FINAL

FEASIBILITY STUDY
OPERABLE UNIT NO. 5, SITE 2

MARINE CORPS BASE,
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0174

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DEPARTMENT OF THE NAVY
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LIST OF ACRONYMS AND ABBREVIATIONS

AQUIRE	Aquatic Retrieval Database
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Federal Ambient Water Quality Criteria
B	Represents that the value is above the instrument detection limit but is below the contract required quantitation limit
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
BI	Biotic Index
BH	Bear Head Creek
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Contaminant of Concern
COPCs	Contaminants of Potential Concern
CRDL	Contract Required Detection Limit
CTO	Contract Task Order
DEM	NC DEHNR Division of Environmental Management
DoN	U.S. Department of the Navy
DQO	Data Quality Objectives
EPA	United States Environmental Protection Agency
EPIC	USEPA Environmental Photographic Interpretation Center
ER-L	EPA Region IV Sediment Screening Value, Effects-Range-Low
ER-M	EPA Region IV Sediment Screening Value, Effects Range-Median
ERA	Ecological Risk Assessment
ESE	Environmental Science and Engineering, Inc.
FFA	Federal Facilities Agreement
FWS	U.S. Fish and Wildlife Service
H'	Species Diversity Coefficient
HI	Hazard Index
HQW	High Quality Water
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
IDL	Instrument Detection Limit
IDW	Investigative Derived Wastes
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
J	Represents that the value is estimated, either for a tentatively identified compound or when a compound is present but the value is below the contract required quantitation limit
JB	Represents that the value is estimated below the contract required detection limit, but greater than the instrument detection limit

K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LANTDIV	Atlantic Division
LOAEL	Lowest Observed Adverse Effect Level
MBI	Macroinvertebrate Biotic Index
MCB	Marine Corps Base
MDG	million gallons per day
mg/L	milligrams per liter
mg/kg	milligram per kilogram
msl	mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NSCRF	National Study of Chemical Residues in Fish
NWI	National Wetlands Inventory
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PC	Pettiford Creek
PCB	polychlorinated biphenyls
PID	photoionization detector
ppt	parts per thousand
QA/QC	Quality Assurance/Quality Control
QI	Quotient Index
RA	Risk Assessment
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RV	Ravine
SA	Site Assessment
SAP	Sampling and Analysis Plan
SCS	Soil Conservation Service
Sj	Jaccard Similarity Coefficient
SOP	Standard Operating Procedure
SSV	USEPA Region IV Sediment Screening Values
Ss	Sorenson Similarity Coefficient
S.U.	Standard Units
SVOCs	semivolatile organic compounds
SWQSVs	Surface Water Quality Screening Values
TAL	Target Analyte List
TCE	trichloroethene
TCL	Target Compound List

TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
TOC	top-of-casing
TPH	Total Petroleum Hydrocarbons
TRC	Technical Review Committee
TRV	Terrestrial Reference Value
µg/g	micrograms per gram
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
USGS	United States Geological Service
UST	underground storage tank
VOCs	volatile organic compounds
Weston	Weston Geophysical Corporation
WC	Wallace Creek
WQS	North Carolina Water Quality Standards
WQSV	EPA Region IV Water Quality Screening Values

EXECUTIVE SUMMARY

Introduction

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

The Fiscal Year 1994 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies several sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. This report documents the FS completed at one of these sites: Site 2 (Former Nursery/Day Care Center). Site 2 comprises Operable Unit (OU) No. 5. The purpose of this FS is to select a remedy that is protective of human health and the environment; attains Federal and State requirements; and is cost effective.

This FS has been conducted in accordance with the guidelines and procedures delineated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions (40 CFR 300.430). The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this FS. This FS has been based on data collected during the RI conducted at Site 2 (Baker, 1994).

Site Description and History

Site 2 is located at the intersection of Holcomb Boulevard and Brewster Boulevard in the northeast portion of MCB Camp Lejeune. The site is characterized by the following physical features. It has relatively flat topography. It is underlain by unconsolidated deposits of sand, silt, and clay. Groundwater was encountered approximately 6 feet below the surface. The

water table is relatively flat, with an estimated groundwater hydraulic gradient of 0.005 feet/feet. Shallow groundwater flow is to the northeast.

The site is generally divided into the Building 712 Area and the Former Storage Area (FSA). The Building 712 Area includes the Lawn Area (LA), Mixing Pad Area (MPA), and the Railroad Drainage Ditches.

From 1945 to 1958, Building 712 was used for the storing, handling, and dispensing of pesticides. Building 712 was later used as a children's day care center. Chemicals known to have been used include: chlordane, DDT, diazinon, and 2,4-D. Chemicals known to have been stored on site include dieldrin, lindane, malathion, silvex, and 2,4,5-T.

The mixing pads consist of two concrete slabs, each approximately 5 feet by 5 feet in size. The pads are located behind Building 712. The former mixing pads are in an area of suspected contamination. Above ground horizontal storage tanks were detected near the mixing pad area in a 1952 aerial photograph included in the Environmental Photographic Interpretation Center (EPIC) Study (EPIC, 1992). The tanks may have been used to store the chemicals/product. Contamination is believed to have occurred as a result of small spills, washout and excess product disposal. During the years of operation, it is reasonable to assume several gallons per year were involved; therefore, estimated quantity involved is on the order of 100 to 500 gallons of liquids containing various concentrations of product. Solid residues in cracks and crevasses may total 1 to 5 pounds. Disposal to Overs Creek is undocumented (Water and Air Research, 1983).

The FSA was used to store bulk materials and vehicles. The following items,within the FSA, were identified in aerial photos included in the EPIC Study:

- A railroad siding, extending from the main line into the FSA
- A crane, possibly located on the railroad siding, that was apparently used to unload materials from railroad cars
- An area of possibly stained surface soil, present along the eastern border of this area

Investigation and Study History

Investigations at Site 2 date back to 1983. The studies/investigations that have been conducted within Site 2 include:

- Initial Assessment Study of MCB Camp Lejeune (Water and Air Research, 1983)
- Confirmation Study for Site 2 (Environmental Science and Engineering, Inc., 1984 and 1986)
- Remedial Investigation for Site 2 (Baker, 1994)

Nature and Extent of Contamination

RI activities included a soil (surface and subsurface) investigation, groundwater investigation (two rounds of groundwater sampling), and surface water/sediment investigation. Based on the results of the environmental investigations conducted at Site 2 during the RI, the following conclusions with respect to the nature and extent of contamination at the site were developed:

- Soil in the vicinity of the former mixing pads has been impacted by pesticide contamination. Detected pesticides include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, heptachlor, alpha-chlordane, and gamma-chlordane. Concentrations of these contaminants range from less than 10 µg/kg to 3,000,000 µg/kg. Soil in this area has also been impacted by semivolatile organic compound (SVOC) contamination. The majority of these are polycyclic aromatic hydrocarbons (PAHs). The maximum SVOC concentration is 14,000 µg/kg. SVOC may be associated with past use of fuel (possibly diesel fuel) as a carrying agent for herbicides or for use in cleaning and operating spraying equipment.

- Pesticide contamination was detected in low concentrations (less than 100 µg/kg) throughout the remainder of Site 2. These concentrations are similar to base-specific background levels and are several orders-of-magnitude lower than pesticide contaminant concentrations detected in the vicinity of the former mixing pads.

- Shallow groundwater in the Former Storage Area has been impacted by volatile organic compound (VOC) contamination. Ethylbenzene (2 - 190 µg/L) and xylenes (total) (1 - 1,800 µg/L) were detected in groundwater samples collected from shallow monitoring wells in the Former Storage Area. The area of highest VOC concentration is at monitoring well 2GW3. VOCs have been detected in this monitoring well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area.

- Inorganics were detected in groundwater samples collected from shallow monitoring wells at the site. Several of these analytes exceeded Federal and/or North Carolina groundwater quality standards. The distribution of detected inorganics in shallow groundwater followed no discernible pattern. Many of the highest concentrations of inorganics were detected in background monitoring wells (2GW9, 2GW8). The concentrations of detected inorganics is much greater in the unfiltered (total) samples than in the filtered (dissolved) samples. This indicates that the inorganics detected in groundwater samples at Site 2 are due predominantly to the presence of soil particles entrained in the groundwater samples and are not attributable to site operations. Some inorganics (arsenic, lead, barium, beryllium, and vanadium) were nonetheless retained as chemicals of concern in the baseline risk assessment.

- Trichloroethene (TCE) was detected at a low concentration (5 µg/L) in deep monitoring well 2GW3D. The extent of this contamination is unknown; however, deep groundwater quality in the Mainside of MCB Camp Lejeune is impacted by other sites (OU Nos. 1 and 2). The presence of TCE in the deep aquifer is not likely associated with Site 2. TCE was not detected in this monitoring well during the second round of groundwater sampling.

- Sediment in the Railroad Drainage Ditch Area has been impacted by pesticide contamination. These contaminants include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. The maximum concentrations of pesticide contamination (250,000 µg/kg) are present in the immediate vicinity of the former mixing pads. PAHs were also detected in low concentrations (less than 200 µg/kg) in sediment from this area.

- Trace levels (less than 3 µg/L) of pesticides (4,4'-DDD and 4,4'-DDT) were detected in surface water samples collected in the Railroad Track Drainage Ditches. Carbon

disulfide, a VOC, was detected (7 µg/L) in surface water from Overs Creek. Copper was also detected (7 µg/L) above applicable Federal and State surface water standards in Overs Creek.

Time-Critical Removal Action

The laboratory analytical data generated during the RI indicate the presence of elevated concentrations of pesticides in soil and sediment near the former washing/mixing pads. Pesticide concentrations in several samples in this area exceed the benchmark risk-based concentrations prepared by USEPA Region III (January 28, 1993). The benchmark risk-based concentration is a value that equates to a 1 x 10^{-6} cleanup action level. The pesticide concentrations were evaluated with respect to Removal Action Criteria outlined in the NCP. The NCP lists a number of criteria that are considered in determining the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) directly applies to the conditions at Site 2.

300.415(b)(2)(i) "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

The presence of pesticide contaminants in this area in concentrations exceeding USEPA benchmark risk-based concentrations indicates that they may pose an imminent and substantial endangerment to public health, or welfare, or the environment.

The DoN will implement a time-critical removal action (TCRA) for this contaminated material. Specific soil and sediment cleanup levels were calculated to determine the approximate extent and volume of material that will need to be removed in the TCRA. These cleanup levels were based on achieving human health risks for a residential area (1 x 10^{-6} risk level). The health-based action levels developed for soil and sediment are also adequately protective of terrestrial and aquatic life.

The results of the risk assessment indicate that there should be no unacceptable risks to human health or the environment posed by exposure to the remaining soils after the remediation of the selected areas in accordance with the TCRA. Therefore, groundwater is the only media which was evaluated in the FS. Baker has estimated that approximately 500 cubic yards of soil and sediments will need to be removed under the TCRA.

Contaminants of Concern, Remediation Goal Options, and Remediation Levels

Contaminants of concern (COC) for this site consist of the contaminants of potential concern (COPC) developed for groundwater media in the RI Report.

The remediation goal options associated with groundwater at Site 2 are presented on Table ES-1. This list was based on a comparison of contaminant-specific ARARs and the site-specific risk-based concentrations (see Section 2.0 of the FS). The basis for each of the remediation goals is also presented in Table ES-1.

In order to determine the final set of COC for Site 2, the contaminant concentrations detected in the groundwater were compared to the preliminary remediation goals presented on Table ES-1. The contaminants which exceeded at least one of the remediation goal options have been retained as final COC. The contaminants that did not exceed any of the preliminary remediation goal options were no longer considered as COC with respect to this FS. Based on this comparison, the groundwater contaminants presented on Table ES-2 exceeded a final remediation goal and will be retained as COC for Site 2.

Remediation levels for each of the final COC are also presented on Table ES-2. The remediation level selected was the most limiting (or conservative) remedial goal option (either ARAR or risk-based) for a particular final COC.

Remedial Action Alternative Development and Evaluation

Based on the information collected during the RI, including the evaluation of potential human health and ecological risks, one groundwater area of concern (AOC) was identified within Site 2. The groundwater sampled from monitoring well 2GW3 showed levels of ethylbenzene (190 µg/L) and total xylenes (1,800J µg/L) that were above the state groundwater standards. None of the other groundwater samples indicated that there was contamination in the shallow aquifer at levels that warranted consideration of remedial action.

To address this AOC, six groundwater Remedial Action Alternatives (RAAs) were developed and evaluated. These alternatives include:

- RAA No. 1 - No Action
- RAA No. 2 - Institutional Controls with Long-Term Monitoring

TABLE ES-1

REMEDIATION GOAL OPTIONS
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Contaminant of Concern	RGO	Unit	Basis of Goal	Corresponding Risk		Detected Concentration Range (µg/L)
					Carcinogenic	Noncarcinogenic	
Groundwater	Acenaphthene	50,637	µg/L	Calculated		HI = 1.0	ND - 2J
	Arsenic	50	µg/L	NCWQS			ND - 23.6
	Barium	2,000	µg/L	MCL/NCWQS			46 - 1,420
	Beryllium	4	µg/L	NCWQS			1 - 2
	4,4'-DDD	94	µg/L	Calculated	ICR = 1.0E-06		ND - 4J
	4,4'-DDT	50	µg/L	Calculated	ICR = 1.0E-06		ND - 9.4
	2,4-Dimethylphenol	16,923	µg/L	Calculated		HI = 1.0	ND - 6
	Ethylbenzene	29	µg/L	NCWQS			ND - 190
	Lead	15	µg/L	MCL/NCWQS			ND - 15.5
	2-Methylnaphthalene	24,211	µg/L	Calculated*		HI = 1.0	ND - 17
	Naphthalene	24,211	µg/L	Calculated		HI = 1.0	ND - 15
	Phenol	487,364	µg/L	Calculated		HI = 1.0	ND - 3
	Trichloroethene	2.8	µg/L	NCWQS			ND - 5
	Vanadium	5,908	µg/L	Calculated		HI = 1.0	9 - 89
	Xylene (total)	530	µg/L	NCWQS			ND - 1800J

Notes: RGO = Remediation Goal Option
ICR = Incremental Lifetime Cancer Risk. An ICR of 1.0E-06 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals. USEPA considers ICRs of 1.0E-04 to 1.0E-06 to be protective of public health (USEPA, 1989a).
HI = Hazard Index. A HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects could occur.
NCWQS = North Carolina Water Quality Standards
MCL = Maximum Contaminant Level
ND = Not Detected
*Naphthalenes toxicity factor was used as a surrogate for 2-methylnaphthalene.

TABLE ES-2

FINAL COC AND REMEDIATION LEVELS
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Final Contaminant of Concern	Remediation Level (µg/L)
Groundwater		
	Ethylbenzene	29
	Trichloroethene	2.8
	Xylene (total)	530
	Lead	15.0

Units: µg/L = microgram per liter

- RAA No. 3 - Collection/Treatment/Discharge to a Sewage Treatment Plant
- RAA No. 4 - Collection/Discharge to a Sewage Treatment Plant
- RAA No. 5 - Collection/Discharge to Site 82 (OU No. 2)
- RAA No. 6 - In Situ Treatment

Net present worth (NPW) costs were developed for RAAs Nos. 2 through 6, using a 30-year remediation time basis and a five percent interest rate.

The No Action RAA (No. 1) is required under CERCLA to compare against other alternatives. There are no capital or operation and maintenance (O&M) costs associated with this alternative.

The Institutional Controls with Long-Term Monitoring RAA (No. 2) primarily involves the institution of ordinances restricting the construction of new potable supply wells in the area. Long- term groundwater monitoring (including on-site and nearby operational supply wells) is also included with this alternative. No capital costs are required to implement this alternative. The NPW of this alternative is approximately $350,000.

RAA No. 3 includes the installation of extraction wells to prevent migration of the plume. Three shallow wells will be installed to a depth of approximately 35 feet to extract groundwater in the surficial aquifer. These wells will be pumped at a rate of approximately 5 gallons per minute. The extracted groundwater will receive treatment via a treatment train that will include air stripping and carbon adsorption. The treatment system may also include a metals removal system. Treated groundwater will be pumped through a force main to a sanitary sewer that discharges to the Hadnot Point Sewage Treatment Plant (STP).

This alternative will also include long-term groundwater monitoring. In addition, restrictions will be placed on the installation of any new potable water supply wells within the vicinity of Site 2. The capital and annual O&M costs associated with RAA No. 3 are $303,000 and $133,000, respectively. The NPW is $1.89 million.

RAA No. 4 focuses on the extraction and discharge of the contaminated groundwater to the Hadnot Point STP. Groundwater will be extracted through three shallow extraction wells, as in RAA No. 3, and pumped untreated through a force main to a sanitary sewer that discharges to the Hadnot Point STP.

In addition, RAA No.4 includes the same institutional controls as RAA Nos. 2 and 3. The capital costs associated with RAA No. 4 are $210,000. The NPW is $1.3 million.

RAA No. 5 considers the discharge of contaminated groundwater to a treatment system to be installed at Site 82 (OU No. 2). Groundwater will be extracted through three shallow extraction wells, as in RAA Nos. 3 and 4, and pumped to the groundwater treatment system planned for Site 82. An on-site pump station at Site 2 will be constructed to pump extracted groundwater through a force main approximately 1.8 miles south to Site 82, where a treatment facility is being designed to treat VOC contaminated groundwater.

In addition, RAA No. 5 includes the same institutional controls as RAA Nos. 2, 3, and 4. The capital costs associated with RAA No. 5 are $323,000. The NPW is $1.44 million.

The last alternative, RAA No. 6, considers the remediation of the contaminated groundwater near monitoring well 2GW3 via an in situ treatment method. For purposes of the FS, the in-situ treatment method evaluated includes air sparging wells and soil venting. Approximately two air sparging wells and two soil venting wells will be installed near monitoring well 2GW3. Air to the sparging wells will be supplied by a low pressure air blower. A separate vacuum system will be used to create the negative pressure needed to withdraw the vapors. With this alternative, no groundwater would be extracted from the aquifer, therefore, no method of groundwater discharge is required.

In addition, RAA No. 6 includes the same institutional controls as RAA Nos. 2, 3, 4 and 5. The capital costs associated with RAA No. 6 are $124,000. The NPW is $1.32 million.

The remedial alternatives for addressing the contaminated groundwater were evaluated against USEPA's nine evaluation criteria. These criteria included overall protection of public health and the environment; compliance with ARARs; long-term effectiveness of permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost USEPA and NC DEHNR acceptance; and community acceptance.

A comparison of these alternatives with respect to these evaluation criteria is provided on Table ES-3.

TABLE ES-3

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
OVERALL PROTECTIVENESS						
• Human Health Protection	No reduction in risk.	Institutional controls provide protection against risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. In-situ treatment provides protection against future potential risk from ingestion.
• Environmental Protection	Allows continued contamination of the groundwater.	Allows continued contamination of the groundwater. Potential natural attenuation of organic contaminants over time.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Level of groundwater contamination is reduced by in situ treatment.
COMPLIANCE WITH ARARs						
• Chemical-Specific ARARs	Will exceed Federal and/or NC groundwater quality ARARs.	Will exceed Federal and/or NC groundwater quality ARARs.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.
• Location-Specific ARARs	Not applicable.	Not applicable.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
• Magnitude of Residual Risk	As migration of groundwater continues, potential risks may increase.	Risk reduced to human health since the use of the groundwater aquifer is restricted.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by in-situ treatment of contaminated groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Institutional controls are reliable if strictly enforced.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	In-situ treatment demonstrated for COCs
• Need for 5-year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT						
• Treatment Process Used	None.	None.	Treatment train for metals removal, air stripping, and activated carbon.	Physical and biological treatment at STP.	Treatment train at Site 82 for metals removal, air stripping, and activated carbon.	In-situ air sparging and soil venting for VOC removal.
• Amount Destroyed or Treated	None.	None.	Majority of contaminants in groundwater.	Majority of contaminants in groundwater.	Majority of contaminant in groundwater plumes.	Majority of contaminant in groundwater plumes.

TABLE ES-3 (Continued)

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
• Reduction of Toxicity, Mobility or Volume	None.	None.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Satisfied.	Satisfied.	Satisfied.	Satisfied.
SHORT-TERM EFFECTIVENESS						
• Community Protection	Risks to community not increased by remedy implementation.	Risks to community not increased by remedy implementation.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.
• Worker Protection	No significant risk to workers.	No significant risk to workers.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.
• Environmental Impacts	None	None	None	None	None	None
• Time Until Action is Complete	Not applicable.	Risks from potential groundwater ingestion reduced within 3 to 6 months due to institutional controls.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.
IMPLEMENTABILITY						
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.
• Ability to Monitor Effectiveness	No monitoring. Failure to detect contamination will result in potential ingestion of contaminated groundwater.	Proposed monitoring will give notice of failure before significant exposure occurs.	Adequate system monitoring.	Adequate system monitoring.	Adequate system monitoring.	Requires indirect monitoring of system performance.
• Availability of Services and Capacities; Equipment	None required.	None required.	Groundwater extraction and treatment equipment is readily available.	Groundwater extraction equipment is readily available.	Groundwater extraction equipment is readily available.	System components readily available.
COSTS Net Present Worth	$0	$350,000	$1.89 million	$1.3 million	$1.44 million	$1.32 million

RAA = Remedial Action Alternative STP = Sewage Treatment Plant ARARs = Applicable or Relevant and Appropriate Requirements

TABLE ES-3

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Limited Action	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
OVERALL PROTECTIVENESS						
• Human Health Protection	No reduction in risk.	Institutional controls provide protection against risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. In-situ treatment provides protection against future potential risk from ingestion.
• Environmental Protection	Allows continued contamination of the groundwater.	Allows continued contamination of the groundwater.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Level of groundwater contamination is reduced by in situ treatment.
COMPLIANCE WITH ARARs						
• Chemical-Specific ARARs	Will exceed Federal and/or NC groundwater quality ARARs.	Will exceed Federal and/or NC groundwater quality ARARs.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.
• Location-Specific ARARs	Not applicable.	Not applicable.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
• Magnitude of Residual Risk	As migration of groundwater continues, potential risks may increase.	Risk reduced to human health since the use of the groundwater aquifer is restricted.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by in-situ treatment of contaminated groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Institutional controls are reliable if strictly enforced.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	In-situ treatment demonstrated for COC
• Need for 5-year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT						
• Treatment Process Used	None.	None.	Treatment train for metals removal, air stripping, and activated carbon.	Physical and biological treatment at STP.	Treatment train at Site 82 for metals removal, air stripping, and activated carbon.	In-situ air sparging and soil venting for VOC removal.

1.0 INTRODUCTION

This report presents the Feasibility Study (FS) for Operable Unit (OU) No. 5, Site 2, Former Nursery/Day Care Center, Marine Corps Base (MCB) Camp Lejeune. This FS has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-D-4814. The development of this report is based on the scope of work for Contract Task Order (CTO) Number 0174.

This FS has been conducted according to the basic methodology outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions (40 CFR 300.430). These NCP regulations were promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. The United States Environmental Protection Agency (USEPA) document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as a guidance document for preparing this report. The FS has been based on data collected during the Remedial Investigation (RI) conducted by Baker (Baker, 1994).

The purpose of the FS for Site 2 is to select a remedy that: is protective of human health and the environment; attains Federal and State requirements that are applicable or relevant and appropriate; and is cost effective.

In general, the FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated, such that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. The FS involves two major phases:

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

The first phase includes the following major activities: (1) developing remedial goal options (RGOs) and remediation levels (RLs), (2) developing general response actions, (3) identifying volumes or areas of affected media, (4) identifying and screening potential technologies and process options, (5) evaluating process options, (6) assembling alternatives, (7) defining

alternatives, and (8) screening and evaluating alternatives. Section 121(b)(1) of CERCLA requires that an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In addition, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management to alternatives involving treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no action alternative should also be developed.

The second major phase of the FS consists of:

- Evaluating the potential alternatives in detail with respect to nine evaluation criteria to address statutory requirements and preferences of CERCLA

- Performing a comparison analysis of the evaluated alternatives

1.1 Site Background Information

Background information pertaining to Site 2 is presented below. Additional details pertaining to the site are presented in the RI Report (Baker, 1994).

1.1.1 Site Description

MCB Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina (Figure 1-1). The base covers approximately 236 square miles and is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is north of the base.

The focused study area for this FS is OU No. 5 which consists of Site 2, Former Nursery/Day Care Center. In general, Site 2 is located at the intersection of Holcomb Boulevard and Brewster Boulevard in the northeast portion of Camp Lejeune. Figure 1-2 presents a site plan of Site 2. The site is made up of two areas: the area around Building 712, including the Lawn Area (LA) and the Mixing Pad Area (MPA); and the Former Storage Area (FSA), which is located on the southern portion of the site. The LA and MPA are separated from the FSA by railroad tracks.

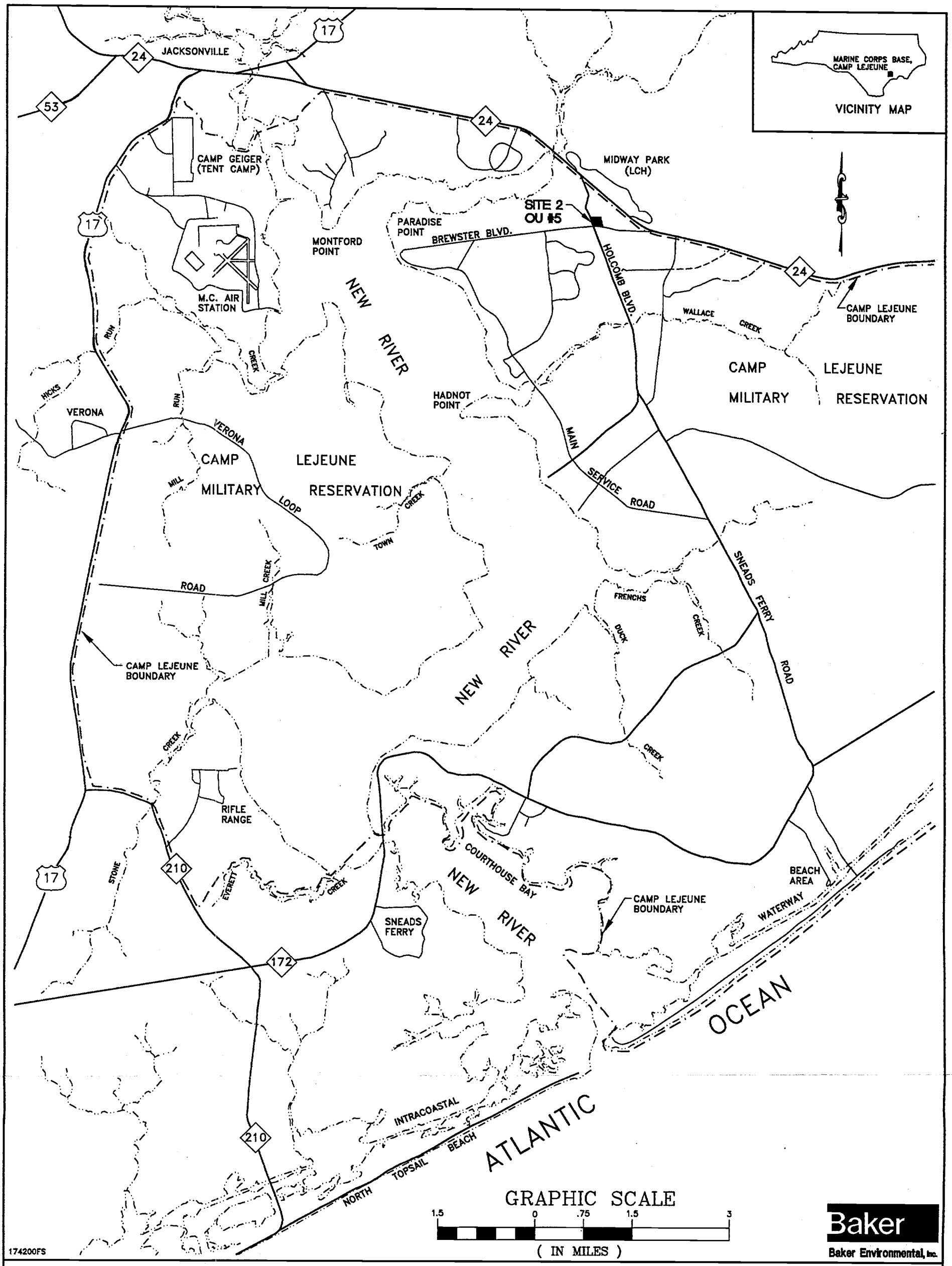

FIGURE 1-1
LOCATION MAP
OPERABLE UNIT No.5, SITE 2
FEASIBILITY STUDY CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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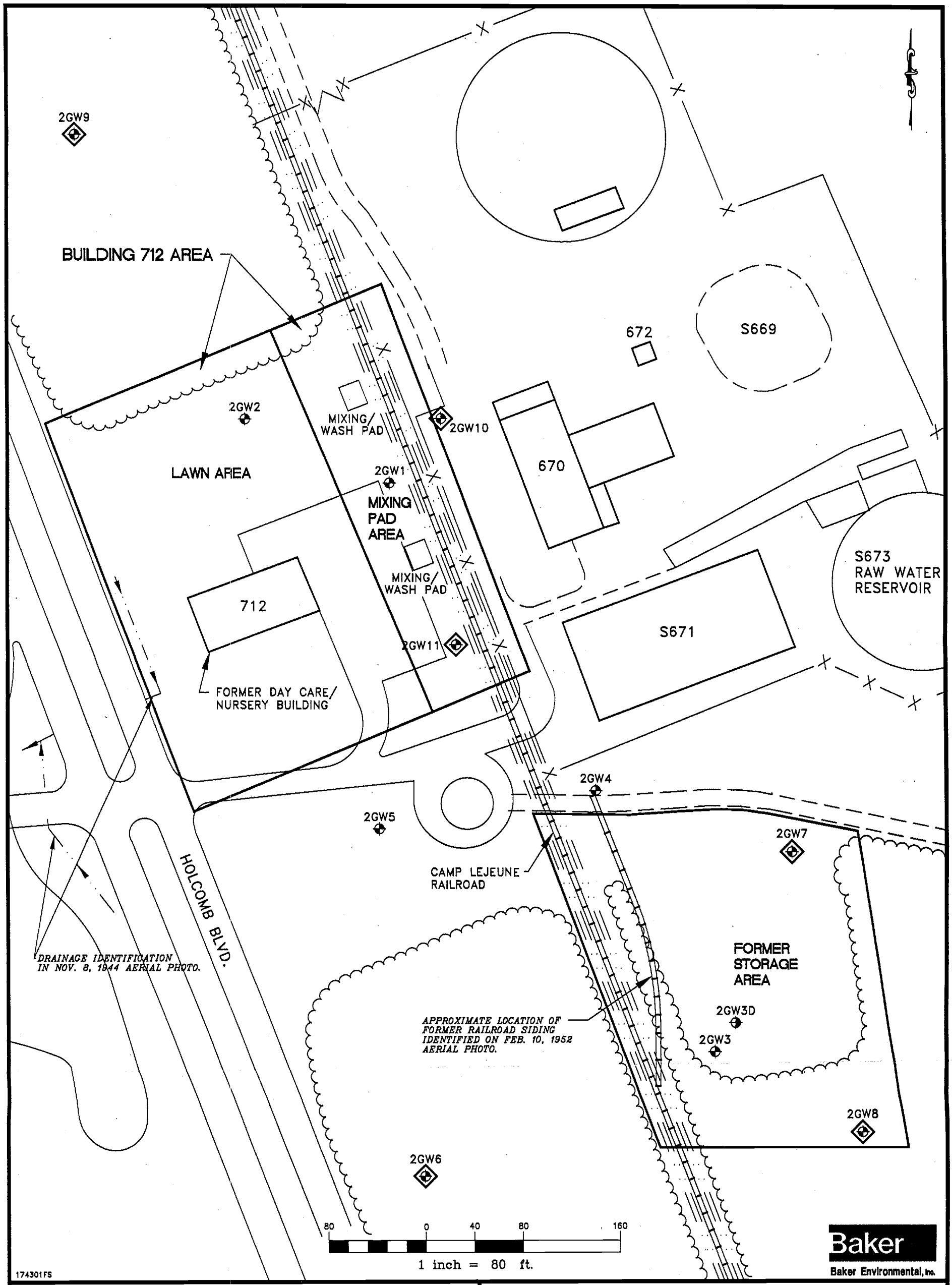


LEGEND

2GW1 EXISTING SHALLOW MONITORING WELL

2GW3D NEWLY INSTALLED SHALLOW MONITORING WELL

2GW3D NEWLY INSTALLED DEEP MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 1-2
SITE PLAN OF
OPERABLE UNIT No.5, SITE 2
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

The land at Site 2 is primarily flat, but dips sharply at the drainage ditches which run parallel to the railroad tracks. There is a drainage ditch on both the east and west side of the railroad tracks. Overland drainage is limited over most of the site due to the flat topography. Drainage along the eastern edge of the Building 712 area is toward these drainage ditches which run in a north-northwest direction towards Overs Creek. Drainage along the western edge of the FSA is also toward these drainage ditches. Another drainage ditch extends westward from the Building 712 area, underneath Holcomb Boulevard.

The site is characterized by the following physical features. It has relatively flat topography. It is underlain by unconsolidated deposits of sand, silt, and clay. Groundwater was encountered approximately 6 feet below the surface. The water table is relatively flat (hydraulic gradient is 0.005 feet/feet). Shallow groundwater flow is to the northeast. Shallow groundwater is reportedly interconnected with the underlying Castle Hayne Aquifer.

1.1.2 Site History

From 1945 to 1958, Building 712 was used for the storing, handling, and dispensing of pesticides. Building 712 was later used as a children's day care center. Chemicals known to have been used include: chlordane, DDT, diazinon, and 2,4-D. Chemicals known to have been stored on site include dieldrin, lindane, malathion, silvex, and 2,4,5-T. The MPA is in an area of suspected contamination. Above ground horizontal storage tanks were detected near the mixing pad area in a 1952 aerial photograph included in the Environmental Photographic Interpretation Center (EPIC) Study (EPIC, 1992). Contamination is believed to have occurred as a result of small spills, washout and excess product disposal. During the years of operation, it is reasonable to assume several gallons per year were involved; therefore, estimated quantity involved is on the order of 100 to 500 gallons of liquids containing various concentrations of product. Solid residues in cracks and crevasses may total 1 to 5 pounds. Disposal to Overs Creek is undocumented (Water and Air Research, 1983).

There is little information regarding operational history of the FSA. Historical aerial photographs indicate that the area was used to store bulk materials and vehicles.

The following items, within the FSA, were identified in aerial photos included in the EPIC Study:

- A railroad siding, extending from the main line into the FSA

- A crane, possibly located on the railroad siding, that was apparently used to unload materials from railroad cars

- An area of possibly stained surface soil, present along the eastern border of this area

1.1.3 Investigation and Study History

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

Previous investigations of hazardous waste sites at MCB Camp Lejeune have been conducted under an IAS and Confirmation Study. The following summarizes previous investigations and their findings as they pertain to Site 2:

1.1.3.1 Initial Assessment Study

An IAS was conducted by Water and Air Research, Inc., in 1983. The IAS identified a number of sites at MCB Lejeune as potential sources of contamination including Site 2. The IAS reviewed historical records and aerial photographs, as well as performed field inspections and personnel interviews to evaluate potential hazards at various sites on MCB Camp Lejeune. Based on review of historical records and general site reconnaissance, Site 2 was among the sites at MCB Camp Lejeune recommended for further study to evaluate the necessity of conducting mitigating actions or clean-up operations.

1.1.3.2 Confirmation Study

A Confirmation Study was conducted by Environmental Science and Engineering, Inc., in 1984. Confirmation study activities were aimed at confirming the existence of contaminants

potentially detrimental to human health and the environment at Site 2. The study included various phases based on the media of interest. A summary of constituents detected in the various media sampled is presented below:

- Soil sample results indicated that pesticides were present in soils surrounding the MPA.

- Analysis of pesticides in the shallow aquifer indicated the presence of trace amounts of pesticides in one well (2GW1). No detected compounds were reported for the nearby water supply wells. In December 1986, a second round of groundwater samples was collected. Trace amounts of pesticides were found in 2GW1 and 2GW3. In addition, ethylbenzene was detected in monitoring well 2GW3 above the North Carolina Groundwater Standard of 29 µg/L. In March 1987, a third round of groundwater samples from a select group of wells revealed trace amounts of pesticides in monitoring well 2GW3 as well as ethylbenzene above the applicable water quality standard.

- In 1986, two surface water/sediment samples were collected from the drainage ditch along the eastern boundary of the site. One surface water/sediment sample revealed the presence of low levels of pesticides.

1.1.3.3 Pre-Remedial Investigation Activities

In July 1992, a geophysical investigation was performed at Site 2 to determine the source of groundwater contamination near monitoring well 2GW3. No anomalies that could serve as sources (i.e., tanks or drums) of groundwater contamination were identified during this investigation. However, an anomalous subsurface feature was detected near monitoring well 2GW3. The data from this anomaly was not conclusive to ascertain whether or not it was a tank, large diameter utility line or other buried structure.

In January 1994, additional geophysical investigation activities were conducted in the vicinity of this anomalous subsurface feature. This focused reinvestigation determined that there were no subsurface features in this area. The fixture that was apparently detected in July 1992 may have been an echo or interference from monitoring well 2GW3 (Baker 1994).

Also in 1992 a limited groundwater sampling program was implemented to obtain preliminary data to streamline RI activities.

1.1.3.4 Remedial Investigation

The RI field program at Site 2 was initiated to characterize potential environmental impacts and threats to human health resulting from previous storage, operational, and disposal activities. Investigation activities commenced in April 1993 and continued through June 1993. The field program consisted of a preliminary site survey; a geophysical survey; a soil gas survey; a soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation (shallow and deep wells), and sampling; a surface water and sediment investigation; and an aquatic and ecological survey.

1.1.4 Nature and Extent of Contamination

Levels of organic contamination including pesticides, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs), and metals are present throughout Site 2 in the various media (i.e., soil, groundwater, surface water, and sediments). Tables 1-1 through 1-13 present a listing of the organic and inorganic constituents detected at the site during the RI. In addition, concentration ranges and frequencies of detection are presented. Pesticides are the predominant contaminants in soil (surface and subsurface) and sediment. SVOCs were also detected in soil. VOCs, SVOCs, pesticides, and inorganics were detected in shallow groundwater. Low levels of VOCs (5.0 µg/l of TCE) were also detected in the deep (100 foot) monitoring well.

This section summarizes the nature and extent of contamination at Site 2. The summary is presented by area of concern (AOC). The following environmental media at Site 2 have been impacted by former site operation activities:

- Soil in the vicinity of the MPA has been impacted by pesticide contamination. This is apparently the result of releases associated with pesticide mixing and washing of pesticide and herbicide spraying equipment. The soil in this area has also been impacted by SVOC contamination. This is apparently the result of petroleum-based solvents or fuels (possibly diesel fuel) being used as a carrying agent for herbicide mixtures and to operate and clean spraying equipment.

- Sediment in the railroad track drainage ditches in the vicinity of the MPA has been impacted by pesticide contamination. SVOCs have also been detected in sediment

samples collected in this area. This is apparently the result of releases associated with herbicide mixing and the cleaning (possibly with diesel fuel) of pesticide and herbicide spraying equipment.

- Soil throughout Site 2 (i.e., outside of the MPA) has been impacted by pesticide contamination that resulted from the former practice of general base-wide spraying of pesticides. The pesticide concentrations in soil in the LA and FSA are several orders of magnitude lower than the pesticide contaminant concentrations detected in the vicinity of the MPA.

- Shallow groundwater in the FSA has been impacted by VOC contamination. Ethylbenzene and xylene (total) were detected in groundwater samples collected from shallow monitoring wells in the FSA. The area of highest VOC concentration is at monitoring well 2GW3. VOCs have been detected in this monitoring well during previous investigations. The extent of VOC contamination appears to be limited to the shallow groundwater in the vicinity of the FSA.

  The source of the shallow groundwater contamination in the FSA has not been determined. Similar contaminants were detected in low levels in one soil boring in the vicinity of monitoring well 2GW3, indicating that the source may have been at or near the surface in this area (e.g., surface spill, etc.).

- Inorganics were detected in groundwater samples collected from shallow monitoring wells at the site. Several of these analytes exceeded Federal and/or North Carolina groundwater quality standards. The distribution of detected inorganics in shallow groundwater followed no discernible pattern that would indicate a likely source. Many of the highest concentrations of inorganics were detected in background monitoring wells (2GW9, 2GW8). The concentrations of detected inorganics is much greater in the unfiltered (total) samples than in the filtered (dissolved) samples. This indicates that the inorganics detected in groundwater samples at Site 2 may be due predominantly to the presence of soil particles entrained in the groundwater samples and may not be attributable to site operations. Some inorganics (arsenic, lead, barium, beryllium, and vanadium) were nonetheless retained as chemicals of concern in the baseline risk assessment.

- Trichloroethene (TCE) was detected at a low concentration (5 µg/L) in deep monitoring well 2GW3D. There is no evidence (documentation, soil samples, shallow groundwater samples) to indicate that this is related to operation activities at Site 2. TCE and other chlorinated hydrocarbons have been detected in deep groundwater in other areas at MCB Camp Lejeune (Geophex, 1991). TCE was not detected in this monitoring well during the second round of groundwater sampling.

- Trace levels of pesticides were detected in surface water samples collected in the railroad drainage ditches. This may be the result of Site 2 operations or general base-wide spraying. Copper was detected above applicable Freshwater Water Quality Screening Value (FWQSV), North Carolina Water Quality Standards (NCWQS), and Federal Ambient Water Quality Criteria (AWQC) applicable to Overs Creek.

1.1.5 Summary of Human Health and Ecological Risks

At the time when RI laboratory analytical results became available and were initially compiled, MCB Camp Lejeune/DoN determined that a Time-Critical Removal Action (TCRA) was appropriate for the pesticide-contaminated soil and sediment in the vicinity of the MPA. The TCRA, which is currently in the design stage, is described in Section 1.2. Because a TCRA will be implemented, the baseline risk assessment (included in the RI Report) considers risks to human health and the environment at this site under two scenarios:

- Risks to human health and the environment without (or before) the TCRA.
- Risks to human health and the environment with (or after) the TCRA.

The following summarizes the human health and ecological risks under these scenarios.

The pesticide contaminated surface soil and sediment at the LA and MPAs (before the proposed TCRA), have the potential to present the greatest adverse human health risks from all media evaluated at Site 2. The risks calculated for this area, after the proposed TCRA, were greatly reduced into acceptable ranges for soil and sediment, for all receptors.

The risks calculated for soil in the FSA area fell within acceptable risk levels (1.0E-06 to 1.0E-4) both before and after the proposed TCRA.

Future potential use of shallow groundwater exhibited unacceptable (i.e., greater than 1×10^{-4} and an HI > 1.0) noncarcinogenic and carcinogenic risks to future resident children and adults due mainly to arsenic, beryllium, and pesticide contamination. However, shallow groundwater is not utilized for potable supply or other uses.

The total site risk at Overs Creek indicates that contamination from Site 2 is not appreciably migrating to the creek, and that adverse human health risks are not expected to occur due to contamination at Overs Creek. No ecological risks (aquatic or terrestrial) existed in the post-TCRA scenario.

Total site incremental lifetime cancer risk and hazard indices for this site are presented in Table 1-14. After completion of the TCRA, total risk for civilian base personnel and construction worker receptors will have ICRs less than 1.0E-06 and HIs less than 1.0. Site risks remain (i.e., ICR greater than 1.0E-04 and HI greater than 1) for the child resident and adult resident (future) receptors due to groundwater contamination. There are no site risks (ICR less than 1.0E-06 and HI less than 1) associated with Overs Creek.

Total risks remaining after the TCRA are attributable to contamination in the shallow groundwater on site. The FS will, therefore, focus on developing remedial action alternatives for mitigating these risks.

1.2 Time-Critical Removal Action

The following subsections describe the TCRA proposed for this site.

1.2.1 Purpose of TCRA

The NCP lists a number of criteria that are considered in determining the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) directly applies to the conditions at Site 2.

> 300./415 (b)(2)(i) "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

There are presently no permanent access restrictions in this area. The building on site is currently used as an administrative office building.

The presence of pesticide contaminants in this area may pose an imminent and substantial endangerment to public health, or welfare, or the environment. In this case, a time-critical (as opposed to non-time critical) removal action would be appropriate. Time-critical removals require less than six months to plan and are the most common type of removal actions. An engineering evaluation and cost analysis (EE/CA) is not required under time-critical removal actions.

There are several major advantages associated with conducting a time-critical removal action under these conditions:

- It would result in the removal of materials that may pose an immediate threat to human health and the environment in a timely fashion.

- The removal could be performed without the need to perform an EE/CA given the relatively non-complex nature of the problem.

- It would serve to focus, and potentially eliminate the need for, feasibility study activities for the soil matrix.

Based on the RI findings and human health and ecological risks, a TCRA for the removal and disposal of contaminated surface and subsurface soil and sediment, identified in the area of the two mixing/wash pads and the former storage area, has been proposed. The TCRA is currently in the design phase.

1.2.2 Remediation Goals

Specific soil and sediment remediation levels have been established to fulfill requirements of the TCRA objectives. These levels were calculated based on future residential land use. Tables 1-15 and 1-16 provide a summary of the soil and sediment remediation levels for the soil and sediment COC. The remediation levels are based on achieving a 1.0E-06 risk level for human health. The results of the ecological RA in the RI Report indicated that adverse ecological impacts to the aquatic environment were not expected to be significant. For terrestrial organisms, pesticides were identified to be the most significant COC that would have the potential for decreased viability for this population. However, after the TCRA, a low

likelihood of decreased viability to the terrestrial population was anticipated. Therefore, no media of concern for the ecological environment was considered for OU No. 5.

Upon completion of the TCRA, the primary sources of contamination at Site 2 will be removed. The only remaining COC will be organic and inorganic contaminants in groundwater. This FS will only address the groundwater.

1.2.3 TCRA Scope of Work

The proposed TCRA includes:

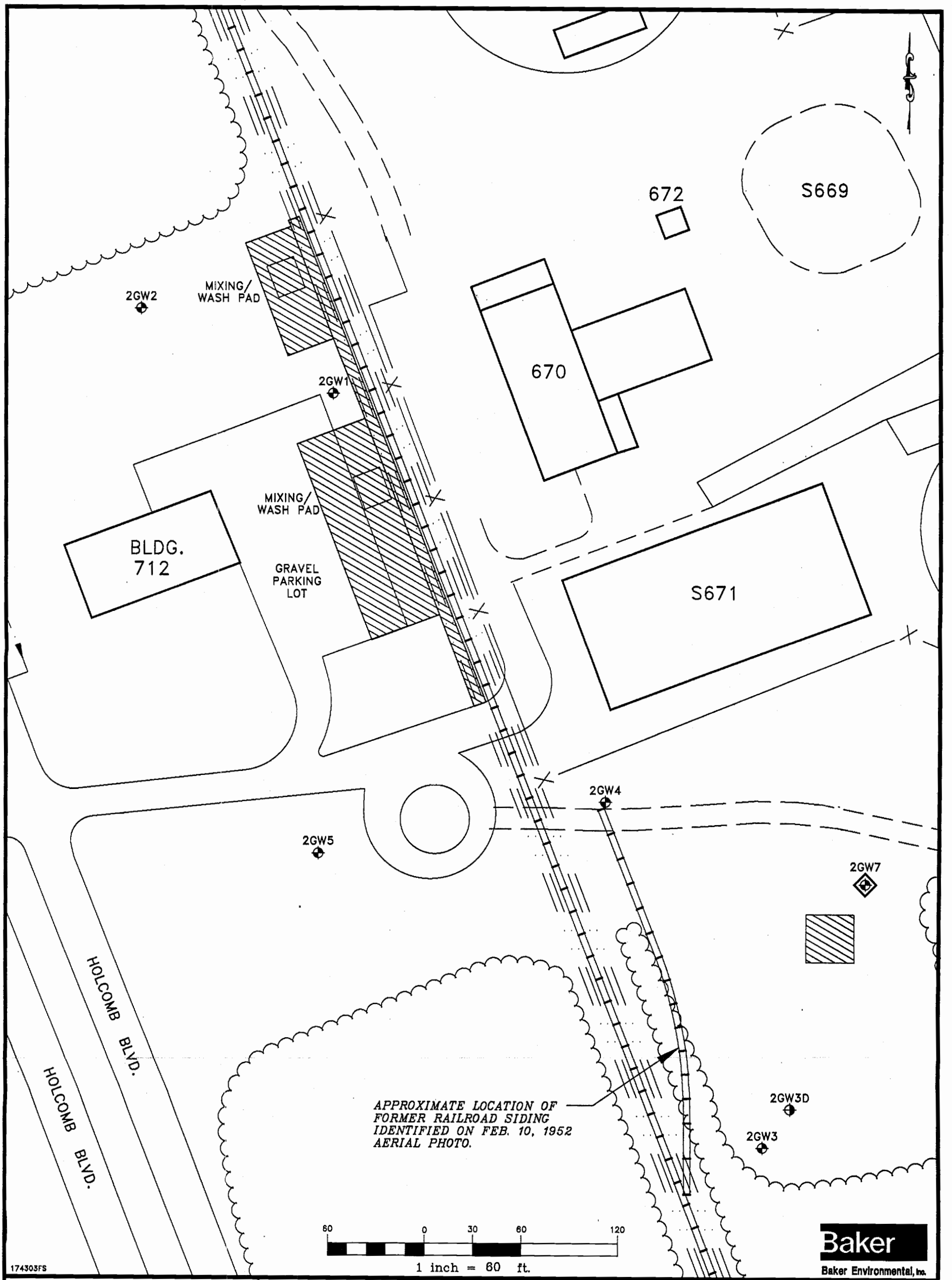
- Excavation of the soil, sediment, and debris from the mixing pad area and FSA
- Confirmation soil sampling and analysis, and additional excavation of material contaminated in excess of the removal action endpoints
- Transportation and disposal of contaminated soil and sediment at a RCRA-permitted hazardous waste landfill
- Site restoration

For the purpose of remedial alternative development and evaluation in the FS, an assumed source area or "hot spot," was developed and identified for remediation as part of the TCRA. Based on design documents being prepared for the TCRA, the areas to be remediated encompass approximately 14,000 square feet (0.3 acres) and a volume of approximately 500 cubic yards. The AOCs were developed primarily for evaluation of removal efforts and potential FS design considerations. Figure 1-3 depicts the areas identified for remediation under the TCRA. More specific information on the planned TCRA is presented in the TCRA Design Package (Baker, 1994).

1.3 Feasibility Study Report Organization

Based on RI findings and the results of the RA, the FS process has emphasized the development of remedial alternatives that meet the following conditions:

- Provide permanent solutions to contamination problems and long-term effectiveness



LEGEND

- 2GW1 – NEWLY INSTALLED SHALLOW MONITORING WELL
- 2GW3D – EXISTING DEEP MONITORING WELL
- 2GW7 – EXISTING SHALLOW MONITORING WELL
- – PROPOSED AREAS (APPROXIMATE) TO BE INCLUDED IN TIME CRITICAL REMOVAL ACTION

SOURCE: LANTDIV, FEB. 1992

FIGURE 1–3
APPROXIMATE AREAS TO BE INCLUDED IN
TIME CRITICAL REMOVAL ACTION
SITE 2
FEASIBILITY STUDY CTO–0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0125166012

- Meet Applicable or Relevant and Appropriate Requirements (ARARs) on a federal level, or a state level if the state requirements are more stringent

The FS Report is organized into six sections. This Introduction section (Section 1.0) presents a brief discussion of the FS process, report organization, site background information,and a summary of the RI conducted at the site. The remediation goal options, remediation levels, and remedial action objectives that have been established for the site are contained in Section 2.0. Identification and preliminary screening of general response actions, remedial action technologies, and process options are contained in Section 3.0. Development and screening of remedial alternatives for groundwater are contained in Section 4.0. The detailed analysis of remedial alternatives and a comparative analysis of alternatives for groundwater are contained in Section 5.0. The detailed analysis is based on a set of nine criteria including effectiveness, implementability, cost, acceptance, and overall protection of human health and the environment. References are listed in Section 6.0.

Three appendices are included with this FS: Appendix A contains a letter referencing factors warranting a TCRA; Appendix B contains action level calculations for obtaining remediation goal objectives; and Appendix C contains costing summaries and backup calculations for the cost estimates presented in Section 5.0.

TABLE 1-1

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA LAWN AND MIXING PAD AREAS - SURFACE SOIL OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Toluene	ND - 6	1/11
Xylene (total)	4 - 5	4/11
Pesticides		
alpha-Chlordane	4.3 - 3,900	9/46
gamma-Chlordane	5.2 - 3,400	6/46
4,4'-DDD	9.8 - 1,200,000	33/46
4,4'-DDE	4.9 - 30,000	38/46
4,4'-DDT	5 - 3,000,000	40/46
Dieldrin	ND - 1,400	1/46
Heptachlor	ND - 280	1/46

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 1-2

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil (0-6 inches)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	<90.5 - 1,490	1,459	2,310 - 9,650	11/11	11/11
Arsenic	<0.44 - 0.91	0.8	0.52 - 4.3	8/11	4/8
Barium	3.5 - 16.5	13	5.1 - 25.9	11/11	4/11
Beryllium	<0.06 - <0.22	0.1	0.22 - 0.22	2/11	2/2
Cadmium	<0.35 - <1.1	0.8	1.1 - 1.1	2/11	2/2
Calcium	108 - 10,700	4,932	508 - 109,000	11/11	8/11
Chromium	<0.06 - <3.2	2	3 - 12.7	10/11	10/10
Cobalt	<0.37 - <1.8	1.6	ND - 2.8	1/11	1/1
Copper	<1.1 - 3.1	2.8	0.46 - 19.9	11/11	4/11
Iron	160 - 1,020	1,051	722 - 3,880	11/11	9/11
Lead	2.0 - 20.4	45	5.7 - 225	11/11	4/11
Magnesium	<20.2 - 200	146	109 - 1,850	11/11	8/11
Manganese	<2.0 - 11.1	14	2.1 - 63.9	11/11	4/11
Mercury	<0.02 - <0.12	0.1	0.25 - 0.69	2/11	2/2
Potassium	54.5 - 102	104	59.6 - 368	11/11	7/11
Selenium	<0.31 - <1.0	0.9	0.66 - 0.82	2/11	0/2
Sodium	<9.4 - 67.5	49	20.7 - 214	11/11	5/11
Thallium	<0.22 - <0.41	0.4	ND - 0.26	1/11	0/1
Vanadium	<2.1 - 5.3	4.6	3.1 - 14.5	11/11	7/11
Zinc	<1.1 - 28.3	23	3.8 - 125	8/11	4/8

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
ND - Not Detected
(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TABLE 1-3

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SUBSURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Xylene (total)	5 - 4,100	2/11
Semivolatiles		
Acenaphthene	ND - 360	1/11
Anthracene	ND - 150	1/11
Fluoranthene	ND - 160	1/11
Fluorene	160 - 700	2/11
2-Methylnaphthalene	1,000 - 14,000	2/11
Naphthalene	130 - 4,800	2/11
n-Nitrosodiphenylamine	340 - 1,000	2/11
Phenanthrene	350 - 1,500	2/11
Pyrene	ND - 160	1/11
Pesticides		
alpha-Chlordane	2.2 - 2,500	6/46
gamma-Chlordane	2.4 - 2,300	4/46
4,4'-DDD	4.2 - 130,000	27/46
4,4'-DDE	4.6 - 6,300	24/46
4,4'-DDT	4 - 82,000	32/46
Heptachlor	ND - 190	1/46

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 1-4

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
LAWN AND MIXING PAD AREAS - SUBSURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil (6 inches to the water table)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	672 - 10,200	8,946	2,840 - 8,770	11/11	0/11
Arsenic	<0.47 - <0.65	0.6	0.62 - 1.3	2/11	2/2
Barium	<4.0 - 10.9	12	3.7 - 18.2	11/11	1/11
Beryllium	<0.05 - <0.23	0.2	0.24 - 0.26	2/11	2/2
Calcium	<10.7 - 81.3	1,508	58.3 - 21,700	11/11	3/11
Chromium	<3.2 - 8.7	8.7	2.4 - 15.1	10/11	2/10
Cobalt	<0.35 - <1.9	1.6	2.4 - 3.2	2/11	2/2
Copper	<0.47 - 1.2	1.6	0.73 - 4.6	5/11	1/5
Iron	126 - 2,840	1,778	324 - 2,560	11/11	1/11
Lead	1.2 - 6.1	9.1	2.9 - 82.1	11/11	2/11
Magnesium	<25.4 - 260	231	81 - 484	10/11	1/10
Manganese	1.2 - 5.2	6.2	2.2 - 12.5	10/11	3/10
Mercury	<0.02 - <0.11	0.1	ND - 0.22	1/11	1/1
Potassium	<81.6 - 187	223	50.5 - 288	11/11	1/11
Sodium	<14.5 - <44.9	41	15.5 - 51.6	11/11	4/11
Vanadium	<1.5 - 13.4	10	3 - 8.6	11/11	0/11
Zinc	<0.19 - 11.6	5.6	1.9 - 29.1	6/11	3/6

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
ND - Not Detected
(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 previous investigations at Camp Lejeune.

TABLE 1-5

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Toluene	ND - 5	1/5
Xylene (total)	ND - 8	1/5
Pesticides		
4,4'-DDD	30 - 1,200	4/5
4,4'-DDE	76 - 230	4/5
4,4'-DDT	4.7 - 9,400	5/5

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected

TABLE 1-6

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil (0-6 inches)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Average Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	<90.5 - 1,490	1,459	4,900 - 8,590	5/5	5/5
Arsenic	<0.44 - 0.91	0.8	0.69 - 0.86	3/5	1/3
Barium	3.5 - 16.5	13	9.7 - 14	5/5	1/5
Beryllium	<0.06 - <0.22	0.1	0.23 - 0.24	3/5	3/3
Calcium	108 - 10,700	4,932	551 - 108,000	5/5	3/5
Chromium	<0.06 - <3.2	2	6.6 - 9.8	5/5	5/5
Copper	<1.1 - 3.1	2.8	0.47 - 8.2	5/5	1/5
Iron	160 - 1,020	1,051	1,760 - 2,980	5/5	5/5
Lead	2.0 - 20.4	45	5.6 - 10.4	5/5	0/5
Magnesium	<20.2 - 200	146	242 - 1,830	5/5	5/5
Manganese	<2.0 - 11.1	14	5.9 - 20.4	5/5	3/5
Mercury	<0.02 - <0.12	0.1	0.34 - 0.44	3/5	3/3
Potassium	54.5 - 102	104	195 - 364	5/5	5/5
Selenium	<0.31 - <1.0	0.9	0.27 - 0.49	3/5	0/3
Silver	<0.37 - 62	1.1	0.71	1/5	0/1
Sodium	<9.4 - 67.5	49	38.1 - 238	5/5	4/5
Vanadium	<2.1 - 5.3	4.6	8.5 - 11.2	5/5	5/5
Zinc	<1.1 - 28.3	23	7.5 - 51.9	4/5	1/4

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TABLE 1-7

SUMMARY OF SITE 2 ORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SUBSURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Organic Chemical	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples
Volatiles		
Xylene (total)*	4 - 5	2/12
Pesticides		
4,4'-DDD	11 - 1,000	6/11
4,4'-DDE	6 - 31	2/11
4,4'-DDT	6 - 1,500	6/11
TEX*		
Toluene	ND - 9.1	1/9
Ethylbenzene	ND - 9.1	1/9
o-Xylene**	ND - 10.3	1/9
m- and p-Xylene**	ND - 14.2	1/9

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
ND - Not Detected
* TEX - Toluene, ethylbenzene, and xylene
** Xylene was analyzed for by the Contract Laboratory Program for organics and by USEPA Method 602. o-Xylene and m- and p-xylene were combined to get a total xylene concentration of 24.5 mg/kg.

TABLE 1-8

SUMMARY OF SITE 2 INORGANIC ANALYTICAL DATA
FORMER STORAGE AREA - SUBSURFACE SOIL
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil (6 inches and below)				
	Base-Specific Background Concentration Range(1)	Twice the Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Background/ No. of Times Detected
Aluminum	672 - 10,200	8,946	1,060 - 17,600	11/11	7/11
Arsenic	<0.47 - <0.65	0.6	0.52 - 1.7	7/11	6/7
Barium	<4.0 - 10.9	12	5.4 - 17.8	11/11	5/11
Beryllium	<0.05 - <0.23	0.2	0.24 - 0.25	3/11	3/3
Cadmium	<0.34 - <1.2	1	1.6	1/11	1/1
Calcium	<10.7 - 81.3	1,508	24.1 - 246,000	11/11	1/11
Chromium	<3.2 - 8.7	8.7	5.2 - 16.6	11/11	2/11
Cobalt	<0.35 - <1.9	1.6	2.5	1/11	1/1
Copper	<0.47 - 1.2	1.6	0.49 - 4.2	8/11	5/8
Iron	126 - 2,840	1,778	998 - 7,240	11/11	7/11
Lead	1.2 - 6.1	9.1	1.2 - 8	11/11	0/11
Magnesium	<25.4 - 260	231	85.7 - 3,860	11/11	8/11
Manganese	1.2 - 5.2	6.2	2.5 - 24.1	11/11	6/11
Mercury	<0.02 - <0.11	0.1	0.22 - 0.39	7/11	7/7
Potassium	<81.6 - 187	223	67.5 - 772	11/11	7/11
Selenium	0.23 - <1.0	0.8	0.29 - 0.63	3/11	0/3
Sodium	<14.5 - <44.9	41	26.6 - 1,030	11/11	5/11
Vanadium	<1.5 - 13.4	10	4.2 - 25.7	11/11	9/11
Zinc	<0.19 - 11.6	5.6	2.5 - 12.6	4/11	1/4

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples from samples taken for Site 2 and previous investigations at Camp Lejeune.

TABLE 1-9

COMPARISON OF SITE 2 GROUNDWATER ANALYTICAL RESULTS TO STANDARDS AND CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Contaminant Frequency/Range			Groundwater Standards and Criteria			Comparison to Standards and Criteria		
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	Background 2-GW09-01	NCWQS (1) (µg/L)	MCLs/ MCLGs (2) (µg/L)	HAs (3) (µg/L)	No. of Positive Detects Above NCWQS	No. of Positive Detects Above MCLs/ MCLGs	No. of Positive Detects Above HAs
Volatile Organics									
Ethylbenzene	2/9	2-190	ND	29	700	700	1/2	0/2	0/2
Trichloroethene	1/9	ND-5	ND	2.8	5/0	300	1/1	0/1 (6)	0/1
Xylene (total)	3/9	1-1800	ND	530	10,000	10,000	1/3	0/3	0/3
Semivolatile Organics									
Acenaphthene	1/8	ND-2	ND	--	--	--	--	--	--
2,4-Dimethylphenol	1/8	ND-6	ND	--	--	--	--	--	--
2-Methylnaphthalene	2/8	3-17	ND	--	--	--	--	--	--
Naphthalene	2/8	2-15	ND	--	--	20	--	--	0/2
Phenol	1/8	ND-3	ND	--	--	400	--	--	0/2
Pesticides									
4,4'-DDD	1/9	ND-4	0.73	--	--	--	--	--	--
4,4'-DDT	1/9	ND-10	1.6	--	--	--	--	--	--

Notes: All concentrations expressed in microgram per liter (µg/L).
-- = Not Available or Not Applicable
(1) NCWQS - North Carolina Water Quality Standards for Groundwater
(2) MCL - Maximum Contaminant Level. Lead and copper standards are an action level.
(3) HA - Lifetime health advisories for 70 kg adult (value for trichloroethene, arsenic, and beryllium is for the 10^{-4} cancer risk).
(4) USEPA, Region III, October 1993.
(5) Value is the value for naphthalene.
(6) Trichloroethene equaled the MCL.
(7) Value is for chromium^{+6}.
(8) Secondary MCL.
(9) Chromium^{+6} value equaled the RBC.

TABLE 1-9 (continued)

COMPARISON OF SITE 2 GROUNDWATER ANALYTICAL RESULTS TO STANDARDS AND CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Contaminant Frequency/Range			Groundwater Standards and Criteria			Comparison to Standards and Criteria		
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	Background 2-GW09-01	NCWQS (1) (µg/L)	MCLs/ MCLGs (2) (µg/L)	HAs (3) (µg/L)	No. of Positive Detects Above NCWQS	No. of Positive Detects Above MCLs/ MCLGs	No. of Positive Detects Above HAs
Inorganics									
Aluminum	8/8	269-36,000	56,300	--	50-200 (8)	--	--	8/8(8)	--
Arsenic	7/8	2.2-23.6	12.9	50	50	2	0/7	0/7	7/7
Barium	8/8	46-1,420	328	2,000	2,000	2,000	0/8	0/8	0/8
Beryllium	2/8	1-2	3	--	4	0.8	--	0/2	2/2
Cadmium	1/8	7	ND	5	5	5	1/1	1/1	1/1
Chromium	5/8	11-18	75	50	100	100	0/5	0/5	0/5
Cobalt	2/8	10-12	10	--	--	--	--	--	--
Copper	8/8	3-10	25	1,000	1,300	--	0/8	0/8	--
Lead	5/8	2.7-15.5	27.2	15	15	--	1/5	1/5	--
Manganese	7/8	21-79	290	50	50 (8)	--	4/7	--	--
Selenium	1/8	4.2	ND	50	50	--	0/1	0/1	--
Vanadium	7/8	9-89	86	--	--	--	--	--	--
Zinc	8/8	6-146	103	2,100	--	200	0/8	--	0/8

Notes: All concentrations expressed in microgram per liter (µg/L).
-- = Not Available or Not Applicable
(1) NCWQS - North Carolina Water Quality Standards for Groundwater
(2) MCL - Maximum Contaminant Level. Lead and copper standards are an action level.
(3) HA - Lifetime health advisories for 70 kg adult (value for trichloroethene, arsenic, and beryllium is for the 10^{-4} cancer risk).
(4) USEPA, Region III, October 1993.
(5) Value is the value for naphthalene.
(6) Trichloroethene equaled the MCL.
(7) Value is for chromium^{+6}.
(8) Secondary MCL.
(9) Chromium^{+6} value equaled the RBC.

TABLE 1-10

COMPARISON OF RAILROAD TRACK DRAINAGE DITCH SURFACE WATER ANALYTICAL DATA TO STATE STANDARDS AND FEDERAL CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Frequency/Range		Comparison to Standards and Criteria			
	No. of Positive Detects/ No. of Samples	Range of Positive Detections (µg/L)	NCWQS[1] (µg/L)	AWQCs[2] (µg/L)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Pesticides						
4,4'-DDD	4/7	0.11 - 1.9	NA	8.3×10^{-4}[3]	--	4/4
4,4'-DDT	2/7	0.74 - 0.94	5.88E-4	2.4E-5	2/2	2/2
Inorganics						
Arsenic	1/1	3.3	NA	2.2E-3	--	1/1
Barium	1/1	85	100	1,000	0/1	0/1
Beryllium	1/1	1.0	6.8E-3	3.7×10^{-2}[4]	1/1	1/1
Chromium	1/1	14	NA	1.7×10^{5}[4]	--	0/1
Copper	1/1	31	NA	1,300[4]	--	0/1
Lead	1/1	23.4	NA	50[4]	--	0/1
Manganese	1/1	58	200	50	0/1	1/1
Vanadium	1/1	15	NA	NA	--	--
Zinc	1/1	418	NA	NA	--	--

Notes: Concentrations expressed in microgram per liter (µg/L).
NA - Not Available
(1) NCWQS - North Carolina Water Quality Standard for Freshwater (human health)
(2) AWQCs - Federal Ambient Water Quality Standards (human health, water and organisms)
(3) Recalculated using IRIS, 1990.
(4) Value withdrawn (Federal Register, December 1992).

TABLE 1-11

COMPARISON OF OVERS CREEK SURFACE WATER ANALYTICAL DATA TO STATE STANDARDS AND FEDERAL CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Frequency/Range		Comparison to Criteria			
	No. of Positive Detects/ No. of Samples	Maximum Positive Detection (µg/L)	NCWQS (1) (µg/L)	AWQCs (2) (µg/L)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Inorganics						
Barium	2/2	25	NA	1,000	--	0/2
Copper	2/2	7	NA	1,300(3)	--	0/2
Manganese	2/2	24	NA	50	--	0/2

Notes: Concentrations expressed in microgram per liter (µg/L).
NA - Not Applicable, no standard promulgated
(1) NCWQS - North Carolina Water Quality Standard for Tidal Saltwaters (human health)
(2) AWQCs - Federal Ambient Water Quality Standards (human health, water and organisms)
(3) Value is calculated using IRIS (USEPA, 1990).

TABLE 1-12

SUMMARY OF SITE 2 SHALLOW SEDIMENT INORGANIC ANALYTICAL DATA RAILROAD TRACK DRAINAGE DITCHES OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Maximum Detected Concentration (mg/kg)	Twice the Average Background Concentration (mg/kg)	Exceeded Background(2)
Aluminum	5,500	4,620	Y
Arsenic	1.4	1.36	Y
Barium	28.5	11.4	Y
Beryllium	0.25	ND	Y
Chromium	6.5	6.9	N
Copper	6.6	2.3	Y
Lead	51.4	12	Y
Manganese	32.3	12.5	Y
Selenium	0.38	ND	Y
Vanadium	11.5	6.6	Y
Zinc	120	21.3	Y

Notes: Units in milligram per kilogram.

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium+6

(4) USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 1-13

SUMMARY OF OVERS CREEK SHALLOW SEDIMENT INORGANIC ANALYTICAL DATA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Maximum Detected Concentration (mg/kg)	Twice the Average Background Concentration (mg/kg)	Exceeded Background(2)
Aluminum	8,680	4,620	Y
Arsenic	0.79	1.36	Y
Barium	114	11.4	Y
Beryllium	0.85	ND	Y
Chromium	9.9	6.9	Y
Copper	6.4	2.3	Y
Lead	8.8	12	Y
Manganese	203	12.5	Y
Selenium	1.7	ND	Y
Thallium	0.31	ND	Y
Vanadium	6.8	6.6	Y
Zinc	69	21.3	Y

Notes: Units in milligram per kilogram.

(1) USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening.

(2) Y/N (yes/no), denotes maximum detected value exceeded risk-based concentration.

(3) Chromium^{+6}

(4) USEPA, 1990. "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites."

TABLE 1-14

TOTAL SITE INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDICES
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas - Time Critical Removal Action		Former Storage Area		Former Storage Area - Time Critical Removal Action		Overs Creek	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Civilian Base Personnel	1E-4	1.3	5E-7	0.008	3E-7	0.004	3E-8	3E-4	--	--
Construction Worker	6E-7	0.1	1E-10	6E-5	4E-8	.005	4E-8	.005	--	--
Child Resident	2E-3	111	3E-4	11	3E-4	12	3E-4	11	--	--
Adult Resident	2E-3	23	7E-4	5	7E-4	5	7E-4	5	--	--
Trespassing Child	--	--	--	--	--	--	--	--	1E-7	1E-3
Trespassing Adult	--	--	--	--	--	--	--	--	9E-8	3E-4

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index

Shading indicates that risk level is not within or fell above acceptable levels.

TABLE 1-15

SUMMARY OF SOIL REMEDIATION LEVELS
TIME-CRITICAL REMOVAL ACTION
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Residential Remediation Level (Carcinogenic) (mg/kg)	Residential Remediation Level (Noncarcinogenic) (mg/kg)
Acenaphthene	(1)	4,153
Anthracene	(1)	20,765
Chlordane (Total)	0.621	4
4,4'-DDD	4	(2)
4,4'-DDE	3	(2)
4,4'-DDT	3	35
Dieldrin	0.05	4
Ethylbenzene	(1)	6,922
Fluoranthene	(1)	2,769
Heptachlor	0.179	35
N-Nitrosopliphenylamine	165	(2)
Naphthalene	(1)	2,769
2-Methylnaphthalene	(1)	2,769*
Phenanthrene	(1)	(2)
Pyrene	(1)	2,076
Toluene	(1)	13,844
Trichloroethene	74	(2)
Xylene (Total)	(1)	138,433

Notes: (1) Cancer slope factor not available
(2) Reference dose not available
* The toxicity factor for naphthalene was used to develop remediation level for 2-methyl naphthalene.
Remediation levels are for the resident child.

TABLE 1-16

SUMMARY OF SEDIMENT REMEDIATION LEVELS
TIME-CRITICAL REMOVAL ACTION
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Residential Remediation Level (Carcinogenic) (mg/kg)	Residential Remediation Level (Noncarcinogenic) (mg/kg)
Chlordane (Total)	4	26
4,4'-DDD	21	(2)
4,4'-DDE	15	(2)
4,4'-DDT	15	216
Dieldrin	(1)	22
Endosulfan II	1	216
Ethylbenzene	(1)	43,260
Naphthalene	(1)	17,304
2-Methylnaphthalene	(1)	17,304*
Xylene (Total)	(1)	865,202

Notes: (1) Cancer slope factor not available
(2) Reference dose not available
* The toxicity factor for naphthalene was used to develop remediation level for 2-methyl naphthalene.
Remediation levels are for the resident child.

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

This section presents the development of Remediation Goal Options (RGOs), Remediation Levels (RLs), and Remediation Action Objectives (RAOs) for Site 2.

2.1 Remediation Goal Options

RGOs are chemical-specific concentration goals established for specific media and land-use combinations for the protection of human health and the environment. The RGOs for Site 2 have been developed with consideration of the TCRA to be conducted pursuant to 40 CFR Part 300.415. There are two general sources of chemical-specific RGOs: (1) concentrations based on Applicable or Relevant and Appropriate Requirements (ARARs) and, (2) risk-based concentrations for the protection of public health and the environment. There are several steps involved in developing RGOs for a site including: identifying the media and contaminants of concern (COC); identifying the routes of exposure; identifying the receptors; and evaluating ARARs. The development of the RGOs via these steps are detailed in the following sections. All summary tables prepared for Section 2 are located at the end of this section.

2.1.1 Media(s) of Concern

The TCRA will address the removal of contaminated soil and sediment at the MPA. The remaining soil and sediment at the site will not pose a human health risk greater than 1.0E-06, which falls within the USEPA's acceptable target risk range of 1.0E-04 to 1.0E-06. Therefore, soil and sediment were not considered as media of concern in this FS. In addition, the risks calculated in the baseline RA for all of the receptors to surface water fell below acceptable risk levels. Therefore, surface water was not considered a media of concern for this FS. However, the results of the RA indicated that groundwater was a media of concern with respect to carcinogenic and noncarcinogenic risks before and after the implementation of the TCRA.

The results of the ecological RA in the RI Report indicated that adverse ecological impacts to the aquatic environment were not expected to be significant. For terrestrial organisms, pesticides were identified to be the most significant COC that would have the potential for decreased viability for this population. However, after the TCRA, a low likelihood of

decreased viability to the terrestrial population was anticipated. Therefore, no media of concern for the ecological environment was considered for OU No. 5.

2.1.2 Contaminants of Concern

Groundwater COC were selected in the baseline RA based on site history, frequency of detection, detected concentrations, toxicity, and comparison to established standards or criteria. The COC identified for groundwater are listed in Table 2-1.

2.1.3 Routes of Exposure and Receptors

The results of the human health RA indicated that the primary exposure route of concern was future ingestion of groundwater. However, currently there are no receptors who are exposed to the shallow groundwater the site. The shallow aquifer is a series of sediments, primarily sand and clay, which commonly extends to depths of 50 to 100 feet. The future development of the shallow aquifer for potable use is unlikely because of the general poor water quality in the shallow zone, poor flow rates, and the unlikely future development of the site for residential housing. All of the groundwater used at MCB, Camp Lejeune is supplied by the deeper Castle Hayne aquifer. There are four water supply wells located in the vicinity of Site 2: 616, 645, 646, and 647. The locations with respect to Site 2 are illustrated on Figure 2-1.

For representative exposure scenarios for the probable future use of the site, the RGOs for groundwater contaminants in the FS were calculated based on the potential exposure of the future construction worker. In addition, as a conservative estimate of exposure and for comparative purposes, RGOs were also calculated for the future residential child and adult exposure scenarios.

2.1.4 Applicable or Relevant and Appropriate Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as

"ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from both Federal and State laws. CERCLA's definition of "Applicable Requirements" is:

> ...cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstance at a CERCLA site. Drinking water criteria may be an applicable requirement for a site with contaminated groundwater that is used as a drinking water source.

CERCLA's definition of "Relevant and Appropriate Requirements" is:

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

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

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

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

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

ARARs can be identified only on a site-specific basis. They depend on the detected contaminants at a site, specific site characteristics, and particular remedial actions proposed for the site. ARARs identified for OU No. 5 are presented in the following section.

2.1.4.1 Chemical-Specific ARARs

The following criteria were used in the selection of chemical-specific ARARs: the North Carolina Water Quality Standards (NCWQSs) applicable to groundwaters, the Federal Primary MCLs, and Federal risk-based Health Advisories (HAs). A brief description of each of these ARARs are presented below and are summarized on Table 2-2.

North Carolina Water Quality Standards (Groundwater) - Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) has established groundwater standards (NCWQSs) for three classifications of groundwater within the State: GA, GSA, and GC. Class GA waters are those groundwaters in the State naturally containing 250 milligram per liter (mg/L) or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the State naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The NCAC T15A:02L.0300 has established sixteen river basins within the State as Class GC groundwaters (15A NCAC 2L.0201 and 2L.0300). Shallow groundwater at MCB Camp Lejeune is currently classified as GA.

The water quality standards for the groundwaters are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the State, which may be tolerated without creating a threat to human health or which would otherwise render the

groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the limit of detectability, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration as determined by the State. Substances which are not naturally occurring, and for which no standard is specified, are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15A NCAC 2L.0202).

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

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of 1.0E-06
- Taste threshold limit value
- Odor threshold limit value
- Federal MCL
- National Secondary Drinking Water Standard (or secondary MCL)

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

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

Health Advisories (HAs) - HAs are guidelines developed by the USEPA Office of Drinking Water which describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. These guidelines are designed to consider both acute and chronic toxic effets in children (assumed body weight of 10 kg) who consume 1 liter of water per day or in adults (assumed body weight of 70 kg) who consume 2 liters of of water per day. Health Advisories are generally available for acute (1 day), subchronic (10 days), chronic (longer term),

approximately seven years, and lifetime exposures based on data describing noncarcinogenic endpoints of toxicity. HAs do not quantitatively incorporate any potential carcinogenic risk from such exposure. Chemical concentration values for carcinogens are correlated with a cancer potency value (unit risks) with assumptions for lifetime exposure and the consumption of drinking water.

Table 2-3 presents the chemical-specific ARARs and to be considered criteria for the groundwater COC at Site 2.

2.1.4.2 Location-Specific ARARs

Potential location-specific ARARs identified for OU No. 5 are listed on Table 2-4. An evaluation determining the applicability of these location-specific ARARs with respect to OU No. 5 is also presented and summarized on Table 2-4. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to OU No. 5:

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

Please note that the citations listed on Table 2-4 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

2.1.4.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for OU No. 5. A set of potential action-specific ARARs are listed on Table 2-5. Note that the citations listed on this table should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference. These ARARs will be evaluated after the remedial action alternatives have been identified for OU No. 5. Additional action-specific ARARs may also be identified and evaluated at that time.

2.1.5 Risk-Based Remediation Goal Options

Risk-based RGOs were developed for the groundwater COC. Derived RGOs for OU No. 5 involved establishing acceptable human health risk criteria and determining allowable risk to COC, which were then used to back calculate media-specific concentrations for established risk levels. For OU No. 5, RGOs were calculated for the receptor most likely to come into contact with the groundwater i.e., the future construction worker. However, for a conservative estimate of exposure, RGOs were also calculated for the future residential child and adult.

The methodology used for the risk-based RGOs is in accordance with USEPA risk assessment guidance (USEPA, 1989a) (USEPA, 1991a). For noncarcinogenic effects, a concentration was calculated that corresponds to an HI of 1.0, or unity, which is the level of exposure to a contaminant from all significant exposure pathways in a given medium below which it is unlikely for even sensitive populations to experience health effects. Based on the NCP (40 CFR 300.430), for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an ICR between 1.0E-04 and 1.0E-06, which corresponds to an ICR over a lifetime as a result of exposure to the potential carcinogen from all significant exposure pathways for a given medium. Therefore, risk-based RGOs for the carcinogenic COC were calculated at three ICR levels; 1.0E-04, 1.0E-05, and 1.0E-06 for all receptors.

Three steps were involved in estimating the risk-based RGOs for COC at OU No. 5. These steps are generally conducted for a media and land-use combination and involved identifying the most significant: (1) exposure pathways and routes, (2) exposure parameters, and (3) equations. The equations included calculations of total intake from a given medium and were based on identified exposure pathways and associated parameters. Equations and input parameters are presented in Appendix B.

2.1.6 Comparison of Risk-Based Remediation Goal Options to Maximum Contaminant Concentrations in Groundwater

This subsection discusses a comparison of risk-based RGOs to maximum contaminant concentrations in groundwater.

Identification of remedial alternatives should not solely be placed on the estimation of risk-based RGOs. Comparison of maximum contaminant concentration to risk-based RGOs was performed to provide a upper-bound conservative estimation, and aid in the screening and identification of remedial alternatives. They are not to be used in making final remedial decisions.

2.1.6.1 Future Residential Child and Adult

The carcinogenic and noncarcinogenic risk-based RGOs, with respect to the future residential child and adult, were calculated for the dermal contact and ingestion of groundwater scenarios. The two exposure pathway scenarios were summed for each receptor to evaluate the additive effects of the COC. Of the residential child and adult, the residential child noncarcinogenic RGOs were the most conservative of the two residential receptors. Likewise, the residential adult carcinogenic RGOs were the most conservative of the the two residential receptors. Therefore, the following discussion reflects this result.

The RGOs calculated for the residential child and a comparison to the maximum groundwater COC concentrations are presented on Table 2-6. As shown on the table, the maximum concentration of arsenic, barium, and 4,4'-DDT exceeded the noncarcinogenic RGOs at the HI of 1.0.

The RGOs calculated for the residential adult and a comparison to the maximum groundwater COC concentrations are presented on Table 2-7. As shown on the table, the maximum concentration of arsenic and beryllium exceeded the carcinogenic RGOs at all three of the ICR levels. In addition, 4,4'-DDD and 4,4'-DDT exceeded the carcinogenic RGOs at the 1.0E-05 and 1.0E-06 ICR levels only.

2.1.6.2 Future Construction Worker

The carcinogenic and noncarcinogenic risk-based RGOs, with respect to a future construction worker, were calculated for the dermal contact and ingestion of groundwater scenarios. The two exposure pathway scenarios were summed to evaluate the additive effects of the COC. The RGOs calculated for this receptor and a comparison to the maximum groundwater COC concentrations are presented on Table 2-8. As shown on the table, none of the maximum concentrations of COC exceeded the carcinogenic RGOs at all three ICR levels or the noncarcinogenic RGOs.

2.1.6.3 Summary of Remediation Goal Options

Table 2-9 presents a summary of RGOs, basis of goal and corresponding risks of groundwater COC for the future construction worker receptor. The future construction worker is the receptor most likely to come into contact with shallow groundwater at Operable Unit No. 5.

2.1.7 Uncertainty Analysis

The general uncertainties associated with calculating risk-based RGOs are summarized below. Most scientific computation involves a limited number of input variables, which are tied together by a scenario to provide a desired output. Some RGO inputs are based on literature values rather than measured values. In such cases the degree of certainty may be expressed as whether the estimate was based on literature values or measured values, not on how well defined the distribution of the input was. Some RGOs are based on estimated parameters; the qualitative statement that the RGOs was based on estimated inputs defines the certainty in a qualitative manner.

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

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

2.2 Remediation Levels

This section presents the Remediation Levels (RLs) chosen for OU No. 5. RLs are chosen by the risk manager for the COC and are also included in the ROD. These numbers derived from

the RGOs presented on Table 2-9 are no longer goals and may be considered required levels for the remedial actions to achieve.

The final COC are selected from that group of groundwater COC that were detected in concentrations exceeding the RGO listed on Table 2-9. The final COC and their associated RLs are presented on Table 2-10. This list was based on a comparison of contaminant-specific ARARs and the site-specific risk-based RGOs. If a COC had an ARAR, the most limiting (or conservative) ARAR was selected as the RL for that contaminant. If a COC did not have an ARAR, the most conservative risk-based RGO was selected for the RL.

In order to determine the final COC for OU No. 5, the contaminant concentrations detected at each site were compared to the RLs. The contaminants which exceeded at least one of the RLs were retained as final COC. The contaminants that did not exceed any of the RLs were no longer considered as COC with respect to this FS.

The final groundwater COC are trichloroethene, ethylbenzene, xylene (total), and lead. Contaminant source areas have been identified based on past operations and supporting analytical data. The groundwater monitoring results suggest that the sources of groundwater contamination are, or were, present in localized areas within Site 2. Organic contaminants were detected in wells located in the FSA. The source is, or was most likely the result of previous site operations since the general groundwater flow is to the north and east. The concentrations of organic and inorganic contaminants detected above Federal and North Carolina groundwater quality standards and inorganic chemicals of concern are presented in Figures 2-2, 2-3, and 2-4, respectively.

2.3 Remedial Action Objectives

The general approach used for development of groundwater containment and treatment scenarios in the FS was to estimate the downgradient edge of contaminated areas based on available information while making only limited assumptions concerning any upgradient extent of contaminant plumes.

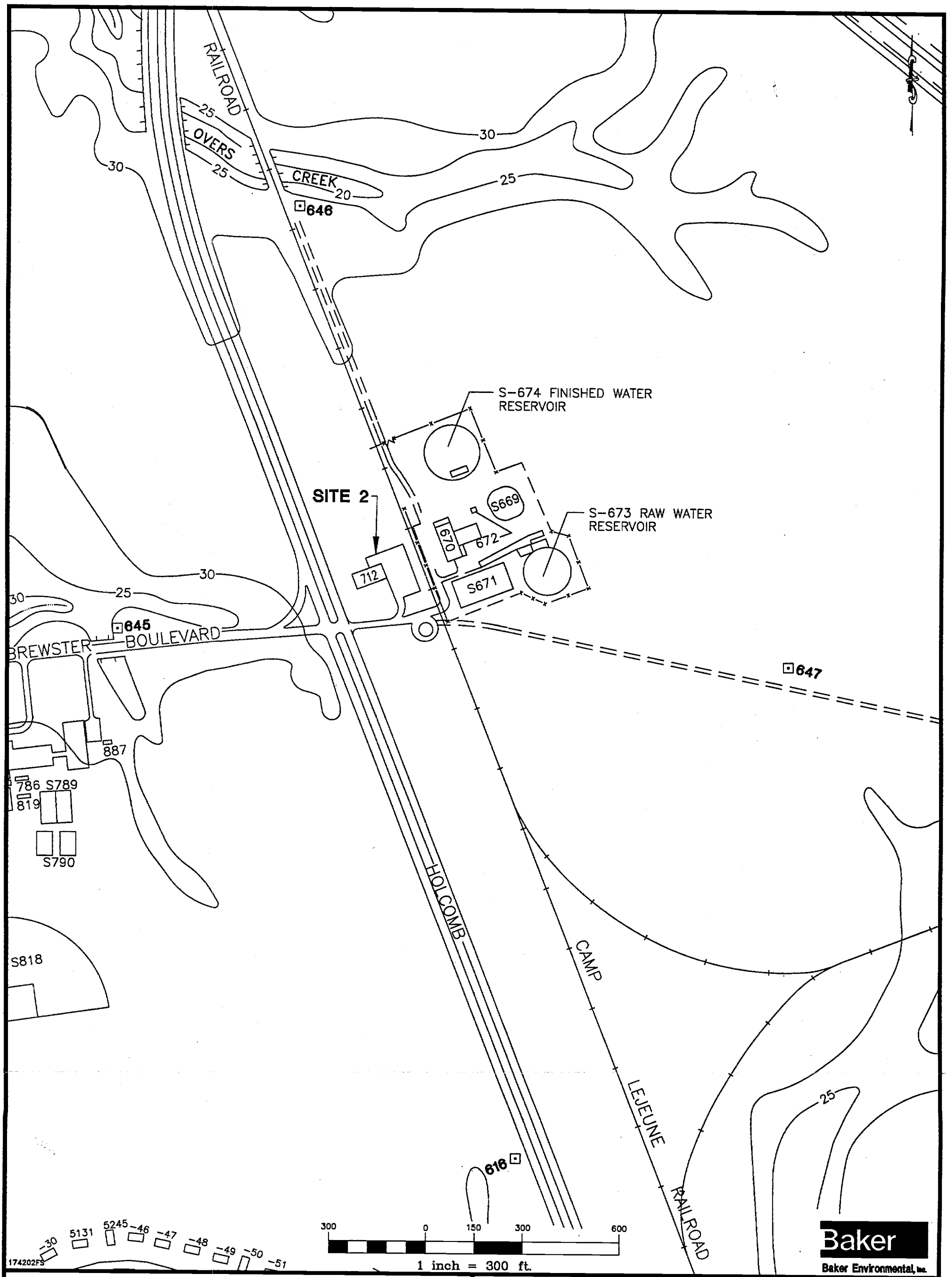
In general, the groundwater remediation levels developed for the organic contaminants were used to estimate the downgradient extent of groundwater defined as "contaminated." As discussed in Section 1.0 and in the RI, the inorganic constituents detected are most likely associated with turbidity in the wells and are well within the typical range for inorganics in

groundwater. During the initial sampling, the organic contaminant trichloroethene was detected in the deep monitoring well 2GW3D, at a concentration equal to the Federal MCL (5 µg/L) and above the state limit of 2.8 µg/L. Additionally, the contaminant (TCE) found in this well is considered to be unrelated to former operations at Site 2 and may be associated with the TCE levels found in the deep aquifer at several locations on base (Geophex, 1991). TCE was not detected in this monitoring well during the second round of sampling. Therefore, the following remedial action objectives will be considered for the shallow groundwater at Site 2:

- To prevent exposure to (ingestion, inhalation, and dermal contact) groundwater COC exceeding the remediation levels

- To prevent further migration of contaminated groundwater in the surficial and Castle Hayne Aquifers

- To restore the groundwater to meet the remediation levels set for the groundwater COC



LEGEND

616 ⊡ WATER SUPPLY WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-1
WATER SUPPLY WELLS IN THE
VICINITY OF SITE 2
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0125166B2Z

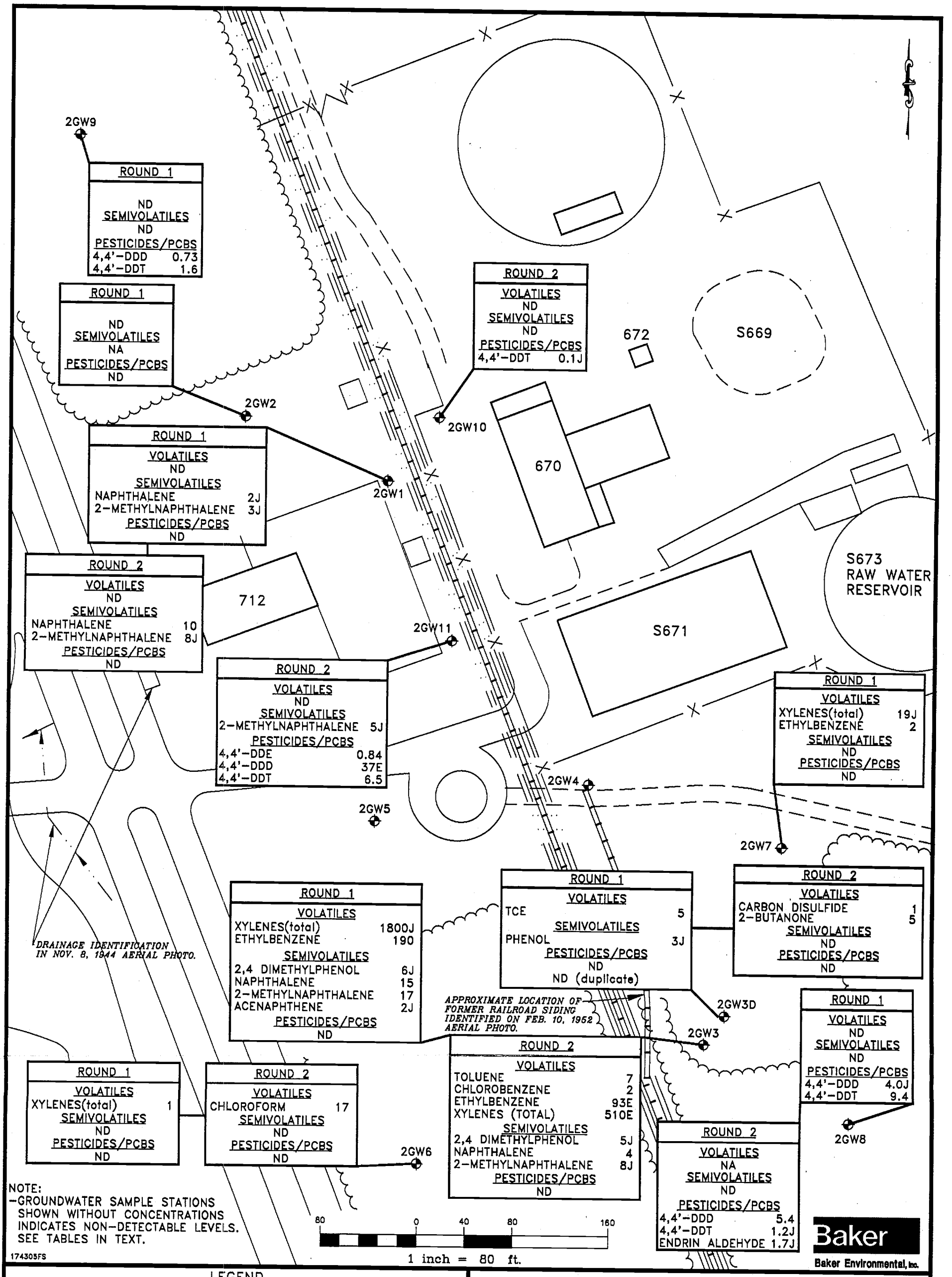
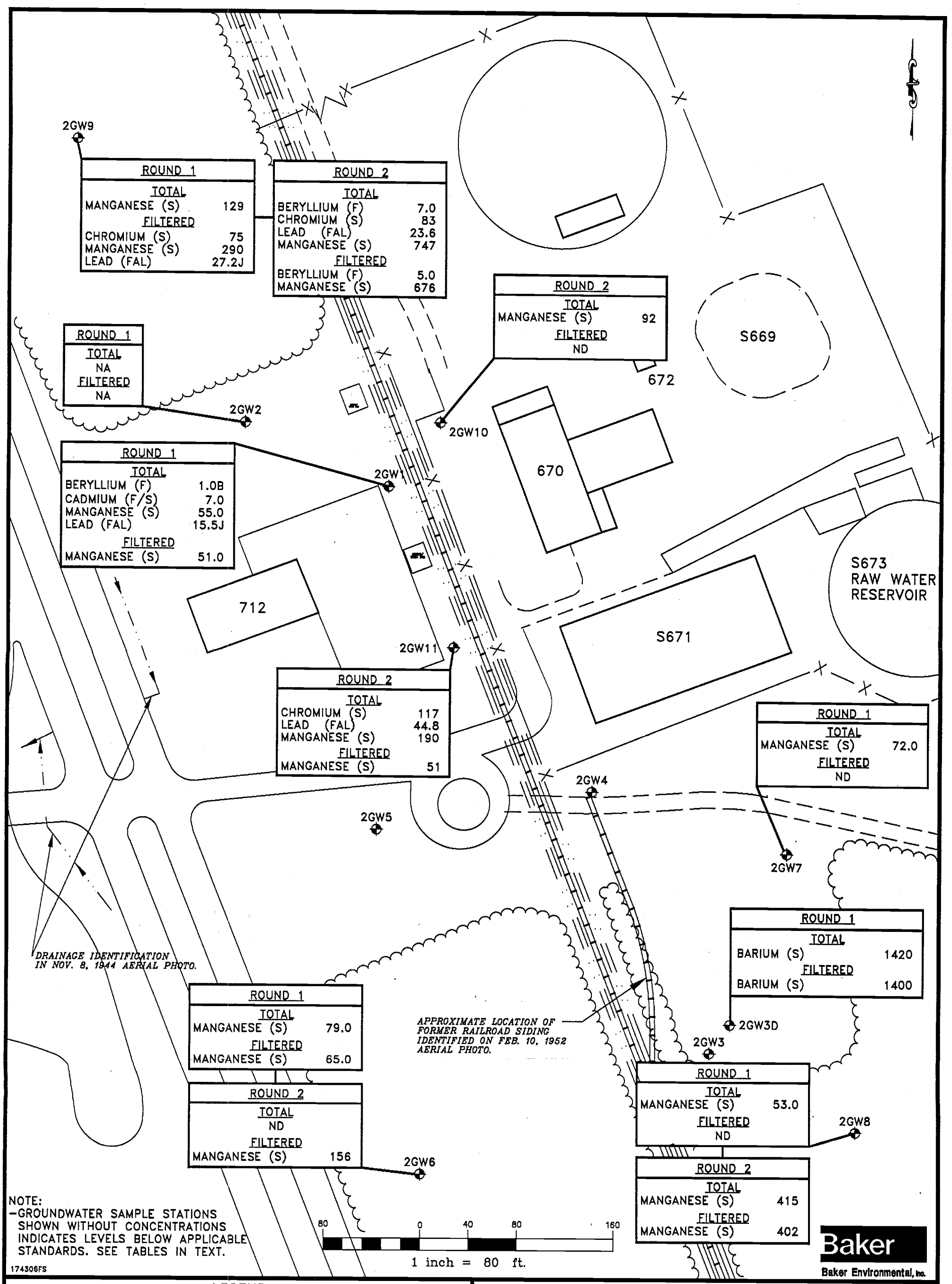


FIGURE 2-2
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN GROUNDWATER
SITE 2
FEASIBILITY STUDY CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

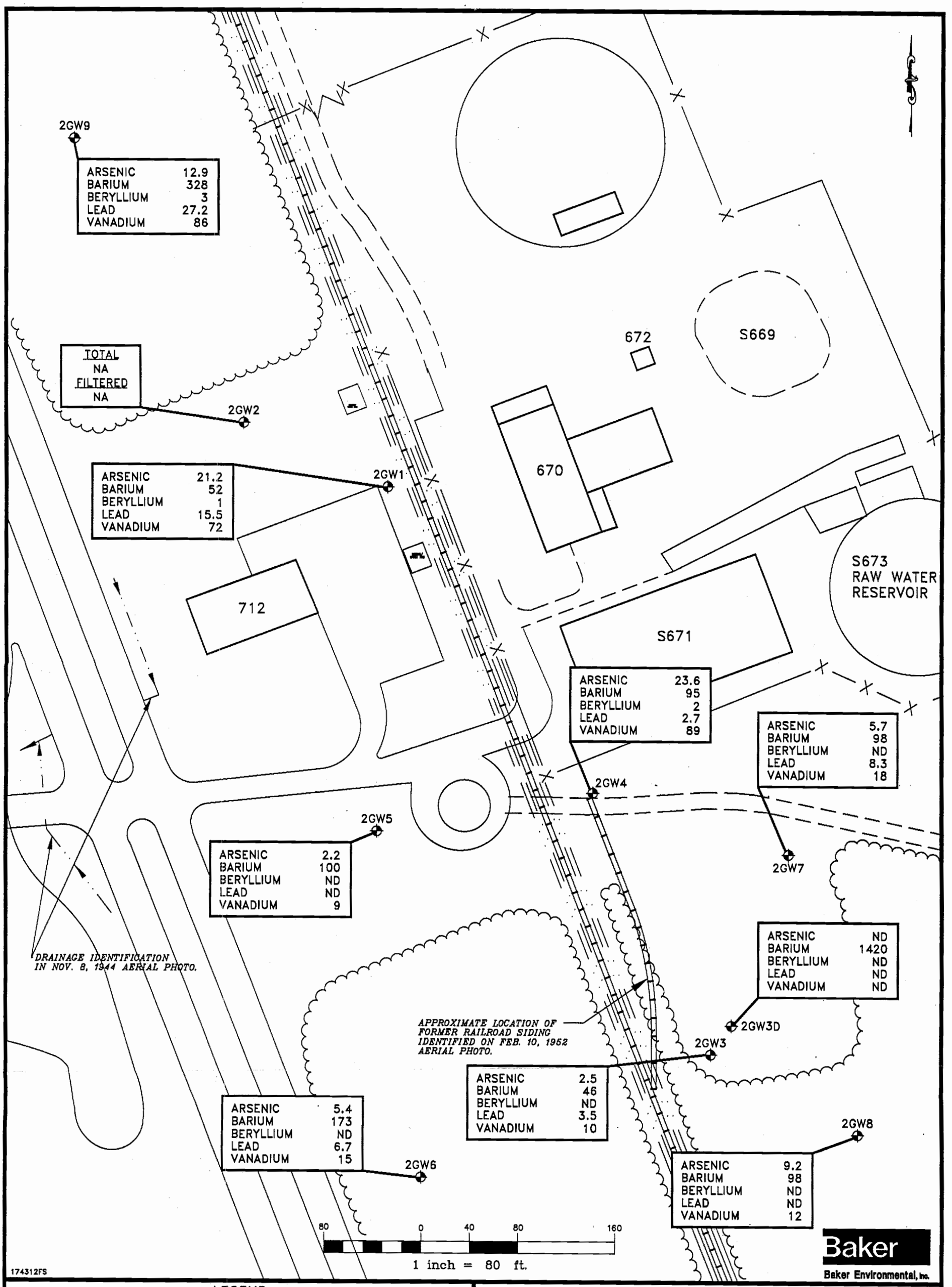


LEGEND

2GW1 ⊕	GROUNDWATER WELL
(F)	EXCEEDS FEDERAL STANDARD
(S)	EXCEEDS STATE STANDARD
(FAL)	FEDERAL ACTION LEVEL
ND	NOT DETECTED ABOVE APPLICABLE STANDARDS
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATIONS

CONCENTRATIONS EXPRESSED IN ug/l(ppb)
SOURCE: LANTDIV, FEB. 1992

FIGURE 2-3
POSITIVE DETECTIONS ABOVE APPLICABLE FEDERAL AND STATE STANDARDS FOR TOTAL AND FILTERED INORGANIC ANALYTES IN GROUNDWATER
SITE 2
FEASIBILITY STUDY CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

2GW1 GROUNDWATER WELL

ND NOT DETECTED

NA NOT ANALYZED

TOTAL INORGANIC CONCENTRATIONS EXPRESSED IN ug/L

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-4
INORGANIC CONCENTRATIONS OF
COCs IN GROUNDWATER
SITE 2
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

TABLE 2-1

PRELIMINARY CONTAMINANTS OF CONCERN
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Contaminant of Concern Evaluated in the Baseline RA (1)
Groundwater	Acenaphthene
	Arsenic
	Barium
	Beryllium
	4,4'-DDD
	4,4'-DDT
	2,4-Dimethylphenol
	Ethylbenzene
	Lead
	2-Methylnaphthalene
	Naphthalene
	Phenol
	Trichloroethene
	Vanadium
	Xylene (total)

Note: (1) This list includes the COC selected for groundwater evaluation for the baseline RA in the RI Report (Baker, 1994).

TABLE 2-2

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL/CONTAMINANT-SPECIFIC		
Safe Drinking Water Act a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing remediation levels for contaminated groundwater used as a potable water supply.
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, trichloroethylene, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	Remedial actions (e.g., air stripping) may result in release of hazardous air pollutants. The treatment design may elect to control equipment air emissions using the same or similar methods.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
National Ambient Air Quality Standards (40 CFR 50)	Standards for the following six criteria pollutants: particulate matter; sulfur dioxide; carbon monoxide; ozone; nitrogen dioxide; and lead. The attainment and maintenance of these standards are required to protect the public health and welfare.	Relevant and appropriate requirements for remedial actions requiring discharge to the atmosphere.
EPA Ambient Water Quality Criteria (Section 304(a)(1) of CWA)	Non-enforceable criterion for water quality for the protection of human health from exposure to contaminants in drinking water and from ingestion of aquatic biota and for the protection of fresh-water and salt-water aquatic life.	Potentially relevant and appropriate for groundwater treatment.
STATE/CONTAMINANT-SPECIFIC		
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2B.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina	Surface water quality standards based on water use and criteria class of surface water.	Relevant and appropriate for remedial actions requiring discharge to surface water.
North Carolina Anti-Degradation Policy for Surface Water (Water Quality Standards Title 15A, Chapter 2, Subchapter 2B)	Provides for an anti-degradation policy for surface water quality. Pursuant to this policy, the requirements of 40 CFR 131.12 are adopted by reference in accordance with General Statute 150B-14(b).	This policy is a TBC requirement for remedial actions requiring discharge to surface water.
North Carolina Groundwater Standards Applicable Statewide	Establishes maximum contaminant concentrations to protect groundwater. These standards are mandatory.	Potentially relevant and appropriate for remedial actions requiring discharge to groundwater.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina DEHNR Regulations	Standards for protection of health of consumers using public drinking water supplies. Establishes MCLs for given contaminants.	Potentially relevant and appropriate in developing remediation goals for contaminated groundwater used as a potable water supply.
North Carolina DEHNR Toxic Air Pollutant Rule Statutory Authority G.S. 143-215.107(a)(1),(3),(4),(5); 143-B-282	A facility shall not emit any toxic air pollutants (as listed in Rule .1104) that may cause or contribute beyond the premises (contiguous property boundary) to any significant ambient air concentration that may adversely affect human health.	Potentially relevant and appropriate for remedial actions requiring discharge to the atmosphere.

TABLE 2-3

CONTAMINANT-SPECIFIC ARARs AND TO BE CONSIDERED CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Groundwater Contaminant of Concern	MCL [1] (µg/L)	NCWQS [2] (µg/L)	Federal Health Advisories [3] (µg/L)	
			For a 10 kg Child Longer Term	For a 70 kg Adult Lifetime
Acenaphthene	--	--	--	--
Arsenic	50	50	--	2[4]
Barium	2,000	2,000	--	2,000
Beryllium	--	4	400	0.8[4]
4,4'-DDD	--	--	--	--
4,4'-DDT	--	--	--	--
2,4-Dimethylphenol	--	--	--	--
Ethylbenzene	700	29	1,000	700
Lead	15	15	--	--
2-Methylnaphthalene	--	--	--	--
Naphthalene	--	--	400	20
Phenol	--	--	6,000	4,000
Trichloroethene	5	2.8	--	300[4]
Vanadium	--	--	--	--
Xylene (total)	10,000	530	40,000	10,000

Notes: [1] MCL = Safe Drinking Water Act Maximum Contaminant Level (MCL for lead is an Action Level)

[2] NCWQS = North Carolina Water Quality Standards for Class GA groundwater

[3] Health Advisories - to be considered criteria

[4] Level at 10^{-4} cancer risk

-- No ARAR available or established

TABLE 2-4

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED LOCATION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ LOCATION-SPECIFIC		
National Historic Preservation Act of 1966 16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	Requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	No known historic properties are within or near OU No. 5, therefore, this act will not be considered as an ARAR.
Archeological and Historic Preservation Act 16 USC 469 and 40 CFR 6.301(c)	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	No known historical or archeological data is known to be present at the site, therefore, this act will not be considered as an ARAR.
Historic Sites, Buildings and Antiquities Act 16 USC 461467 and 40 CFR 6.301(a)	Requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	No known historic sites, buildings or antiquities are within or near OU No. 5, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act 16 USC 661-666	Requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	Overs Creek and the drainage ditch adjacent to the railroad tracks are located near and within the operable unit boundaries, respectively. If remedial actions are implemented that modify this creek or drainage channel, this will be an applicable ARAR.
Federal Endangered Species Act 16 USC 1531, 50 CFR 200, and 50 CFR 402	Requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	Many protected species have been cited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991), (Fussell, 1991), (Walters, 1991). Therefore, this will be considered as an ARAR.

TABLE 2-4 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED LOCATION-SPECIFIC CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina Endangered Species Act GS 113-331 to 113-337	Per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rare species, and the State watch list.	Since the American alligator has been sighted in nearby surface water features, this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) 33 USC 403	Requires permit for structures or work in or affecting navigable waters.	No remedial actions will affect the navigable waters of the New River. Therefore, this act will not be considered as an ARAR.
Executive Order 11990 on Protection of Wetlands Executive Order Number 11990 and 40 CFR 6	Establishes special requirements for Federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Based on a review of Wetland Inventory Maps, the lower reaches of Overs Creek has areas of wetlands. Therefore, this will be an applicable ARAR.
Executive Order 11988 on Floodplain Management Executive Order Number 11988, and 40 CFR 6	Establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Based on the Federal Emergency Management Agency's Flood Insurance Rate Map for Onslow County, the site is primarily within a minimal flooding zone (outside the 500-year floodplain). The creek is within the 100-year floodplain (FEMA, 1987). Therefore, this may be an ARAR for the operable unit.
Wilderness Act 16 USC 1131 and 50 CFR 35.1	Requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	No known federally owned wilderness areas near the operable unit exist, therefore, this act will not be considered as an ARAR.
National Wildlife Refuge System 16 USC 668, and 50 CFR 27	Restricts activities within a National Wildlife Refuge.	No known National Wildlife Refuge areas near the operable unit exist, therefore, this will not be considered as an ARAR.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED LOCATION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
Scenic Rivers Act 16 USC 1271, and 40 CFR 6.302(e)	Requires action to avoid adverse effects on designated wild or scenic rivers.	No known wild or scenic rivers near the operable unit exist, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act 16 USC 1451	Requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	No activities will affect land or water uses in a coastal zone, therefore, this act will not be considered as an ARAR.
Clean Water Act (Section 404) 33 USC 404	Prohibits discharge of dredged or fill material into wetland without a permit.	No actions to discharge dredged or fill material into wetlands will be considered for the operable unit, therefore, this act will not be considered as an ARAR.
RCRA Location Requirements 40 CFR 264.18	Limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	These requirements may be applicable if the remedial actions for the operable unit includes the on-site storage, treatment, or disposal of RCRA hazardous waste. Therefore, these requirements may be an applicable ARAR for the operable unit.

TABLE 2-5

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED ACTION-SPECIFIC CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ACTION-SPECIFIC		
OSHA Requirements (29 CFR Parts 1910, 1926, and 1904)	Regulations provide occupational safety and health requirements applicable to workers engaged in on-site field activities.	Required for site workers during construction and operation of remedial activities. Applicable to all actions at the site.
DOT Rules for Hazardous Materials Transportation (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Remedial actions may include off-site treatment and disposal of contaminated groundwater. Applicable for any action requiring off-site transportation of hazardous materials.
Resource Conservation and Recovery Act (RCRA) Subtitle C		
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Primary site contaminants are not considered to be listed wastes. However, contaminated media may be considered hazardous by characteristic.
Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262-265, and 266)	Regulates the treatment, storage, and disposal of hazardous waste.	During remediation, treatment, storage, and disposal activities may occur. Materials may be classified as hazardous wastes.
RCRA Subtitle D	Regulates the treatment, storage, and disposal of solid waste and materials designated by the State as special waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid and/or special waste.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED ACTION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
RCRA Land Disposal Restrictions (LDRs) Requirements (40 CFR Part 268)	Restricts certain listed or characteristic hazardous waste from placement or disposal on land (includes injection wells) without treatment. Provides treatment standards and Best Demonstrated Available Technology (BAT).	LDRs may prohibit or govern the implementation of certain remedial alternatives. Extraction and treatment and/or movement of RCRA hazardous waste may trigger LDR requirements for the waste. Reinjection of treated groundwater into or above an underground source of drinking water may be exempt from LDRs given the treatment of the groundwater meets exemption requirements.
Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0-28)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	To be considered (TBC) as remedial action may include air stripping.
General Pretreatment Regulations for Existing and New Sources of Pollutants (40 CFR Part 403)	Regulations promulgated under the Clean Water Act. Includes provisions for effluent discharge to Publicly Owned Treatment Works (POTW). Discharge of pollutants that pass through or interfere with the POTW, contaminate sludge, or endanger health/safety of POTW workers is prohibited. These regulations should be used in conjunction with local POTW pretreatment program requirements.	Applicable for remedial actions involving discharge to a sanitary sewer.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED ACTION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section .0100)	Regulates point-source discharges through the North Carolina permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	May be applicable for actions requiring discharge to the ditches on site. The base currently has a North Carolina permit for surface water discharge to the ditch to the north of the site. This permit may need to be modified.
Protection of Archaeological Resources (32 CFR Parts 229 and 229.4; 43 CFR Parts 107 and 171.1-5)	Develops procedures for the protection of archaeological resources.	Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and State archaeologists.
North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A)	Regulates stormwater management and erosion/ sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities (i.e., excavation of soil and sediment).

TABLE 2-6

GROUNDWATER REMEDIATION GOAL OPTIONS
FUTURE RESIDENT CHILD
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Child (Carcinogenic)* (µg/L)			Child (Noncarcinogenic)** (µg/L)	Maximum Contaminant of Concern Concentration
	1.0E-04	1.0E-05	1.0E-06		
Acenaphthene	(1)	(1)	(1)	935	2
Arsenic	10	1	0.1	5	23.6
Barium	(1)	(1)	(1)	1,091	1,420
Beryllium	4	0.4	0.04	78	2
4,4'-DDD	48	4.8	0.48	(2)	4
4,4'-DDT	28	2.8	0.28	4	9.4
2,4-Dimethylphenol	(1)	(1)	(1)	312	6
Ethylbenzene	(1)	(1)	(1)	398	190
Lead	(1)	(1)	(1)	(2)	15.5
2-Methylnaphthalene	(1)	(1)	(1)	546	17
Naphthalene	(1)	(1)	(1)	546	15
Phenol	(1)	(1)	(1)	9,225	3
Trichloroethene	1,604	160	16.05	91	5
Vanadium	(1)	(1)	(1)	109	89
Xylene (total)	(1)	(1)	(1)	26,886	1,800

Notes: * Carcinogenic risk based on an incremental risk of 1.0E-06 level.
** Noncarcinogenic risk based on a hazard index of 1.0.
(1) Remediation level not calculated since a Cancer Slope Factor is not available.
(2) Remediation level not calculated since a reference dose is not available.

Bold indicates the maximum concentration of contaminant of concern exceeds noncarcinogenic RGO.

TABLE 2-7

GROUNDWATER REMEDIATION GOAL OPTIONS
FUTURE RESIDENT ADULT
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Adult (Carcinogenic)* (µg/L)			Adult (Noncarcinogenic)** (µg/L)	Maximum Contaminant of Concern Concentration
	1.0E-04	1.0E-05	1.0E-06		
Acenaphthene	(1)	(1)	(1)	2,180	2
Arsenic	5	0.5	0.05	11	23.6
Barium	(1)	(1)	(1)	2,544	1,420
Beryllium	2	0.2	0.02	182	2
4,4'-DDD	20	2	0.2	(2)	4
4,4'-DDT	11	1.1	0.11	8	9.4
2,4-Dimethylphenol	(1)	(1)	(1)	728	6
Ethylbenzene	(1)	(1)	(1)	740	190
Lead	(1)	(1)	(1)	(2)	15.5
2-Methylnaphthalene	(1)	(1)	(1)	1,220	17
Naphthalene	(1)	(1)	(1)	1,220	15
Phenol	(1)	(1)	(1)	21,399	3
Trichloroethene	740	74	7.4	209	5
Vanadium	(1)	(1)	(1)	254	89
Xylene (total)	(1)	(1)	(1)	59,863	1,800

Notes: * Carcinogenic risk based on an incremental risk of 1.0E-06 level.
** Noncarcinogenic risk based on a hazard index of 1.0.
(1) Remediation level not calculated since a Cancer Slope Factor is not available.
(2) Remediation level not calculated since a reference dose is not available.

Bold indicates the maximum concentration of contaminant of concern exceeds noncarcinogenic RGO.

TABLE 2-8

GROUNDWATER REMEDIATION GOAL OPTIONS
FUTURE CONSTRUCTION WORKER
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Construction Worker (Carcinogenic)* (µg/L)			Construction Worker (Noncarcinogenic)** (µg/L)	Maximum Contaminant of Concern Concentration
	1.0E-04	1.0E-05	1.0E-06		
Acenaphthene	(1)	(1)	(1)	50,637	2
Arsenic	3,376	338	34	253	23.6
Barium	(1)	(1)	(1)	59,076	1,420
Beryllium	1,374	137	14	4,220	2
4,4'-DDD	9,367	937	94	(2)	4
4,4'-DDT	4,957	496	50	120	9.4
2,4-Dimethylphenol	(1)	(1)	(1)	16,923	6
Ethylbenzene	(1)	(1)	(1)	9,316	190
Lead	(1)	(1)	(1)	(2)	15.5
2-Methylnaphthalene	(1)	(1)	(1)	24,211	17
Naphthalene	(1)	(1)	(1)	24,211	15
Phenol	(1)	(1)	(1)	487,364	3
Trichloroethene	495,221	49,522	4,952	4,669	5
Vanadium	(1)	(1)	(1)	5,908	89
Xylene (total)	(1)	(1)	(1)	1.1E+06	1,800

Notes: * Carcinogenic risk based on an incremental risk of 1.0E-06 level.
** Noncarcinogenic risk based on a hazard index of 1.0.
(1) Remediation level not calculated since a Cancer Slope Factor is not available.
(2) Remediation level not calculated since a reference dose is not available.

TABLE 2-9

SUMMARY OF RGOs, BASIS OF GOAL AND CORRESPONDING RISK FOR GROUNDWATER COC
FUTURE CONSTRUCTION WORKER
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Contaminant of Concern	RGO	Unit	Basis of Goal	Corresponding Risk		Detected Concentration Range (µg/L)
					Carcinogenic	Noncarcinogenic	
Groundwater	Acenaphthene	50,637	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 2J
	Arsenic	50	µg/L	NCWQS			ND - 23.6
	Barium	2,000	µg/L	MCL/NCWQS			46 - 1,420
	Beryllium	4	µg/L	NCWQS			1 - 2
	4,4'-DDD	94	µg/L	Carcinogenic Risk	ICR = 1.0E-06		ND - 4J
	4,4'-DDT	50	µg/L	Carcinogenic Risk	ICR = 1.0E-06		ND - 9.4
	2,4-Dimethylphenol	16,923	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 6
	Ethylbenzene	29	µg/L	NCWQS			ND - 190
	Lead	15	µg/L	MCL/NCWQS			ND - 15.5
	2-Methylnaphthalene	24,211	µg/L	Noncarcinogenic Risk*		HI = 1.0	ND - 17
	Naphthalene	24,211	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 15
	Phenol	487,364	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 3
	Trichloroethene	2.8	µg/L	NCWQS			ND - 5
	Vanadium	5,908	µg/L	Noncarcinogenic Risk		HI = 1.0	9 - 89
	Xylene (total)	530	µg/L	NCWQS			ND - 1800J

Notes: RGO = Remediation Goal Option
ICR = Incremental Lifetime Cancer Risk. An ICR of 1.0E-06 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals. USEPA considers ICRs of 1.0E-04 to 1.0E-06 to be protective of public health (USEPA, 1989a).
HI = Hazard Index. A HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects could occur.
NCWQS = North Carolina Water Quality Standards
MCL = Maximum Contaminant Level
ND = Not Detected
*Naphthalenes toxicity factor was used as a surrogate for 2-methylnaphthalene.

TABLE 2-10

FINAL COC AND REMEDIATION LEVELS
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Final Contaminant of Concern	Remediation Level (µg/L)	Basis of Remediation Level
Groundwater			
	Ethylbenzene	29	NCWQS
	Trichloroethene	2.8	NCWQS
	Xylene (total)	530	NCWQS
	Lead	15.5	MCL/NCWQS

Units: µg/L = microgram per liter

3.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES

This section includes the identification and preliminary screening of a set of remedial action technologies that may be applicable for the remediation of the groundwater at Site 2. Section 3.1 identifies a set of general response actions that may be applicable to the operable unit. Section 3.2 includes the identification of a set of remedial technologies applicable to groundwater remediation. Section 3.3 presents the preliminary screening of the set of identified remedial technologies and process options. Section 3.4 presents the process option evaluation. All of the tables in Section 3.0 are presented at the end of this section.

3.1 General Response Actions

General response actions are broad-based medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. The general response actions that will satisfy the remedial action objectives identified for Site 2 are listed on Table 3-1. As shown on the table, four general response actions have been identified for the groundwater objectives: no action, institutional controls, containment actions, and collection/treatment actions. A brief description of each of the above-mentioned general response actions follows.

3.1.1 No Action

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

3.1.2 Institutional Controls

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

3.1.3 Containment Actions

Containment measures include various technologies which contain and/or isolate the COCs on a site. The measures are designed to isolate so as to prevent direct exposure with or migration of the contaminated media without disturbing or removing the waste from the site. Containment actions generally serve to cover, seal, chemically stabilize, or provide an effective barrier against specific areas of contamination. These actions may be applicable to groundwater at Site 2.

3.1.4 Collection/Treatment Actions

Collection/treatment actions are typically associated with groundwater or surface water. For this FS, only groundwater collection/treatment actions will be addressed. For groundwater, collection/treatment actions may include one of the following options: (1) collecting the contaminated groundwater, treating it on site, and then discharging or reinjecting it; (2) collecting the groundwater and then treating it off site; and (3) treating the groundwater in situ.

3.2 Identification of Remedial Action Technologies and Process Options

In this step, an extensive set of potentially applicable technology types and process options will be identified for each of the general response actions identified for the contaminated groundwater at Site 2. The term "technology type" refers to general categories of technologies such as chemical treatment, thermal treatment, biological treatment, and in situ treatment. The term "technology process option" refers to specific processes within each technology type, for example rotary kiln, fluidized bed, and multiple hearth incineration are process options of thermal treatment. Several technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Remedial action technologies potentially applicable to the site are listed on Table 3-2 with respect to their corresponding general response action. The applicable process options associated with each of the listed technologies are also listed on the table.

3.3 Preliminary Screening of Remedial Action Technologies and Process Options

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

As shown on Table 3-3, several technologies and/or process options were eliminated from further evaluation since they were determined to be inappropriate for the site-specific characteristics and/or contaminant-specific characteristics of Site 2. The groundwater technologies/options that were eliminated include:

- Vertical Barriers
- Horizontal Barriers
- Reverse Osmosis
- Oil/Water Separation
- Chemical Dechlorination
- Plasma Arc Torch
- Pyrolysis
- Wet Air Oxidation

The technologies and process options that passed this preliminary screening are listed on Table 3-4.

3.4 Process Option Evaluation

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

the specific process option used to implement the remedial action may not be selected until the remedial design phase.

The process options listed on Table 3-4 were evaluated based on effectiveness, implementability, and relative cost. The effectiveness evaluation focused on: the potential effectiveness of process options in meeting the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phase; and how reliable the process is with respect to the COCs. The implementability evaluation focused on the administrative feasibility of implementing a technology (e.g., obtaining permits), since the technical implementability was previously considered in the preliminary screening. The cost evaluation played a limited role in this screening. Only relative capital and operating and maintenance (O&M) costs were used instead of detailed estimates. Per the USEPA FS guidance, the cost analysis was made on the basis of engineering judgment.

A summary of the process option evaluation is presented on Table 3-5 for groundwater. It is important to note that the elimination of a process option does not mean that the process option/technology can never be reconsidered for the site. As previously stated, the purpose of this part of the FS process is to simplify the development and evaluation of potential alternatives.

Table 3-6 identifies the screened set of technologies/process options that will be used to develop potential remedial alternatives in Section 4.0.

TABLE 3-1

GENERAL RESPONSE ACTIONS FOR OPERABLE UNIT NO. 5
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Area of Concern	Remedial Action Objective	General Response Action
Groundwater	Surficial and Castle Hayne Aquifers(1)	• Prevent exposure to (ingestion, inhalation, and dermal contact) groundwater COCs exceeding the remediation goals. • Prevent the horizontal and vertical migration of contaminated groundwater in the Surficial and Castle Hayne Aquifers. • Restore the groundwater aquifer to meet the remediation goals set for the groundwater COCs	• No Action • Institutional Controls • Containment Actions • Collection/Treatment Actions

(1) There is no confining layer between the Surficial and Castle Hayne Aquifers at this operable unit. Therefore, both aquifers act as one water bearing zone.

TABLE 3-2

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 5 FEASIBILITY STUDY CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option
No Action	No Action	Not Applicable
Institutional Controls	Monitoring	Groundwater Monitoring
	Ordinances	Aquifer-Use Restrictions
	Access Restrictions	Deed Restrictions
		Fencing
Containment Actions	Capping	Clay/Soil Cap
		Asphalt /Concrete Cap
		Soil Cover
		Multilayered Cap
	Vertical Barriers	Grout Curtain
		Slurry Wall
		Sheet Piling
		Rock Grouting
	Horizontal Barriers	Grout Injection
		Block Displacement
	Extraction	Extraction Wells
	Subsurface Drains	Interceptor Trenches
	Discharge	Reinjection • Injection Wells • Infiltration Galleries
Collection/Treatment Actions	Extraction	Extraction Wells
	Subsurface Drains	Interceptor Trenches
	Biological Treatment	Aerobic
		Anaerobic
	Physical/Chemical Treatment	Air Stripping
		Steam Stripping
		Carbon Adsorption
		Reverse Osmosis
		Ion Exchange
		Chemical Reduction
		Chemical Oxidation
		Neutralization
		Precipitation
		Oil/Water Separation
		Filtration
		Flocculation
		Sedimentation
		Chemical Dechlorination

TABLE 3-2 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 5
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option
Collection/Treatment Actions (Cont)	Thermal Treatment	Incineration • Liquid Injection • Rotary Kiln • Fluidized Bed • Multiple Hearth
		Molten Salt
		Plasma Arc Torch
		Pyrolysis
		Wet Air Oxidation
	Off-Site Treatment	POTW
		RCRA Facility
		Sewage Treatment Plant
		Pipeline to other IRP site
	In Situ Treatment	Biodegradation
		Air Sparging/Soil Venting
	On-Site Discharge	Surface Water (Overs Creek)
		Reinjection • Injection Wells • Infiltration Galleries
	Off-Site Discharge	POTW
		Pipeline to River (New River)
		Sewage Treatment Plant
		Drinking Water Plant
		Deep Well Injection
		Pipeline to other IRP site

TABLE 3-3

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No action - contaminated groundwater remains as is.	Potentially applicable to any site; required by the NCP.	Retained
Institutional Controls	Monitoring	Groundwater Monitoring	Ongoing monitoring of existing wells.	Potentially applicable.	Retained
	Ordinances	Aquifer-Use Restrictions	Prohibit the use of the contaminated aquifer as a drinking water source.	Potentially applicable.	Retained
	Access Restrictions	Deed Restrictions	Limit the future use of land including placement of wells.	Potentially applicable.	Retained
		Fencing	Limit access by installing a fence around contaminated area.	Potentially applicable; some fencing already exists.	Retained
Containment Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Soil Cover Multilayered Cap	Capping material placed over areas of contamination.	Potentially applicable.	Retained
	Vertical Barriers	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to contain contamination.	The heterogeneity of the fill material at the Operable Unit may prevent a "gap-free" curtain. No continuous confining layer under the sites for the wall to adjoin to.	Eliminated
		Slurry Wall	Trench around areas of contamination. The trench is filled with a soil bentonite slurry to limit migration of contaminants.	No continuous confining layer under the sites for the wall to adjoin to.	Eliminated
		Sheet Piling	Interlocking sheet pilings installed via drop hammer around areas of contamination.	No continuous confining layer under the sites for the wall to key into.	Eliminated
		Rock Grouting	Specialty operation for sealing fractures, fissures, solution cavities, or other voids in rock to control flow of groundwater.	No rock at the site.	Eliminated
	Horizontal Barriers	Grout Injection	Pressure injection of grout to form a bottom seal across a site at a specific depth.	Technique is in the experimental stage. Depth of the contaminated groundwater at the sites would limit its use.	Eliminated
		Block Displacement	Continued pumping of grout into specially notched holes causing displacement of a block of contaminated earth.	Depth of contaminated groundwater would limit its use. Technique is in the experimental stage.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Containment Actions (cont)	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater.	Depth of the contaminated groundwater will limit its use. Applicable to only the shallow groundwater. May be applicable for preventing migration of groundwater to Overs Creek.	Retained
	Discharge	Reinjection: • Injection Wells • Infiltration Galleries	The extracted groundwater can be reinjected back into the aquifer (following some treatment) to enhance the collection of contaminated groundwater via extraction wells.	Deep injection wells potentially applicable. Site geology and low water table may prohibit the use of infiltration galleries.	Retained
Collection/Treatment Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Potentially applicable	Retained
		Extraction/Injection Wells	Injection wells inject uncontaminated groundwater to enhance collection of contaminated groundwater via the extraction wells. Or the injection wells can also inject material into an aquifer to remediate groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater	Applicable to only the shallow groundwater. May be applicable for preventing migration of groundwater.	Retained
	Biological Treatment	Aerobic	Degradation of organics using microorganisms in an aerobic environment.	Potentially applicable to organic contaminants of concern.	Retained
		Anaerobic	Degradation of organics using microorganisms in an anaerobic environment	Potentially applicable to some of the groundwater contaminants of concern (multi-chlorinated compounds with three or more chlorines). Possible use as pretreatment for aerobic treatment.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Collection/Treatment Actions (cont)	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air. Applicable to volatile organics and some SVOCs.	Potentially applicable for VOCs and selected number of SVOCs.	Retained
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air. Applicable to a wide range of organics.	Potentially applicable for VOCs and selected number of SVOCs.	Retained
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to wide range of organics.	Potentially applicable	Retained
		Reverse Osmosis	Using high pressure to force water through a membrane leaving contaminants behind. Applicable to dissolved solids (organic and inorganic).	Not applicable for most of the constituents of concern.	Eliminated
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Applicable for inorganics, not organics.	Potentially applicable	Retained
		Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility. Applicable to chromium, mercury and lead.	Potentially applicable	Retained
		Chemical Oxidation	Addition of an oxidizing agent to raise the oxidation state of a substance. Applicable to cyanide, organics, and some inorganics.	Potentially applicable	Retained
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. Applicable to acidic or basic waste streams.	Although pH is not a concern at the operable unit, neutralization may be applicable in a treatment train with precipitation.	Retained
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Potentially applicable for inorganics.	Retained
		Oil/Water Separation	Materials in solution are transferred into a separate phase for removal. Applicable to petroleum hydrocarbons.	Not necessary for the contaminants of concern. No free phase product detected at the sites.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Collection/Treatment Actions (cont)	Physical/Chemical Treatment (cont)	Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable	Retained
		Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Potentially applicable	Retained
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. Applicable to suspended solids.	Potentially applicable	Retained
		Chemical Dechlorination (KPEG)	Process which uses specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to toxify them to form other less harmful compounds. Applicable to PCBs, chlorinated hydrocarbons and dioxins.	Not applicable to the groundwater contaminants of concern.	Eliminated
	Thermal Treatment	Incineration • Liquid Injection • Rotary Kiln • Fluidized Bed • Multiple Hearth	Combustion of waste at high temperatures. Different incinerator types can be applicable to pumpable organic wastes, combustible liquids, soils, slurries, or sludges.	Potentially applicable	Retained
		Molten Salt	Advanced incineration; waste contacts hot molten salt to undergo catalytic destruction. Applicable for hazardous liquids, low ash, high chlorine wastes.	Potentially applicable	Retained
		Plasma Arc Torch	Advanced incineration; pyrolyzing wastes into combustible gases in contact with a gas which has been energized to its plasma state by an electrical discharge. Applicable for liquid organic waste.	Lack of operational experience	Eliminated

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Collection/Treatment Actions (cont)	Thermal Treatment	Pyrolysis	Advanced incineration; thermal conversion of organic material into solid, liquid, and gaseous components; takes place in an oxygen-deficient atmosphere. Applicable for organics and inorganics.	Typically used for compounds not conductive to conventional incineration; Operable Unit No. 5 compounds are suitable to other incineration methods.	Eliminated
		Wet Air Oxidation	Advanced incineration; aqueous phase oxidation of dissolved or suspended organic substances at elevated temperatures and pressures. Applicable for organics with high COD, high strength wastes, and for oxidizable inorganics.	Typically used for compounds not conductive to conventional incineration; Operable Unit No. 5 compounds are suitable to other incineration methods.	Eliminated
	Off-site Treatment	POTW	Extracted groundwater discharged to Jacksonville POTW for treatment.	Potentially applicable	Retained
		RCRA Facility	Extracted groundwater discharged to licensed RCRA facility for treatment and/or disposal.	Potentially applicable	Retained
		Sewage Treatment Plant	Extracted groundwater discharged to Hadnot Point STP for treatment.	Potentially applicable	Retained
		Pipeline to other IRP Site	Extracted groundwater discharged to Operable Unit No. 2.	Potentially applicable	Retained
	In Situ Treatment	Biodegradation	System of introducing nutrients and oxygen to waste for the stimulation or augmentation of microbial activity to degrade contamination. Applicable to a wide range of organic compounds.	Potentially applicable to shallow aquifer.	Retained
		Air Sparging/Soil Venting	"In Situ Air Stripping". Used in combination with treatment of soils in the unsaturated zone. Applicable to organics.	Potentially applicable as a shallow aquifer technology. In deep zones, well spacing requirements make the use cost prohibitive.	Retained

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Collection/Treatment Actions (cont)	On-Site Discharge	Surface Water	Treated water discharged to stream on the site (i.e., Overs Creek).	Potentially applicable	Retained
		Reinjection • Injection Wells • Infiltration Galleries	Treated water reinjection into the site aquifer via use of shallow infiltration galleries (trenches) or via deep injection wells.	Deep injection wells potentially applicable. Site geology and low water table may prohibit the use of infiltration galleries.	Retained
	Off-Site Discharge	POTW	Treated water discharged to Jacksonville POTW.	Potentially applicable	Retained
		Pipeline to River	Treated water discharged to river off site (i.e., New River).	Potentially applicable	Retained
		Sewage Treatment Plant	Treated water discharged to Hadnot Point Sewage Treatment Plant	Potentially applicable	Retained
		Drinking Water Plant	Treated water discharged to Camp Lejeune Drinking Water Treatment Plant	Potentially applicable	Retained
		Deep Well Injection	Treated water is reinjected into the brine aquifer located under the Castle Hayne Aquifer.	Potentially applicable	Retained
		Pipeline to other IRP Site	Extracted groundwater discharged to Operable Unit No. 2	Potentially applicable	Retained

TABLE 3-4

SET OF POTENTIAL TECHNOLOGIES/PROCESS OPTIONS THAT PASSED THE PRELIMINARY SCREENING FEASIBILITY STUDY CTO-0174 MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option
No Action	No Action	Not Applicable
Institutional Controls	Monitoring	Groundwater Monitoring
	Ordinances	Aquifer-Use Restrictions
	Access Restrictions	Deed Restrictions
		Fencing
Containment Actions	Capping	Clay/Soil Cap
		Asphalt/Concrete Cap
		Soil Cover
		Multilayered Cap
	Extraction	Extraction Wells
	Subsurface Drains	Interceptor Trenches
	Discharge	Reinjection - Injection wells
Collection/Treatment Actions	Extraction	Extraction Wells
	Subsurface Drains	Interceptor Trenches
	Biological Treatment	Aerobic
		Anaerobic
	Physical/Chemical Treatment	Air Stripping
		Steam Stripping
		Carbon Adsorption
		Ion Exchange
		Chemical Reduction
		Chemical Oxidation
		Neutralization
		Precipitation
		Filtration
		Flocculation
		Sedimentation
	Thermal Treatment	Incineration
		Molten Salt
	Off-Site Treatment	POTW
		RCRA Facility
		Sewage Treatment Plant
		Pipeline to IRP Site
	In Situ Treatment	Air Sparging/Soil Venting
		Biodegradation
	On-Site Discharge	Surface Water
		Reinjection - Injection wells
	Off-Site Discharge	POTW
		Pipeline to River
		Sewage Treatment Plant
		Drinking Water Plant
		Deep Well Injection
		Pipeline to IRP Site

TABLE 3-5

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
No Action	No Action	Not Applicable	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Retained
Institutional Controls	Monitoring	Groundwater Monitoring	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Retained
	Ordinances	Aquifer-Use Restrictions	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Retained
	Access Restrictions	Deed Restrictions	• Does not meet remediation goals alone • No exposures during implementation • Effectiveness dependent on continued future implementation	• Easily implemented • Legal requirements	Negligible cost	Retained
		Fencing	• Does not meet remediation goals alone • Minimal to low exposures during implementation	• Easily implemented • No legal requirements	Low capital, low O&M	Retained
Containment Actions	Extraction	Extraction Wells	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation	• Easily installed • Equipment readily available • No permits required	Moderate capital, low O&M	Eliminated
	Subsurface Drains	Interceptor Trenches	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation • Applicable for shallow groundwater plumes only • Slower recovery than extraction wells • More effective for low permeability soils than extraction wells	• Equipment readily available • Requires extensive excavation/trenching • Requires more area than extraction wells	Low to moderate capital, low O&M	Eliminated
	Discharge	Reinjection - Injection Wells	• Effective for containing a contaminated groundwater plume if used in conjunction with extraction wells • Potential exposures during implementation • Injection wells effectiveness is dependent on site geology • Wells tend to clog in time	• Easily installed • Equipment readily available • No permits required • Requires pilot test • Significant maintenance	Moderate capital, moderate O&M	Eliminated

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions	Extraction	Extraction Wells	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation	• Easily implemented • Equipment readily available • No permits required	Moderate capital, low O&M	Retained
	Subsurface Drains	Interceptor Trenches	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation • Applicable for shallow groundwater plumes • Slower recovery than extraction wells • More effective for low permeability soils than extraction wells	• Equipment readily available • Requires extensive excavation/trenching • Requires more area than extraction wells	Low to moderate capital, low O&M	Eliminated
	Biological Treatment	Aerobic	• May be able to meet remediation goals • Potential exposures during implementation • Effectiveness dependent on strength and biodegradability of contaminants	• Equipment should be easily obtainable • Mobile units available • May require bench-scale testing • Low strength of contaminated groundwater may make operation difficult	Moderate capital, moderate O&M	Eliminated
		Anaerobic	• May be able to meet remediation goals • Potential exposures during implementation • Effectiveness dependent on strength and anaerobic biodegradability of contaminants • Very slow process	• Equipment should be easily obtainable • Mobile units available • May require bench-scale testing • Low strength of contaminated groundwater may make operation difficult	Moderate capital, moderate O&M	Eliminated

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions (Cont)	Physical/ Chemical Treatment	Air Stripping	• Can potentially meet remediation goals for organics • Feasible for large volumes of moderate to low soluble VOC-contaminated water • Lower efficiency in cold weather • Proven and widely used technology • Potential exposures during implementation • May require pretreatment for metals	• Equipment readily available • Many mobile units available • May require bench-scale testing • Off-gas and/or tower scale treatment may be required • May require air emissions permit	Moderate capital, low to moderate O&M	Retained
		Steam Stripping	• Can potentially meet remediation goals • Feasible for large volumes of VOC-contaminated water • Lower efficiency in cold weather • May require pretreatment for metals and oils and grease • Typically used for less volatile or highly soluble compounds	• Readily available, not as common as air stripping • May require air emissions permits • Off-gas and/or tower scale treatment may be required	Moderate capital, moderate to high O&M	Eliminated
		Carbon Adsorption	• Can potentially meet remediation goals • Applicable to a wide variety of organics and inorganics • Can be used as a polishing step following air stripping • Proven and widely used technology	• Equipment readily available • Many prefabricated mobile units available • May require bench-scale testing • Spent carbon must be properly handled	Moderate capital (dependent on loading requirements), moderate to high O&M	Retained
		Ion Exchange	• May not meet all remediation goals • Effective and reliable; proper pretreatment required • Typically used as a polishing step for removal of selected dissolved metals • Insensitive to variations in flow rates • Pretreatment for oil and grease required	• Full-scale industrial use for recovery of valuable metals • Equipment is widely available • Regeneration solutions are generally readily available • Bench-testing required • Residuals include waste solutions and spent resins	Moderate to high capital, moderate to high O&M	Eliminated

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions (Cont)	Physical/ Chemical Treatment (Cont)	Chemical Reduction	• May not meet all remediation goals • Well studied and understood reaction • It is not a selective process • Limited to a few selected metals (chromium, mercury, lead) • Typically followed by precipitation • If complex wastewater - oxidized chemicals may be reduced to more toxic forms	• Simple and readily available equipment • The continuous process configuration is easily automated • Easily implemented	Low to moderate capital, moderate to high O&M	Eliminated
		Chemical Oxidation	• May not meet all remediation goals • Reliable and proven on industrial wastewaters for metals (manganese, iron) treatment. Can be used alone or in conjunction with precipitation	• Well-demonstrated at hazardous waste sites in pilot- and full-scale • Readily available, conventional equipment required • Bench scale testing normally required	Low to moderate capital, moderate to high O&M	Eliminated
		Neutralization	• Will not meet all remediation goals • Can be used in a treatment train for pH adjustment	• Widely used and well demonstrated • Simple and readily available equipment/materials • Bench-scale studies may be required	Low capital, low to moderate O&M	Retained
		Precipitation	• May meet inorganic remediation goals • Effective, reliable, permanent, and conventional technology • Typically used for removal of heavy metals • Followed by solids-separation method • Generates sludge which can be voluminous, difficult to dewater, and may require treatment	• Widely used and well demonstrated • Equipment is basic and easily designed • Compact, single units that are deliverable to the site • Requires bench- or pilot-scale tests	Low capital, moderate O&M	Retained
		Filtration	• Will not meet inorganic remediation goals alone • Conventional, proven method of removing suspended solids from wastewater • Does not remove other contaminants • Pretreatment for oil and grease required • Generates a sludge which requires proper handling	• Equipment is relatively simple to install and no chemicals are required • Pilot study is required • Package units available	Low capital, low O&M	Retained

TABLE 3-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions (Cont)	Physical/ Chemical Treatment (Cont)	Flocculation	• May not meet inorganic remediation goals • Well established technology • Applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to other types of treatment • Performance depends on the variability of the composition of the waste being treated	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	Low capital, moderate O&M	Retained
		Sedimentation	• Will not meet inorganic remediation goals alone • Effective for removing suspended solids and precipitated materials from wastewater • Performance depends on density and particle size of the solids; effective charge on the suspended particles; types of chemicals used in pretreatment; surface loading; upflow rate; and rejection time • Feasible for large volumes of water to be treated	• Sedimentation tanks demonstrated and proven successful at hazardous waste sites • Effluent streams include the effluent water, scum, and settled solids	Moderate capital, moderate O&M	Eliminated
	Thermal Treatment	Incineration	• May meet remediation goals • Capable of burning waste in any physical form • Susceptible to thermal shock • Low thermal efficiency • Potential exposures during operation	• Commercially available and widely used • Requires air emission controls and extensive maintenance • Skilled workers required • Generates exhaust gases and ash residue	High capital, moderate to high O&M	Eliminated

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions (Cont)	Thermal Treatment (cont)	Molten Salt	• May meet remediation goals • Applicable for the destruction of liquids and solids • Appears to be sensitive to materials containing high ash content or high chlorine content • Molten salt produced may be corrosive • Potential exposures during operation	• Emerging technology • Developmental, pilot-scale units available • Requires frequent bed replacement	High capital, moderate to high O&M	Eliminated
	Off-Site Treatment	POTW	• Effectiveness and reliability require pilot test to determine	• Existing POTW may need upgraded • Readily implementable if POTW will grant permission; otherwise may not be feasible • Permit required	Moderate capital, moderate O&M	Eliminated
		RCRA Facility	• Effective and reliable treatment • Transportation required	• Dependent on availability of and distance to nearest RCRA facility	Moderate capital, moderate O&M	Eliminated
		Sewage Treatment Plant	• Effectiveness and reliability require pilot test to determine	• Readily implementable if STP will accept waste; otherwise may not be feasible • Modifications to permits may be required	Moderate capital, low O&M	Retained
		Pipeline to IRP Site	• Effective and reliable treatment method	• Equipment is readily available • A treatment system is planned for Operable Unit No. 2	Moderate capital, moderate O&M	Retained
	In Situ Treatment	Biodegradation	• Dependent on geology • Generally considered a shallow soil/ groundwater technology only	• Emerging technology • Equipment and materials should be readily available • Treatability studies required • May reduce the remediation time as compared to bioremediation alone	Low capital, low O&M	Retained
		Air Sparging and Soil Venting	• Highly dependent on geology • Monitoring via wells may not be effective • Generally considered a shallow aquifer technology only	• Emerging technology • Equipment and materials should be readily available • Treatability studies required • May reduce the remediation time as compared to bioremediation alone	Low capital, low O&M	Retained

TABLE 3-5 (Continued)

SUMMARY OF GROUNDWATER PROCESS OPTION EVALUATION
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Collection/ Treatment Actions (Cont)	On-Site Discharge	Surface Water	• Effective and reliable discharge method	• May require impact studies to assess affects to environment • NPDES permit required	Low to moderate capital, low O&M	Eliminated
		Reinjection - Injection Wells	• Injection wells effectiveness is highly dependent on site geology • Wells tend to clog in time • Potential exposures during implementation	• Easily installed • Equipment readily available • No permits required • Require pilot test • Significant maintenance	Moderate capital, moderate O&M	Eliminated
	Off-Site Discharge	POTW	• Effective and reliable discharge method	• Discharge permits required • Acceptance by a local POTW may be difficult to obtain	High capital, moderate O&M	Eliminated
		Pipeline to New River	• Effective and reliable discharge method	• Discharge permits required • Distance to New River from operable unit may make this option difficult to implement	Moderate to high capital, low O&M	Eliminated
		Sewage Treatment Plant	• Effective and reliable discharge method	• Discharge permit may need modified • Capacity of the Hadnot Point STP may not be able to accept the flow	Low capital, low O&M	Retained
		Drinking Water Treatment Plant	• Effective discharge option • Innovative approach • Reuse of water	• Drinking water plant's discharge. Permit may need modified • May require groundwater treatment system to be modified • May be difficult to gain acceptance	Moderate capital, low O&M	Eliminated
		Deep Well Injection	• Injection wells effectiveness is highly dependent on site geology • Wells may clog in time	• Discharge permit required • Injection wells must be installed	Moderate capital, moderate O&M	Eliminated
		Pipeline to IRP Site	• Effective discharge option • Innovative approach	• Easily installed • Equipment readily available • Requires coordination with schedule for remedial action at Operable Unit No. 2	Moderate capital, low O&M	Retained

TABLE 3-6

FINAL SET OF POTENTIAL REMEDIAL ACTION TECHNOLOGIES
AND PROCESS OPTIONS
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater Monitoring
		Ordinances	Aquifer-Use Restrictions
		Access Restrictions	Deed Restrictions
			Fencing
	Collection/Treatment Actions	Extraction	Extraction Wells
		Physical/Chemical Treatment	Air Stripping
			Carbon Adsorption
			Neutralization
			Precipitation
			Filtration
			Flocculation
		Off-Site Treatment	Sewage Treatment Plant
			Pipeline to IRP Site
		In Situ Treatment	Air Sparging/Soil Venting
		Off-Site Discharge	Sewage Treatment Plant
			Pipeline to IRP Site

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, general response actions and the process options chosen to represent the various technology types applicable for Site 2 will be combined to form groundwater remedial action alternatives (RAAs) for the operable unit. Following development, each alternative may be evaluated against the short-term and long-term aspects of three criteria: effectiveness, implementability, and cost (i.e, the preliminary screening). The RAAs with the most favorable composite evaluation of all criteria will be retained for further consideration during the detailed evaluation presented in Section 5.0. Note that the preliminary screening at this step of the FS is optional. It will only be conducted if too many alternatives are initially developed.

4.1 Development of Alternatives

The general response actions and process options chosen to represent the various applicable technologies identified on Table 3-6 have been combined into RAAs potentially applicable for the contaminated groundwater within the operable unit. Table 4-1 presents the set of RAAs developed for remediating the contaminated groundwater within the operable unit. The components of each RAA (i.e., technology type and process option) and the area or volume included under each RAA is presented in the table. Six RAAs have been identified for groundwater ranging from no action to groundwater extraction and treatment. A description of each of the RAAs is presented below.

4.1.1 Groundwater RAA No. 1: No Action

Under the No Action Alternative, no remedial actions will be performed to reduce the toxicity, mobility, or volume of the contaminants in the groundwater at Site 2. Under this alternative, the contaminants identified in the shallow and deep portions of the aquifer will remain, which will result in the potential for further migration of the contaminated plume. Aquifer restoration may result through natural processes such as biological degradation, attenuation, and dispersion.

The no action alternative is required by the NCP to provide a baseline for comparison with other RAAs. Since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.1.2 Groundwater RAA No. 2: Institutional Controls with Long-Term Monitoring

Under Groundwater RAA No. 2, no remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants in the groundwater at Site 2. The only actions included under this RAA are institutional controls (i.e., monitoring, ordinances, and aquifer-use restrictions). Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion.

RAA No. 2 will include the following three institutional controls: long-term groundwater monitoring, aquifer-use restrictions, and fencing. The RAA will include semiannual sampling and analysis of 12 existing monitoring wells and 3 supply wells at the operable unit (see Figures 1-2 and 2-1). As shown on Figure 1-2, the wells to be sampled are located near the area of contamination. As listed below, the wells to be monitored include one deep monitoring well, 11 shallow monitoring wells, and three operational supply wells.

Deep Wells	Shallow Wells		Supply Wells
2GW3D	2GW1	2GW7	616
	2GW2	2GW8	646
	2GW3	2GW9	647
	2GW4	2GW10	
	2GW5	2GW11	
	2GW6		

Additional wells may be added to the monitoring program, if necessary. The monitoring program will include the following:

- Analyses
  - TCL VOCs
  - Barium
  - Beryllium
  - Cadmium
  - Chromium
  - Lead
  - Manganese
  - Total Suspended Solids
  - Total Dissolved Solids
- Frequency:
  - Years 1-2: Quarterly
  - Years 3-5: Semiannually
  - Years 6-30: Annually

Aquifer-use restrictions will be placed on the local supply wells. Supply Well 645 is currently inactive. Under RAA No. 2, this well will remain inactive. The locations of the Supply Wells 616, 645, 646, and 647 are shown on Figure 2-1.

Restrictions concerning the installation of any new potable water supply wells within the vicinity of Site 2 will be recommended. This area has previously been proposed to be a groundwater preservation area for consideration as a potential water supply well field site (Geophex, 1991; page 32). This should be reevaluated in light of the results of the RI/FS.

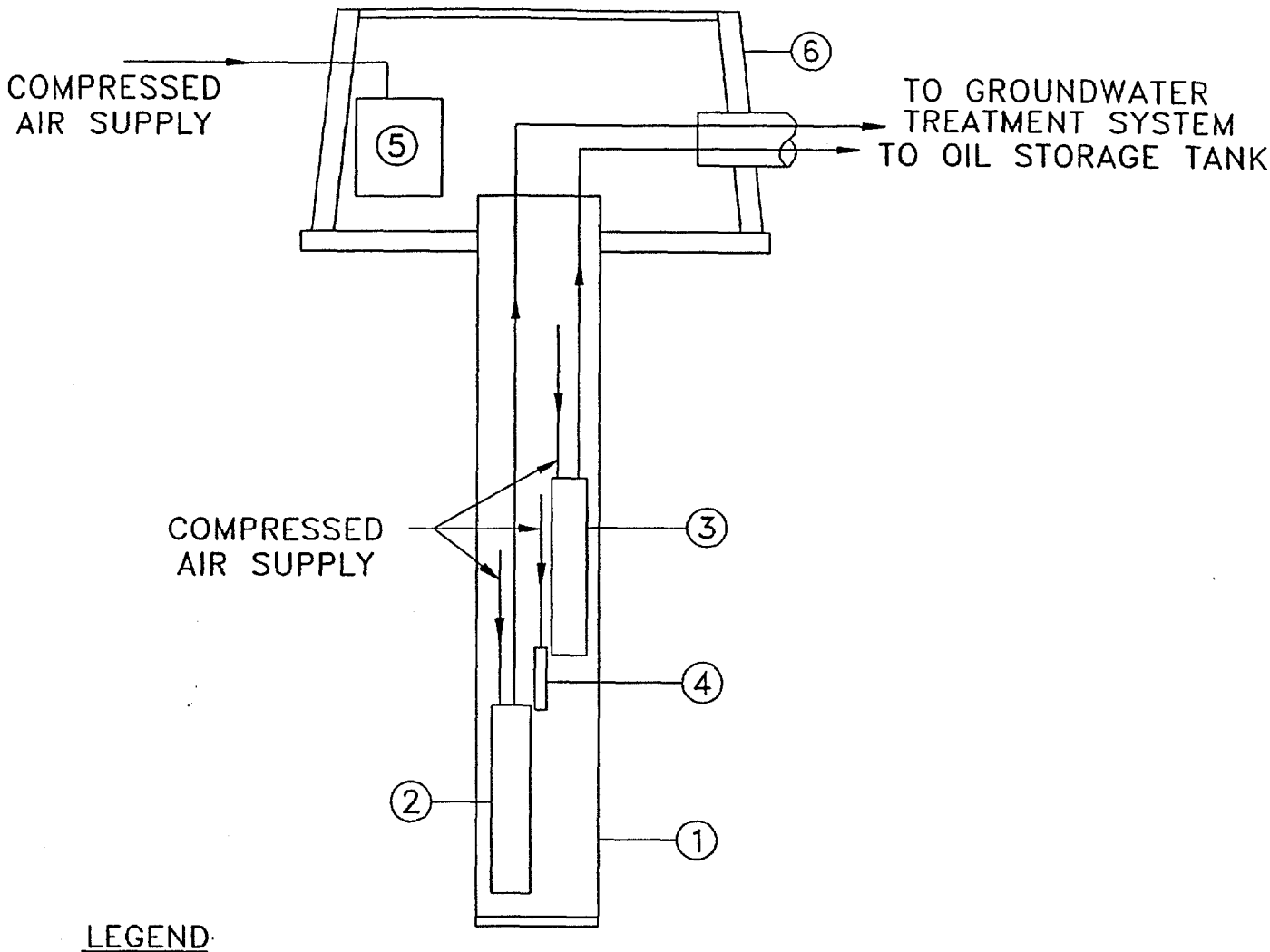
In the event that the monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.1.3 Groundwater RAA No. 3: Collection/Treatment/Discharge to a Sewage Treatment Plant

In general, RAA No. 3 includes the collection and treatment of the shallow contaminated plume. In addition, this RAA includes the same institutional controls as Groundwater RAA No. 2 (Institutional Controls with Long-Term Monitoring). Under this RAA, the contaminated groundwater plume originating from Site 2 will be collected via a system of extractions wells placed near monitoring well 2GW3, and downgradient from the area of contamination. Extracted groundwater will be treated on site via one of a combination of applicable treatment options (treatment train), and then discharged via a force main to a sanitary sewer manhole located west of the site. Details of the extraction system and treatment system are discussed below.

Groundwater Extraction System - Under RAA No. 3, groundwater in the shallow aquifer near monitoring well 2GW3 will be withdrawn through a network of three 6-inch diameter extraction wells pumping at a rate of 5 gallons per minute (gpm) each and installed at a depth of approximately 35 feet. A typical extraction well is shown on Figure 4-1.

The proposed locations of the extraction wells are shown on Figure 4-2. The locations for the wells were based on several factors including estimated radius of influence dimensions; spacings of overlapping cones of depressions; and accessibility. A radius of influence of 75 feet was used for placing the shallow extraction wells. This radius of influence and the estimated



LEGEND

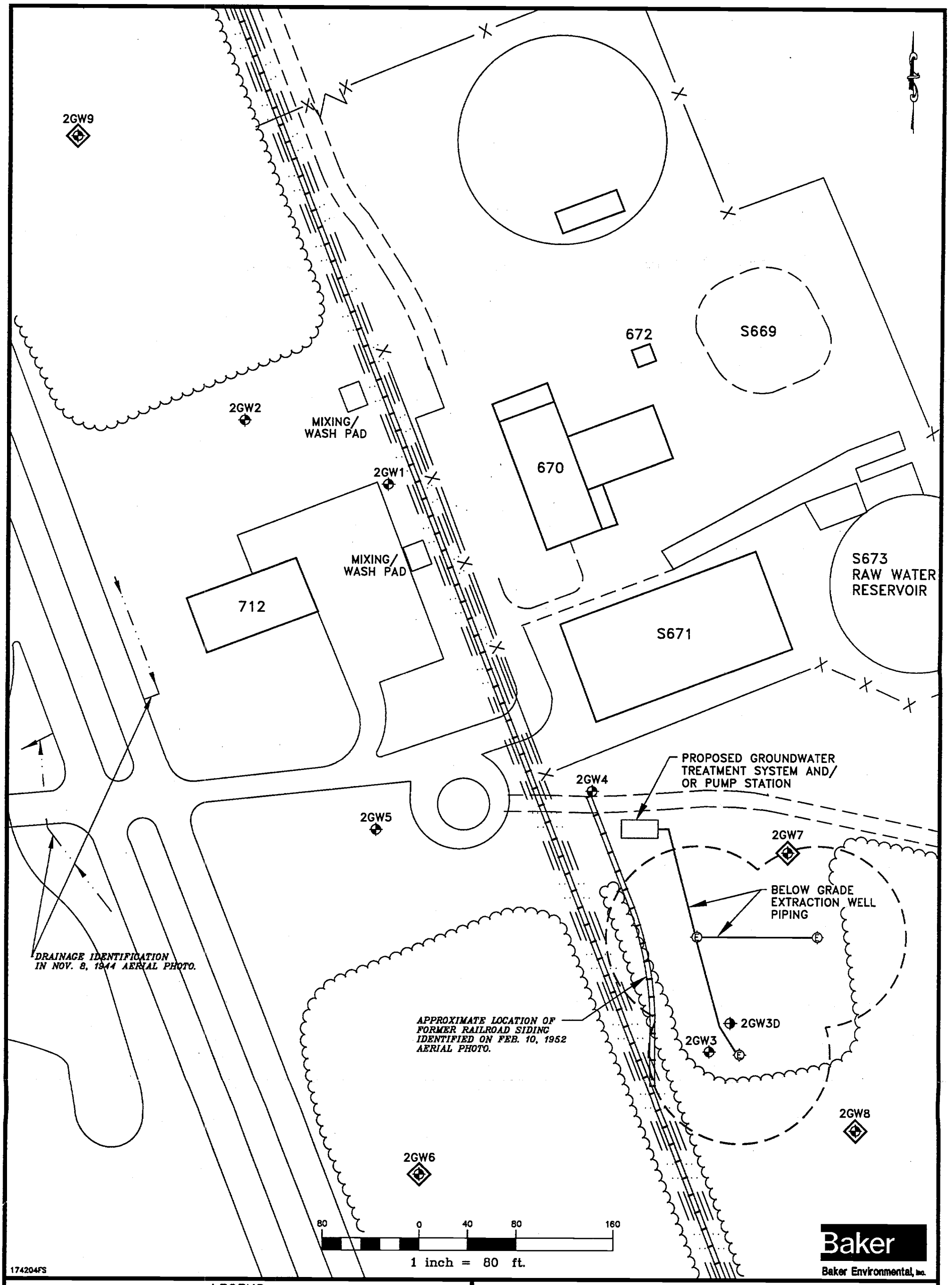
1. RECOVERY WELL
2. GROUNDWATER PUMP
3. PRODUCT PUMP
4. BUBBLER PROBE
5. CONTROLLER
6. PRECAST MANHOLE

Baker

Baker Environmental, Inc.

FIGURE 4-1
TYPICAL SHALLOW GROUNDWATER
DUAL PUMP EXTRACTION WELL
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 2GW1 — EXISTING SHALLOW MONITORING WELL
- 2GW3D — NEWLY INSTALLED SHALLOW MONITORING WELL
- 2GW3D — NEWLY INSTALLED DEEP MONITORING WELL
- E — PROPOSED EXTRACTION WELL
- ESTMATED INFLUENCE AREA

SOURCE: LANTDIV, FEB. 1992

FIGURE 4–2
GROUNDWATER RAA Nos. 3, 4 and 5
PRPOSED EXTRACTION WELL LOCATIONS
SITE 2
FEASIBILITY STUDY CTO–0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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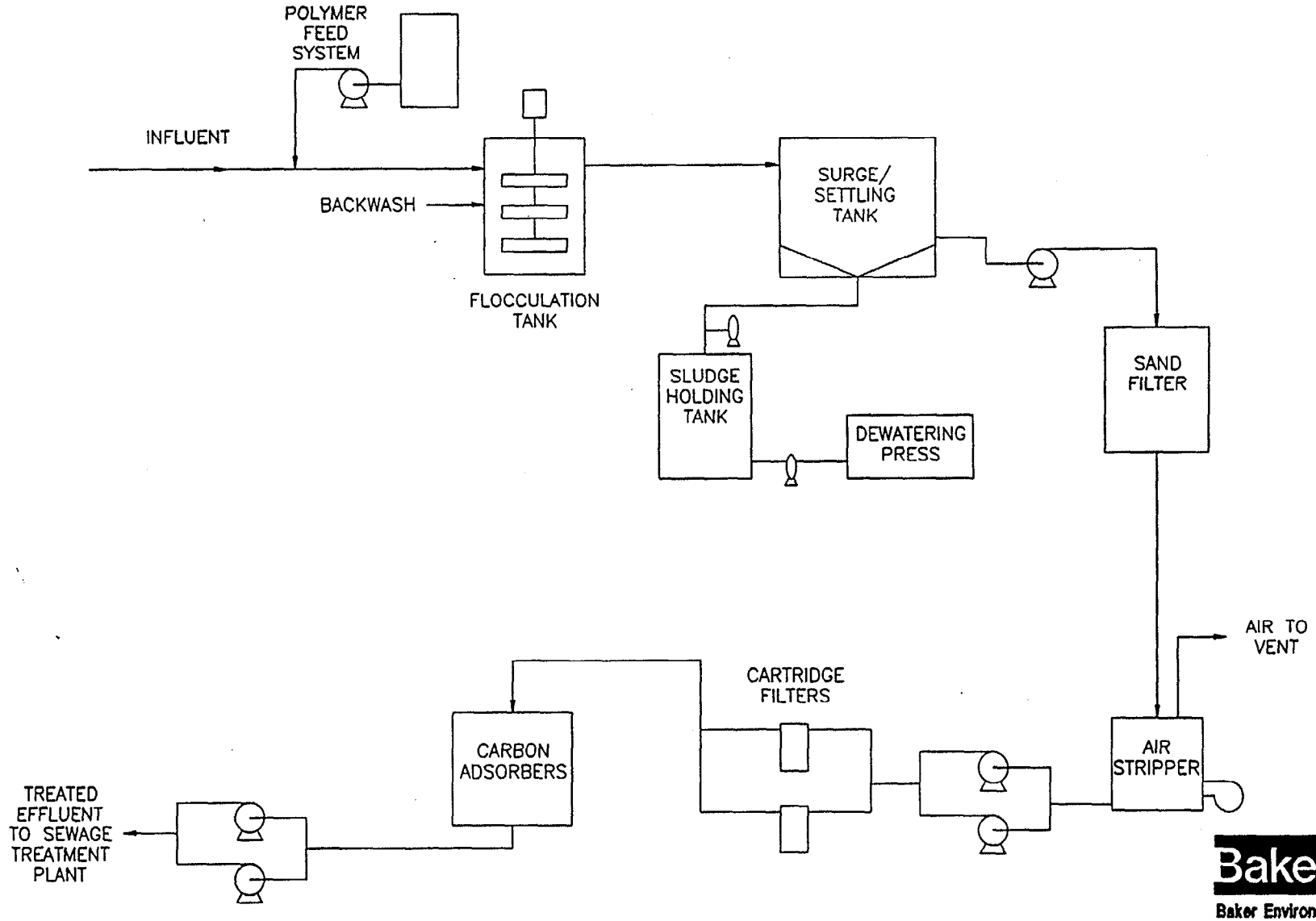
pumping rate were based on information obtained from pumping tests conducted at nearby sites within MCB Camp Lejeune (Baker, 1993c). Additional extraction wells will be added to the system if groundwater monitoring indicates that the groundwater is significantly deteriorating in other areas of the site.

Treatment System - The groundwater treatment system will consist of a treatment train of several technologies. A typical process schematic of the type of treatment system included under this RAA is presented on Figure 4-3. Once extracted, the contaminated groundwater will be pumped to an on-site pretreatment system for the removal of inorganic COCs (such as barium, beryllium, chromium, lead, and manganese), by filtration. Please note that the other process options applicable to inorganic removal that passed the screening in Section 3.3 are still potential technologies. Bench-scale treatability studies and/or literature searches will be required to design the pretreatment system. Residuals generated from the pretreatment system such as sludges will need to be tested and disposed of properly. Based on the metals concentrations of the residuals, disposal may be at an off-site landfill. Any annual cost allowance of $25,000 was to cover sludge disposal costs and spent carbon replacement.

The pretreated effluent from the inorganic removal system will be pumped to a treatment system which will be designed for the removal of organic COCs including TCE, acenaphthene, ethylbenzene, naphthalene, and xylene. The physical/chemical treatment system will consist of an air stripping unit and an activated carbon adsorption unit. The air stripping unit will be designed for the removal of the volatile organic COCs, and for a maximum flow of approximately 15 gpm (based on three shallow wells pumping at 5 gpm). Residuals generated from the air stripper will include air emissions contaminated with organics. Based on the VOC levels in the groundwater, it is assumed that vapor recovery equipment, such as vapor-phase activated carbon, will not be required.

The aqueous effluent from the stripper will be pumped to the activated carbon adsorption unit for final removal (polishing) of the organic compounds. The carbon adsorption system will include granular activated carbon (GAC). The final design of the carbon system will be based on the contact time determined from bench-scale test results. Spent carbon generated from this process will either be properly disposed off site, or shipped to a carbon regeneration facility. The selection of the spent carbon option will be based on economics. Typically, off-site disposal or off-site regeneration of spent carbon is more economical than on-site regeneration for small volumes of water. Note that air emissions will be monitored during groundwater treatment activities.



Baker

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FIGURE 4-3
GROUNDWATER RAA No. 3:
TREATMENT SYSTEM SCHEMATIC
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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Discharge of the Treated Water - Treated groundwater will be pumped through a 2-inch force main to a sanitary sewer which discharges to the Hadnot Point Sewage Treatment Plant (STP). The sanitary sewer is located approximately 1,500 feet west of the site on Brewster Avenue. The location of the proposed force main for RAA No. 3 is shown on Figure 4-4.

Institutional Controls

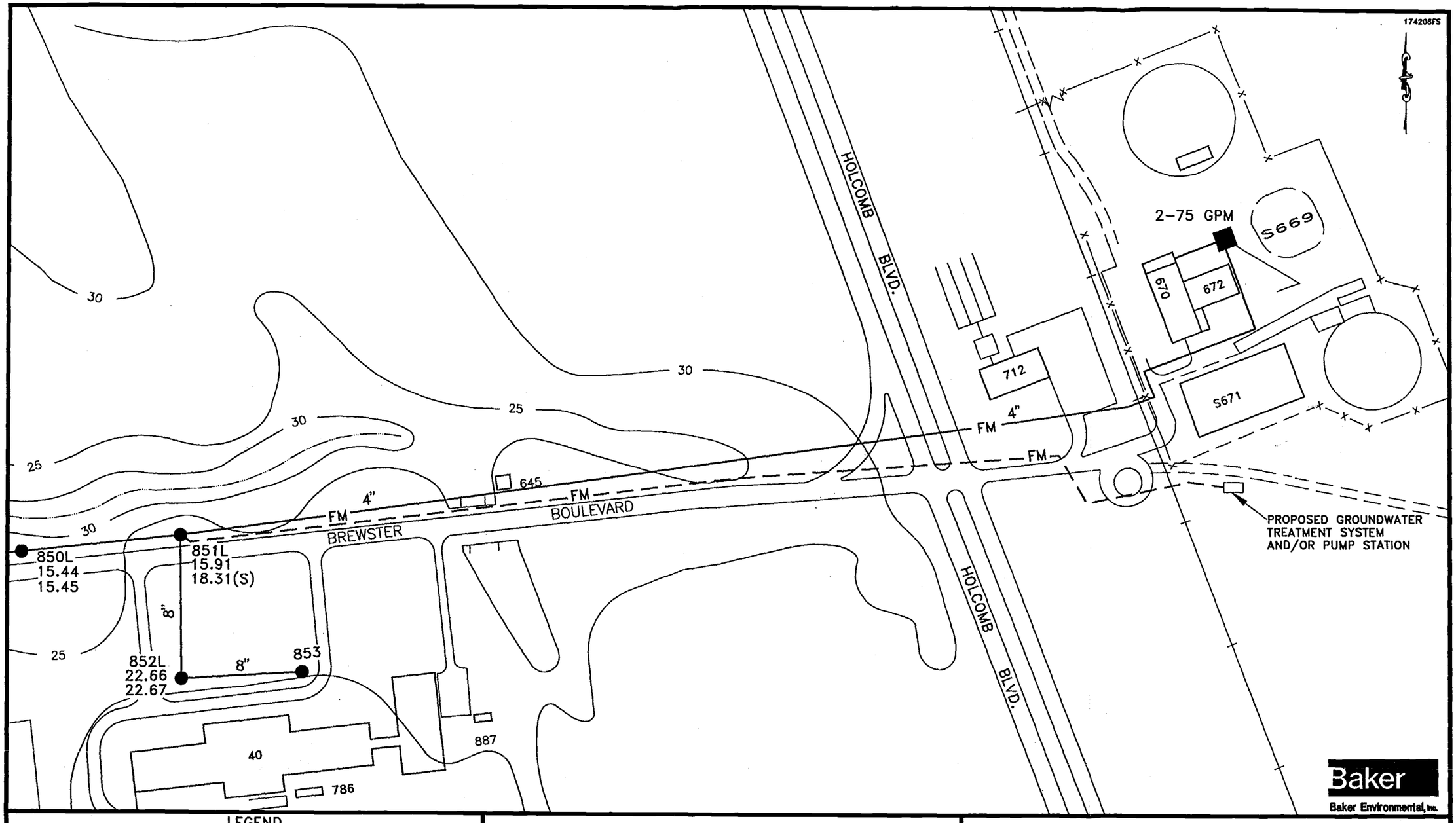
Groundwater RAA No. 3 will include the same three institutional controls included with Groundwater RAA No. 2: long-term groundwater monitoring, aquifer-use restrictions, and fencing. Therefore, the discussion of institutional controls presented in Section 4.1.2 for Groundwater RAA No. 2 applies to this RAA.

In the event that the long-term groundwater monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. These actions could include a modification of pumping rates at each well or the installation of additional wells as needed. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.1.4 Groundwater RAA No. 4: Collection/Discharge to a Sewage Treatment Plant

RAA No. 4 focuses on collection and discharge of the contaminated groundwater to the Hadnot Point STP. Groundwater collection and discharge will continue until the remediation goals are met. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, and 3. The placement of wells within this area should result in a cone of influence that will capture contaminants at the downgradient edge of the plume over time. The major components of Groundwater RAA No. 4 are described below.

Groundwater Extraction System - Under RAA No. 4, groundwater in the shallow aquifer near monitoring well 2GW3 will be withdrawn through a series of three shallow wells pumping at a rate of 5 gpm and installed at a depth of 35 feet. The proposed locations of the extraction wells are the same as RAA No. 3, and are shown on Figure 4-2. The proposed extraction wells will be centered on the area of the highest contamination (near monitoring well 2GW3) and immediately downgradient of this area. A radius of influence of 75 feet and a pumping rate of 5 gpm was assumed for the shallow extraction wells. Additional extraction wells will be added



LEGEND

—FM— EXISTING SANITARY FORCE MAIN

--FM-- PROPOSED GROUNDWATER FORCE MAIN

SOURCE: LANTDIV, FEB. 1992

150 0 75.5 150 300

1 inch = 150 ft.

FIGURE 4-4
GROUNDWATER RAA NOs 3 and 4:
GROUNDWATER FORCE MAIN DISCHARGE
FEASIBILITY STUDY CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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to the system if groundwater monitoring indicates that the groundwater is significantly deteriorating in other areas of the site.

Treatment System - Under RAA No. 4, the extracted groundwater will receive no "on-site" treatment. Treatment will be provided by the Hadnot Point STP.

Discharge of the Extracted Groundwater - The extracted groundwater will be pumped through a 1,500 foot force main to a sanitary sewer which discharges to the Hadnot Point STP. The location of the proposed force main is the same as RAA No. 3, and is shown on Figure 4-4.

Institutional Controls

Groundwater RAA No. 4 will include the same three institutional controls included with Groundwater RAAs Nos. 2 and 3: long-term groundwater monitoring, aquifer-use restrictions, and fencing. Therefore, the discussion of institutional controls presented in Section 4.1.2 for Groundwater RAA No. 2 applies to this RAA. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

In the event that the long-term groundwater monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.1.5 Groundwater RAA No. 5: Collection/Discharge to Site 82

In general, RAA No. 5 is identical to RAA No. 4, except the extracted groundwater will be discharged to the groundwater treatment system to be installed at Site 82 at MCB Camp Lejeune. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, 3 and 4. The objective of this RAA is to eliminate the contaminants in the groundwater and to mitigate the further migration of the existing groundwater plume. The major components of Groundwater RAA No. 5 are described below.

Groundwater Extraction System - Under this RAA, groundwater in the shallow aquifer near monitoring well 2GW3 will be withdrawn through a series of three extraction wells pumping at a rate of 5 gpm and installed at a depth of 35 feet. The proposed locations of these extraction wells are the same as RAA Nos. 3, 4, and 5 and are shown on Figure 4-2. The proposed extraction wells will be centered on the area of highest contamination (near monitoring well 2GW3). A radius of influence of 75 feet and a pumping rate of 5 gpm were assumed for the shallow extraction wells. Additional extraction wells will be added to the system if groundwater monitoring indicates that the groundwater is significantly deteriorating in other areas of the site.

Treatment System - Under this alternative, the extracted groundwater will receive no "on-site" treatment. Treatment will be provided by the treatment system to be constructed at Site 82. This treatment system will consist of a metals removal system, air stripping, and granular activated carbon. Additional information on this system is presented in the "Final Feasibility Study for Operable Unit No. 2" (Baker, 1993b).

Discharge of the Extracted Groundwater - The extracted groundwater will be discharged to the treatment system to be installed at Site 82. An on-site pump station will be constructed to pump the extracted groundwater through a force main south to Site 82. The force main will be installed parallel to the railroad right-of-way, and will be approximately 1.8 miles long.

Institutional Controls

Groundwater RAA No. 5 will include the same three institutional controls included with Groundwater RAAs Nos. 2, 3, and 4: long-term groundwater monitoring, aquifer-use restrictions, and fencing. Therefore, the discussion of institutional controls presented in Section 4.1.2 for Groundwater RAA No. 2 applies to this RAA.

In the event that the long-term groundwater monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.1.6 Groundwater RAA No. 6: In Situ Treatment

RAA No. 6 considers the remediation of the contaminated shallow groundwater near monitoring well 2GW3 via an in situ treatment method. The objective of this RAA is to reduce the COCs in the groundwater to the remediation goals established in Section 2.0. For the purposes of this FS, and based on the results of preliminary screening, the selected in situ treatment method is a combination of soil vapor extraction (SVE) and air sparging. This remediation technology is described below.

SVE is an in situ soil remediation process. There are various names used for this process, including soil venting, in situ volatilization and vapor extraction. For the purpose of this FS, the terms SVE and air sparging are used to describe this treatment process.

Air sparging is a process which provides in situ removal of VOCs from groundwater and saturated soils by injecting air under pressure. Air sparging essentially creates a crude air stripper in the subsurface, with the saturated soil acting as the packing (Angell, 1992). This method allows for the effective removal of VOCs without groundwater recovery. Air sparging works in two basic ways. First, it strips the contamination from the aquifer and brings it up to the vadose zone where a bioventing system helps create bacteria colonies that consume the organic contaminants. Secondly, the air increases the dissolved oxygen content of the water, which allows the naturally occurring bacteria in the aquifer to grow and consume contamination within the aquifer.

SVE is used to ensure proper air flow and to collect the vapors within the vadose zone. In many applications, the use of soil venting wells allows the treatment zone to be better defined within the contaminant plume. SVE helps to control the lateral movement of the air as it passes from the groundwater into the vadose zone.

Treatment System - The air sparging/SVE system will consist of a network of air sparging wells, which are designed to inject air into the groundwater, and soil vents, which are installed to collect and withdraw vapors from the unsaturated soils. Air will be supplied by a low pressure blower system installed near the air sparging wells. A separate vacuum system will be used to create the negative pressure needed to withdraw the vapors. A pilot study and/or a soil vapor survey will be required to determine to optimum location for the air sparging and soil venting wells. A schematic of the air sparging/SVE system is shown on Figure 4-5. Figure 4-6 shows the proposed SVE system site layout.

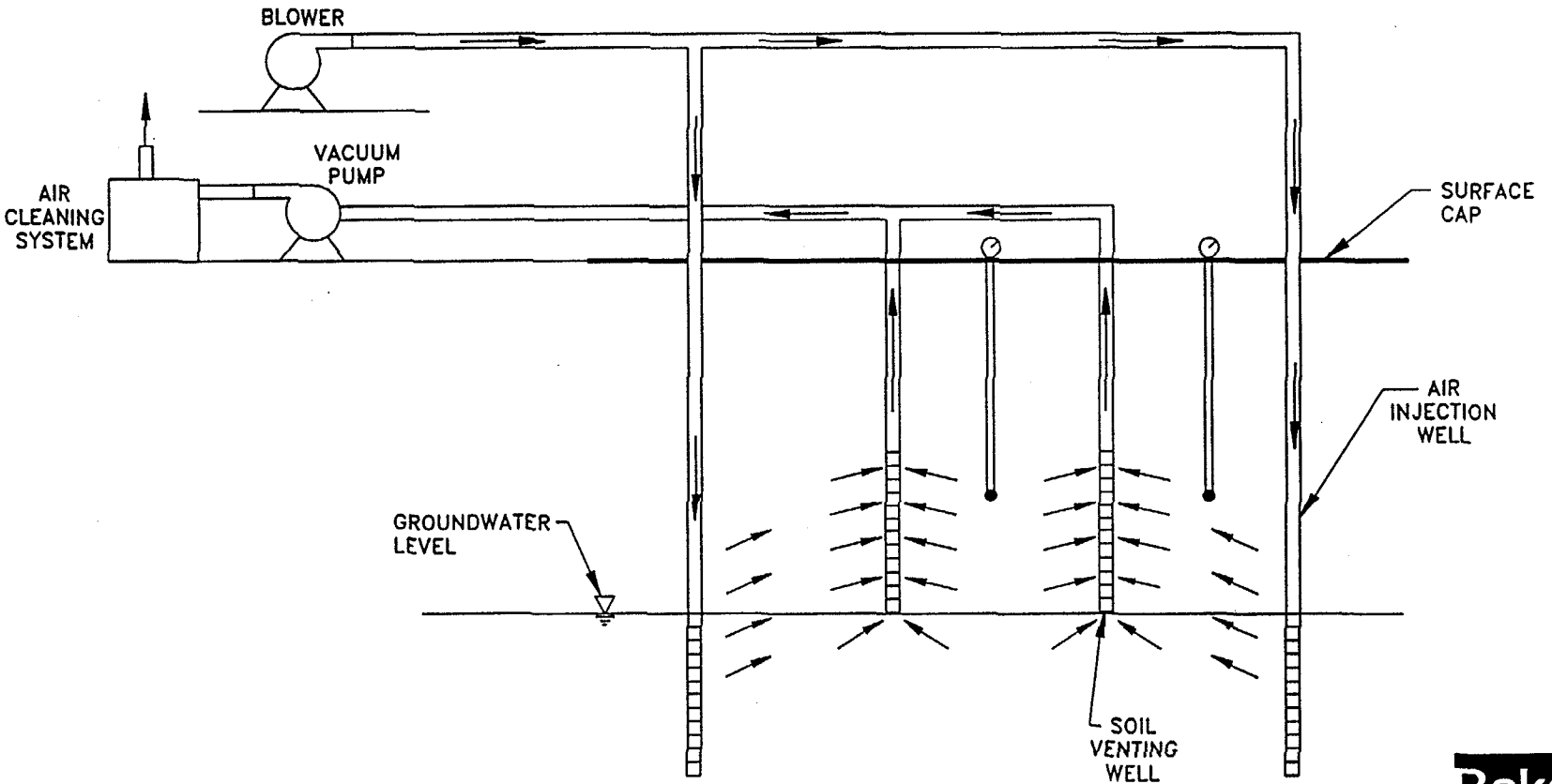

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FIGURE 4-5
GROUNDWATER RAA No. 6
AIR SPARGING/SOIL VENTING
SYSTEM SCHEMATIC
SITE 2
FEASIBILITY STUDY CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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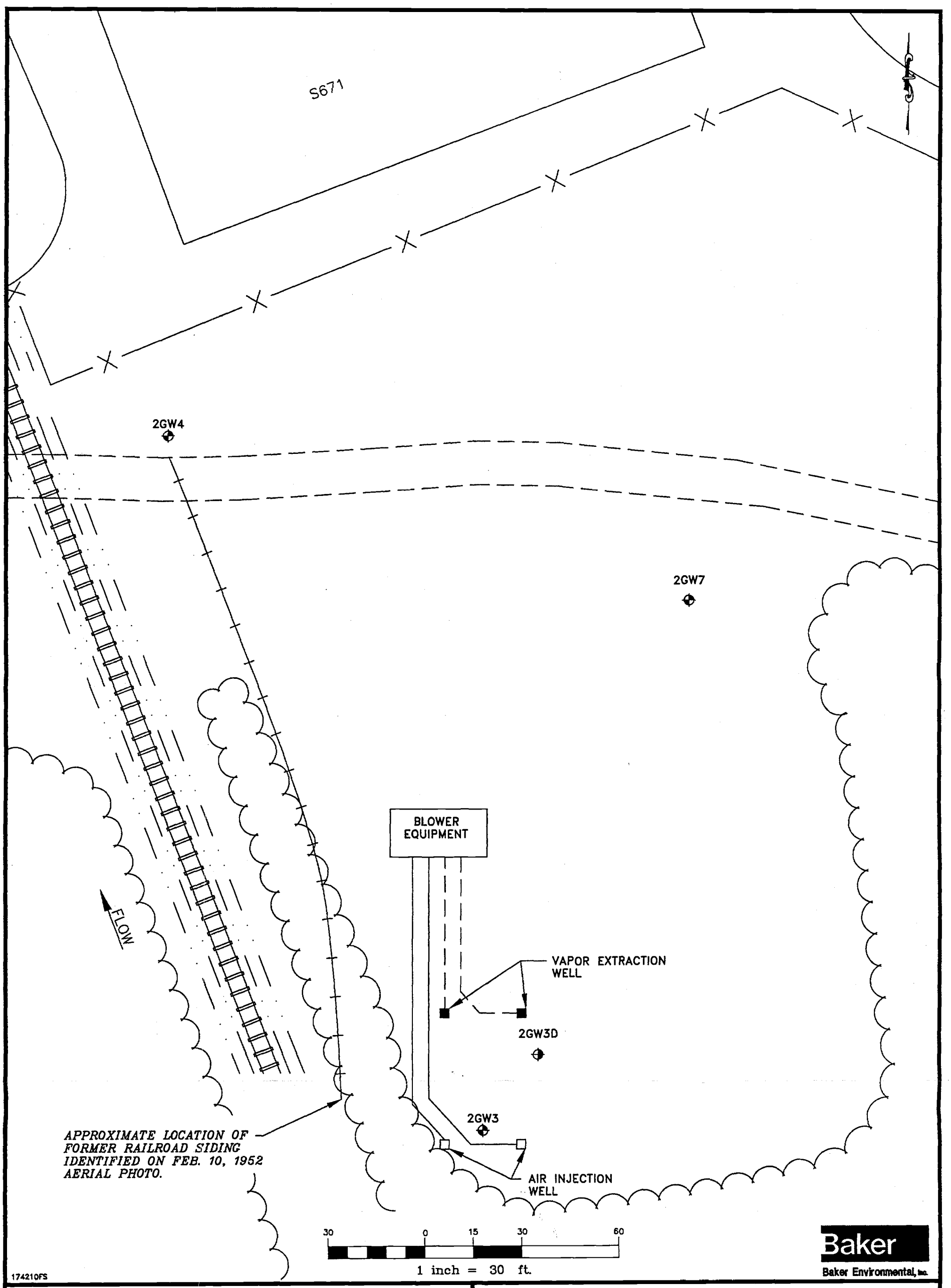

LEGEND

2GW3 EXISTING GROUNDWATER MONITORING WELL LOCATION

AIR INJECTION WELL

VAPOR EXTRACTION WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-6
GROUNDWATER RAA No. 6:
SOIL VAPOR EXTRACTION SYSTEM SITE LAYOUT
SITE 2
FEASIBILITY STUDY CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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Institutional Controls

Groundwater RAA No. 6 will include the same three institutional controls included with Groundwater RAAs Nos. 2, 3, 4, and 5: long-term groundwater monitoring and aquifer-use restrictions. Therefore, the discussion of institutional controls presented in Section 4.1.2 for Groundwater RAA No. 2 applies to this RAA.

In the event that the long-term groundwater monitoring program indicates that the groundwater conditions are deteriorating, other actions will be taken. In addition, since contaminants will remain at the site under this alternative, the USEPA is required by the NCP [40 CFR 300.515(e)(ii)] to review the effects of this alternative no less often than every five years.

4.2 Screening of Alternatives

Typically, this section of the FS presents the initial screening of the potential RAAs. The objective of this screening is to make comparisons between similar alternatives, so that only the most promising ones are carried forward for further evaluation (USEPA, 1988a). This screening is an optional step in the FS process and is usually conducted if there are too many RAAs to conduct the detailed evaluation. For Site 2, the decision was made not to conduct this preliminary RAA screening step and to include all of the developed RAAs in the detailed evaluation presented in Section 5.0.

TABLE 4-1

POTENTIAL SET OF GROUNDWATER REMEDIAL ACTION ALTERNATIVES
FEASIBILITY STUDY CTO-0174
MCB CAMP LEJEUNE, NORTH CAROLINA

Technology Type	Process Option	Area or Volume	Remedial Action Alternatives					
			1	2	3	4	5	6
			No Action	Institutional Controls with Long-Term Monitoring	Collection/ Treatment/ Discharge to STP	Collection/ Discharge to STP	Collection/ Discharge to Site 82	In Situ Treatment
Monitoring	Groundwater Monitoring	10 Existing monitoring wells and 3 supply wells		X	X	X	X	X
Ordinances	Aquifer-Use Restrictions	Supply Well 645		X	X	X	X	X
Access Restrictions	Restrictions	Former Storage Area		X	X	X	X	X
	Fencing							
Extraction	Extraction Wells	3 Extraction wells placed for treatment			X	X	X	
Physical/ Chemical Treatment	Treatment Train Consisting of Air Stripping, Carbon Adsorption, and Metals Removal	Extracted groundwater			X		X	
Off-Site Treatment	Treatment at Biological STP	Extracted groundwater				X		
	Treatment at IRP Site	Extracted groundwater					X	
In Situ Treatment	Air Sparging and Soil Venting	In-place groundwater						X
Off-site Discharge	Sewage Treatment Plant	Treated groundwater			X	X		
	Off-Site IRP Site	Treated groundwater					X	

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section of the FS contains the detailed analysis of the set of RAAs developed in Section 4.0. This analysis has been conducted to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD) (USEPA, 1988a).

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

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

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

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

5.1 Individual Analysis of Alternatives

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

The cost estimates that have been developed for each of the alternatives include both capital and operational expenditures. The cost evaluation presents the net present worth (NPW) values for each of the alternatives such that the options can be easily compared. The accuracy

of each cost estimate depends on the assumptions made and the availability of costing information. The present worth costs were calculated assuming a 30-year operational period (based on USEPA guidance) for all of the alternatives, a five percent discount factor, and a zero percent inflation rate. All costs presented in the following sections have been updated to 1993 dollar values. The individual cost estimates are included in Appendix C.

5.1.1 Groundwater RAA No. 1: No Action

Description

Under the Groundwater RAA No. 1, the groundwater in the aquifer at the operable unit will remain as is. Under this alternative, the contaminants identified in the shallow and deep portions of the aquifer will remain, which will result in the potential for further migration of the contaminated plumes. Aquifer restoration may result through natural processes such as biological degradation, attenuation, and dispersion.

Assessment

Overall Protection of Human Health and the Environment

Under this alternative, the existing contamination in the groundwater aquifer (both shallow and deep portions) will have the potential for further migration both horizontally and vertically. Therefore, this alternative does not provide for any protection to human health or the environment.

Compliance With ARARs

Under the No Action RAA, the groundwater quality in the aquifer will continue to exceed the Federal and/or North Carolina contaminant-specific ARARs established for the COCs. No action-specific or location-specific ARARs apply to this RAA.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this alternative will not reduce any potential risks present at the sites with respect to the contaminants in the groundwater. In time, natural bacteriological attenuation may lessen the potential for risks.

In terms of the adequacy and reliability of controls used to manage treatment residuals or untreated wastes that will remain at the operable unit, the No Action RAA does not include any type of controls for the remaining contamination. Therefore, this RAA is not considered reliable.

The No Action RAA would require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Overall, the Groundwater RAA No. 1 can not be considered as an effective or permanent RAA.

Reduction of Toxicity, Mobility, or Volume

No form of treatment is included under the No Action RAA (with the exception of natural biodegradation). Therefore, a very limited amount of the contaminants in the groundwater aquifer will be destroyed or treated. This RAA does not satisfy the statutory preference for treatment.

Short-Term Effectiveness

Since there are no remedial action activities associated with RAA No. 1, the risks to the community are not increased by the implementation of this RAA. In addition, there are no significant risks to workers with respect to implementation. The current impacts to the environment from the existing conditions will continue. The time required to meet the remedial response objectives can not be estimated.

Implementability

With respect to technical implementability, RAA No. 1 is the easiest alternative to implement since there are no construction or operation activities. In addition, this RAA does not include any actions to monitor its effectiveness. In terms of administrative feasibility, this alternative should not require coordination with other agencies (i.e., no permits are necessary). The availability of services, materials, and/or technologies is not applicable to this alternative.

Cost

There are no capital costs or O&M costs associated with this alternative. Therefore, the NPW is $0.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.1.2 Groundwater RAA No. 2: Institutional Controls with Long-Term Monitoring

Description

Under Groundwater RAA No. 2, only institutional controls with long-term monitoring including long-term groundwater monitoring and aquifer-use restrictions will be included. Aquifer restoration may occur through natural processes such as biological degradation, attenuation, and dispersion. The RAA will include semiannually sampling and analysis of groundwater from 1 deep monitoring well, 11 shallow monitoring wells, and 3 local supply wells for five years. The monitoring program will include the following:

- Analyses
  - TCL VOCs
  - Barium
  - Beryllium
  - Cadmium
  - Chromium
  - Lead
  - Manganese
  - Total Suspended Solids
  - Total Dissolved Solids
- Frequency:
  - Years 1-2: Quarterly
  - Years 3-5: Semiannually
  - Years 6-30: Annually

Aquifer-use restrictions will be placed on the one currently closed local supply well. In addition, restrictions concerning the installation of any new potable water supply wells within 2,000 feet of Site 2 will be recommended.

Assessment

Overall Protection of Human Health and the Environment

Under this RAA, the existing contamination in the groundwater aquifer will have the potential for further migration both horizontally and vertically. Currently, one supply well in the area of contamination is not operating. Supply wells located outside the area of contamination are monitored periodically by the base and are not contaminated.

If the aquifer-use restrictions are strictly enforced, and monitoring of the plume and operational supply wells is implemented, this RAA will provide protection to human health with a reduction in the potential for groundwater ingestion. This RAA allows continued contamination of the groundwater, therefore, it provides little, if any, protection to the environment.

Compliance With ARARs

Under RAA No. 2, the groundwater quality in the aquifer will exceed the Federal and/or North Carolina contaminant-specific ARARs established for the COCs. No action-specific or location-specific ARARs apply to this RAA.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this RAA will reduce the risks to human health since the use of the groundwater as a potable water source near the sites will be restricted. Risks would remain under this RAA if the groundwater at the site was used as a drinking water source without treatment.

The adequacy and reliability of the controls included under this RAA (i.e., aquifer-use restrictions) is effective. If strictly enforced, these controls will reduce the risks associated with the ingestion of the contaminated groundwater. If not strictly enforced, these controls would not be adequate.

RAA No. 2 would require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume

No form of treatment is included under RAA No. 2 (with the exception of natural biodegradation). Therefore, a very limited amount of the contaminants in the groundwater aquifer will be destroyed or treated. This RAA does not satisfy the statutory preference for treatment.

Short-Term Effectiveness

Since there are only administrative activities associated with RAA No. 2, the risks to the community (base personnel) are not increased by the implementation of this RAA. In addition, there are no significant risks to workers. The current impacts to the environment from the existing conditions will continue. Under this RAA, the potential risks associated with contaminated groundwater will be reduced due to institutional controls within 3 to 6 months.

Implementability

With respect to technical implementability, RAA No. 2 is easy to implement since the only activities are administrative or involve groundwater monitoring. The monitoring wells already have been installed at the sites. The proposed monitoring will indicate if the groundwater quality is significantly deteriorating. In terms of administrative feasibility, this alternative should not require coordination with other agencies following the ROD (i.e., no approvals of permits or other actions are necessary). The required sampling equipment and materials are readily available.

Cost

There are minimal capital costs associated with RAA No. 2. An annual O&M cost of approximately $57,100 is projected for the quarterly sampling for the first two years. Approximately $28,550 is projected for the semiannual sampling for years three through five. After five years, annual groundwater monitoring was assumed, with an estimated annual cost

of $15,475. Assuming a monitoring period of 30 years and an annual percentage rate of five percent, the NPW of this RAA No. 2 is approximately $350,000.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.1.3 Groundwater RAA No. 3: Collection/Treatment/Discharge to Sewage Treatment Plant

Description

In general, RAA No. 3 includes the containment of the contaminated plumes via extraction and treatment. In addition, this RAA includes the same institutional controls as Groundwater RAA No.2 (Institutional Controls with Long-Term Monitoring). The objective of this RAA is to reduce or eliminate the potential for further migration of the existing groundwater contaminant plume at the operable unit. A series of shallow extraction wells will be installed near monitoring well 2GW3. The extracted groundwater will be treated on site via a combination of several treatment technologies including metals removal, air stripping, and carbon adsorption. Treated water will be pumped to a sanitary sewer that discharges to the Hadnot Point STP.

The RAA will include sampling and analysis of groundwater from 1 deep monitoring well, 11 shallow monitoring wells, and 3 local supply wells. The monitoring program will include the following:

- Analyses
  - TCL VOCs
  - Barium
  - Beryllium
  - Cadmium
  - Chromium
  - Lead
  - Manganese
  - Total Suspended Solids
  - Total Dissolved Solids

- Frequency:
  - Years 1-2: Quarterly
  - Years 3-5: Semiannually
  - Years 6-30: Annually

After five years, the site will be evaluated, using the semiannual sampling data, to determine if sampling can occur less often. Aquifer-use restrictions will be placed on the one currently closed local supply well. In addition, restrictions will be placed on the installation of any new wells within the vicinity of Site 2.

Assessment

Overall Protection of Human Health and the Environment

Under this RAA, the migration of the contaminated plume will be mitigated, further reducing the potential risks associated with groundwater exposure (via operating supply wells). If the aquifer-use restrictions and monitoring program are strictly enforced, this RAA will provide additional reduction in the potential for groundwater ingestion. This RAA reduces the continued migration of the contaminant plume, therefore, it provides protection to the environment.

Compliance With ARARs

Under RAA No. 3, the groundwater quality in the aquifer will be improved at the initiation of the groundwater pump and treat system. The Federal and/or North Carolina contaminant-specific ARARs established for the COCs may be met under this RAA over time. Location-specific ARARs are not applicable to this alternative. Action-specific ARARs such as NPDES and air emission permits may apply to this RAA.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this RAA will reduce the risks to human health for the following reasons: (1) the migration of the contaminant plume is mitigated, and (2) the use of the groundwater as a potable water source near the sites is restricted. Following the completion of this RAA, there should be low residual risks remaining at the operable unit with respect to the contaminated groundwater.

Groundwater pump and treat methods are both adequate and reliable to some extent. All of the technologies/process options are proven and commercially used. As with most equipment, there is a potential for replacement and/or repairs. The adequacy and reliability of the institutional controls are effective.

Since this RAA is expected to take many years to reach remediation goals, it will require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume

Under this RAA, the groundwater will be treated via a treatment system consisting of, but not limited to, air stripping, carbon adsorption, and metals removal. This RAA is designed to reduce the mobility of the contaminants in the groundwater. This RAA satisfies the statutory preference for treatment.

Short-Term Effectiveness

The risks to the community/base personnel will be slightly increased due to a temporary increase in dust production and volatilization during the installation of underground piping for the groundwater treatment system. Workers will require additional protection during the installation and operation of the groundwater treatment system. Environmental impacts will include aquifer drawdown during groundwater extraction. With respect to time to complete the remedial action, the groundwater pump and treat system will be operated for many years, and the contaminant plume may not ever be completely remediated due to the thickness and horizontal characteristics of the aquifer. For FS purposes, 30 years has been estimated.

Implementability

With respect to technical implementability, the groundwater pump and treat system will require operation. If necessary, the extraction system would be relatively easy to expand with the addition of extraction wells and piping. The monitoring wells have already been installed at the sites. The proposed monitoring will indicate if the groundwater quality is significantly deteriorating or improving as a result of this action. In terms of administrative feasibility,

this alternative will require permission for discharge into the Base sanitary sewer system. This RAA requires treatment plant operators.

Cost

The capital costs associated with RAA No. 3 are estimated to be $303,000. An annual O&M cost of approximately $162,760 is projected for the operation of the extraction/treatment system and the quarterly groundwater monitoring program for years one and two. Approximately $134,210 is projected for system operation and semiannual sampling for years three through five. After five years, annual groundwater monitoring was assumed. Assuming a monitoring period of 30 years and an annual percentage rate of five percent, the NPW of RAA No. 3 is approximately $1,890,000. Refer to Appendix C for the cost estimate for this RAA.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.1.4 Groundwater RAA No. 4: Collection/Discharge to a Sewage Treatment Plant

Description

RAA No. 4 includes the extraction of the contaminated groundwater via extraction wells and discharge to the Hadnot Point STP for treatment. Under RAA No. 4, no on-site treatment system will be provided, as treatment will take place at the STP. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2 and 3. Like RAA No. 3 the objective of this RAA is to reduce or eliminate the potential for further migration of the existing groundwater contaminant plume at the operable unit.

The RAA will include semiannual sampling and analysis of groundwater from one deep monitoring well, nine shallow monitoring wells, and three local supply wells (TCL volatile organics) for five years. After five years, the site will be evaluated using the semiannual

sampling data to determine if sampling can occur less often. Aquifer-use restrictions will be placed on the one currently closed local supply well. In addition, restrictions will be placed restricting the installation of any new wells within the vicinity of Site 2.

Assessment

Overall Protection of Human Health and the Environment

Under this RAA, the migration of the contaminated plume will be mitigated, further reducing the potential risks associated with groundwater exposure (via operating wells). If the aquifer-use restrictions and monitoring program are strictly enforced, this RAA will provide additional reduction in the potential for groundwater ingestion. This RAA reduces the continued migration of the contaminant plume, therefore, it provides protection to the environment.

Compliance With ARARs

Under RAA No. 4, the groundwater quality in the aquifer will be improved with the initiation of the groundwater extraction and treatment. The Federal and/or North Carolina contaminant-specific ARARs established for the COCs in groundwater may be met under this RAA over time. Location-specific ARARs are not applicable to this alternative. With respect to action-specific ARARs, the Hadnot Point STP may have to modify its existing NPDES permit to accept this waste stream.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this RAA will reduce the risks to human health for the following reasons: (1) the migration of the contaminant plume in mitigated, (2) the use of the groundwater as a potable water source near the sites will be restricted, and (3) the operating supply wells in the area will be monitored. Following the completion of this RAA, there will likely be low residual risks remaining at the operable unit with respect to using the aquifer at Site 2 as a potable supply.

The source removal activities under this RAA are reliable and adequate. Groundwater pumping methods are both adequate and reliable to some extent. The use of biological treatment (at the STP) to remove the COCs has been documented. However, the impact that

the COCs may have on the overall operation of the STP cannot accurately be predicted. As with most equipment, there is a potential for replacement and/or repairs. The adequacy and reliability of the institutional controls are effective.

Since this RAA is expected to take many years to reach the remediation goals, it will require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume

Under this RAA, groundwater will be treated via the physical and biological treatment system at the STP. This RAA is designed to reduce the toxicity, mobility, and volume of the contaminants in the groundwater. This RAA satisfies the statutory preference for treatment.

Short-Term Effectiveness

The risks to the community will be slightly increased due to a temporary increase in dust production and volatilization during the installation of underground piping for the groundwater extraction system. Workers will require additional protection during the installation and operation of the groundwater extraction and pumping system. Environmental impacts will include aquifer drawdown during groundwater extraction. With respect to time to complete the remedial action, the groundwater extraction system will be operated for many years, prior to achieving complete groundwater restoration. For costing purposes, 30 years of operation has been estimated.

Implementability

With respect to technical implementability, the groundwater extraction and pumping system will require operation. If necessary, the extraction system would be easy to expand. The monitoring wells have already been installed at the sites. The proposed monitoring program will indicate if the groundwater quality is significantly deteriorating. In terms of administrative feasibility, this alternative may require a modification to the Hadnot Point STP NPDES permit or permission for other discharge. This RAA will require routine operation and maintenance for the groundwater extraction system.

Cost

The capital costs associated with RAA No. 4 are estimated to be $210,000. An O&M cost of approximately $106,220 is projected for the operation of the extraction/treatment system and the quarterly groundwater monitoring program for years one and two. Approximately $77,670 is projected for system operation and semiannual sampling for years three through five. After five years, annual groundwater monitoring was assumed. Assuming a monitoring period of 30 years and an annual percentage rate of five percent, the NPW of RAA No. 4 is approximately $1,300,000. Refer to Appendix C for the cost estimate for this RAA.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.1.5 Groundwater RAA No. 5: Collection/Discharge to Site 82

Description

RAA No. 5 includes the extraction of the contaminated groundwater via extraction wells and discharge to the planned groundwater treatment system to be constructed at Site 82 (OU No. 2). Under RAA No. 5, no on-site treatment system will be provided, as treatment will take place at OU No. 2. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, 3, and 4. The objective of this RAA is to reduce or eliminate the potential for further migration of the existing groundwater plume at Site 2.

The RAA will include semiannual sampling and analysis (TCL volatile organics) of groundwater from one deep monitoring well, nine shallow monitoring wells, and three local supply wells for five years. After five years, the site will be evaluated using the semiannual sampling data to determine if sampling can occur less often. Aquifer-use restrictions will be placed on the one currently closed local supply wells. In addition, restrictions will be placed on the installation of any new wells within the vicinity of Site 2.

Assessment

Overall Protection of Human Health and the Environment

Under this RAA, the contaminated groundwater will be removed and treated, reducing the potential risks associated with groundwater degradation in supply wells. If the aquifer-use restrictions and monitor program are strictly enforced, this RAA will provide additional reduction in the potential for groundwater degradation. This RAA reduces the continued contamination of the groundwater via contaminant removal, therefore, it provides protection to the environment.

Compliance With ARARs

Under RAA No. 5, the groundwater quality in the aquifer will be improved with the initiation of the groundwater extraction and treatment. The Federal and/or North Carolina contaminant-specific ARARs established for the effluent discharge will potentially be met under this RAA in time. ARARs associated with groundwater quality will be met over time. Location-specific ARARs are not applicable to this alternative. Action-specific ARARs such as NPDES and air emission permits may apply to this RAA.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this RAA will reduce the risks to human health for the following reasons: (1) the contaminated groundwater will be extracted and treated, (2) the use of the groundwater as a potable water source near the sites will be restricted, and (3) existing supply wells will be monitored.

The source removal activities under this RAA are reliable and adequate. Groundwater pump and treat methods are both adequate and reliable for extracting and treating the groundwater. All of the technologies/process options for treating the effluent at OU No. 2 are proven and commercially used. As with most equipment, there is a potential for replacement and/or repairs. The adequacy and reliability of the institutional controls are affective.

Since this RAA will take several years to meet the remediation goals, it will require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume

Under this RAA, the groundwater within the contaminant plume will be treated at OU No. 2 via a treatment system consisting of, but not limited to, air stripping, carbon adsorption, and metals removal. This RAA is designed to reduce the toxicity, mobility, and volume of the contaminants in the groundwater. This RAA satisfies the statutory preference for treatment.

Short-Term Effectiveness

The risks to the community will be slightly increased due to a temporary increase in dust production and volatilization during the installation of underground piping for the groundwater extraction system. Workers will require additional protection during the installation and operation of the groundwater extraction and pumping system. Environmental impacts will include aquifer drawdown during groundwater extraction. With respect to time to complete the remedial action, the groundwater extraction system will be operated for many years. For costing purposes, 30 years has been estimated.

Implementability

With respect to technical implementability, the groundwater pump and treat system will require operation. If necessary, the extraction system would be easy to expand. The monitoring wells associated with long-term monitoring already have been installed at the sites. The proposed monitoring will indicate if the groundwater quality is significantly deteriorating, or improving.

Once in operation, the pumping system at OU No. 2 will require maintenance. Items of concern would be the extraction pumps and the pumping system.

In terms of administrative feasibility, this alternative would require coordination with other agencies for possible NPDES and air permits. No problems are anticipated with the availability of any of the required equipment, laboratory services, or associated materials.

Cost

The capital costs associated with RAA No. 5 are estimated to be $323,000. An O&M cost of approximately $108,220 is projected for the operation of the extraction/treatment system and the quarterly groundwater monitoring program for years one and two. Approximately $79,670 is projected for system operation and semiannual sampling for years three through five. After five years, annual groundwater monitoring was assumed. Assuming a monitoring period of 30 years and an annual percentage rate of five percent, the NPW of RAA No. 5 is approximately $1,440,000. Refer to Appendix C for the cost estimate for this RAA.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.1.6 Groundwater RAA No. 6: In Situ Treatment

RAA No. 6 provides for remediation of the contaminated plume via an air sparging and soil venting system. In this method, air will be injected into the groundwater through air sparging wells. The air acts to strip and remove the VOC contaminants from the groundwater. Soil venting wells will be placed to control air flow and to collect vapors within the vadose zone. The collected vapors would be treated to remove the contaminants prior to the air being vented to the atmosphere. No groundwater is removed in this alternative, therefore, groundwater does not have to be discharged to a STP or a watercourse. The objective of this RAA is to reduce the COCs in the groundwater to levels that meet the remediation goals, and to reduce the potential for further migration of the existing groundwater plume at Site 2. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, 3, 4, and 5.

The RAA will include semiannual sampling and analysis (TCL volatile organics) of groundwater from one deep monitoring well, nine shallow monitoring wells, and three local supply wells for five years. After five years, the site will be evaluated using the semiannual sampling data to determine if sampling can occur less often. Aquifer-use restrictions will be

placed on the one currently closed local supply well. In addition, restrictions will be placed on the installation of any new wells within the vicinity of Site 2.

Assessment

Overall Protection of Human Health and the Environment

Under this RAA, the contaminated groundwater will be treated, reducing the potential risks associated with groundwater degradation in supply wells. If the aquifer-use restrictions and monitor program are strictly enforced, this RAA will provide additional reduction in the potential for groundwater degradation. This RAA reduces the continued contamination of the groundwater via contaminant in-situ treatment, therefore, it provides protection to the environment.

Compliance with ARARs

Under RAA No. 6, the groundwater quality in the aquifer will be improved with the initiation of the groundwater treatment system. ARARs associated with groundwater quality will be met over time. The timeframe to achieve the remediation goals is difficult to estimate due to the nature of the groundwater contamination, and the hydrogeologic complexity of the site. Location-specific ARARs are not applicable to this alternative. Action-specific ARARs such as air emission permits may apply to this RAA.

Long-Term Effectiveness and Permanence

In terms of the magnitude of residual risks remaining at the operable unit, this RAA will reduce the risks to human health for the following reasons: (1) the contaminated groundwater will be treated, (2) the use of the groundwater as a potable water source near the sites will be restricted, and (3) existing supply wells will be monitored.

The treatment activities under this RAA are reliable and adequate. In-situ treatment methods are both adequate and reliable for treating the groundwater, but not for recovering all groundwater contaminants that would be present via partitioning between groundwater and aquifer solids. This technology/process option for treating the groundwater is being used at other NPL sites. As with most equipment, there is a potential for replacement and/or repairs. The adequacy and reliability of the institutional controls are effective.

Since this RAA will take several years to meet the remediation goals, it will require USEPA's 5-year review to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume

Under this RAA, the groundwater within the contaminant plume will be treated via an in-situ air sparging and soil venting process. This RAA is designed to reduce the toxicity, mobility, and volume of the contaminants in the groundwater. This RAA satisfies the statutory preference for treatment.

Short-Term Effectiveness

The risks to the community will be slightly increased due to a temporary increase in dust production and volatilization during the installation of underground piping for the groundwater treatment system. Workers will require additional protection during the installation and operation of the groundwater treatment system. With respect to time, the system will be operated for a period of 2 to 5 years. However, for costing purposes, 30 years has been estimated.

Implementability

With respect to technical implementability, the air sparging/soil venting SVE system will require operation. If necessary, the system would be easy to expand. The monitoring wells associated with long-term monitoring already have been installed at the sites. The proposed monitoring will indicate if the groundwater quality is significantly deteriorating, or improving.

Once in operation, the system will require maintenance. Items of concern would be the air sparging blowers and vacuum blowers, the vapor phase carbon units, and spent carbon. Time would be required in this alternative for the removal and replacement of spent carbon.

In terms of administrative feasibility, this alternative would require coordination with other agencies for possible air permits. No problems are anticipated with the availability of any of the required equipment, laboratory services, or associated materials.

Cost

The capital costs associated with RAA No. 6 are estimated to be $124,000. An O&M cost of approximately $113,440 is projected for the operation of the air sparging/soil venting SVE system and the quarterly groundwater monitoring program for years one and two. Approximately $84,890 is projected for system operation and semiannual sampling for years three through five. After five years, annual groundwater monitoring was assumed. Assuming a monitoring period of 30 years and an annual percentage rate of five percent, the NPW of RAA No. 6 is approximately $1,320,000. Refer to Appendix C for the cost estimate for this RAA.

USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

Community Acceptance

To be addressed following the public comment period associated with the PRAP.

5.2 Comparative Analysis

This FS has identified and evaluated a range of RAAs potentially applicable to the media of concern at Site 2. Table 5-1 presents a summary of this evaluation. A comparative analysis in which the alternatives are evaluated in relation to one another with respect to the nine evaluation criteria is presented below. The purpose of this analysis is to identify the relative advantages and disadvantages of each RAA.

5.2.1 Overall Protection of Human Health and the Environment

RAA No. 1 (No Action) does not provide protection to human health or the environment. Under the Institutional Controls with Long-Term Monitoring RAA (No. 2), institutional controls will provide protection to human health, although the potential for further migration of the contaminated groundwater still exists. All of the remaining Groundwater RAAs provide protection of human health and the environment. RAA Nos. 3, 4, 5, and 6 provide protection through preventing further migration of the contaminated groundwater plume and

providing treatment. It should be noted that RAAs Nos. 3, 4, 5, and 6 may result in complete restoration of the plume over time; however, remediation will continue for many years. RAA No. 6 may provide for the shortest time to restore the plume maybe as short as two to five years.

5.2.2 Compliance with ARARs

RAA Nos. 1 and 2 will potentially exceed Federal and State ARARs. RAA Nos. 3, 4, and 5 will potentially meet all of their respective ARARs for the treated effluent. In time, RAA Nos. 3, 4, 5, and 6 will meet the groundwater remediation goals.

5.2.3 Long-Term Effectiveness and Permanence

RAA No. 1 will not reduce potential risks due to exposure to contaminated groundwater. Risks will be reduced under RAA Nos. 2 through 6 through the implementation of the institutional controls and/or treatment. The reliability of enforcing aquifer-use restrictions is effective. RAAs 3 through 6 will provide additional long-term effectiveness and permanence because they use a form of treatment to reduce the potential hazards posed by the COCs present in the groundwater aquifer.

All of the RAAs will require a 5-year review. However, RAA No. 6 may meet treatment goals in less than 5 years.

5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

No form of treatment is included under RAA Nos. 1 and 2. RAA Nos. 1 and 2 do not satisfy the statutory preference for treatment, whereas the other RAAs do satisfy the preference. All of the "treatment" RAAs will provide reduction of toxicity, mobility and/or volume of contaminants in the groundwater aquifers.

5.2.5 Short-Term Effectiveness

Risks to community and workers are not increased with the implementation of RAA Nos. 1 and 2. Current impacts from existing conditions will continue under these two RAAs. Under RAA Nos. 3, 4, 5, and 6, risks to the community and workers will be slightly increased due to a temporary increase in dust production and volatilization during the installation of the piping

for the groundwater treatment system or piping system (during treatment operations for the workers). In addition, aquifer drawdown will occur under RAA Nos. 3, 4, and 5.

5.2.6 Implementability

No construction, operation, or administrative activities are associated with RAA No. 1. There are no construction or operation activities associated with RAA No. 2 other than groundwater sampling which is easily performed. RAA No. 3 will require operation of a groundwater pump and treatment system which can be labor intensive. RAA Nos. 4 and 5 will require operation of a groundwater extraction system only. RAA No. 6 will require operation of an in situ system.

5.2.7 Cost

Costs for RAAs 1 through 6 are summarized below. Refer to Appendix C for details on development of costs.

	Remedial Action Alternatives					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Capital Costs	$0	$0	$303,000	$210,000	$323,000	$124,000
O&M Costs						
Years 1 & 2	$0	$57,100	$162,760	$106,220	$108,220	$113,440
Years 3-5	$0	$28,550	$134,210	$77,670	$79,670	$84,890
Years 6-30	$0	$15,475	$119,935	$63,395	$65,395	$70,615
Present Worth	$0	$350,000	$1,890,000	$1,300,000	$1,440,000	$1,320,000

5.2.8 USEPA/State Acceptance

To be addressed following USEPA/NC DEHNR review of the PRAP.

5.2.9 Community Acceptance

To be addressed following the public comment period associated with the PRAP.

TABLE 5-1

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
FEASIBILITY STUDY - CTO-0174
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
OVERALL PROTECTIVENESS						
• Human Health Protection	No reduction in risk.	Institutional controls provide protection against risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. In-situ treatment provides protection against future potential risk from ingestion.
• Environmental Protection	Allows continued contamination of the groundwater.	Allows continued contamination of the groundwater. Potential natural attenuation of organic contaminants over time.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Level of groundwater contamination is reduced by in situ treatment.
COMPLIANCE WITH ARARs						
• Chemical-Specific ARARs	Will exceed Federal and/or NC groundwater quality ARARs.	Will exceed Federal and/or NC groundwater quality ARARs.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.
• Location-Specific ARARs	Not applicable.	Not applicable.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
• Magnitude of Residual Risk	As migration of groundwater continues, potential risks may increase.	Risk reduced to human health since the use of the groundwater aquifer is restricted.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by in-situ treatment of contaminated groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Institutional controls are reliable if strictly enforced.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	In-situ treatment demonstrated for COCs
• Need for 5-year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT						
• Treatment Process Used	None.	None.	Treatment train for metals removal, air stripping, and activated carbon.	Physical and biological treatment at STP.	Treatment train at Site 82 for metals removal, air stripping, and activated carbon.	In-situ air sparging and soil venting for VOC removal.
• Amount Destroyed or Treated	None.	None.	Majority of contaminants in groundwater.	Majority of contaminants in groundwater.	Majority of contaminant in groundwater plumes.	Majority of contaminant in groundwater plumes.

TABLE 5-1 (Continued)

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
FEASIBILITY STUDY - CTO-0174
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
• Reduction of Toxicity, Mobility or Volume	None.	None.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Satisfied.	Satisfied.	Satisfied.	Satisfied.
SHORT-TERM EFFECTIVENESS						
• Community Protection	Risks to community not increased by remedy implementation.	Risks to community not increased by remedy implementation.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.
• Worker Protection	No significant risk to workers.	No significant risk to workers.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.
• Environmental Impacts	None	None	None	None	None	None
• Time Until Action is Complete	Not applicable.	Risks from potential groundwater ingestion reduced within 3 to 6 months due to institutional controls.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.
IMPLEMENTABILITY						
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.
• Ability to Monitor Effectiveness	No monitoring. Failure to detect contamination will result in potential ingestion of contaminated groundwater.	Proposed monitoring will give notice of failure before significant exposure occurs.	Adequate system monitoring.	Adequate system monitoring.	Adequate system monitoring.	Requires indirect monitoring of system performance.
• Availability of Services and Capacities; Equipment	None required.	None required.	Groundwater extraction and treatment equipment is readily available.	Groundwater extraction equipment is readily available.	Groundwater extraction equipment is readily available.	System components readily available.
COSTS Net Present Worth	$0	$350,000	$1.89 million	$1.3 million	$1.44 million	$1.32 million

RAA = Remedial Action Alternative STP = Sewage Treatment Plant ARARs = Applicable or Relevant and Appropriate Requirements

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Appendix A
Baker Environmental, Inc.
Letter Regarding Time-Critical Removal Action

Baker

Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

(412) 269-6000
FAX (412) 269-2002

July 13, 1993

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Building N-26)
Norfolk, Virginia 23511-2699

Attn: Ms. Linda Berry, P.E.
Code 1823

Re: Contract N62470-89-D-4814
Navy CLEAN, District III
Contract Task Order (CTO) 0174
RI/FS at Operable Unit No. 5 (Site 2)
Marine Corps Base Camp Lejeune, North Carolina
Time Critical Removal Action Evaluation

Dear Ms. Berry:

Baker Environmental, Inc. (Baker) is currently conducting RI/FS activities at Operable Unit No. 5 (Site 2) at Marine Corps Base (MCB) Camp Lejeune, North Carolina. Soil, groundwater, surface water, and sediment samples were collected during the field investigation in late April 1993. The majority of the validated laboratory analytical results for these samples has been received by Baker.

A preliminary assessment of the available data indicate the presence of elevated concentrations of pesticides in soil at two discrete areas on-site. The purpose of this correspondence is to present these results to you and evaluate them with respect to Removal Action Criteria outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This may be of assistance to you in determining if a removal action is warranted for this site.

SITE EVALUATION

Elevated concentrations of pesticides have been detected in the soil surrounding two former pesticide mixing/washing pads on-site. Detected pesticides include:

COMPOUND	MAXIMUM CONCENTRATION	BENCHMARK RISK-BASED CONCENTRATION (USEPA)
4,4'-DDD	1,200 ppm	7.1 ppm
4,4'-DDE	130 ppm	5 ppm
4,4'-DDT	2,500 ppm	5 ppm

The benchmark risk-based concentration was prepared by USEPA Region III (January 28, 1993) and applies to soils in residential areas. The benchmark risk-based concentration is a value that equates to a 1×10^{-6} cleanup action level. Baker has used these values in this preliminary evaluation. Site-specific cleanup action levels, however, will be generated in association with the risk assessment and will likely be higher than the benchmark values.

The elevated concentrations of pesticides appear to be limited to the immediate vicinity of the two former washing/mixing pads. A conservative estimate of the volume of soil impacted by pesticide contamination is presented below:

PAD	LENGTH	WIDTH	DEPTH	TOTAL
North Pad	94 ft	47 ft	4 ft	17,672 ft^3
South Pad	157 ft	46 ft	4 ft	28,888 ft^3
			TOTAL	46,560 ft^3
			(or)	1,724 yds^3

REMOVAL CRITERIA

The NCP lists a number of criteria that are considered in determining the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) directly applies to the conditions at Site 2.

300.415 (b)(2)(i) "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

There are presently no access restrictions in this area. The building on site is currently used as an administrative office building.

The presence of pesticide contaminants in this area may pose an imminent and substantial endangerment to public health, or welfare, or the environment. In this case, a time-critical (as opposed to non-time critical) removal action would be appropriate. Time-critical removals require less than six months to plan and are the most common type of removal actions. An engineering evaluation and cost analysis (EE/CA) is not required under time-critical removal actions.

There are several major advantages associated with conducting a time-critical removal action under these conditions:

- It would result in the removal of materials that may pose an immediate threat to human health and the environment in a timely fashion.

- The removal could be performed without the need to perform an EE/CA or FS given the relatively non-complex nature of the problem.
- It would serve to focus, and potentially eliminate the need for, feasibility study activities for the soil matrix.

RECOMMENDATIONS

A time-critical removal action is appropriate at Site 2 considering the small volume of waste involved and the potential health risks associated with prolonged exposure. In order for LANTDIV to determine the appropriate disposal/treatment options, soil samples should be collected and analyzed to determine whether the pesticide-contaminated soil is characteristically hazardous. This determination will have a significant bearing on the cost of disposal. Non-hazardous waste could be disposed of at a price of approximately $90-100 cy whereas hazardous waste disposal will cost approximately $250-300 cy (assuming no further treatment is required). Therefore, it is recommended that additional soil samples be collected from Site 2 soils for full TCLP, corrosivity, reactivity, and ignitability analysis.

The additional sampling and analysis can be conducted as part of this CTO by utilizing the negotiated Unit Cost clusters for sampling and analysis. It is recommended that within the area of concern, three soil samples are collected for analysis. One sample should be collected near the mixing pads where the highest pesticide levels were detected. Two other soil samples should be collected from areas representing moderate to low levels of pesticides above the preliminary action levels. The determination of which areas of soil contamination exhibit hazardous characteristics will be required prior to initiation of the removal action.

Baker hopes that you find this correspondence useful in your assessment of this site. If you have any questions regarding this matter, or would like to discuss it further, please contact me at (412) 269-2038 or Mr. Raymond P. Wattras (Activity Coordinator) at (412) 269-2016.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Raymond P. Wattras
for Donald C. Shields
Project Manager

DCS/nd

cc: Mr. Keith Simmons, P.E., Code 0223
Ms. Lee Anne Rapp, Code 183
Ms. Beth Hacic, Code 02231

Appendix B
Groundwater, Soil, and Sediment RGO Calculations

CALCULATION OF SURFACE SOIL ACTION LEVELS - RESIDENTIAL
OPERABLE UNIT NO.5, SITE 2
REMEDIAL INVESTIGATION, CTO-0174
MCB, CAMP LEJEUNE, NORTH CAROLINA

PURPOSE: CALCULATE SOIL ACTION LEVELS PROTECTIVE OF HUMAN HEALTH SUBSEQUENT TO EXPOSURE.
DERMAL CONTACT AND INCIDENTAL INGESTION SCENARIOS

PERTINENT EQUATIONS: CARCINOGENIC CONTAMINANT ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm ^ 2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

INCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

TOTAL RISK = (DERMAL DOSE + ACCIDENTAL ING. DOSE)*CPF

WHERE: CPF = THE CARCINOGENIC POTENCY FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
ACCIDENTAL ING. DOSE = C*K2

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CPF)

NONCARCINOGENIC ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm ^ 2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

ACCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

HAZARD = (DERMAL DOSE + ACCIDENTAL ING. DOSE)/RfD

WHERE: RfD = THE REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
ACCIDENTAL ING. DOSE = C*K4

ACTION LEVEL (C) = HAZARD*RfD/(K3 + K4)

RESIDENT-CHILD WHERE: TOTAL RISK = 1.0E-06 WHERE: HAZARD = 1.0

CONTAMINANT	SA (cm ^ 2)	AI (mg/D)	AD (mg/cm ^ 2*d	EF (d/yr)	ED (yr)	AF SKIN	AF GUT	CF (Kg/mg)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CPF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL(ppm)	NONCARC. ACTION LEVEL(ppm
NAPHTHALENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		4.00E-02	0.0	2768.6
2-METHYLNAPHTHAL	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		4.00E-02	0.0	2768.6
ACENAPHTHENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		6.00E-02	0.0	4153.0
PHENANTHRENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		3.00E-02	0.0	2076.5
ANTHRACENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		3.00E-01	0.0	20764.9
FLUORANTHENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		4.00E-02	0.0	2768.6
PYRENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		3.00E-02	0.0	2076.5
N-NITROSODIPHENYL	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	4.90E-03		164.8	0.0
4,4'-DDT	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	3.40E-01	5.00E-04	2.4	34.6
4,4'-DDE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	3.40E-01		2.4	0.0
4,4'-DDD	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	2.40E-01		3.4	0.0
DIELDRIN	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	1.60E+01	5.00E-05	0.05	3.5
HEPTACHLOR	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	4.50E+00	5.00E-04	0.18	34.6
CHLORDANE (TOTAL)	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1	1.30E+00	6.00E-05	0.62	4.2
FLUORENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		4.00E-02	0.0	2768.6
TOLUENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		2.00E-01	0.0	13843.2
ETHYLBENZENE	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		1.00E-01	0.0	6921.6
XYLENE (TOTAL)	2600	200	1	350	6	0.01	1	1E-06	15	25550	2190	1.42E-07	1.10E-06	1.66E-06	1.28E-05	1.00E-06	1		2.00E+00	0.0	138432.4
ARSENIC	2600	200	1	350	6	0.001	1	1E-06	15	25550	2190	1.42E-08	1.10E-06	1.66E-07	1.28E-05	1.00E-06	1	7.50E-01	3.00E-04	1.2	23.2

FILE: 74SOILAC.WK1

CALCULATION OF SURFACE SOIL ACTION LEVELS - RESIDENTIAL
OPERABLE UNIT NO.5, SITE 2
REMEDIAL INVESTIGATION, CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE SOIL ACTION LEVELS PROTECTIVE OF HUMAN HEALTH SUBSEQUENT TO EXPOSURE.
DERMAL CONTACT AND INCIDENTAL INGESTION SCENARIOS

PERTINENT EQUATIONS: CARCINOGENIC CONTAMINANT ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

INCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

TOTAL RISK = (DERMAL DOSE + ACCIDENTAL ING. DOSE)^CPF

WHERE: CPF = THE CARCINOGENIC POTENCY FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
ACCIDENTAL ING. DOSE = C*K2

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CPF)

NONCARCINOGENIC ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

ACCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

HAZARD = (DERMAL DOSE + ACCIDENTAL ING. DOSE)/RfD

WHERE: RfD = THE REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
ACCIDENTAL ING. DOSE = C*K4

ACTION LEVEL (C) = HAZARD*RfD/(K3 + K4)

RESIDENT-ADULT WHERE: TOTAL RISK = 1.0E-06 WHERE: HAZARD = 1.0

CONTAMINANT	SA (cm^2)	AI (mg/D)	AD (mg/cm^2*d	EF (d/yr)	ED (yr)	AF SKIN	AF GUT	CF (Kg/mg)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HAZAR	CPF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL(ppm)	NONCARC. ACTION LEVEL(ppm
NAPHTHALENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		4.00E-02	0.0	18364.8
2-METHYLNAPHTHAL	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		4.00E-02	0.0	18364.8
ACENAPHTHENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		6.00E-02	0.0	27547.2
PHENANTHRENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		3.00E-02	0.0	13773.6
ANTHRACENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		3.00E-01	0.0	137735.8
FLUORANTHENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		4.00E-02	0.0	18364.8
FLUORENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		4.00E-02	0.0	18364.8
PYRENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		3.00E-02	0.0	13773.6
N-NITROSODIPHENYL	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	4.90E-03		218.6	0.0
4,4'-DDT	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	3.40E-01	5.00E-04	3.2	229.6
4,4'-DDE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	3.40E-01		3.2	0.0
4,4'-DDD	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	2.40E-01		4.5	0.0
DIELDRIN	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	1.60E+01	5.00E-05	0.07	23.0
HEPTACHLOR	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	4.50E+00	5.00E-04	0.24	229.6
CHLORDANE (TOTAL)	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1	1.30E+00	6.00E-05	0.82	27.5
TOLUENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		2.00E-01	0.0	91823.9
ETHYLBENZENE	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		1.00E-01	0.0	45911.9
XYLENE (TOTAL)	5900	100	1	350	30	0.01	1	1E-06	70	25550	10950	3.46E-07	5.87E-07	8.06E-07	1.37E-06	1.00E-06	1		2.00E+00	0.0	918239.0
ARSENIC	5900	100	1	350	30	0.001	1	1E-06	70	25550	10950	3.46E-08	5.87E-07	8.06E-08	1.37E-06	1.00E-06	1	1.75E+00	3.00E-04	0.9	206.8

FILE: 74SOILAC.WK1

CALCULATION OF SEDIMENT ACTION LEVELS - RESIDENTIAL
OPERABLE UNIT NO.5, SITE 2
REMEDIAL INVESTIGATION, CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE SEDIMENT ACTION LEVELS PROTECTIVE OF HUMAN HEALTH SUBSEQUENT TO EXPOSURE.
DERMAL CONTACT AND INCIDENTAL INGESTION SCENARIOS

PERTINENT EQUATIONS: CARCINOGENIC CONTAMINANT ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

INCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

TOTAL RISK = (DERMAL DOSE + ACCIDENTAL ING. DOSE)*CPF

WHERE: CPF = THE CARCINOGENIC POTENCY FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
ACCIDENTAL ING. DOSE = C*K2

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CPF)

RESIDENT-CHILD WHERE: TOTAL RISK = 1.0E-06

NONCARCINOGENIC ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

ACCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

HAZARD = (DERMAL DOSE + ACCIDENTAL ING. DOSE)/RfD

WHERE: RfD = THE REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
ACCIDENTAL ING. DOSE = C*K4

ACTION LEVEL (C) = HAZARD*RfD/(K3 + K4)

WHERE: HAZARD = 1.0

CONTAMINANT	SA (cm^2)	AI (mg/D)	AD (mg/cm^2*d	EF (d/yr)	ED (yr)	AF SKIN	AF GUT	CF (Kg/mg)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CPF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL(ppm)	NONCARC. ACTION LEVEL(ppm
NAPHTHALENE	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1		4.00E-02	0	17304
2-METHYLNAPHTHA	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1		4.00E-02	0	17304
4,4'-DDT	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	3.40E-01	5.00E-04	15	216
4,4'-DDE	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	3.40E-01		15	0
4,4'-DDD	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	2.40E-01		21	0
DIELDRIN	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	1.60E+01	5.00E-05	0	22
ENDOSULFAN II	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	4.50E+00	5.00E-04	1	216
CHLORDANE (TOTA	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1	1.30E+00	6.00E-05	4	26
ETHYLBENZENE	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1		1.00E-01	0	43260
XYLENE (TOTAL)	2600	200	1	56	6	0.010	1	1E-06	15	25550	2190	2.28E-08	1.75E-07	2.66E-07	2.05E-06	1.00E-06	1		2.00E+00	0	865202
BERYLLIUM	2600	200	1	56	6	0.001	1	1E-06	15	25550	2190	2.28E-09	1.75E-07	2.66E-08	2.05E-06	1.00E-06	1	4.30E+00	5.00E-03	1	2413

FILE: 74SEDAC.WQ1

CALCULATION OF SEDIMENT ACTION LEVELS - RESIDENTIAL
OPERABLE UNIT NO.5, SITE 2
REMEDIAL INVESTIGATION, CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE SEDIMENT ACTION LEVELS PROTECTIVE OF HUMAN HEALTH SUBSEQUENT TO EXPOSURE.
DERMAL CONTACT AND INCIDENTAL INGESTION SCENARIOS

PERTINENT EQUATIONS: CARCINOGENIC CONTAMINANT ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

INCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (70yrs * 365) (d)

TOTAL RISK = (DERMAL DOSE + ACCIDENTAL ING. DOSE)*CPF

WHERE: CPF = THE CARCINOGENIC POTENCY FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
ACCIDENTAL ING. DOSE = C*K2

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CPF)

NONCARCINOGENIC ACTION LEVELS

DERMAL DOSE = (C)(SA)(AD)(EF)(ED)(AF)(CF)/(BW)(AT)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE SOIL ADHERENCE FACTOR (mg/cm^2*d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

ACCIDENTAL INGESTION DOSE = (C)(AI)(D)(YRS)(AF)(CF)/(BW)(LF)

WHERE: C = THE CONTAMINANT CONCENTRATION (mg/Kg)
AI = THE AMOUNT INGESTED (g/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
CF = THE CONVERSION FACTOR (Kg/mg)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (ED * 365) (d)

HAZARD = (DERMAL DOSE + ACCIDENTAL ING. DOSE)/RfD

WHERE: RfD = THE REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
ACCIDENTAL ING. DOSE = C*K4

ACTION LEVEL (C) = HAZARD*RfD/(K3 + K4)

RESIDENT-ADULT WHERE: TOTAL RISK = 1.0E-06 WHERE: HAZARD = 1.0

CONTAMINANT	SA (cm^2)	AI (mg/D)	AD (mg/cm^2*d	EF (d/yr)	ED (yr)	AF SKIN	AF GUT	CF (Kg/mg)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HAZAR	CPF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL(ppm)	NONCARC. ACTION LEVEL(ppm
NAPHTHALENE	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1		4.00E-02	0	309322
2-METHYLNAPHTHA	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1		4.00E-02	0	309322
4,4'-DDT	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	3.40E-01	5.00E-04	53	3867
4,4'-DDE	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	3.40E-01		53	0
4,4'-DDD	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	2.40E-01		75	0
DIELDRIN	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	1.60E+01	5.00E-05	1	387
ENDOSULFAN II	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	4.50E+00	5.00E-04	4	3867
CHLORDANE (TOTA	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1	1.30E+00	6.00E-05	14	464
ETHYLBENZENE	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1		1.00E-01	0	773305
XYLENE (TOTAL)	1800	100	1	28	30	0.01	1	1E-06	70	25550	10950	8.45E-09	4.70E-08	1.97E-08	1.10E-07	1.00E-06	1		2.00E+00	0	15466102
BERYLLIUM	1800	100	1	28	30	0.001	1	1E-06	70	25550	10950	8.45E-10	4.70E-08	1.97E-09	1.10E-07	1.00E-06	1	4.30E+00	5.00E-03	5	44818

FILE: 74SEDAC.WQ1

CALCULATION OF GROUNDWATER INGESTION ACTION LEVELS - CONSRUCTION WORKER EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(T)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI * RfD/(K3 + K4)

CONSTRUCTION WORKER WHERE: TOTAL RISK = 10-06 AND HI = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-06	1		4.00E-02	0	24211
2-METHYLNAPHTHALEN	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-06	1		4.00E-02	0	24211
ACENAPHTHENE	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-06	1		6.00E-02	0	50637
TRICHLOROETHENE	5900	1	1.6E-02	1	0.001	30	1	70	25550	365	1.6E-06	1.7E-05	1.1E-04	1.2E-03	1E-06	1	1.10E-02	6.00E-03	4952	4669
ETHYLBENZENE	5900	1	1.38E+00	1	0.001	30	1	70	25550	365	1.4E-04	1.7E-05	9.6E-03	1.2E-03	1E-06	1		1.00E-01	0	9316
XYLENE (TOTAL)	5900	1	7.7E-02	1	0.001	30	1	70	25550	365	7.6E-06	1.7E-05	5.3E-04	1.2E-03	1E-06	1		2.00E+00	0	1171239
4,4'-DDD	5900	1	2.8E-01	1	0.001	30	1	70	25550	365	2.8E-05	1.7E-05	1.9E-03	1.2E-03	1E-06	1	2.40E-01		94	0
4,4'-DDT	5900	1	4.3E-01	1	0.001	30	1	70	25550	365	4.3E-05	1.7E-05	3.0E-03	1.2E-03	1E-06	1	3.40E-01	5.00E-04	50	120
PHENOL	5900	1	8.2E-03	1	0.001	30	1	70	25550	365	8.1E-07	1.7E-05	5.7E-05	1.2E-03	1E-06	1		6.00E-01	0	487364
2,4-DIMETHYLPHENOL	5900	1	1.1E-03	1	0.001	30	1	70	25550	365	1.1E-07	1.7E-05	7.6E-06	1.2E-03	1E-06	1		2.00E-02	0	16923
ARSENIC	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-06	1	1.75E+00	3.00E-04	34	253
BARIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-06	1		7.00E-02	0	59076
BERYLLIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-06	1	4.30E+00	5.00E-03	14	4220
VANADIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-06	1		7.00E-03	0	5908

FILE NAME: CWAL6.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - CONSTRUCTION WORKER EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS
RESIDENT

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI * RfD/(K3 + K4)

CONSTRUCTION WORKER WHERE: ICR = 1E-05 AND HI = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	T (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-05	1		4.00E-02	0	24211
2-METHYLNAPHTHALENE	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-05	1		4.00E-02	0	24211
ACENAPHTHENE	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-06	1.1E-05	1.2E-03	1E-05	1		6.00E-02	0	50637
TRICHLOROETHENE	5900	1	1.6E-02	1	0.001	30	1	70	25550	365	1.6E-06	1.7E-06	1.1E-04	1.2E-03	1E-05	1	1.10E-02	6.00E-03	49522	4669
ETHYLBENZENE	5900	1	1.38E+00	1	0.001	30	1	70	25550	365	1.4E-04	1.7E-05	9.6E-03	1.2E-03	1E-05	1		1.00E-01	0	9316
XYLENE (TOTAL)	5900	1	7.7E-02	1	0.001	30	1	70	25550	365	7.6E-06	1.7E-06	5.3E-04	1.2E-03	1E-05	1		2.00E+00	0	1171239
4,4'-DDD	5900	1	2.8E-01	1	0.001	30	1	70	25550	365	2.8E-05	1.7E-05	1.9E-03	1.2E-03	1E-05	1	2.40E-01		937	0
4,4'-DDT	5900	1	4.3E-01	1	0.001	30	1	70	25550	365	4.3E-05	1.7E-05	3.0E-03	1.2E-03	1E-05	1	3.40E-01	5.00E-04	496	120
PHENOL	5900	1	8.2E-03	1	0.001	30	1	70	25550	365	8.1E-07	1.7E-05	5.7E-05	1.2E-03	1E-05	1		6.00E-01	0	487364
2,4-DIMETHYLPHENOL	5900	1	1.1E-03	1	0.001	30	1	70	25550	365	1.1E-07	1.7E-05	7.6E-06	1.2E-03	1E-05	1		2.00E-02	0	16923
ARSENIC	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-05	1	1.75E+00	3.00E-04	338	253
BARIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-05	1		7.00E-02	0	59076
BERYLLIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-05	1	4.30E+00	5.00E-03	137	4220
VANADIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-05	1		7.00E-03	0	5908

FILE NAME: CWALS.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - CONSTRUCTION WORKER EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = THE ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = THE AMOUNT INGESTED (L/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CPF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C * K1
INCIDENTAL INGESTION DOSE = C * K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C * K3
INCIDENTAL INGESTION DOSE = C * K4

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI * RfD/(K3 + K4)

CONSTRUCTION WORKER WHERE: ICR = 10-04 AND HAZARD INDEX = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-04	1		4.00E-02	0	24211
2-METHYLNAPHTHALENE	5900	1	6.9E-02	1	0.001	30	1	70	25550	365	6.8E-06	1.7E-05	4.8E-04	1.2E-03	1E-04	1		4.00E-02	0	24211
ACENAPHTHENE	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-04	1		6.00E-02	0	50637
TRICHLOROETHENE	5900	1	1.6E-02	1	0.001	30	1	70	25550	365	1.6E-06	1.7E-05	1.1E-04	1.2E-03	1E-04	1	1.10E-02	6.00E-03	495221	4669
ETHYLBENZENE	5900	1	1.38E+00	1	0.001	30	1	70	25550	365	1.4E-04	1.7E-05	9.6E-03	1.2E-03	1E-04	1		1.00E-01	0	9316
XYLENE (TOTAL)	5900	1	7.7E-02	1	0.001	30	1	70	25550	365	7.6E-06	1.7E-05	5.3E-04	1.2E-03	1E-04	1		2.00E+00	0	1171239
4,4'-DDD	5900	1	2.8E-01	1	0.001	30	1	70	25550	365	2.8E-05	1.7E-05	1.9E-03	1.2E-03	1E-04	1	2.40E-01		9367	0
4,4'-DDT	5900	1	4.3E-01	1	0.001	30	1	70	25550	365	4.3E-05	1.7E-05	3.0E-03	1.2E-03	1E-04	1	3.40E-01	5.00E-04	4957	120
PHENOL	5900	1	8.2E-03	1	0.001	30	1	70	25550	365	8.1E-07	1.7E-05	5.7E-05	1.2E-03	1E-04	1		6.00E-01	0	487364
2,4-DIMETHYLPHENOL	5900	1	1.1E-03	1	0.001	30	1	70	25550	365	1.1E-07	1.7E-05	7.6E-06	1.2E-03	1E-04	1		2.00E-02	0	16923
ARSENIC	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-04	1	1.75E+00	3.00E-04	3376	253
BARIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-04	1		7.00E-02	0	59076
BERYLLIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-04	1	4.30E+00	5.00E-03	1374	4220
VANADIUM	5900	1	1.55E-03	1	0.001	30	1	70	25550	365	1.5E-07	1.7E-05	1.1E-05	1.2E-03	1E-04	1		7.00E-03	0	5908

FILE NAME: CWAL4.WQ1

OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS
RESIDENT

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(T)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = ICR/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI * RfD/(K3 + K4)

RESIDENTIAL CHILD WHERE: ICR = 10-06 AND HI = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	8.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-06	1		4.00E-02	0.00	546
2-METHYLNAPHTHALENE	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	8.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-06	1		4.00E-02	0.00	546
ACENAPHTHENE	8500	1	1.5E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-06	1		6.00E-02	0.00	935
TRICHLOROETHENE	8500	1	1.6E-02	0.25	0.001	350	6	15	25550	2190	1.9E-04	5.5E-03	2.2E-03	6.4E-02	1E-06	1	1.10E-02	6.00E-03	16.06	91
ETHYLBENZENE	8500	1	1.3E+00	0.25	0.001	350	6	15	25550	2190	1.6E-02	5.5E-03	1.9E-01	6.4E-02	1E-06	1		1.00E-01	0.00	366
XYLENE (TOTAL)	8500	1	7.7E-02	0.25	0.001	350	6	15	25550	2190	9.0E-04	5.5E-03	1.0E-02	6.4E-02	1E-06	1		2.00E+00	0.00	26886
4,4'-DDD	8500	1	2.8E-01	0.25	0.001	350	6	15	25550	2190	3.3E-03	5.5E-03	3.8E-02	6.4E-02	1E-06	1	2.40E-01		0.48	0
4,4'-DDT	8500	1	4.3E-01	0.25	0.001	350	6	15	25550	2190	5.0E-03	5.5E-03	5.8E-02	6.4E-02	1E-06	1	3.40E-01	5.00E-04	0.28	4
PHENOL	8500	1	8.2E-03	0.25	0.001	350	6	15	25550	2190	9.6E-05	5.5E-03	1.1E-03	6.4E-02	1E-06	1		6.00E-01	0.00	9225
2,4-DIMETHYLPHENOL	8500	1	1.1E-03	0.25	0.001	350	6	15	25550	2190	1.3E-05	5.5E-03	1.5E-04	6.4E-02	1E-06	1		2.00E-02	0.00	312
ARSENIC	8500	1	1.5E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-06	1	1.75E+00	3.00E-04	0.10	5
BARIUM	8500	1	1.5E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-06	1		7.00E-02	0.00	1091
BERYLLIUM	8500	1	1.5E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-06	1	4.30E+00	5.00E-03	0.04	78
VANADIUM	8500	1	1.5E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-06	1		7.00E-03	0.00	109

FILE NAME: GWACT&.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - RESIDENTIAL EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = ICR/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI*RfD/(K3 + K4)

RESIDENTIAL CHILD WHERE: ICR = 10-05 AND HI = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	6.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-05	1		4.00E-02	0.00	546
2-METHYLNAPHTHALEN	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	6.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-05	1		4.00E-02	0.00	548
ACENAPHTHENE	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-05	1		6.00E-02	0.00	935
TRICHLOROETHENE	8500	1	1.6E-02	0.25	0.001	350	6	15	25550	2190	1.9E-04	5.5E-03	2.2E-03	6.4E-02	1E-05	1	1.10E-02	6.00E-03	160.45	91
ETHYLBENZENE	8500	1	1.38E+00	0.25	0.001	350	6	15	25550	2190	1.6E-02	5.5E-03	1.9E-01	6.4E-02	1E-05	1		1.00E-01	0.00	398
XYLENE (TOTAL)	8500	1	7.7E-02	0.25	0.001	350	6	15	25550	2190	9.0E-04	5.5E-03	1.0E-02	6.4E-02	1E-05	1		2.00E+00	0.00	26886
4,4'-DDD	8500	1	2.6E-01	0.25	0.001	350	6	15	25550	2190	3.3E-03	5.5E-03	3.8E-02	6.4E-02	1E-05	1	2.40E-01		4.77	0
4,4'-DDT	8500	1	4.3E-01	0.25	0.001	350	6	15	25550	2190	5.0E-03	5.5E-03	5.6E-02	6.4E-02	1E-05	1	3.40E-01	5.00E-04	2.80	4
PHENOL	8500	1	8.2E-03	0.25	0.001	350	6	15	25550	2190	9.6E-05	5.5E-03	1.1E-03	6.4E-02	1E-05	1		6.00E-01	0.00	9225
2,4-DIMETHYLPHENOL	8500	1	1.1E-03	0.25	0.001	350	6	15	25550	2190	1.3E-05	5.5E-03	1.5E-04	6.4E-02	1E-05	1		2.00E-02	0.00	312
ARSENIC	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-05	1	1.75E+00	3.00E-04	1.04	5
BARIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-05	1		7.00E-02	0.00	1091
BERYLLIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-05	1	4.30E+00	5.00E-03	0.42	78
VANADIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-05	1		7.00E-03	0.00	109

FILE NAME: GWACT5.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - RESIDENTIAL EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI*RfD/(K3 + K4)

RESIDENTIAL CHILD WHERE: ICR = 10-04 AND HI = 1

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	8.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-04	1		4.00E-02	0.00	546
2-METHYLNAPHTHALENE	8500	1	6.9E-02	0.25	0.001	350	6	15	25550	2190	8.0E-04	5.5E-03	9.4E-03	6.4E-02	1E-04	1		4.00E-02	0.00	546
ACENAPHTHENE	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-04	1		6.00E-02	0.00	935
TRICHLOROETHENE	8500	1	1.6E-02	0.25	0.001	350	6	15	25550	2190	1.9E-04	5.5E-03	2.2E-03	6.4E-02	1E-04	1	1.10E-02	6.00E-03	1604.54	91
ETHYLBENZENE	8500	1	1.38E+00	0.25	0.001	350	6	15	25550	2190	1.6E-02	5.5E-03	1.9E-01	6.4E-02	1E-04	1		1.00E-01	0.00	396
XYLENE (TOTAL)	8500	1	7.7E-02	0.25	0.001	350	6	15	25550	2190	9.0E-04	5.5E-03	1.0E-02	6.4E-02	1E-04	1		2.00E+00	0.00	26886
4,4'-DDD	8500	1	2.8E-01	0.25	0.001	350	6	15	25550	2190	3.3E-03	5.5E-03	3.8E-02	6.4E-02	1E-04	1	2.40E-01		47.68	0
4,4'-DDT	8500	1	4.3E-01	0.25	0.001	350	6	15	25550	2190	5.0E-03	5.5E-03	5.8E-02	6.4E-02	1E-04	1	3.40E-01	5.00E-04	28.05	4
PHENOL	8500	1	8.2E-03	0.25	0.001	350	6	15	25550	2190	9.6E-05	5.5E-03	1.1E-03	6.4E-02	1E-04	1		6.00E-01	0.00	9225
2,4-DIMETHYLPHENOL	8500	1	1.1E-03	0.25	0.001	350	6	15	25550	2190	1.3E-05	5.5E-03	1.5E-04	6.4E-02	1E-04	1		2.00E-02	0.00	312
ARSENIC	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-04	1	1.75E+00	3.00E-04	10.39	5
BARIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-04	1		7.00E-02	0.00	1091
BERYLLIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-04	1	4.30E+00	5.00E-03	4.23	78
VANADIUM	8500	1	1.55E-03	0.25	0.001	350	6	15	25550	2190	1.8E-05	5.5E-03	2.1E-04	6.4E-02	1E-04	1		7.00E-03	0.00	109

FILE NAME: GWACT4.WQ1

OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS
RESIDENT

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(T)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE: RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = ICR/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI * RfD/(K3 + K4)

RESIDENTIAL ADULT

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-06	1		4.00E-02	0.00	1220
2-METHYLNAPHTHALENE	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-06	1		4.00E-02	0.00	1220
ACENAPHTHENE	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-06	1		6.00E-02	0.00	2180
TRICHLOROETHENE	22800	2	1.6E-02	0.25	0.001	350	30	70	25550	10950	5.4E-04	1.2E-02	1.2E-03	2.7E-02	1E-06	1	1.10E-02	6.00E-03	7.40	209
ETHYLBENZENE	22800	2	1.38E+00	0.25	0.001	350	30	70	25550	10950	4.6E-02	1.2E-02	1.1E-01	2.7E-02	1E-06	1		1.00E-01	0.00	740
XYLENE (TOTAL)	22800	2	7.7E-02	0.25	0.001	350	30	70	25550	10950	2.6E-03	1.2E-02	6.0E-03	2.7E-02	1E-06	1		2.00E+00	0.00	59663
4,4'-DDD	22800	2	2.8E-01	0.25	0.001	350	30	70	25550	10950	9.4E-03	1.2E-02	2.2E-02	2.7E-02	1E-06	1	2.40E-01		0.20	0
4,4'-DDT	22800	2	4.3E-01	0.25	0.001	350	30	70	25550	10950	1.4E-02	1.2E-02	3.4E-02	2.7E-02	1E-06	1	3.40E-01	5.00E-04	0.11	8
PHENOL	22800	2	8.2E-03	0.25	0.001	350	30	70	25550	10950	2.8E-04	1.2E-02	5.4E-04	2.7E-02	1E-06	1		6.00E-01	0.00	21399
2,4-DIMETHYLPHENOL	22800	2	1.1E-03	0.25	0.001	350	30	70	25550	10950	3.7E-05	1.2E-02	8.6E-05	2.7E-02	1E-06	1		2.00E-02	0.00	728
ARSENIC	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-06	1	1.75E+00	3.00E-04	0.05	11
BARIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-06	1		7.00E-02	0.00	2544
BERYLLIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-06	1	4.30E+00	5.00E-03	0.02	182
VANADIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-06	1		7.00E-03	0.00	254

FILE NAME: GWACT6.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - RESIDENTIAL EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = ICR/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI*RfD/(K3 + K4)

RESIDENTIAL ADULT CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-05	1		4.00E-02	0.00	1220
2-METHYLNAPHTHALEN	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-05	1		4.00E-02	0.00	1220
ACENAPHTHENE	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-05	1		6.00E-02	0.00	2180
TRICHLOROETHENE	22800	2	1.6E-02	0.25	0.001	350	30	70	25550	10950	5.4E-04	1.2E-02	1.2E-03	2.7E-02	1E-05	1	1.10E-02	6.00E-03	74.05	209
ETHYLBENZENE	22800	2	1.38E+00	0.25	0.001	350	30	70	25550	10950	4.6E-02	1.2E-02	1.1E-01	2.7E-02	1E-05	1		1.00E-01	0.00	740
XYLENE (TOTAL)	22800	2	7.7E-02	0.25	0.001	350	30	70	25550	10950	2.6E-03	1.2E-02	6.0E-03	2.7E-02	1E-05	1		2.00E+00	0.00	59863
4,4'-DDD	22800	2	2.8E-01	0.25	0.001	350	30	70	25550	10950	9.4E-03	1.2E-02	2.2E-02	2.7E-02	1E-05	1	2.40E-01		1.97	0
4,4'-DDT	22800	2	4.3E-01	0.25	0.001	350	30	70	25550	10950	1.4E-02	1.2E-02	3.4E-02	2.7E-02	1E-05	1	3.40E-01	5.00E-04	1.13	6
PHENOL	22800	2	8.2E-03	0.25	0.001	350	30	70	25550	10950	2.8E-04	1.2E-02	6.4E-04	2.7E-02	1E-05	1		6.00E-01	0.00	21399
2,4-DIMETHYLPHENOL	22800	2	1.1E-03	0.25	0.001	350	30	70	25550	10950	3.7E-05	1.2E-02	8.6E-05	2.7E-02	1E-05	1		2.00E-02	0.00	728
ARSENIC	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-05	1	1.75E+00	3.00E-04	0.48	11
BARIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-05	1		7.00E-02	0.00	2544
BERYLLIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-05	1	4.30E+00	5.00E-03	0.20	182
VANADIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-05	1		7.00E-03	0.00	254

FILE NAME: GWACT5.WQ1

CALCULATION OF GROUNDWATER ACTION LEVELS - RESIDENTIAL EXPOSURES
OPERABLE UNIT NO.5, SITE 2
FEASIBILITY STUDY CTO-0174
MCB, CAMP LEJUENE, NORTH CAROLINA

PURPOSE: CALCULATE GROUNDWATER ACTION LEVELS PROTECTIVE OF HUMAN HEALTH UPON EXPOSURE.
DERMAL CONTACT AND INGESTION SCENARIOS

PERTINENT EQUATIONS:

CARCINOGENS AND NONCARCINOGENS:
DERMAL DOSE = (C)(SA)(ABS)(EF)(ED)(ET)(CF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
SA = EXPOSED SKIN SURFACE AREA (cm)
AD = ABSORPTION RATE (mg/cm^2 hr)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
ET = TIME OF EACH EXPOSURE (hrs)
CF = CONVERSION (L/cm^3)
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INGESTION DOSE = (C)(IR)(EF)(ED)(AF)/(BW)(AT)

WHERE:
C = CONTAMINANT CONCENTRATION * 1000 (ug/L)
IR = AMOUNT INGESTED (L/d)
EF = EXPOSURE FREQUENCY (d/yr)
ED = EXPOSURE DURATION (yrs)
AF = THE ABSORBED FRACTION OF THE CONTAMINANT
BW = AVERAGE BODY WEIGHT OF THE RECEPTOR (Kg)
AT = AVERAGING TIME (days) (CARCINOGENS = 365d/yr * 70 yrs)
(NONCARCINOGENS = 365 d/yr * ED yr)

INCREMENTAL CANCER RISK (ICR) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)*CSF

WHERE:
CSF = CARCINOGENIC SLOPE FACTOR (Kg*d/mg)
DERMAL DOSE = C*K1
INCIDENTAL INGESTION DOSE = C*K2

HAZARD INDEX (HI) = (DERMAL DOSE + INCIDENTAL INGESTION DOSE)/RfD

WHERE:
RfD = REFERENCE DOSE (mg/Kg*d)
DERMAL DOSE = C*K3
INCIDENTAL INGESTION DOSE = C*K4

ACTION LEVEL (C) = TOTAL RISK/(K1 + K2)(CSF)

ACTION LEVEL (C) = HI*RfD/(K3 + K4)

RESIDENTIAL ADULT

CONTAMINANT	SA (cm^2)	IR (L/d)	PC (cm/hr)	ET (hr/d)	CF (L/cm^3)	EF (d/yr)	ED (yr)	BW (Kg)	AT (CARC) (d)	AT (NON) (d)	K1	K2	K3	K4	ICR	HI	CSF (Kg*d/mg)	RfD (mg/Kg*d)	CARC. ACTION LEVEL (ug/L)	NONCARC. ACTION LEVEL (ug/L)
NAPHTHALENE	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-04	1		4.00E-02	0.00	1220
2-METHYLNAPHTHALENE	22800	2	6.9E-02	0.25	0.001	350	30	70	25550	10950	2.3E-03	1.2E-02	5.4E-03	2.7E-02	1E-04	1		4.00E-02	0.00	1220
ACENAPHTHENE	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-04	1		6.00E-02	0.00	2180
TRICHLOROETHENE	22800	2	1.6E-02	0.25	0.001	350	30	70	25550	10950	5.4E-04	1.2E-02	1.2E-03	2.7E-02	1E-04	1	1.10E-02		740.48	0
ETHYLBENZENE	22800	2	1.36E+00	0.25	0.001	350	30	70	25550	10950	4.6E-02	1.2E-02	1.1E-01	2.7E-02	1E-04	1		1.00E-01	0.00	740
XYLENE (TOTAL)	22800	2	7.7E-02	0.25	0.001	350	30	70	25550	10950	2.6E-03	1.2E-02	6.0E-03	2.7E-02	1E-04	1		2.00E+00	0.00	59863
4,4'-DDD	22800	2	2.8E-01	0.25	0.001	350	30	70	25550	10950	9.4E-03	1.2E-02	2.2E-02	2.7E-02	1E-04	1	0.24		19.74	0
4,4'-DDT	22800	2	4.3E-01	0.25	0.001	350	30	70	25550	10950	1.4E-02	1.2E-02	3.4E-02	2.7E-02	1E-04	1	0.34	0.0005	11.26	8
PHENOL	22800	2	8.2E-03	0.25	0.001	350	30	70	25550	10950	2.8E-04	1.2E-02	6.4E-04	2.7E-02	1E-04	1		0.6	0.00	21399
2,4-DIMETHYLPHENOL	22800	2	1.1E-03	0.25	0.001	350	30	70	25550	10950	3.7E-05	1.2E-02	8.6E-05	2.7E-02	1E-04	1		0.02	0.00	728
ARSENIC	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-04	1	1.75	0.0003	4.85	11
BARIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-04	1		0.07	0.00	2544
BERYLLIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-04	1	4.3	0.005	1.97	182
VANADIUM	22800	2	1.55E-03	0.25	0.001	350	30	70	25550	10950	5.2E-05	1.2E-02	1.2E-04	2.7E-02	1E-04	1		0.007	0.00	254

FILE NAME: GWAGT4.WQ1

Appendix C
Remedial Action Alternative Cost Calculations

TABLE C-1 CTO-0174
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 2
LIMITED ACTION

O & M COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Groundwater Monitoring - Years 1 -						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	60	$375	$22,500		15 samples; quarterly	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
Groundwater Monitoring - Years 3 -						15 wells sampled semiannually.	
Labor	Hours	180	$35	$6,300		15 wells x 2 samplers x 3 hrs/well x 2 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
Groundwater Monitoring Years 6 - 3						15 wells sampled annually.	
Labor	Hours	90	$40	$3,600		15 wells x 2 samplers x 3 hrs/well x 1 event	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; annually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$2,750	$2,750		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	1	$3,500	$3,500		1 report per sampling event	Engineering estimate
Total Annual O&M Costs, Years 1 - 2					$57,100	For years 1 and 2	
Total Annual O&M Costs, Years 3 - 5					$28,550	For years 3 through 5	
Total Annual O&M Costs, Years 6 - 30					$15,475	For years 6 through 30	
Approximate Present Worth Value					$350,000		

TABLE C-2 CTO-0174
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 3
COLLECTION/TREATMENT/DISCHARGE TO STP

CAPITAL COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump Sum	1	$15,000	$15,000			Engineering Estimate
Miscellaneous	Lump Sum	1	$10,000	$10,000		Utilities hook-up, site preparation	Engineering Estimate
					$25,000		
Groundwater Extraction System							
Driller Mobilization	Lump Sum	1	$3,000	$3,000			Basic Ordering Agreement
Extraction Well - Shallow (3)	Per Foot	105	$450	$47,250		6" stainless steel, 35 ' deep	Engineering Estimate
Well Development	Per Well	3	$375	$1,125			Engineering Estimate
Extraction Pump at 3 Wells	Per Pump	3	$9,500	$28,500			Vendor Quote
Piping From Wells	Per Foot	300	$15	$4,500		HDPE pipe, PVC casing, w/trench	Basic Ordering Agreement
					$84,375		
Pretreatment System	Lump Sum	1	$22,000	$22,000		Inorganics removal	Vendor Information
Physical/Chemical Treatment System							
Air Stripper	Lump Sum	1	$11,800	$11,800		Air stripper, pumps, controls	Vendor Information
Carbon Adsorption	Lump Sum	1	$10,000	$10,000		Carbon units, pumps, electric, etc.	Vendor Information
Misc. Equipment	Lump Sum	1	$15,000	$15,000		Sludge dewatering press, holding tank	Vendor Information
Treatment Building	Lump Sum	1	$15,000	$15,000		8 ft. by 16 ft.	Vendor Information
					$73,800		
Discharge of Treated Water							
Surface Infastructure	Lump Sum	1	$5,000	$5,000		Site power, conduits, piping	Engineering Estimate
Effluent Pump Station	Lump Sum	1	$4,600	$4,600		Package duplex pump station	Engineering Estimate
Discharge Piping	Per Foot	1500	$10	$15,000		PVC pipe, w/trench	Engineering Estimate
					$24,600		
Demobilization							
Administrative Activities	Lump Sum	1	$10,000	$10,000		Project close out doc. and reporting	Engineering Estimate
Site Restoration	Lump Sum	1	$5,000	$5,000		General site cleanup, revegetation, etc.	Engineering Estimate
Equipment and Temporary Utilities	Lump Sum	1	$2,000	$2,000			Engineering Estimate
					$17,000		
Subtotal Capital Cost					$224,775		
Engineering @ 10%				$22,478			
Contingencies @ 20%				$44,955			
Pilot Studies @ 5%				$11,239			
Total Capital Costs					$303,446		

TABLE C-2 (continued)
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 3
COLLECTION/TREATMENT/DISCHARGE TO STP

O & M COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Groundwater Monitoring - Years 1 - 2						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	60	$375	$22,500		15 samples; quarterly	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
					$57,100		
Groundwater Monitoring - Years 3 - 5						15 wells sampled semiannually.	
Labor	Hours	180	$35	$6,300		15 wells x 2 samplers x 3 hrs/well x 2 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
					$28,550		
Groundwater Monitoring Years 6 - 30						15 wells sampled annually.	
Labor	Hours	90	$35	$3,150		15 wells x 2 samplers x 3 hrs/well x 1 event	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; annually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$2,500	$2,500		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	1	$3,000	$3,000		1 report per sampling event	Engineering estimate
					$14,275		
System Operation and Maintenance							
Electricity	Per Year	1	$12,000	$12,000		Pretreatment, treatment, building	Engineering estimate
Materials	Per Year	1	$12,000	$12,000		Chemicals, polymer, etc.	Engineering estimate
Material Handling	Per Year	1	$25,000	$25,000		Spent carbon, sludge disposal	Engineering estimate
Operating Labor	Per Year	1	$15,000	$15,000		Approx. 2 hours/day @ $30.00/hr	Engineering estimate
Maintenance Labor	Per Year	1	$4,300	$4,300		Approx. 12 hours/month @ $30.00/hr	Engineering estimate
Administration	Per Year	1	$5,000	$5,000		Approx. 12 hours/month @ $35.00/hr	Engineering estimate
					$73,300		
Effluent Sampling							
Labor	Hours	96	$35	$3,360		8 hours/month	Engineering Estimate
Laboratory Analysis - TCL VOA	Sample	56	$375	$21,000		Samples: 1/week + 1/quarter	Engineering Estimate
Reporting	Per Quarter	4	$2,000	$8,000		Lab reports, etc (1 report/quarter)	Engineering Estimate
					$32,360		
Total Annual O&M Costs, Years 1 - 2					$162,760	For years 1 and 2	
Total Annual O&M Costs, Years 3 - 5					$134,210	For years 3 through 5	
Total Annual O&M Costs, Years 6 - 30					$119,935	For years 6 through 30	
Approximate Present Worth Value					$1,890,000		

TABLE C-3 CTO-0174
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 4
COLLECTION/DISCHARGE TO STP

CAPITAL COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump Sum	1	$5,000	$5,000			Engineering Estimate
Miscellaneous	Lump Sum	1	$10,000	$10,000		Utilities hook-up, site preparation	Engineering Estimate
					$15,000		
Groundwater Extraction System							
Driller Mobilization	Lump Sum	1	$3,000	$3,000			Basic Ordering Agreement
Extraction Well - Shallow (3)	Per Foot	105	$450	$47,250		6" stainless steel, 35 ' deep	Engineering Estimate
Well Development	Per Well	3	$375	$1,125			Engineering Estimate
Extraction Pumps	Per Pump	3	$9,500	$28,500			Vendor Quote
Piping From Wells	Per Foot	300	$15	$4,500		HDPE pipe, PVC casing, w/trench	Basic Ordering Agreement
Equipment Building	Lump Sum	1	$15,000	$15,000		8 ft. by 16 ft.	Engineering Estimate
					$99,375		
Discharge of Groundwater							
Surface Infastructure	Lump Sum	1	$5,000	$5,000		Site power, conduits, piping	Engineering Estimate
Effluent Pump	Lump Sum	1	$4,600	$4,600		Package duplex pump station	Engineering Estimate
Discharge Piping	Per Foot	1500	$10	$15,000		PVC pipe, w/trench	Engineering Estimate
					$24,600		
Demobilization							
Administrative Activities	Lump Sum	1	$10,000	$10,000		Project close out doc. and reporting	Engineering Estimate
Site Restoration	Lump Sum	1	$5,000	$5,000		General site cleanup, revegetation, etc.	Engineering Estimate
Equipment and Temporary Utilities	Lump Sum	1	$2,000	$2,000			Engineering Estimate
					$17,000		
Subtotal Capital Cost					$155,975		
Engineering @ 10%				$15,598			
Contingencies @ 20%				$31,195			
Pilot Studies @ 5%				$7,799			
Total Capital Costs					$210,566		

TABLE C-3 (continued)
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 4
COLLECTION/DISCHARGE TO STP

O & M COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Groundwater Monitoring - Years 1 - 2						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	60	$375	$22,500		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
					$57,100		
Groundwater Monitoring Years 3 - 5						15 wells sampled semiannually.	
Labor	Hours	180	$35	$6,300		15 wells x 2 samplers x 3 hrs/well x 2 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
					$28,550		
Groundwater Monitoring Years 6 - 30						15 wells sampled annually.	
Labor	Hours	90	$35	$3,150		15 wells x 2 samplers x 3 hrs/well x 1 event	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$2,500	$2,500		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	1	$3,000	$3,000		1 report per sampling event	Engineering estimate
					$14,275		
System Operation and Maintenance							
Electricity	Per Year	1	$6,000	$6,000		Air compressors and pumping equip.	Engineering estimate
Operating Labor	Per Year	1	$3,600	$3,600		Approx. 10 hours/month @ $30.00/hr	Engineering estimate
Maintenance Labor	Per Year	1	$2,160	$2,160		Approx. 6 hours/month @ $30.00/hr	Engineering estimate
Administration	Per Year	1	$5,000	$5,000		Approx. 12 hours/month @ $35.00/hr	Engineering estimate
					$16,760		
Effluent Sampling							
Labor	Hours	96	$35	$3,360		8 hours/month	Engineering Estimate
Laboratory Analysis - TCL VOA	Sample	56	$375	$21,000		Samples: 1/week + 1/quarter	Engineering Estimate
Reporting	Per Quarter	4	$2,000	$8,000		Lab reports, etc (1 report/quarter)	Engineering Estimate
					$32,360		
Total Annual O&M Costs, Years 1 - 2					$106,220	For years 1 and 2	
Total Annual O&M Costs, Years 3 - 5					$77,670	For years 3 through 5	
Total Annual O&M Costs, Years 6 - 30					$63,395	For years 6 through 30	
Approximate Present Worth Value					$1,300,000		

TABLE C-4 CTO-0174
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 5
COLLECTION/DISCHARGE TO SITE 82 (O U NO. 2)

CAPITAL COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump Sum	1	$5,000	$5,000			Engineering Estimate
Miscellaneous	Lump Sum	1	$10,000	$10,000		Utilities hook-up, site preparation	Engineering Estimate
					$15,000		
Groundwater Extraction System							
Driller Mobilization	Lump Sum	1	$3,000	$3,000			Basic Ordering Agreement
Extraction Well - Shallow (3)	Per Foot	105	$450	$47,250		6" stainless steel, 35 ' deep	Engineering Estimate
Well Development	Per Well	3	$375	$1,125			Engineering Estimate
Extraction Pumps	Per Pump	3	$9,500	$28,500			Engineering Estimate
Piping From Wells	Per Foot	300	$15	$4,500		Stainless steel pipe w/tench	Basic Ordering Agreement
Equipment Building	Lump Sum	1	$15,000	$15,000		8 ft. by 16 ft.	Engineering Estimate
					$99,375		
Discharge of Groundwater							
Surface Infastructure	Lump Sum	1	$5,000	$5,000		Site power, conduits, piping	Engineering Estimate
Effluent Pump	Lump Sum	1	$4,600	$4,600		Package duplex pump station	Engineering Estimate
Discharge Piping	Per Foot	9800	$10	$98,000		PVC pipe, w/trench	Engineering Estimate
					$107,600		
Demobilization							
Administrative Activities	Lump Sum	1	$10,000	$10,000		Project close out doc. and reporting	Engineering Estimate
Site Restoration	Lump Sum	1	$5,000	$5,000		General site cleanup, revegetation, etc.	Engineering Estimate
Equipment and Temporary Utilities	Lump Sum	1	$2,000	$2,000			Engineering Estimate
					$17,000		
Subtotal Capital Cost					$238,975		
Engineering @ 10%				$23,898			
Contingencies @ 20%				$47,795			
Pilot Studies @ 5%				$11,949			
Total Capital Costs					$322,616		

TABLE C-4 (continued)
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 5
COLLECTION/DISCHARGE TO SITE 82 (O U NO. 2)

O & M COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Groundwater Monitoring - Years 1 - 2						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	60	$375	$22,500		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
					$57,100		
Groundwater Monitoring Years 3 - 5						15 wells sampled semiannually.	
Labor	Hours	180	$35	$6,300		2 samplers; 3 hrs/well average	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
					$28,550		
Groundwater Monitoring Years 6 - 30						15 wells sampled annually.	
Labor	Hours	90	$35	$3,150		2 samplers; 3 hrs/well average	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; annually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$2,500	$2,500		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	1	$3,000	$3,000		1 report per sampling event	Engineering estimate
					$14,275		
System Operation and Maintenance							
Electricity	Per Year	1	$8,000	$8,000		Air compressors and pumping equip.	Engineering estimate
Operating Labor	Per Year	1	$3,600	$3,600		Approx. 10 hours/month @ $30.00/hr	Engineering estimate
Maintenance Labor	Per Year	1	$2,160	$2,160		Approx. 6 hours/month @ $30.00/hr	Engineering estimate
Administration	Per Year	1	$5,000	$5,000		Approx. 12 hours/month @ $35.00/hr	Engineering estimate
					$18,760		
Effluent Sampling							
Labor	Hours	96	$35	$3,360		8 hours/month	Engineering Estimate
Lab. Analysis - TCL VOA/Metals	Sample	56	$375	$21,000		Samples: 1/week + 1/quarter	Engineering Estimate
Reporting	Per Quarter	4	$2,000	$8,000		Lab reports, etc (1 report/quarter)	Engineering Estimate
					$32,360		
Total Annual O&M Costs, Years 1 - 2					$108,220	For years 1 and 2	
Total Annual O&M Costs, Years 3 - 5					$79,670	For years 3 through 5	
Total Annual O&M Costs, Years 6 - 30					$65,395	For years 6 through 30	
Approximate Present Worth Value					$1,440,000		

TABLE C-5 CTO-0174
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 6
IN-SITU GROUNDWATER TREATMENT

CAPITAL COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Mobilization							
Equipment	Lump Sum	1	$5,000	$5,000			Engineering Estimate
Miscellaneous	Lump Sum	1	$10,000	$10,000		Utilities hook-up, site preparation	Engineering Estimate
					$15,000		
Groundwater Extraction System							
Driller Mobilization	Lump Sum	1	$3,000	$3,000			Basic Ordering Agreement
Air Sparging Well - (2)	Per well	2	$4,000	$8,000		6" PVC, 25 ' deep	Engineering Estimate
Soil Venting Well - (2)	Per well	2	$4,000	$8,000		6" PVC, 25 ' deep	Engineering Estimate
Well Development	Per Well	4	$375	$1,500			Engineering Estimate
Piping From Wells	Per Foot	300	$15	$4,500		PVC pipe w/trench	Basic Ordering Agreement
					$25,000		
Air Sparging/Soil venting							
Equipment	Lump Sum	1	$15,000	$15,000		Blowers, vacuum pumps, etc.	Engineering Estimate
Carbon Adsorption	Lump Sum	1	$10,000	$10,000		Carbon units, pumps, electric, etc.	Engineering Estimate
Treatment Building	Lump Sum	1	$15,000	$15,000		8 ft. by 16 ft.	Engineering Estimate
					$40,000		
Demobilization							
Administrative Activities	Lump Sum	1	$5,000	$5,000		Project close out doc. and reporting	Engineering Estimate
Site Restoration	Lump Sum	1	$5,000	$5,000		Gencral site cleanup, revegetation, etc.	Engineering Estimate
Equipment	Lump Sum	1	$2,000	$2,000			Engineering Estimate
					$12,000		
Subtotal Capital Cost					$92,000		
Engineering @ 10%				$9,200			
Contingencies @ 20%				$18,400			
Pilot Studies @ 5%				$4,600			
Total Capital Costs					$124,200		

TABLE C-5 (continued)
DETAIL COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 6
IN-SITU GROUNDWATER TREATMENT

O & M COST ESTIMATE 23-Jun-94

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	BASIS OR COMMENTS	SOURCE
Groundwater Monitoring - Years 1 - 2						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	60	$375	$22,500		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
					$57,100		
Groundwater Monitoring Years 3 - 5						15 wells sampled semiannually.	
Labor	Hours	180	$35	$6,300		2 samplers; 3 hrs/well average	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
					$28,550		
Groundwater Monitoring Years 6 - 30						15 wells sampled annually.	
Labor	Hours	90	$35	$3,150		2 samplers; 3 hrs/well average	Engineering estimate
Lab. Analysis - TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; annually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$2,500	$2,500		Incl. travel, lodging, supplies,- 2 people	Engineering estimate
Reporting	Sample Event	1	$3,000	$3,000		1 report per sampling event	Engineering estimate
					$14,275		
System Operation and Maintenance							
Electricity	Per Year	1	$8,000	$8,000		Blowers, vacuum pumps, etc.	Engineering estimate
Material Handling	Per Year	1	$4,500	$4,500		Spent carbon replacement	Engineering estimate
Operating Labor	Per Year	1	$3,600	$3,600		Approx. 10 hours/month @ $30.00/hr	Engineering estimate
Maintenance Labor	Per Year	1	$2,880	$2,880		Approx. 8 hours/month @ $30.00/hr	Engineering estimate
Administration	Per Year	1	$5,000	$5,000		Approx. 12 hours/month @ $35.00/hr	Engineering estimate
					$23,980		
Effluent Sampling							
Labor	Hours	96	$35	$3,360		8 hours/month	Engineering Estimate
Laboratory Analysis - TCL VOA	Sample	56	$375	$21,000		Samples: 1/week + 1/quarter	Engineering Estimate
Reporting	Per Quarter	4	$2,000	$8,000		Lab reports, etc (1 report/quarter)	Engineering Estimate
					$32,360		
Total Annual O&M Costs, Years 1 - 2					$113,440	For years 1 and 2	
Total Annual O&M Costs, Years 3 - 5					$84,890	For years 3 through 5	
Total Annual O&M Costs, Years 6 - 30					$70,615	For years 6 through 30	
Approximate Present Worth Value					$1,320,000		

Note: Present worth value calculated for 30 years. However, the in-situ system would probably operate approximately 5 years, which results in an approximate present worth value of $490,000.