Storage Lots 203/201 Shallow Aquifer		#6, Storage Lots 203/201 Deep Aquifer		#24, Industrial Fly Ash Dum		#28, HP Burn Dump	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Wells		Wells		Wells		Wells
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				48		2400		48		44
NUMBER OF EXTRACTION WELLS/TRENCHES				12		12		12		11
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA		NA
IF EXTRACTION WELL, # WELLS				12		12		12		11
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH										
CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH										
O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL										
CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	12	$60,000.00	12	$60,000.00	12	$60,000.00	11	$55,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	12	$48,000.00	12	$48,000.00	12	$48,000.00	11	$44,000.00
Submersible Pump	EACH	$1,800.00	12	$21,600.00	12	$21,600.00	12	$21,600.00	11	$19,800.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	12	$24,000.00	12	$24,000.00	12	$24,000.00	11	$22,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	12	$18,000.00	12	$18,000.00	12	$18,000.00	11	$16,500.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$173,600.00		$173,600.00		$173,600.00		$159,300.00
EXTRACTION WELL										
O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	12	$1,800.00	12	$1,800.00	12	$1,800.00	11	$1,650.00
Maintenance Labor										
General	WELL	$1,400.00	12	$16,800.00	12	$16,800.00	12	$16,800.00	11	$15,400.00
Maintenance Materials	WELL	$1,000.00	12	$12,000.00	12	$12,000.00	12	$12,000.00	11	$11,000.00
SUBTOTAL - O&M COST				$30,600.00		$30,600.00		$30,600.00		$28,050.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$173,600.00		$173,600.00		$173,600.00		$159,300.00
O&M (TOTAL)				$30,600.00		$30,600.00		$30,600.00		$28,050.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
HADNOT POINT OUTFALL AREA SITE

SITE IDENTIFICATION			#78, Operable Unit 1		#80, Paradise Pt. Golf Course					
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Well		Well				
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				160		8				
NUMBER OF EXTRACTION WELLS/TRENCHES				32		2				
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA				
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA				
IF EXTRACTION WELL, # WELLS				32		2				
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST				
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00				
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00				
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00				
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00				
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00				
SUBTOTAL - CAPITAL COST				$0.00		$0.00				
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00				
Maintenance Labor										
General	HOUR	$29.10	NA	$0.00	NA	$0.00				
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00				
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00				
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00				
SUBTOTAL - O&M COST				$0.00		$0.00				
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST				
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	32	$160,000.00	2	$10,000.00				
Extraction Well Discharge Piping	WELL	$4,000.00	32	$128,000.00	2	$8,000.00				
Submersible Pump	EACH	$1,800.00	32	$57,600.00	2	$3,600.00				
Miscellaneous Well Appurtenances	EACH	$2,000.00	32	$64,000.00	2	$4,000.00				
Pump Control Panel (1 per pump)	EACH	$1,500.00	32	$48,000.00	2	$3,000.00				
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00				
SUBTOTAL - CAPITAL COST				$459,600.00		$30,600.00				
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	32	$4,800.00	2	$300.00				
Maintenance Labor										
General	WELL	$1,400.00	32	$44,800.00	2	$2,800.00				
Maintenance Materials	WELL	$1,000.00	32	$32,000.00	2	$2,000.00				
SUBTOTAL - O&M COST				$81,600.00		$5,100.00				
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$459,600.00		$30,600.00				
O&M (TOTAL)				$81,600.00		$5,100.00				

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
RIFLE RANGE OUTFALL AREA SITES

SITE IDENTIFICATION			Rifle Range, Bldg. 72 (Former MCX Gas Station)		Hypothetical Site (typical for all hypothetical site		#68, Rifle Range Dump		#69, Rifle Range Chemical Dum	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Trench		Well		Well		Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				1.5		5		8		8
NUMBER OF EXTRACTION WELLS/TRENCHES				1		2		2		2
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				50		NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				1		NA		NA		NA
IF EXTRACTION WELL, # WELLS				NA		2		2		2
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH CAPITAL COSTS										
BP Trench (Excavation & Installation)	LF	$675.00	50	$33,750.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	50	$750.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	1	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	1	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$39,800.00		$0.00		$0.00		$0.00
INTERCEPTOR TRENCH O&M COSTS										
Electricity (Trench Pump(s))	EACH	$150.00	1	$150.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor										
General	HOUR	$29.10	52	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	40	$1,200.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	-	$4,000.00	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	-	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$8,850.00		$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL CAPITAL COSTS										
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	NA	$0.00	2	$10,000.00	2	$10,000.00	2	$10,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	NA	$0.00	2	$8,000.00	2	$8,000.00	2	$8,000.00
Submersible Pump	EACH	$1,800.00	NA	$0.00	2	$3,600.00	2	$3,600.00	2	$3,600.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	NA	$0.00	2	$4,000.00	2	$4,000.00	2	$4,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	2	$3,000.00	2	$3,000.00	2	$3,000.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$0.00		$30,600.00		$30,600.00		$30,600.00
EXTRACTION WELL O&M COSTS										
Electricity (Submersible Well Pump)	EACH	$150.00	NA	$0.00	2	$300.00	2	$300.00	2	$300.00
Maintenance Labor										
General	WELL	$1,400.00	NA	$0.00	2	$2,800.00	2	$2,800.00	2	$2,800.00
Maintenance Materials	WELL	$1,000.00	NA	$0.00	2	$2,000.00	2	$2,000.00	2	$2,000.00
SUBTOTAL - O&M COST				$0.00		$5,100.00		$5,100.00		$5,100.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:										
CAPITAL (TOTAL)				$39,800.00		$30,600.00		$30,600.00		$30,600.00
O&M (TOTAL)				$8,850.00		$5,100.00		$5,100.00		$5,100.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
COURTHOUSE BAY OUTFALL AREA SITES

SITE IDENTIFICATION			Hypothetical Site (typical for all hypothetical sites)		#65, Engineering Area Dump		#73, Courthouse Bay LDA	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Well		Well		Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				5		20		20
NUMBER OF EXTRACTION WELLS/TRENCHES				2		5		5
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA
IF EXTRACTION WELL, # WELLS				2		5		5
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH								
CAPITAL COSTS								
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00
INTERCEPTOR TRENCH								
O&M COSTS								
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor								
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL								
CAPITAL COSTS								
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	5	$25,000.00	5	$25,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	5	$20,000.00	5	$20,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	5	$9,000.00	5	$9,000.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	5	$10,000.00	5	$10,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	5	$7,500.00	5	$7,500.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$73,500.00		$73,500.00
EXTRACTION WELL								
O&M COSTS								
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	5	$750.00	5	$750.00
Maintenance Labor								
General	WELL	$1,400.00	2	$2,800.00	5	$7,000.00	5	$7,000.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	5	$5,000.00	5	$5,000.00
SUBTOTAL - O&M COST				$5,100.00		$12,750.00		$12 750 00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:								
CAPITAL (TOTAL)				$30,600.00		$73,500.00		$73,500.00
O&M (TOTAL)				$5,100.00		$12,750.00		$12,750.00

COST ESTIMATE
CAPITAL AND OPERATION & MAINTENANCE
GROUNDWATER EXTRACTION SYSTEM
ONSLOW BEACH OUTFALL AREA SITES

SITE IDENTIFICATION			Hypothetical Site (typical for all hypothetical sites)		#12, Explosive Ordnance Disposal		#30, SF Tank Sludge Area	
GROUNDWATER COLLECTION TECHNOLOGY SPECIFIED				Well		Well		Well
ESTIMATED TOTAL GROUNDWATER FLOW (GPM)				5		12		12
NUMBER OF EXTRACTION WELLS/TRENCHES				2		3		3
IF TRENCH, SPECIFY TRENCH LENGTH (LF)				NA		NA		NA
IF TRENCH, # PUMPS (1 PUMP/200 LF)				NA		NA		NA
IF EXTRACTION WELL, # WELLS				2		3		3
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
INTERCEPTOR TRENCH								
CAPITAL COSTS								
BP Trench (Excavation & Installation)	LF	$675.00	NA	$0.00	NA	$0.00	NA	$0.00
Geotextile Fabric	LF	$15.00	NA	$0.00	NA	$0.00	NA	$0.00
Submersible Pumps	EACH	$1,800.00	NA	$0.00	NA	$0.00	NA	$0.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	NA	$0.00	NA	$0.00	NA	$0.00
Master Control Panel (1 for total system)	EACH	$2,000.00	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - CAPITAL COST				$0.00		$0.00		$0.00
INTERCEPTOR TRENCH								
O&M COSTS								
Electricity (Trench Pump(s))	EACH	$150.00	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Labor								
General	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Annual Inspection	HOUR	$29.10	NA	$0.00	NA	$0.00	NA	$0.00
Maintenance Materials	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
Trench Maintenance	LS	-	NA	$0.00	NA	$0.00	NA	$0.00
SUBTOTAL - O&M COST				$0.00		$0.00		$0.00
GROUNDWATER COLLECTION TECHNOLOGY AND ASSOCIATED COST COMPONENT	UNIT	UNIT COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST	SITE-SPECIFIC QUANTITY	SITE-SPECIFIC TOTAL COST
EXTRACTION WELL								
CAPITAL COSTS								
Install 6" dia. extraction well (matl, labor, mob.)	WELL	$5,000.00	2	$10,000.00	3	$15,000.00	3	$15,000.00
Extraction Well Discharge Piping	WELL	$4,000.00	2	$8,000.00	3	$12,000.00	3	$12,000.00
Submersible Pump	EACH	$1,800.00	2	$3,600.00	3	$5,400.00	3	$5,400.00
Miscellaneous Well Appurtenances	EACH	$2,000.00	2	$4,000.00	3	$6,000.00	3	$6,000.00
Pump Control Panel (1 per pump)	EACH	$1,500.00	2	$3,000.00	3	$4,500.00	3	$4,500.00
Master Control Panel (1 for total system)	EACH	$2,000.00	1	$2,000.00	1	$2,000.00	1	$2,000.00
SUBTOTAL - CAPITAL COST				$30,600.00		$44,900.00		$44,900.00
EXTRACTION WELL								
O&M COSTS								
Electricity (Submersible Well Pump)	EACH	$150.00	2	$300.00	3	$450.00	3	$450.00
Maintenance Labor								
General	WELL	$1,400.00	2	$2,800.00	3	$4,200.00	3	$4,200.00
Maintenance Materials	WELL	$1,000.00	2	$2,000.00	3	$3,000.00	3	$3,000.00
SUBTOTAL - O&M COST				$5,100.00		$7,650.00		$7,650.00
GROUNDWATER EXTRACTION/COLLECTION SYSTEM:								
CAPITAL (TOTAL)				$30,600.00		$44,900.00		$44,900.00
O&M (TOTAL)				$5,100.00		$7,650.00		$7,650.00

Appendix D
Detailed Cost Estimates for Groundwater Treatment Systems (Scenarios A-E)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "A"

PRETREATMENT WITH OIL/WATER SEPARATION

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 5 gpm

Contaminants of Concern = VOCs, Oil & Grease

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	6,500.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (3)	7,400.00
Effluent Transfer Pumps/Level Controls/Motor Starter (3)	2,000.00
Secondary Treatment (Carbon Polishing)	
Carbon Adsorbers (1000# units) (4)	10,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator Sludge) (5)	4,300.00
Purchased Equipment (Subtotal)	30,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (6)	3,000.00
Electrical (10% purchased equipment cost) (6)	3,000.00
Instrumentation (5% purchased equipment cost) (6)	1,500.00
Installation (assume 40 % purchased equipment cost) (6)	12,000.00
Treatment Building (20' X 20' @ $50/SF) (7)	20,000.00
Subtotal Direct Capital Cost	69,500.00
Construction Contingency (20% Subtotal Direct Capital Cost) (8)	13,900.00
TOTAL DIRECT CAPITAL COST	83,400.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	5,000.00
Engineering Services (10% Total Direct Capital Cost) (9)	8,300.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	4,600.00
Health and Safety (3% Total Direct Capital Cost)	2,500.00
Legal (3% Total Direct Capital Cost)	2,500.00
TOTAL INDIRECT CAPITAL COST	22,900.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	106,300.00

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "A"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(4) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(5) Cost for sludge holding tank based on estimated sludge generation of approximately 200 gallons per week (from oil/water separator) allowing approximately 5 - 6 weeks storage capacity (1,000 gallon tank).

(6) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(7) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 5 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(8) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(9) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "A"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Oil/Water Separation System Pumps)	500.00
Treatment	
Air stripper blower, transfer pump	3,300.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (polymer) (2)	1,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	180.00
Sludge Disposal ($500/pick-up-disposal,9 pick-ups per year) (4)	4,500.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	2,800.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	5,500.00
Administration (20% labor/25% materials)	7,500.00
Total Operation & Maintenance	60,000.00

O&M COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blower, and pumps assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for and polymers based on estimate of one 55gal drum per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 0.6 lb/day, for "low" organic stream (<.2 ppm) at 5 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 4 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 160 gallons per week sludge (from oil/water separator) Sludge will be transferred to a 1,000 gallon holding tank, which will provide approximately 5 - 6 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every six weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $210 per sample for TCL VOCs.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 4 hours

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "A"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:
Flow = 15 gpm
Contaminants of Concern = VOCs, Oil & Grease

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	22,175.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (3)	9,800.00
Effluent Transfer Pumps/Level Controls/Motor Starter (3)	2,000.00
Secondary Treatment (Carbon Polishing)	
Carbon Adsorbers (1000# units) (4)	10,000.00
Backwash System (5)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator Sludge) (6)	5,500.00
Purchased Equipment (Subtotal)	71,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (7)	7,000.00
Electrical (10% purchased equipment cost) (7)	7,000.00
Instrumentation (5% purchased equipment cost) (7)	4,000.00
Installation (assume 40 % purchased equipment cost) (7)	28,000.00
Treatment Building (20' X 20' @ $50/SF) (8)	20,000.00
Subtotal Direct Capital Cost	137,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (9)	27,400.00
TOTAL DIRECT CAPITAL COST	164,400.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	9,900.00
Engineering Services (10% Total Direct Capital Cost) (10)	16,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	9,000.00
Health and Safety (3% Total Direct Capital Cost)	5,000.00
Legal (3% Total Direct Capital Cost)	5,000.00
TOTAL INDIRECT CAPITAL COST	44,900.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	209,300.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "A"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(4) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(5) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(6) Cost for sludge holding tank based on estimated sludge generation of approximately 560 gallons per week (from oil/water separator). Thus, approximately 3 weeks storage capacity provided (1,500 gallon tank).

(7) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(8) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(9) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(10) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "A"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Oil/Water Separation System Pumps)	600.00
Treatment	
Air stripper blower, transfer pump	4,200.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (polymer) (2)	1,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	480.00
Sludge Disposal ($500/pick-up-disposal,17 pick-ups per year) (4)	6,500.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	2,800.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	5,460.00
Administration (20% labor/25% materials)	7,500.00
Total Operation & Maintenance	63,000.00

O&M COST COMPONENT ASSUMPTIONS

(1) Electricity costs based on estimated rated horsepower of air stripper blower and pumps assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for polymers based on estimate of one 55gal drum each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 1.8 lb/day, for "low" organic stream (<.2 ppm) at 15 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 1.5 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 560 gallons per week sludge (from oil/water separator) Sludge will be transferred to a 1,500 gallon holding tank, which will provide approximately 3 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 3 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $210 per sample for TCL VOCs.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 4 hours

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

Basis:

Flow = 15 gpm

Contaminants of Concern = Metals, Oil & Grease

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Primary Treatment Equipment (1)	
Oil/Water Separator System (2)	22,175.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	29,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (4)	5,500.00
Purchased Equipment (Subtotal)	57,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (5)	6,000.00
Electrical (10% purchased equipment cost) (5)	6,000.00
Instrumentation (5% purchased equipment cost) (5)	3,000.00
Installation (assume 40 % purchased equipment cost) (5)	23,000.00
Treatment Building (20' X 20' @ $50/SF) (6)	20,000.00
Subtotal Direct Capital Cost	115,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (7)	23,000.00
TOTAL DIRECT CAPITAL COST	138,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	8,300.00
Engineering Services (10% Total Direct Capital Cost) (8)	14,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	8,000.00
Health and Safety (3% Total Direct Capital Cost)	4,000.00
Legal (3% Total Direct Capital Cost)	4,000.00
TOTAL INDIRECT CAPITAL COST	38,300.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	176,300.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Primary treatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Cost for sludge holding tank based on estimated sludge generation of approximately 700 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 2 weeks storage capacity (1,500 gallon tank).

(5) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(6) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(7) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(8) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Primary Treatment (Mixers,Pumps)	2,000.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (pH chemicals, polymer) (2)	5,000.00
Material Handling	
Sludge Disposal ($500/pick-up-disposal,26 pick-ups per year) (3)	13,000.00
Operating Labor (4)	30,000.00
Maintenance Labor (4)	5,600.00
Sampling Labor (4)	3,000.00
Analytical (Samples) (4)	7,150.00
Administration (20% labor/25% materials)	9,000.00
Total Operation & Maintenance	76,000.00

O&M COST COMPONENT ASSUMPTIONS

(1) Electricity costs based on estimated rated horsepower of pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of four 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Cost for sludge disposal based on estimated generation of 700 gallons per week sludge (from oil/water separator and sedimentation/ clarification). Sludge will be transferred to a 1,500 gallon holding tank, which will provide approximately 2 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 2 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(4) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.

Sampling labor assumes 8 hours per month, at $29.10 per hour.

Analytical sampling costs based on 26 samples per year, @ $275 per sample for TCL Inorganics.

(Cost per sample based on Wadsworth Alert Fee Schedule).

Maintenance labor assumes heavy maintenance required once per month for 8 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

Basis:

Flow = 25 gpm

Contaminants of Concern = Metals, Oil&Grease

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Primary Treatment Equipment (1)	
Oil/Water Separator System (2)	24,875.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (4)	6,500.00
Purchased Equipment (Subtotal)	71,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (5)	7,000.00
Electrical (10% purchased equipment cost) (5)	7,000.00
Instrumentation (5% purchased equipment cost) (5)	4,000.00
Installation (assume 40 % purchased equipment cost) (5)	28,000.00
Treatment Building (20' X 20' @ $50/SF) (6)	20,000.00
Subtotal Direct Capital Cost	137,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (7)	27,000.00
TOTAL DIRECT CAPITAL COST	164,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	10,000.00
Engineering Services (10% Total Direct Capital Cost) (8)	16,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	9,000.00
Health and Safety (3% Total Direct Capital Cost)	5,000.00
Legal (3% Total Direct Capital Cost)	5,000.00
TOTAL INDIRECT CAPITAL COST	45,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	209,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Primary treatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Cost for sludge holding tank based on estimated sludge generation of approximately 1200 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 1.5 weeks storage capacity (2,000 gallon tank).

(5) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(6) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 25 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(7) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(8) Engineering services includes site assesments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "B"

PRIMARY TREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Primary Treatment (Mixers,Pumps)	2,000.00
Treatment	
Building Operation (Power, lights, etc...)	1,200.00
Materials (pH chemicals, polymer) (2)	8,200.00
Material Handling	
Sludge Disposal ($500/pick-up-disposal,36 pick-ups per year) (3)	18,000.00
Operating Labor (4)	30,000.00
Maintenance Labor (4)	5,600.00
Sampling Labor (4)	3,000.00
Analytical (Samples) (4)	7,150.00
Administration (20% labor/25% materials)	9,800.00
Total Operation & Maintenance	85,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of six 55gal drums per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Cost for sludge disposal based on estimated generation of 1200 gallons per week sludge (from oil/water separator and sedimentation/ clarification). Sludge will be transferred to a 2,000 gallon holding tank, which will provide approximately 1.5 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately 3 times per month, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(4) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $275 per sample for TCL Inorganics.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 16 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "C"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 15 gpm

Contaminants of Concern = SVOCs, Oil & Grease, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	22,175.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	29,000.00
Primary Treatment Equipment	
Carbon Adsorbers (1000# units) (4)	10,000.00
Backwash System (5)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (6)	5,500.00
Purchased Equipment (Subtotal)	89,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (7)	9,000.00
Electrical (10% purchased equipment cost) (7)	9,000.00
Instrumentation (5% purchased equipment cost) (7)	4,000.00
Installation (assume 40 % purchased equipment cost) (7)	36,000.00
Treatment Building (20' X 20' @ $50/SF) (8)	20,000.00
Subtotal Direct Capital Cost	167,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (9)	33,400.00
TOTAL DIRECT CAPITAL COST	200,400.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	12,000.00
Engineering Services (10% Total Direct Capital Cost) (10)	20,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	11,000.00
Health and Safety (3% Total Direct Capital Cost)	6,000.00
Legal (3% Total Direct Capital Cost)	6,000.00
TOTAL INDIRECT CAPITAL COST	55,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	255,400.00

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "C"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that SVOCs and pesticides are present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(5) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(6) Cost for sludge holding tank based on estimated sludge generation of approximately 700 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 2 weeks storage capacity (1,500 gallon tank).

(7) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(8) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(9) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(10) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "C"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,000.00
Treatment	
Primary Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (pH chemicals, polymer) (2)	5,000.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	480.00
Sludge Disposal ($500/pick-up-disposal,26 pick-ups per year) (4)	13,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	8,400.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	23,400.00
Administration (20% labor/25% materials)	9,500.00
Total Operation & Maintenance	96,000.00

O&M COST COMPONENT ASSUMPTIONS

(1) Electricity costs based on estimated rated horsepower of pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of four 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 1.8 lb/day, for "low" organic stream (<.2 ppm) at 15 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 1.5 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 700 gallons per week sludge (from oil/water separator and sedimentation/clarification). Sludge will be transferred to a 1,500 gallon holding tank, which will provide approximately 2 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 2 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $900 per sample for TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 12 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "C"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 25 gpm

Contaminants of Concern = SVOCs, Oil&Grease, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	24,875.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Primary Treatment Equipment	
Carbon Adsorbers (2000# units) (4)	15,000.00
Backwash System (5)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (6)	6,500.00
Purchased Equipment (Subtotal)	108,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (7)	11,000.00
Electrical (10% purchased equipment cost) (7)	11,000.00
Instrumentation (5% purchased equipment cost) (7)	5,000.00
Installation (assume 40 % purchased equipment cost) (7)	43,000.00
Treatment Building (30' X 30' @ $50/SF) (8)	45,000.00
Subtotal Direct Capital Cost	223,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (9)	45,000.00
TOTAL DIRECT CAPITAL COST	268,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	16,000.00
Engineering Services (10% Total Direct Capital Cost) (10)	27,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	15,000.00
Health and Safety (3% Total Direct Capital Cost)	8,000.00
Legal (3% Total Direct Capital Cost)	8,000.00
TOTAL INDIRECT CAPITAL COST	74,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	342,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "C"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Equipment consists of (2) 2000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that SVOCs and pesticides are present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 2000 pound carbon units in series.

(5) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(6) Cost for sludge holding tank based on estimated sludge generation of approximately 1200 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 1.5 weeks storage capacity (2,000 gallon tank).

(7) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(8) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately \$50 per square foot of building. For a 25 gpm system, assume a treatment building of 30' X 30', approx. 900 SF, @ \$50/SF.

(9) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(10) Engineering services includes site assesments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "C"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,000.00
Primary Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,000.00
Materials (pH chemicals, polymer) (2)	8,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	800.00
Sludge Disposal ($500/pick-up-disposal,36 pick-ups per year) (4)	18,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	11,200.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	23,400.00
Administration (20% labor/25% materials)	10,900.00
Total Operation & Maintenance	110,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $150/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of six 55gal drums per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 3.0 lb/day, for "low" organic stream (<.2 ppm) at 25 gpm. Based on this estimate, and 2,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 1200 gallons per week sludge (from oil/water separator and sedimentation/clarification). Sludge will be transferred to a 2,000 gallon holding tank, which will provide approximately 1.5 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately 3 times per month, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $900 per sample for TCL SVOCs, TCL Pesticides, and TCL Inorganics.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 16 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "C"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:
Flow = 50 gpm
Contaminants of Concern = SVOCs, Oil&Grease, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	26,600.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	61,000.00
Primary Treatment Equipment	
Carbon Adsorbers (10000# units) (4)	90,000.00
Backwash System (5)	27,600.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (6)	8,300.00
Purchased Equipment (Subtotal)	214,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (7)	21,000.00
Electrical (10% purchased equipment cost) (7)	21,000.00
Instrumentation (5% purchased equipment cost) (7)	11,000.00
Installation (assume 40 % purchased equipment cost) (7)	86,000.00
Treatment Building (40' X 40' @ $50/SF) (8)	80,000.00
Subtotal Direct Capital Cost	433,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (9)	87,000.00
TOTAL DIRECT CAPITAL COST	520,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	31,000.00
Engineering Services (10% Total Direct Capital Cost) (10)	52,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	29,000.00
Health and Safety (3% Total Direct Capital Cost)	16,000.00
Legal (3% Total Direct Capital Cost)	16,000.00
TOTAL INDIRECT CAPITAL COST	144,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	664,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "C"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Equipment consists of (2) 10000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that SVOCs and pesticides are assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 10000 pound carbon units in series.

(5) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(6) Cost for sludge holding tank based on estimated sludge generation of approximately 2300 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 1.3 weeks storage capacity (3,000 gallon tank).

(7) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(8) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 50 gpm system, assume a treatment building of 40' X 40', approx. 1600 SF, @ $50/SF.

(9) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(10) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "C"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,380.00
Primary Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,000.00
Materials (pH chemicals, polymer) (2)	8,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	2,000.00
Sludge Disposal ($500/pick-up-disposal,36 pick-ups per year) (4)	18,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	11,200.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	23,400.00
Administration (20% labor/25% materials)	10,900.00
Total Operation & Maintenance	111,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $150/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of six 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 6.0 lb/day, for "low" organic stream (<.2 ppm) at 50 gpm. Based on this estimate, and 10,000 lb carbon unit, carbon would be anticipated to last for almost a 4 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 2300 gallons per week sludge (from oil/water separator and sedimentation/clarification). Sludge will be transferred to a 3,000 gallon holding tank, which will provide approximately 1.3 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately 3 times per month, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $900 per sample for TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 16 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL,

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 5 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	6,500.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	15,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (4)	7,400.00
Effluent Transfer Pumps/Level Controls/Motor Starter (4)	2,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (1000# units) (5)	10,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (6)	4,300.00
Purchased Equipment (Subtotal)	45,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (7)	5,000.00
Electrical (10% purchased equipment cost) (7)	5,000.00
Instrumentation (5% purchased equipment cost) (7)	2,000.00
Installation (assume 40 % purchased equipment cost) (7)	18,000.00
Treatment Building (20' X 20' @ $50/SF) (8)	20,000.00
Subtotal Direct Capital Cost	95,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (9)	19,000.00
TOTAL DIRECT CAPITAL COST	114,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	6,800.00
Engineering Services (10% Total Direct Capital Cost) (10)	11,400.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	6,300.00
Health and Safety (3% Total Direct Capital Cost)	3,400.00
Legal (3% Total Direct Capital Cost)	3,400.00
TOTAL INDIRECT CAPITAL COST	31,300.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	145,300.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL,
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(6) Cost for sludge holding tank based on estimated sludge generation of approximately 200 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 4 weeks storage capacity (1,000 gallon tank).

(7) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(8) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately \$50 per square foot of building. For a 5 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ \$50/SF.

(9) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(10) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Cost for sludge holding tank based on estimated sludge generation of approximately 700 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 2 weeks storage capacity (1,500 gallon tank).

(8) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(9) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 30' X 30', approx. 900 SF, @ $50/SF.

(10) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(11) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL,
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,000.00
Treatment	
Air stripper blower, transfer pump	3,300.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (pH chemicals, polymer) (2)	5,000.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	180.00
Sludge Disposal ($500/pick-up-disposal,13 pick-ups per year) (4)	6,500.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	6,000.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	9,000.00
Total Operation & Maintenance	95,000.00

O&M COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blower, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of four 55gal drums per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 0.6 lb/day, for "low" organic stream (<.2 ppm) at 5 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 4 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 200 gallons per week sludge (from oil/water separator and sedimentation/ clarification). Sludge will be transferred to a 1,000 gallon holding tank, which will provide approximately 4 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every four weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 8 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 15 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	22,175.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	29,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (4)	9,800.00
Effluent Transfer Pumps/Level Controls/Motor Starter (4)	2,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (1000# units) (5)	10,000.00
Backwash System (6)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (7)	5,500.00
Purchased Equipment (Subtotal)	100,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (8)	10,000.00
Electrical (10% purchased equipment cost) (8)	10,000.00
Instrumentation (5% purchased equipment cost) (8)	5,000.00
Installation (assume 40 % purchased equipment cost) (8)	40,000.00
Treatment Building (30' X 30' @ $50/SF) (9)	45,000.00
Subtotal Direct Capital Cost	210,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (10)	42,000.00
TOTAL DIRECT CAPITAL COST	252,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	15,100.00
Engineering Services (10% Total Direct Capital Cost) (11)	25,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	14,000.00
Health and Safety (3% Total Direct Capital Cost)	8,000.00
Legal (3% Total Direct Capital Cost)	8,000.00
TOTAL INDIRECT CAPITAL COST	70,100.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	322,100.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Cost for sludge holding tank based on estimated sludge generation of approximately 700 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 2 weeks storage capacity (1,500 gallon tank).

(8) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(9) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 30' X 30', approx. 900 SF, @ $50/SF.

(10) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(11) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,000.00
Treatment	
Air stripper blower, transfer pump	4,200.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,000.00
Materials (pH chemicals, polymer) (2)	5,000.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	480.00
Sludge Disposal ($500/pick-up-disposal,26 pick-ups per year) (4)	13,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	8,400.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	9,530.00
Total Operation & Maintenance	107,000.00

O&M COST COMPONENT ASSUMPTIONS

(1) Electricity costs based on estimated rated horsepower of air stripper blower, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $150/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of four 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 1.8 lb/day, for "low" organic stream (<.2 ppm) at 15 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 1.5 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 700 gallons per week sludge (from oil/water separator and sedimentation/ clarification). Sludge will be transferred to a 1,500 gallon holding tank, which will provide approximately 2 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 2 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.

Sampling labor assumes 8 hours per month, at $29.10 per hour.

Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).

Maintenance labor assumes heavy maintenance required once per month for 12 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 25 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	24,875.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	40,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Unit (4)	11,300.00
Effluent Transfer Pumps/Level Controls/Motor Starter (4)	2,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (2000# units) (5)	15,000.00
Backwash System (6)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (7)	6,500.00
Purchased Equipment (Subtotal)	122,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (8)	12,000.00
Electrical (10% purchased equipment cost) (8)	12,000.00
Instrumentation (5% purchased equipment cost) (8)	6,000.00
Installation (assume 40 % purchased equipment cost) (8)	49,000.00
Treatment Building (30' X 30' @ $50/SF) (9)	45,000.00
Subtotal Direct Capital Cost	246,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (10)	49,000.00
TOTAL DIRECT CAPITAL COST	295,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	18,000.00
Engineering Services (10% Total Direct Capital Cost) (11)	30,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	16,000.00
Health and Safety (3% Total Direct Capital Cost)	9,000.00
Legal (3% Total Direct Capital Cost)	9,000.00
TOTAL INDIRECT CAPITAL COST	82,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	377,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 1 low-profile air stripping unit, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 2000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 2000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Cost for sludge holding tank based on estimated sludge generation of approximately 1200 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 1.5 weeks storage capacity (2,000 gallon tank).

(8) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(9) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 25 gpm system, assume a treatment building of 30' X 30', approx. 900 SF, @ $50/SF.

(10) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(11) Engineering services includes site assesments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,000.00
Treatment	
Air stripper blower, transfer pump	4,200.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,000.00
Materials (pH chemicals, polymer) (2)	8,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	800.00
Sludge Disposal ($500/pick-up-disposal,36 pick-ups per year) (4)	18,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	11,200.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	10,100.00
Total Operation & Maintenance	119,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blower, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $150/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of six 55gal drums per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 3.0 lb/day, for "low" organic stream (<.2 ppm) at 25 gpm. Based on this estimate, and 2,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 1200 gallons per week sludge (from oil/water separator and sedimentation/ clarification). Sludge will be transferred to a 2,000 gallon holding tank, which will provide approximately 1.5 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately 3 times per month, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 16 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 50 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	26,600.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	61,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Units (4)	20,000.00
Effluent Transfer Pumps/Level Controls/Motor Starters (4)	4,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (10000# units) (5)	90,000.00
Backwash System (6)	27,600.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (7)	8,300.00
Purchased Equipment (Subtotal)	238,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (8)	24,000.00
Electrical (10% purchased equipment cost) (8)	24,000.00
Instrumentation (5% purchased equipment cost) (8)	12,000.00
Installation (assume 40 % purchased equipment cost) (8)	95,000.00
Treatment Building (40' X 40' @ $50/SF) (9)	80,000.00
Subtotal Direct Capital Cost	473,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (10)	95,000.00
TOTAL DIRECT CAPITAL COST	568,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	34,000.00
Engineering Services (10% Total Direct Capital Cost) (11)	57,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	31,000.00
Health and Safety (3% Total Direct Capital Cost)	17,000.00
Legal (3% Total Direct Capital Cost)	17,000.00
TOTAL INDIRECT CAPITAL COST	156,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	724,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 2 low-profile air stripping units in series, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 10000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 10000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Cost for sludge holding tank based on estimated sludge generation of approximately 2300 gallons per week (combined from oil/water separator and sedimentation/clarification), allowing approximately 1.3 weeks storage capacity (3,000 gallon tank).

(8) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(9) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 50 gpm system, assume a treatment building of 40' X 40', approx. 1600 SF, @ $50/SF.

(10) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(11) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	2,380.00
Treatment	
Air stripper blower, transfer pump	6,600.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,000.00
Materials (pH chemicals, polymer) (2)	8,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	2,000.00
Sludge Disposal ($500/pick-up-disposal,36 pick-ups per year) (4)	18,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	11,200.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	10,100.00
Total Operation & Maintenance	123,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blowers, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $150/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of six 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 6.0 lb/day, for "low" organic stream (<.2 ppm) at 50 gpm. Based on this estimate, and 10,000 lb carbon unit, carbon would be anticipated to last for almost a 4 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 2300 gallons per week sludge (from oil/water separator and sedimentation/clarification). Sludge will be transferred to a 3,000 gallon holding tank, which will provide approximately 1.3 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately 3 times per month, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 16 hours (including sludge pump out, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 100 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	29,950.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	92,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Units (4)	30,000.00
Effluent Transfer Pumps/Level Controls/Motor Starters (4)	4,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (10000# units) (5)	90,000.00
Backwash System (6)	27,600.00
Miscellaneous	
Sludge Dewatering Press and Air Operated Press Feed Pump (7)	24,500.00
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (8)	8,000.00
Purchased Equipment (Subtotal)	306,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (9)	31,000.00
Electrical (10% purchased equipment cost) (9)	31,000.00
Instrumentation (5% purchased equipment cost) (9)	15,000.00
Installation (assume 40 % purchased equipment cost) (9)	122,000.00
Treatment Building (60' X 40' @ $50/SF) (10)	120,000.00
Subtotal Direct Capital Cost	625,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (11)	125,000.00
TOTAL DIRECT CAPITAL COST	750,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	45,000.00
Engineering Services (10% Total Direct Capital Cost) (12)	75,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	41,000.00
Health and Safety (3% Total Direct Capital Cost)	23,000.00
Legal (3% Total Direct Capital Cost)	23,000.00
TOTAL INDIRECT CAPITAL COST	207,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	957,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 2 low-profile air stripping units in series, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 10000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 10000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Capital cost included for on-site sludge dewatering equipment because quantity estimated would justify on-site dewatering as opposed to off-site haul and disposal. Capital cost for a dewatering press and air operated sludge pump is based on cost for HPIA operable unit groundwter treatment system design (80 gpm and 60 mg/L TSS, influent).

(8) Cost for sludge holding tank based on estimated sludge generation of approximately 4800 gallons per week (combined from oil/water separator and sedimentation/clarification). Tank sized for 2500 gallons, which would require 2 press runs per week.

(9) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(10) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 100 gpm system, assume a treatment building of 60' X 40', approx. 2400 SF, @ $50/SF.

(11) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(12) Engineering services includes site assessments, treatability studies, etc...

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	3,300.00
Treatment	
Air stripper blower, transfer pump	8,400.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,400.00
Materials (pH chemicals, polymer) (2)	16,400.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	4,000.00
Sludge Disposal (assume $100/ton) (4)	7,300.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	8,400.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	12,400.00
Total Operation & Maintenance	125,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blowers, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $200/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of twelve 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 12.0 lb/day, for "low" organic stream (<.2 ppm) at 100 gpm. Based on this estimate, and 10,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Sludge disposal costs based on estimated sludge filter cake production of 73 ton/year, at a hazardous waste landfill, at $100/ton.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required 12 hours per month (including sludge dewatering runs, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:

Flow = 150 gpm

Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	36,750.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	117,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Units (4)	45,000.00
Effluent Transfer Pumps/Level Controls/Motor Starters (4)	6,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (20000# units) (5)	130,000.00
Backwash System (6)	27,600.00
Miscellaneous	
Sludge Dewatering Press and Air Operated Press Feed Pump (7)	24,500.00
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (8)	8,000.00
Purchased Equipment (Subtotal)	395,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (9)	40,000.00
Electrical (10% purchased equipment cost) (9)	40,000.00
Instrumentation (5% purchased equipment cost) (9)	20,000.00
Installation (assume 40 % purchased equipment cost) (9)	158,000.00
Treatment Building (60' X 60' @ $50/SF) (10)	180,000.00
Subtotal Direct Capital Cost	833,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (11)	167,000.00
TOTAL DIRECT CAPITAL COST	1,000,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	60,000.00
Engineering Services (10% Total Direct Capital Cost) (12)	100,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	55,000.00
Health and Safety (3% Total Direct Capital Cost)	30,000.00
Legal (3% Total Direct Capital Cost)	30,000.00
TOTAL INDIRECT CAPITAL COST	275,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	1,275,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost indeces for applicable years where necessary.

(4) Costs based on 3 low-profile air stripping units in series, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 20000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 20000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(7) Capital cost included for on-site sludge dewatering equipment because quantity estimated would justify on-site dewatering as opposed to off-site haul and disposal. Capital cost for a dewatering press and air operated sludge pump is based on cost for HPIA operable unit groundwter treatment system design (80 gpm and 60 mg/L TSS, influent).

(8) Cost for sludge holding tank based on estimated sludge generation of approximately 7000 gallons per week (combined from oil/water separator and sedimentation/clarification). Tank sized for 2500 gallons, which would require 3 press runs per week.

(9) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(10) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 150 gpm system, assume a treatment building of 60' X 60', approx. 3600 SF, @ $50/SF.

(11) Construction Contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(12) Engineering services includes site assessments, treatability studies, etc..

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	4,430.00
Treatment	
Air stripper blower, transfer pump	12,600.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,400.00
Materials (pH chemicals, polymer) (2)	16,400.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	5,100.00
Sludge Disposal (assume $100/ton) (4)	11,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	11,200.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	12,940.00
Total Operation & Maintenance	138,000.00

OPERATION & MAINTENANCE COST COMPONENT ASSUMPTIONS:

(1) Electricity costs based on estimated rated horsepower of air stripper blowers, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $200/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of twelve 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 18.0 lb/day, for "low" organic stream (<.2 ppm) at 150 gpm. Based on this estimate, and 20,000 lb carbon unit, carbon would be anticipated to last for almost a 3 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Sludge disposal costs based on estimated sludge filter cake production of 110 ton/year, at a hazardous waste landfill, at $100/ton.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required 16 hours per month (including sludge dewatering runs, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:
Flow = 200 gpm
Contaminants of Concern = VOCs, SVOCs, Metals, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	41,500.00
pH Adjustment/Polymer Addition-Flocculation/Sedimentation (Metals Removal) (3)	139,000.00
Primary Treatment Equipment (VOCs)	
Low Profile Air Stripping Units (4)	60,000.00
Effluent Transfer Pumps/Level Controls/Motor Starters (4)	8,000.00
Secondary Treatment (SVOCs, Pesticides Adsorption)	
Carbon Adsorbers (20000# units) (5)	130,000.00
Backwash System (6)	27,600.00
Miscellaneous	
Sludge Dewatering Press and Air Operated Press Feed Pump (7)	24,500.00
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (8)	8,300.00
Purchased Equipment (Subtotal)	439,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (9)	44,000.00
Electrical (10% purchased equipment cost) (9)	44,000.00
Instrumentation (5% purchased equipment cost) (9)	22,000.00
Installation (assume 40 % purchased equipment cost) (9)	176,000.00
Treatment Building (60' X 60' @ $50/SF) (10)	180,000.00
Subtotal Direct Capital Cost	905,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (11)	181,000.00
TOTAL DIRECT CAPITAL COST	1,086,000.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	65,000.00
Engineering Services (10% Total Direct Capital Cost)	109,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	60,000.00
Health and Safety (3% Total Direct Capital Cost)	33,000.00
Legal (3% Total Direct Capital Cost)	33,000.00
TOTAL INDIRECT CAPITAL COST	300,000.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	1,386,000.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "D"
PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL
PRIMARY TREATMENT WITH AIR STRIPPING
AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease; precipitation (pH Adjustment) to precipitate metals (2 stage); coagulation/flocculation (addition of polymer to create particle flocs, assist settling characteristics; and sedimentation/clarification for settling of suspended solids.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of two-stage pH adjustment (2 tanks, mixers, pH chemical metering pumps, pH control module); addition of polymer to enhance coagulation/flocculation (mix tank with mixer, polymer make-up tank, mixer, and polymer feed pump). Costs based on unit costs obtained for Presque Isle Groundwater Treatment System, some adjusted for capacity difference using Six-Tenths Factor Rule and ratio of cost Indeces for applicable years where necessary.

(4) Costs based on 4 low-profile air stripping units in series, includes blower, trays, lid with exhaust connection and demister, and integral effluent sump base. Also includes options for effluent transfer pump and controls. Cost not included for equipment to treat vapor phase air emissions. Existing groundwater pump and treat system at Hadnot Point Industrial Area does not have air emission treatment equipment (i.e. direct discharge to atmosphere from air stripper). Addition of air emission treatment equipment would add significant cost to the overall capital cost of the system.

(5) Equipment consists of (2) 20000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that air stripper will remove majority of high concentration VOCs, lower concentration SVOCs, pesticides assumed to be present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 20000 pound carbon units in series.

(6) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).
off-site haul and disposal. Capital cost for a dewatering press and air operated sludge pump is based on cost for HPIA operable unit groundwter treatment system design (80 gpm and 60 mg/L TSS, influent).

(8) Cost for sludge holding tank based on estimated sludge generation of approximately 9100 gallons per week (combined from oil/water separator and sedimentation/clarification). Tank sized for 3000 gallons, which would require 3 press runs per week.

(9) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(10) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 200 gpm system, assume a treatment building of 60' X 60', approx. 3600 SF, @ $50/SF.

(11) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(12) Engineering services includes site assessments, treatability studies, etc....

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE

SCENARIO "D"

PRETREATMENT WITH OIL/WATER SEPARATION AND METALS REMOVAL

PRIMARY TREATMENT WITH AIR STRIPPING

AND SECONDARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Mixers,Pumps)	4,430.00
Treatment	
Air stripper blower, transfer pump	16,760.00
Post Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	2,400.00
Materials (pH chemicals, polymer) (2)	16,400.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	7,700.00
Sludge Disposal (assume $100/ton) (4)	13,100.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	8,400.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	29,000.00
Administration (20% labor/25% materials)	12,400.00
Total Operation & Maintenance	144,000.00

(1) Electricity costs based on estimated rated horsepower of air stripper blowers, pumps and mixers assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $200/month, 12 months/year.

(2) Material costs for pH adjustment chemicals and polymers based on estimate of twelve 55gal drums each per year (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Costs based on estimates from previous feasibility study for chemicals, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 24.0 lb/day, for "low" organic stream (<.2 ppm) at 200 gpm. Based on this estimate, and 20,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Sludge disposal costs based on estimated sludge filter cake production of 131 ton/year, at a hazardous waste landfill, at $100/ton.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $1,110 per sample for TCL VOCs, TCL SVOCs, TCL Pesticides, and TCL Inorganics. (Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required 12 hours per month (including sludge dewatering runs, etc...)

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:
Flow = 15 gpm
Contaminants of Concern = Oil & Grease, SVOCs, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	22,175.00
Primary Treatment Equipment	
Carbon Adsorbers (1000# units) (3)	10,000.00
Backwash System (4)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (5)	5,500.00
Purchased Equipment (Subtotal)	60,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (6)	6,000.00
Electrical (10% purchased equipment cost) (6)	6,000.00
Instrumentation (5% purchased equipment cost) (6)	3,000.00
Installation (assume 40 % purchased equipment cost) (6)	24,000.00
Treatment Building (20' X 20' @ $50/SF) (7)	20,000.00
Subtotal Direct Capital Cost	119,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (8)	23,800.00
TOTAL DIRECT CAPITAL COST	142,800.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	8,600.00
Engineering Services (10% Total Direct Capital Cost) (9)	14,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	8,000.00
Health and Safety (3% Total Direct Capital Cost)	4,000.00
Legal (3% Total Direct Capital Cost)	4,000.00
TOTAL INDIRECT CAPITAL COST	38,600.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	181,400.00

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

Basis:
Flow = 25 gpm
Contaminants of Concern = Oil & Grease, SVOCs, Pesticides

CAPITAL COST COMPONENT	ESTIMATED COST ($)
DIRECT CAPITAL COSTS	
Pretreatment Equipment (1)	
Oil/Water Separator System (2)	24,875.00
Primary Treatment Equipment	
Carbon Adsorbers (2000# units) (3)	15,000.00
Backwash System (4)	22,000.00
Miscellaneous	
Sludge Holding Tank (Oil/Water Separator and Sedimentation/Clarification Sludge) (5)	6,500.00
Purchased Equipment (Subtotal)	68,000.00
Treatment System Miscellaneous Capital Costs	
Piping (10% purchased equipment cost) (6)	7,000.00
Electrical (10% purchased equipment cost) (6)	7,000.00
Instrumentation (5% purchased equipment cost) (6)	3,000.00
Installation (assume 40 % purchased equipment cost) (6)	27,000.00
Treatment Building (20' X 20' @ $50/SF) (7)	20,000.00
Subtotal Direct Capital Cost	132,000.00
Construction Contingency (20% Subtotal Direct Capital Cost) (8)	26,400.00
TOTAL DIRECT CAPITAL COST	158,400.00
INDIRECT CAPITAL COSTS	
Design Services (6% Total Direct Capital Cost)	9,500.00
Engineering Services (10% Total Direct Capital Cost) (9)	16,000.00
Supervision, Inspection & Overhead (5.5% Total Direct Capital Cost)	9,000.00
Health and Safety (3% Total Direct Capital Cost)	5,000.00
Legal (3% Total Direct Capital Cost)	5,000.00
TOTAL INDIRECT CAPITAL COST	44,500.00
TOTAL CAPITAL COST (TREATMENT SYSTEM ONLY)	202,900.00

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of (2) 2000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that SVOCs and pesticides are present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 2000 pound carbon units in series.

(4) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(5) Cost for sludge holding tank based on estimated sludge generation of approximately 1000 gallons per week (from oil/water separator) A 2000 gallon tank will allow approximately 2 weeks storage capacity.

(6) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(7) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 25 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(8) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(9) Engineering services includes site assessments, treatability studies, etc...

APPENDIX D

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Oil/Water Separation System Pumps)	600.00
Treatment	
Primary Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (polymer) (2)	1,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	480.00
Sludge Disposal ($500/pick-up-disposal, 17 pick-ups per year) (4)	8,500.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	2,800.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	16,250.00
Administration (20% labor/25% materials)	7,500.00
Total Operation & Maintenance	72,000.00

O&M COST COMPONENT ASSUMPTIONS

(1) Electricity costs based on estimated rated horsepower of pumps assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material cost for polymer based on estimate of one 55gal drum per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Cost based on estimates from previous feasibility study for polymer, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 1.8 lb/day, for "low" organic stream (<.2 ppm) at 15 gpm. Based on this estimate, and 1,000 lb carbon unit, carbon would be anticipated to last for almost a 1.5 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 560 gallons per week sludge (from oil/water separator) Sludge will be transferred to a 1,500 gallon holding tank, which will provide approximately 3 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 3 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $625 per sample for TCL SVOCs and TCL Pesticides.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 4 hours (including sludge pump out, etc...)

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

CAPITAL COST COMPONENT ASSUMPTIONS:

(1) Pretreatment equipment consists of oil/water separation to remove oil & grease.

(2) This system includes a slant rib coalescing oil/water separator unit with dense pak for fine oil drop removal, oil pump out equipment, effluent pump out equipment, and sludge pump out equipment. Cost is based on a budgetary quote via phone conversation with Frank Timblin (F.H. Timblin - rep. for Great Lakes Environmental).

(3) Equipment consists of (2) 1000 pound carbon units operated in series with appropriate connections for influent feed, backwash, etc.. Unit size based on assumption that SVOCs and pesticides are present at "low" concentrations less than 0.2 ppm. For flow and this concentration, Encotech recommended (2) 1000 pound carbon units in series.

(4) Backwash system includes service tank (backwash water supply), backwash water collection tank, backwash sludge removal pump, and backwash water supply pump. Backwash capacity based on 15 GPM/SF for a 12 minute cycle. Costs based on costs developed for other similar groundwater treatment system designs (Presque Isle, JC Cleaners).

(5) Cost for sludge holding tank based on estimated sludge generation of approximately 560 gallons per week (from oil/water separator) A 1,500 gallon tank will allow approximately 3 weeks storage capacity.

(6) Costs estimated for piping, electrical, instrumentation, and installation based on estimated percentage of total purchased equipment cost. Percentages based on range of suggested values in "Peters & Timmerhaus - Plant Design and Economics for Chemical Engineers".

(7) Cost for treatment building based on costs developed for a similar project, where costs were developed including concrete, masonry, thermal and moisture protection, wood and plastics, doors, windows & glass, finishes, ventilation and electrical. Total cost for project divided by square footage of building design, equal to approximately $50 per square foot of building. For a 15 gpm system, assume a treatment building of 20' X 20', approx. 400 SF, @ $50/SF.

(8) Construction contingency estimated at 20% of subtotal direct capital costs, based on preliminary costs. MIL-HDBK-1010 uses a 5% contingency.

(9) Engineering services includes site assessments, treatability studies, etc...

CAPITAL AND OPERATION & MAINTENANCE COST ESTIMATE
SCENARIO "E"
PRETREATMENT WITH OIL/WATER SEPARATION
PRIMARY TREATMENT WITH LIQUID-PHASE CARBON ADSORPTION

OPERATION & MAINTENANCE COST COMPONENT	ESTIMATED COST ($/YEAR)
Electricity (1)	
Pretreatment (Oil/Water Separation System Pumps)	600.00
Treatment	
Primary Treatment (Backwash Pump)	100.00
Building Operation (Power, lights, etc...)	1,200.00
Materials (polymer) (2)	1,200.00
Material Handling	
Carbon Regeneration/Replacement (Post Treatment) (3)	800.00
Sludge Disposal ($500/pick-up-disposal, 26 pick-ups per year) (4)	13,000.00
Operating Labor (5)	30,000.00
Maintenance Labor (5)	2,800.00
Sampling Labor (5)	3,000.00
Analytical (Samples) (5)	16,250.00
Administration (20% labor/25% materials)	7,500.00
Total Operation & Maintenance	76,000.00

O&M COST COMPONENT ASSUMPTIONS

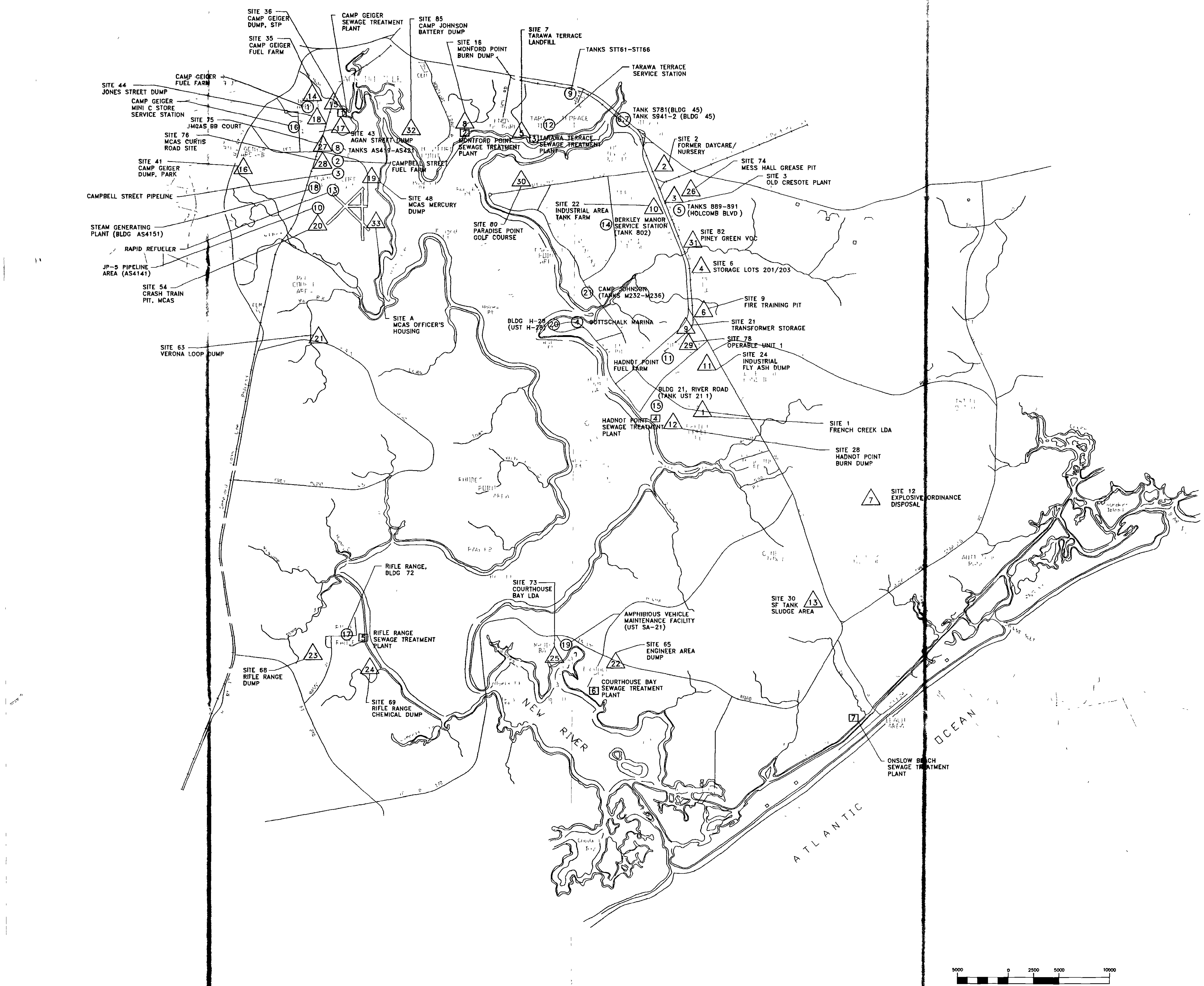
(1) Electricity costs based on estimated rated horsepower of pumps assuming 24 hour per day operation, 365 day per year at $0.0675/kw*hr. Building operation electrical costs based on assumption of $100/month, 12 months/year.

(2) Material cost for polymer based on estimate of one 55gal drum per year each (strictly an assumption at this point, since specific data is not available to calculate dosage requirements. Cost based on estimates from previous feasibility study for polymer, adjusted for year 1993.

(3) Carbon regeneration/replacement cost based on estimate provided by Encotech. Specifically, assume $.60/lb spent carbon (reactivation) and $.85/lb new carbon (for carbon lost during reactivation). Carbon exhaustion rate estimated by Encotech to be 3.0 lb/day, for "low" organic stream (<.2 ppm) at 25 gpm. Based on this estimate, and 2,000 lb carbon unit, carbon would be anticipated to last for almost a 2 year period. Ten and thirty year periods were assumed, and reactivation costs and replacement based on an average of changeouts required for these two time periods.

(4) Cost for sludge disposal based on estimated generation of 1000 gallons per week sludge (from oil/water separator) Sludge will be transferred to a 2000 gallon holding tank, which will provide approximately 2 weeks storage. Therefore, it is assumed that based on this low quantity, on-site dewatering would not be cost effective. This cost assumes that a vacuum truck will come to the site approximately every 2 weeks, to remove and dispose of sludge. The cost is estimated assuming a cost of $500 per pick-up/disposal.

(5) Operating Labor for plant assumes 4 hr/day, 260 day per year (excludes weekends), and $29.10 per hour.
Sampling labor assumes 8 hours per month, at $29.10 per hour.
Analytical sampling costs based on 26 samples per year, @ $625 per sample for TCL SVOCs and TCL Pesticides.
(Cost per sample based on Wadsworth Alert Fee Schedule).
Maintenance labor assumes heavy maintenance required once per month for 4 hours (including sludge pump out, etc...)



LEGEND

- INSTALLATION RESTORATION (IR) SITE
- UNDERGROUND STORAGE TANK (UST) SITE
- SEWAGE TREATMENT PLANT

DATE	DECEMBER 1993
SCALE	1" = 5000'
DRAWN	REL
REVIEWED	DPJ
SO #	19140-52-SRN
CADD #	140200DF

NORTH

EFFLUENT STUDY FOR INSTALLATION RESTORATION AND UNDERGROUND STORAGE TANKS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

INSTALLATION RESTORATION SITES AND UNDERGROUND STORAGE TANK SITES LOCATION MAP

SCALE 1" = 5000'

DATE DECEMBER 1993

FIGURE No

2