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MARINE CORPS BASE CAMP LEJEUNE LONG-TERM MONITORING OPTIMIZATION CASE STUDY

August 1999

Prepared for
Department of the Navy RAO/LTM Optimization Working Group

FINAL

MARINE CORPS BASE CAMP LEJEUNE
LONG-TERM MONITORING
OPTIMIZATION CASE STUDY

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
AST	aboveground storage tank
bgl	below ground level
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Protocol
COC	contaminant of concern
DENR	North Carolina Department of Environment and Natural Resources
DNAPL	dense non-aqueous phase liquid
DON	Department of the Navy
EPA	Environmental Protection Agency
FFA	Federal Facilities Agreement
GIS	geographic information system
gpm	gallon per minute
HPIA	Hadnot Point Industrial Area
IRA	interim remedial action
IRD	Installation Restoration Division
IRP	Installation Restoration Program
LANTDIV	Atlantic Division
L/min	liter per minute
LTM	long-term monitoring
LUST	Leaking Underground Storage Tank
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MNA	monitored natural attenuation
msl	mean sea level
ND	non-detect
NFA	No Further Action
NFESC	Naval Facilities Engineering Service Center
NPL	National Priorities List

LIST OF ACRONYMS (Continued)

O&M	operation and maintenance
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
POL	petroleum, oil, and lubricants
ppm	parts per million
QA/QC	quality assurance/quality control
RBC	risk-based criteria
ROD	Record of Decision
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TAL	Total Analyte List
TBC	to-be-considered
TCA	trichloroethane
TCE	trichloroethene
TCL	Total Compound List
TI	Technical Impracticability
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
USMC	United States Marine Corps
UST	underground storage tank
UTL	upper tolerance limit
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

ES.1 Purpose of the Plan

The purpose of this case study is to evaluate the monitoring programs for six Operable Units (OUs) at Marine Corps Base (MCB) Camp Lejeune, North Carolina. Specific recommendations to streamline long-term monitoring (LTM) and avoid some of the costs associated with monitoring at the OUs are included in this case study. A discussion of site closeout strategy is also presented. In addition, best practices that have been implemented at the installation and may be incorporated into the strategy of other facilities are documented in this plan.

This case study was conducted for the Naval Facilities Engineering Service Center (NFESC) under a Broad Agency Announcement contract. NFESC is assisting a Department of the Navy working group that will develop guidance on optimizing monitoring and remedial action operations for Navy/Marine Corps activities. This working group is comprised of members from NFESC, Atlantic Division (LANTDIV), other Engineering Field Divisions/Activities, Naval Facilities Engineering Command, and Chief of Naval Operations. The working group selected six OUs at MCB Camp Lejeune for this case study. Similar case studies are also underway at two other Navy facilities. The "lessons learned" and findings from these case studies will be used to develop the guidance document

ES.2 Optimization Approach

The approach used to evaluate and optimize the LTM programs at MCB Camp Lejeune includes an assessment of five basic areas:

- The number of monitoring points;
- The duration and frequency of monitoring;
- The efficiency of current field procedures;
- The analyte list and analytical methods; and
- Reporting and data management protocols.

Section ES.6 summarizes the recommendations for each of these areas.

ES.3 LTM Program at Camp Lejeune

The LTM program at MCB Camp Lejeune currently includes six OUs. There are a total of 13 sites at these six OUs. Nine are included in the LTM program, two required no further action, and one was closed out following a removal action. Another site was removed from the LTM program following several rounds of non-detect (ND) data. By the end of calendar year 1999, it is anticipated that an additional three sites will have been eliminated from the LTM program. It is also anticipated that Records of Decision (RODs) will be put in place during 1999 for two more OUs that will be added to the LTM program.

ES.4 Best Practices Already in Place

There have been several commendable examples of program streamlining in the MCB Camp Lejeune LTM program. These include:

- Use of decision criteria to remove sites from the LTM program;
- Detailed work plans for the entire LTM program;
- Trend analysis and plume contour maps to make recommendations for program improvements;
- Inspection and abandonment of deteriorating wells;
- Semiannual or annual monitoring for the entire LTM program;

- A "team approach" with regulators and the community;
- A streamlined reporting process; and
- Electronic data handling.

ES.5 Site Strategy Considerations

In preparation for the 5-year review, scheduled for calendar year 1999, there are several site strategies to consider. These include:

- Assessing the role of natural attenuation at the LTM sites;
- Tracking cost and performance data for the pump and treat systems at OU Nos. 1 and 2; and
- Pursuing a potential technical impracticability waiver for the pump and treat system at OU No. 2.

ES.6 Recommended Optimization of LTM

Following is a summary of specific recommendations made for the LTM program at MCB Camp Lejeune, based on the optimization approach outlined in Section ES.2.

Monitoring Point Reduction— Although the LTM program for Camp Lejeune includes a reasonable number of wells at each site to achieve program objectives, there are a few wells that may be eliminated from the program without compromising quality. The elimination of five groundwater monitoring wells at OU No. 2 and two surface water and sediment sample locations at OU No. 4 from the LTM program is recommended. In addition, the current policy of regularly inspecting wells and abandoning those found to be in deteriorating condition should be continued as a way to further reduce the number of monitoring points.

Duration and Frequency Reduction—Several of the semiannual monitoring reports discuss the natural occurrence of high levels of metals in groundwater at Camp Lejeune. A small Basewide background metals study is recommended as a potential tool for decreasing the duration of monitoring at sites where metals are contaminants of concern. This strategy may not be necessary for Site 28 (OU No. 7), which may be closed out during calendar year 1999, but may be very helpful in eventually closing out Site 41 (OU No. 4).

Several of the deep wells at OU No. 2 have already been reduced to annual monitoring. Two deep wells at OU No. 1 and one at OU No. 12 may also be reduced to annual monitoring. Reducing the sampling frequency of upgradient or background wells to annual monitoring is another recommended approach for achieving frequency reduction.

Field Procedure Efficiency Improvements—Low-flow purging, or "micropurging", using the stabilization of water quality parameters as the purge criteria, is recommended. Consideration should be given to the installation of a dedicated sampling system to save labor, eliminate the need for equipment blanks, and improve sample quality.

Simplification of Analyses—The analyte list may be significantly simplified by eliminating compounds not detected in four rounds of sampling. In addition, Contract Laboratory Protocol (CLP) metals are being recommended for elimination from the OU No. 2 LTM program by the LTM contractor. A background metals study, recommended as a tool to help close metal-contaminated sites, may also help to eliminate metals from the analyte list at some sites.

Report Streamlining—Camp Lejeune has already made considerable efforts in streamlining the semiannual reporting process. Further streamlining of the reporting effort by decreasing text discussion and consolidating graphic and tabular data is recommended.

Data Analysis—There are currently plans to incorporate the electronic data from the LTM program into the active Geographic Information System (GIS) application for Camp Lejeune. The Base should complete this task as soon as possible so that spatial and other data analysis tools are available for LTM and site closeout decision making. In addition, having a GIS application for the LTM program will significantly improve the quality of presentations to regulators and the public.

ES.7 Benefits

The benefits of applying the above recommendations include a potential annual LTM program cost savings of approximately 18% of the analytical budget, or $6000, and approximately 50% of the field labor budget, or $30,000. These figures do not include all of the possible savings, such as for reporting and data management, and it is estimated that it may take two years to recoup some recommended capital expenditures.

There are additional potential benefits of implementing the suggestions summarized above and detailed within this case study. It is anticipated that data, report, and presentation quality may be improved as a result of some of the recommended monitoring program changes.

1.0 INTRODUCTION

The following sections explain the purpose, approach, and content of this long-term monitoring (LTM) optimization case study for Marine Corps Base (MCB) Camp Lejeune.

1.1 Purpose and Objectives

The primary purpose of this case study is to assess the LTM strategy and progress for LTM sites at MCB Camp Lejeune, North Carolina. Included in this approach are recommendations to optimize any active LTM programs, along with a discussion of site closeout decisions that can be supported by LTM data. The objectives of this report are to:

- Evaluate ongoing LTM programs and make recommendations for cost savings that can be realized without a loss of quality;
- Assess the site closeout strategy and LTM decision-making process and provide recommendations that would help to optimize them; and
- Document best practices that have been implemented by the Base, and may be considered for incorporation into the strategies of other bases.

1.2 Document Organization

Section 1.3 outlines the approach that is followed to formulate optimization recommendations for the LTM program. The remainder of the document is organized as follows:

Section 2.0, **Location and Physical Setting of MCB Camp Lejeune—** This section gives the general location of the installation and the LTM OUs. A summary of the local geology, hydrology, and geography is also provided.

Section 3.0, Background Information for LTM Operable Units—This section describes the background, regulatory framework, and status of active monitoring at the six Operable Units (OUs) included in this study. Best practices that have already been implemented for this program are also presented.

Section 4.0, Recommended Optimization of Monitoring Systems— On the basis of site information, site strategy, and LTM optimization recommendations are provided in this section.

Section 5.0, Evaluation of Optimization— This section gives an estimate of potential cost avoidance and effects on data quality.

Section 6.0, References—This section provides a list of the documents cited in the report.

1.3 Optimization Approach

This case study focuses on ways to reduce the resources expended on OUs with ongoing monitoring of groundwater, without compromising program quality. Six Camp Lejeune OUs with active monitoring were evaluated for this case study: OU Nos. 1, 2, 4, 5, 7, and 12.

There are five general optimization strategies that may be used to increase cost effectiveness of LTM programs. They include:

- Reducing the number of monitoring points;
- Assuring efficient field procedures;
- Reducing monitoring duration and/or frequency;
- Simplifying analytical protocols; and
- Streamlining data management and reporting.

Figure 1-1 shows a graphic representation of the above process. In addition, Table 1-1 includes more detailed rationale for each of these strategies as they apply to MCB Camp Lejeune's LTM program.

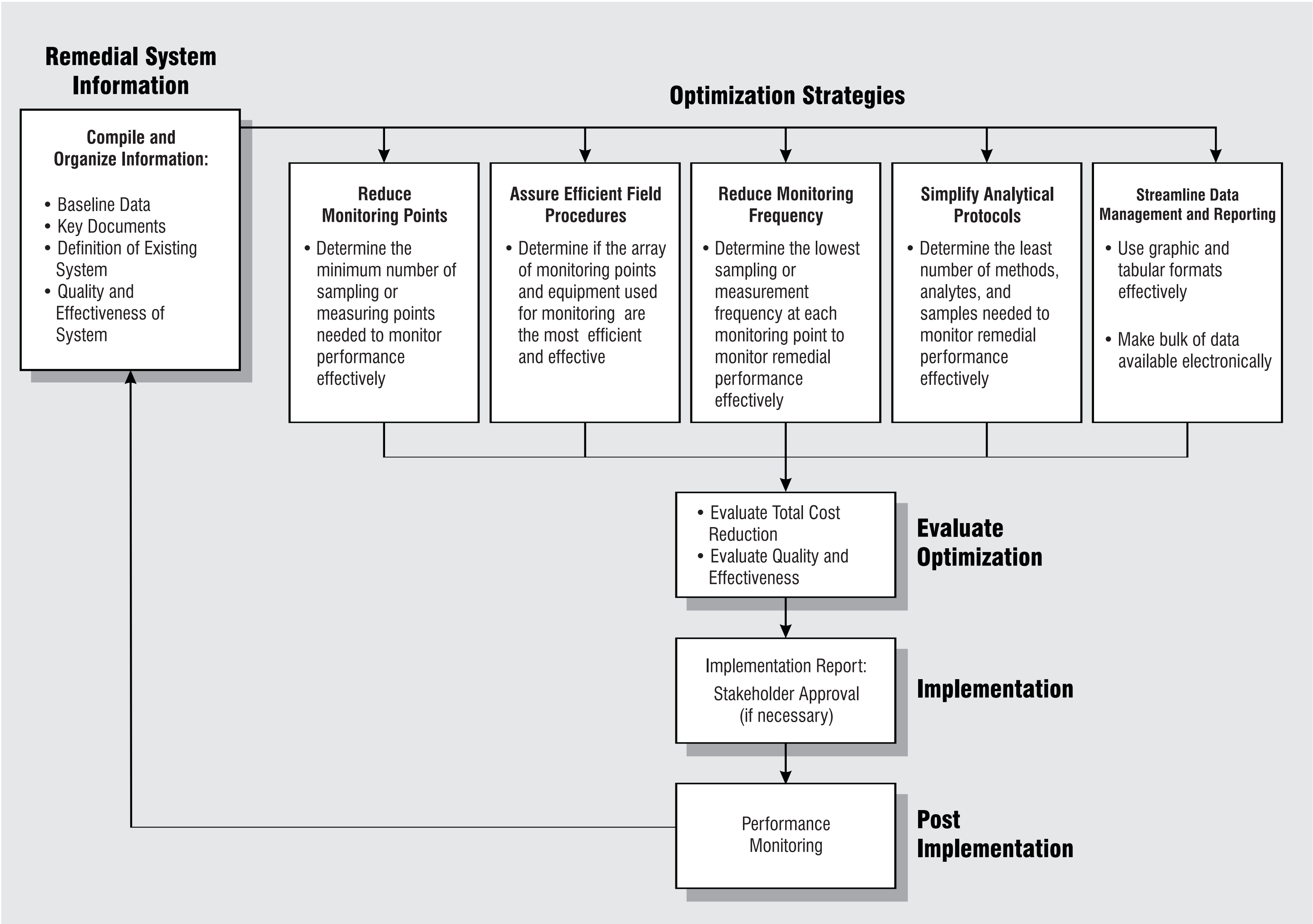


Figure 1-1. LTM Program Optimization Process

Table 1-1
Application of the LTM Program Optimization Strategies to Camp Lejeune

Optimization Strategy	Example Data for Camp Lejeune	Example Optimization Rationale
Reduce the number of monitoring points	Constituent concentrations collected at a specific monitoring point (e.g., contaminant concentrations in a particular groundwater monitoring well).	• If points were not sampled, the same decisions about contaminant extent or remedial performance can be made with data from other points in the monitoring system. • The contamination has been drawn away from the monitoring point by the remedial action. • Concentrations obtained at other monitoring points are more representative and reliable than at this monitoring point. • The potential for lateral or vertical migration to this monitoring point has been eliminated or decreased; therefore, monitoring the point is unnecessary. • Concentrations at this monitoring point have reached and consistently remained below the cleanup goal; continued sampling is not necessary. • The concentrations obtained from this point have historically been redundant with adjacent points (i.e., identical or similar results).
	Nonchemical data measured at a monitoring point (e.g., water level measurements).	• The measurements from this location have stabilized (leveled off in four or five most recent events); therefore, additional measurements from the point are unnecessary. • Measurements obtained from this point have historically been redundant with adjacent points. • The same decision about contaminant extent or remedial performance could have been made with data from the remaining monitoring points if this point was not measured.
	Sampling or measuring point depth	• Sampling or measurements are no longer required at a specific depth because vertical migration is observed not to be occurring or cleanup at that particular depth is complete.
Reduce measurement frequency	Contaminant concentrations in samples	• The data collected from one season, or one time of day, are more representative of conditions than other times; therefore, sample/measure at the most representative time only. • Concentrations or measurements have stabilized or reached an asymptotic level; changes can be monitored with sampling at a lesser frequency.
	Velocity of contaminant migration in soil gas or percolating water (from permeability and gradient data)	• The monitoring frequency can be decreased such that time between sample collections is more than the minimum time interval necessary for the contaminant to migrate between monitoring points.

Table 1-1
(Continued)

Optimization Strategy	Example Data for Camp Lejeune	Example Optimization Rationale
Simplify analytical protocols	Constituent concentration data collected at a particular monitoring point	• Sampling for methods currently being performed can be deleted if the method is not needed to demonstrate cleanup progress, remedial performance, or natural attenuation. • The total time interval of sampling for undetected, "potential" analytes should be limited; delete analyses for potential contaminants if they have not been detected in the first year of samples (not to include degradation products). • Analyses should be performed only with the method(s) appropriate for indicator compounds or elements that are most indicative of contaminant extent.
	Historical quality control assessments	• Precision, accuracy, representativeness, and completeness of methods have been historically demonstrated; QC sampling and analyses can be reduced with no loss of quality.
Ensure efficient field procedures	Data acquisition methods	• Measuring points that are not open (for example, screened) at the proper depth or horizontal location to provide accurate measurements should be not be monitored. • Purging and sampling methods should be the most cost effective methods available without compromising sample quality. • An automated recording device/data logger/telephonic transmitter may be added to critical locations to improve the timing of measurements and save labor costs over the time interval of monitoring.

2.0 LOCATION AND PHYSICAL SETTING OF MCB CAMP LEJEUNE

MCB Camp Lejeune is a 236-square mile (153,439-acre) training base for the United States Marine Corps (USMC). The installation is located in Onslow County, North Carolina, and has 14 miles of coastline on the Atlantic Ocean.

2.1 Location of MCB Camp Lejeune and Case Study Operable Units

An inset to Figure 2-1 shows the general location of the Base. There are six OUs that are undergoing active monitoring at MCB Camp Lejeune. These are:

- OU No. 1 (Sites 21, 24, and 78);
- OU No. 2 (Sites 6, 9, and 82);
- OU No. 4 (Sites 41 and 74);
- OU No. 5 (Site 2);
- OU No. 7 (Sites 1, 28, and 30); and
- OU No. 12 (Site 3).

The locations of these OUs at MCB Camp Lejeune are shown in Figure 2-1. A description and background for each of the OUs is provided in Section 3.0.

2.2 Physical Setting

This section describes the geology, hydrogeology, and geography at MCB Camp Lejeune. The information in this section is summarized from the *Basewide Remediation Assessment Groundwater Study* (Baker Environmental, April 1998).

2.2.1 Geology

MCB Camp Lejeune is located in the Atlantic Coastal Plain geologic province. The Atlantic Coastal Plain consists of unconsolidated sediments ranging in size from clay to gravel. These sediments were eroded from the Appalachian and Piedmont geologic provinces to the west. They were transported by fluvial processes and deposited in alluvial fans and as tidal marine muds during advance and retreat of the ocean. These sediments overlie the Precambrian igneous and metamorphic bedrock in this area.

2.2.2 Hydrogeology

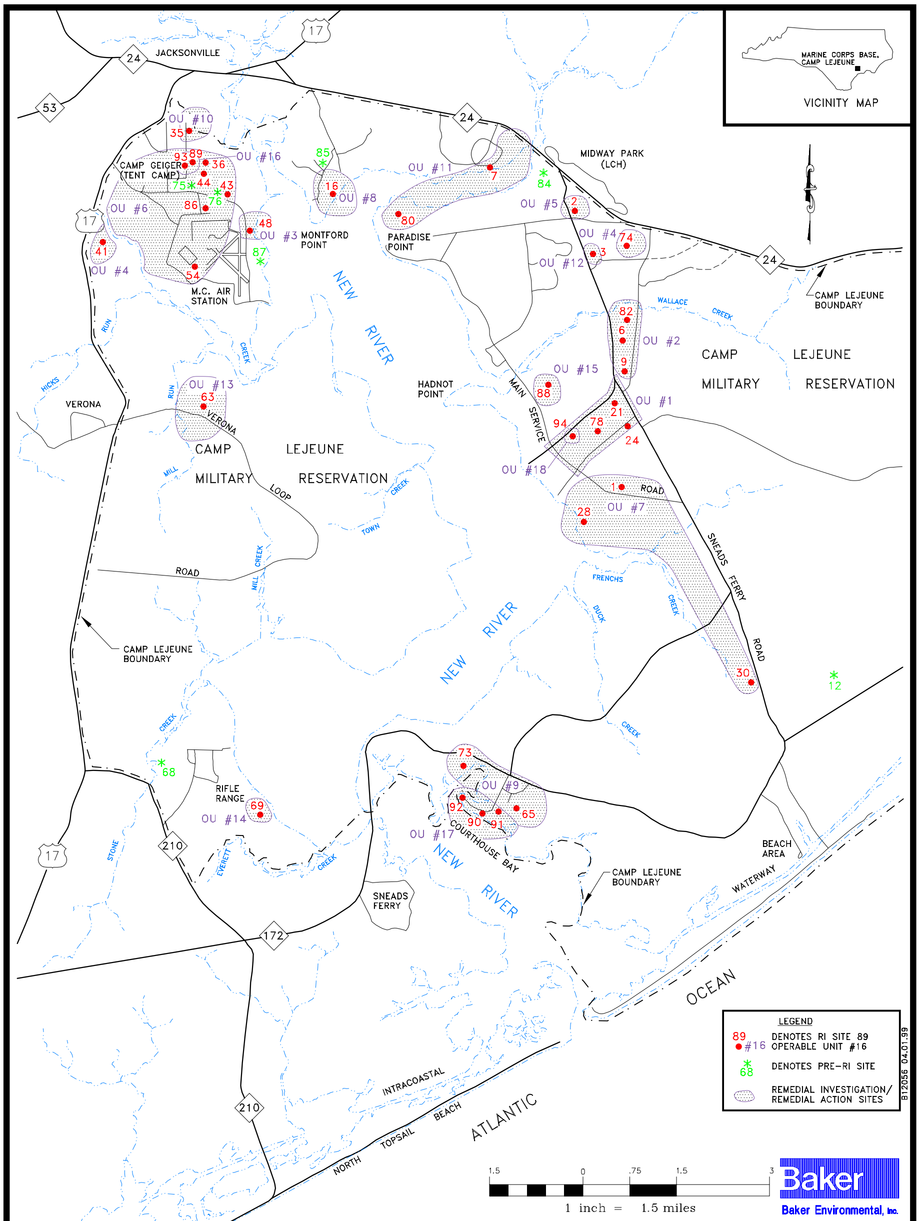
Surface water—The majority of MCB Camp Lejeune drains into the New River, which bisects the Base. In the vicinity of Camp Lejeune, the New River flows to the south, through a wide estuary, and into the Atlantic Ocean via the New River Inlet. Several other small coastal creeks also drain parts of Camp Lejeune. These drain into the Intercoastal Waterway and eventually into the Atlantic Ocean via a series of inlets.

Groundwater—An unnamed surficial unit is the shallowest water-bearing formation underlying Camp Lejeune. The thickness of the surficial aquifer ranges from 0 to 73 feet. The next water-bearing unit is the Castle Hayne Aquifer, which consists primarily of fine sand, shell, and limestone. The Castle Hayne confining unit, composed of clay and sandy clay, separates the Castle Hayne aquifer from the surficial unit. In the area of Camp Lejeune, the confining unit averages 9 feet thick, except near the New River and some of its larger tributaries where there is full communication between the surficial unit and the Castle Hayne Aquifer. The Castle Hayne aquifer averages approximately 350 feet thick. The conceptual model of these aquifers is shown in Figure 2-2.

There are five more aquifers that underlie Camp Lejeune. These are the Beaufort, the Peedee, the Black Creek, and the Upper and Lower Cape Fear aquifers. All of these aquifers are over 400 feet deep and are isolated from the shallower units by the Beaufort confining layer

Groundwater monitoring and aquifer testing studies at MCB Camp Lejeune have focused on the surficial unit and the Castle Hayne aquifer. This is because

Figure 2-1. General Location Map of Operable Units at MCB Camp Lejeune.



OPERABLE UNIT AND SITE LOCATION MAP

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

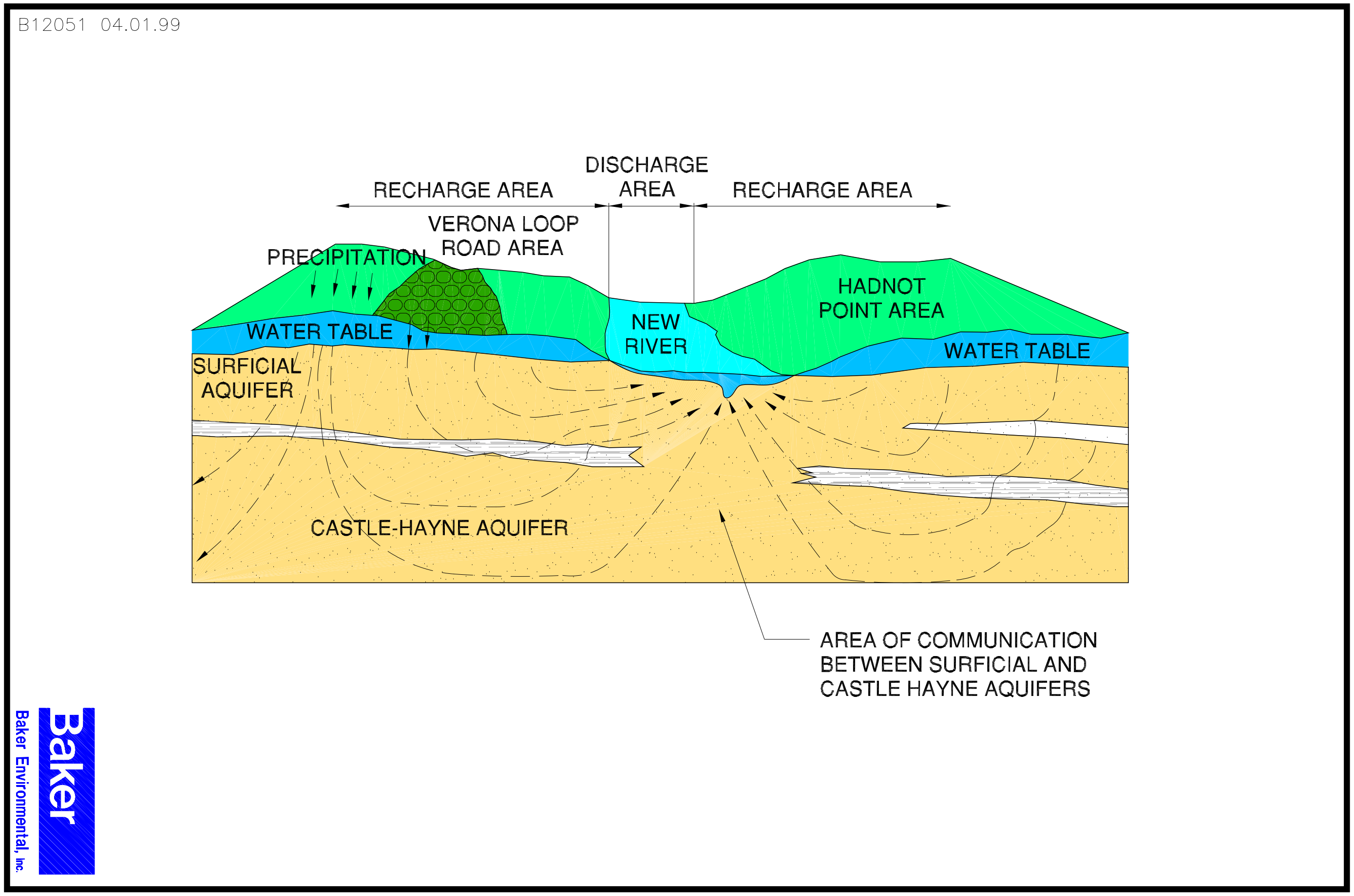


Figure 2-2. Conceptual Model of Shallow Aquifers at MCB Camp Lejeune.

contamination from installation activities is limited to these two water-bearing units and is prevented from migration to deeper aquifers by the Beaufort confining layer. In addition, the Castle Hayne Aquifer is used for domestic water supply at MCB Camp Lejeune.

Groundwater discharge areas on Camp Lejeune include the New River, its tributaries, and other surface water bodies such as wetlands and streams.

2.2.3 Geography

Construction of MCB Camp Lejeune was initiated in 1941. Today, more than 40,000 military, civilian, and contract personnel work at Camp Lejeune. The nearest community to the installation is the City of Jacksonville, North Carolina, with a population of approximately 75,000.

Land use around MCB Camp Lejeune includes residential, park, industrial, and commercial properties. On Base, natural areas such as wetlands and wooded areas are interspersed with developed land that houses administrative and mission related buildings and airfield facilities. It is not anticipated that land use, either on- or off-Base, will change significantly in the foreseeable future.

3.0 BACKGROUND INFORMATION FOR LTM OPERABLE UNITS

The following sections describe the MCB Camp Lejeune OUs and sites that are currently undergoing monitoring. Site activity status, regulatory framework, and best practice information is also provided here. Tables 3-1, 3-2, and 3-3 summarize the information for each site. This information is taken primarily from the record of decision (ROD) for each OU.

3.1 Operable Unit Background Information

MCB Camp Lejeune was put on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) in October 1989. Following this, the Department of the Navy (DON), the U.S. Environmental Protection Agency (EPA) Region IV, and the North Carolina Department of Environment and Natural Resources (DENR) entered into a Federal Facilities Agreement (FFA) to ensure that all releases at the installation were properly investigated and treated as necessary to protect public health, welfare, and the environment (Baker Environmental, April 1998).

A total of 42 Installation Restoration Program (IRP) sites and 135 underground storage tank (UST) sites have been identified at Camp Lejeune. The UST sites are under the Petroleum, Oil, and Lubricants (POL) Leaking Underground Storage Tank (LUST) program. This program falls under the responsibility of the Installation Restoration Division (IRD). Approximately 28 of the 42 IRP sites are currently undergoing or have been proposed for groundwater remediation. All of the OUs evaluated in this case study have RODs in place, and many have active remediation in progress. A 5-year review of the LTM program at Camp Lejeune will take place in mid-1999. The following subsections provide descriptions, regulatory information, and site activity status for each of the OUs discussed in this document.

3.1.1 OU No. 1 (Sites 21, 24, and 78)

Description—OU No. 1 occupies approximately 690 acres, one mile east of the New River. It consists of Site 21, Transformer Storage Lot 140; Site 24, Industrial Fly Ash Dump; and Site 78, Hadnot Point Industrial Area (HPIA).

Site 21 has had a history of pesticide usage and reported transformer oil disposal (Baker Environmental, September 1994a). This site includes the Former Pesticide Mixing/Disposal Area, located in the southern portion of the site. It is thought that approximately 350 gallons of pesticide mixing equipment wash water was discharged to the ground surface each week in 1977. Although this site was active from 1958 to 1977, it is not known how long the washing activities took place.

The Former Transformer Oil Disposal Pit is also located at Site 21, in the northeastern part of the site. This area was reportedly used to dispose of transformer oil from 1950 to 1951. The total quantity of transformer oil disposed in this area is unknown.

Site 24 was used for the disposal of fly ash, cinders, solvents, spent paint stripper, sewage sludge, and water treatment sludge from the late 1940s until 1980 (Baker Environmental, September 1994a). As a result of disposal activities at this site, there are five main areas of concern: the Spiractor Sludge Disposal Area, the Fly Ash Disposal Area, the Borrow and Debris Disposal Area, and two Buried Metal Areas.

Site 78, the HPIA, was the first area developed at MCB Camp Lejeune. The source of contamination at this site is the various industrial shops, gas stations, storage yards, USTs, etc.

Table 3-1. Summary of OU and Site Information for MCB Camp Lejeune

Operable Unit	Site	Description	Years of Operation	Contaminated Media	Contaminants of Concern
OU No. 1	21	Transformer Storage Lot 140	1958 to 1977	Soil	Pesticides and PCBs
	24	Industrial Fly Ash Dump	1940s to 1980	Groundwater and soil	Groundwater: metals and heptachlor epoxide Soils: pesticides and metals
	78	Hadnot Point Industrial Area	1940s to present	Groundwater and soil	Groundwater: VOCs (BTEX and chlorinated solvents) and metals Soils: pesticides and SVOCs
OU No. 2	6	Open Storage Lot 201 and Open Storage Lot 203	1940s to 1980s	Groundwater and soil	Groundwater: VOCs Soils: pesticides, PCBs, VOCs, SVOCs, and metals
	9	Fire Fighting Training Pit at Piney Green Road	1960s to present	NA	NA
	82	Piney Green VOC Site	Unknown	Groundwater and soil	Groundwater: VOCs Soils: pesticides, PCBs, VOCs, SVOCs, and metals
OU No. 4	41	Camp Geiger Dump Near the Former Trailer Park	1946 to 1970	Groundwater, surface water, and sediment	Groundwater: VOCs, pesticides, phenols, metals, explosives Surface water: phenols, pesticides Sediments: phenols, metals
	74	Mess Hall Grease Pit Disposal Area	1950s and 1960s	Groundwater and soil	Groundwater: pesticides (DDE and DDT) Soils: pesticides (DDD, DDE, and DDT)
OU No. 5	2	Building 712 (Lawn Area and Mixing Pad Area) and Former Storage Area	1945 to 1958	Groundwater, sediment, and soil	Groundwater: VOCs (BTEX) Sediments: pesticides, SVOCs Soils: pesticides, SVOCs
OU No. 7	1	French Creek Liquids Disposal Area	1940s to present	Groundwater and soil	Groundwater: VOCs (TCE), SVOCs, metals Soils: pesticides, PCBs, VOCs, SVOCs
	28	Hadnot Point Burn Dump	1946 to 1971	Groundwater, surface water, sediment, and soil	Groundwater: VOCs, SVOCs, pesticides, metals Surface water: metals Sediments: metals, pesticides Soils: pesticides, PCBs, VOCs, SVOCs, and metals
	30	Sneads Ferry Road Fuel Tank Sludge Area	Unknown	Groundwater, surface water, sediment, and soil	Groundwater: metals Surface water: lead and mercury Sediments: bis(2-Ethylhexyl)phthalate Soils: 1,1,1,-TCA, chromium
OU No. 12	3	Old Creosote Plant	1951 to 1952	Groundwater and soil	Groundwater: PAHs, BTEX Soils: PAHs, BTEX

BTEX = Benzene, toluene, ethylbenzene, and xylenes.
NFA = No further action.
OU = Operable Unit.
PAHs = Polyaromatic hydrocarbons.
PCBs = Polychlorinated biphenyls.
SVOC = Semivolatile organic compound.
TCA = Trichloroethane.
VOC = Volatile organic compound.

Table 3-2. Summary of MCB Camp Lejeune LTM Regulatory Framework

Operable Unit	Date of ROD	Site	Remedy Components	Cleanup Criteria for Active Systems	Criteria to Stop Monitoring
OU No. 1	September 1994	21	• Excavate approximately 1050 cubic yards of soil contaminated with PCBs and pesticides for off-site disposal.	Groundwater: Federal MCLs, State groundwater standards, risk-based levels Soil: EPA Region III RBCs (See Appendix A)	Three rounds of non-detect (ND) data or risk-based levels if contaminant concentrations at the site approach action levels but do not further decrease.
		24	• Restrict the use of nearby water supply and restrict the installation of new water supply wells within the OU. • Implement an LTM program.		
		78	• Pump and treat contaminated groundwater from extraction wells installed within the plumes at Site 78. • Restrict the use of nearby water supply and restrict the installation of new water supply wells within the OU. • Implement an LTM program.		
OU No. 2	September 1993	6 and 82	• Pump and treat contaminated groundwater from the deep and shallow portions of the aquifer. • Restrict the use of nearby water supply wells and restrict the installation of new water supply wells within the OU. • Implement an LTM program. • Implement in situ treatment via volatilization or vapor extraction of approximately 16,500 cubic yards of VOC contaminated soil. • Excavate approximately 2500 cubic yards of soil contaminated with PCBs and pesticides for off-site disposal.	Groundwater: Federal MCLs, State groundwater standards, risk-based levels Soil: Toxic Substances Control Act (TSCA) nonresidential guidance (PCBs), risk based action levels (See Appendix A)	Three rounds of ND data or risk-based levels if contaminant concentrations at the site approach action levels but do not further decrease.
		9	• No further action.		
OU No. 4	June 1995	41	• Designate site as restricted in the Base Master Plan and prohibit invasive construction or residential use. • Restrict groundwater usage and prohibit installation of any new water supply wells within 500 ft of the site boundaries. • Implement a groundwater, surface water, and sediment monitoring program.	NA	Three rounds of ND data or risk-based levels if contaminant concentrations at the site approach action levels but do not further decrease.
		74	• Designate site as restricted in the Base Master Plan and prohibit invasive construction or residential use. • Restrict groundwater usage and prohibit installation of any new water supply wells within 500 ft of the site boundaries. • Implement a groundwater monitoring program.		

Table 3-2 (Continued)

Operable Unit	Date of ROD	Site	Remedy Components	Cleanup Criteria for Active Systems	Criteria to Stop Monitoring
OU No. 5	September 1994	2	• Restrict the installation of new potable water supply wells within the vicinity of Site 2. • Implement LTM program for groundwater quality.	NA	Three rounds of ND data or risk-based levels if contaminant concentrations at the site approach action levels but do not further decrease.
OU No. 7	December 1995	1	• Implement semiannual groundwater monitoring for VOCs. • Restrict aquifer use as a potable water source, via the Base Master Plan. • Implement deed restrictions that will limit the future use of land at the site.	NA	Three rounds of ND data or risk-based levels if contaminant concentrations at the site approach action levels but do not further decrease.
		28	• Implement semiannual groundwater monitoring for VOCs, lead, and manganese. • Restrict aquifer use as a potable water source, via the Base Master Plan. • Implement deed restrictions that will limit the future use of land at the site.		
		30	• NFA		
OU No. 12	January 1997	3	• Excavate soils in the area of concern to a depth of 9 ft below ground level (bgl) or just above the water table. • Treat soils using aerobic solid-phase biological treatment in a biocell. • Implement land use restrictions that will limit future land development at the site until soil remediation has been completed. • Sample groundwater from seven site monitoring wells on a quarterly basis for TCL VOCs, and SVOCs. • Implement aquifer use restrictions to prohibit future use of aquifers within a 1000 ft radius of Site 3.	Federal soil screening levels as TBCs.	

EPA = Environmental Protection Agency.
ND = Non-detect.
OU = Operable Unit.
RBCs = Risk-based criteria.
SVOC = Semivolatile organic compound.
TBCs = To-be-considered standards.
TCL = Target compound list.
VOC = Volatile organic compound.

Table 3-3. Summary of MCB Camp Lejeune Monitoring Status

Operable Unit	Site	Status of Monitoring	Monitored Media	Sampling Frequency: Initial/Current (or Final)	Current Number of Monitoring Points	Remedial Actions
OU No.1	21	NFA	NA	NA	NA	Soil removal action completed in 1993
	24	Begun in 1997, discontinued July 1998	Groundwater	Quarterly/ Semiannually	NA	NA
	78	Active, begun in 1997	Groundwater	Quarterly/ Semiannually	19 wells	Two active pump and treat systems
OU No. 2	6 and 82	Active, begun in 1997	Groundwater	Quarterly/ Semiannually[1]	28 wells	Pump and treat system, inactive SVE system, soil removal action completed in 1995
	9	NFA	NA	NA	NA	NA
OU No. 4	41	Active, begun in 1997	Groundwater, surface water, and sediment	Semiannually/ Semiannually	5 wells, 8 surface water, and 8 sediment locations	NA
	74	Begun in 1997, will be discontinued in 1998	Groundwater	Semiannually/ Semiannually	4 wells	NA
OU No. 5	2	Active, begun in 1996	Groundwater	Quarterly/ Semiannually	8 wells	Soil removal action completed in 1993
OU No. 7	1	Begun in 1998; expected to be discontinued in 1999	Groundwater	Semiannually/ Semiannually	8 wells	NA
	28	Begun in 1998, may be discontinued in 1999	Groundwater, surface water, and sediment	Semiannually/ Semiannually	7 wells, 3 surface water and 3 sediment locations	NA
	30	NFA	NA	NA	NA	NA
OU No. 12	3	Active, begun in 1998	Groundwater	Semiannually/ Semiannually	8 wells	Soil removal action slated for 1999

[1]Nine deep wells at OU No. 2 are monitored annually.

NA = Not applicable.
NFA = No further action.
OU = Operable Unit.

Regulatory Framework—An ROD was put in place for OU No. 1 in September 1994. This ROD specified an interim remedial action (IRA) of pumping and treating for two plumes located at Site 78.

The final remedy for the site is listed in Table 3-2. The ROD states that the selected remedy will be operated until the remediation levels for soil and groundwater contaminants of concern (COCs) are met. Appendix A lists the specific concentrations for the COCs at OU No. 1 (Baker Environmental, September 1994a).

Activity Status—The LTM program at OU No. 1 began in 1997. The program initially called for quarterly sampling but was reduced to semiannual in July of 1997, after two rounds of data were collected. A removal action to eliminate soils contaminated with PCBs was specified in the ROD for Site 21. The removal action was conducted in 1993, and no further action is required for Site 21. Site 24 was eliminated from the LTM program in July of 1998, after several rounds of non-detects (NDs) for key site contaminants. Currently, 15 shallow wells, two intermediate-depth wells, and two deep wells are being monitored at Site 78, for a total of 19 wells. The sampling points for Site 78 are shown in Figure 3-1.

Two pump and treat systems have been operating at Site 78 since 1995. This site has two distinctive plumes, north and south, that are being treated by the systems.

3.1.2 OU No. 2 (Sites 6, 9, and 82)

Description—OU No. 2 covers an area of 210 acres and is located in the northern part of the Base, directly north of OU No. 1. OU No. 2 consists of Sites 6, 9, and 82.

Site 6 includes four main areas of concern. These are: Open Storage Lot 201, Open Storage Lot 203, the wooded area surrounding these storage lots, and a ravine. Open Storage Lot 201 is approximately 25 acres in size and is used to store military equipment, vehicles, lumber, oils and lubricants, non-PCB (polychlorinated biphenyl) transformers and other supplies. The current size of Open Storage Lot 203 is approximately 41 acres. It is no longer an active storage area, but was once reportedly used for disposing of PCBs, cleaning solvents, electrolytes from used batteries, waste oils, and other wastes. The lot still contains scrap materials and other debris. Fuel storage tanks and various drums have also been identified at this site.

The ravine and woods in the area of Lots 201 and 203 are randomly littered with drums, tires, metal scrap, and other debris.

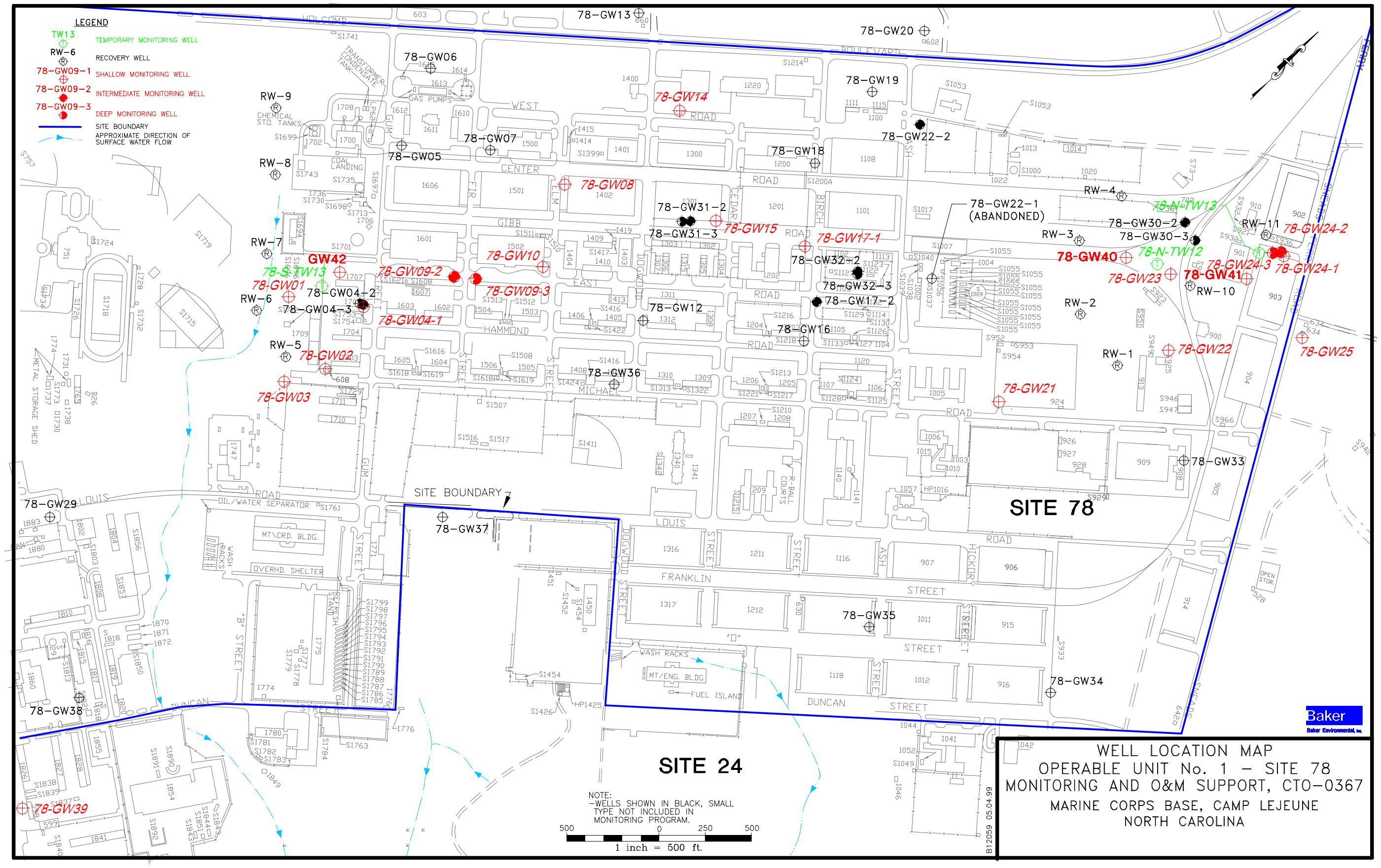
Site 9 is the Fire Fighting Training Pit at Piney Green Road. This site occupies approximately 2.6 acres, and is just south of Site 6. It consists of an asphalt-lined fire training pit, an oil/water separator, four aboveground storage tanks (ASTs), three propane tanks, and a fire tower. Two of the ASTs at the site are not used, although fire training exercises are still conducted at the site.

Site 82 is the Piney Green Road VOC (volatile organic compounds) Site. This site is approximately 30 acres in area and is located north of Site 6. This site is littered with debris such as communication wire, spent ammunition casings, and empty or rusted drums (Baker Environmental, September 1993).

Regulatory Framework—The ROD for OU No. 2 is dated September 1993. The major components of the selected remedy for OU No. 2 are listed in Table 3-2. The remediation goals for groundwater at OU No. 2 are given in Appendix A (Baker Environmental, September 1993).

Activity Status—Quarterly monitoring began at OU No. 2 in the summer of 1997, and continued until the summer of 1998. Semiannual monitoring

Figure 3-1. Sample Location Map for OU No. 1, Site 78



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has just begun, and the next round is due during the winter of 1999. A total of 28 wells, 16 deep and 12 shallow, are monitored as part of the LTM program for this OU. The monitoring network for Sites 6 and 82 is shown in Figure 3-2.

Contamination at this old material storage site consists of chlorinated solvents and metals. The chlorinated solvents have affected the deeper Castle Haynes Aquifer, whereas metal contamination is primarily in the surficial unit.

At one time, a soil vapor extraction (SVE) system operated at the site as part of the ROD remedy. Currently, a large pump and treat system (300 gallons per minute) has been operating at the site since the fall of 1996. Four deep (100 to 175 feet) and 6 shallow (20 to 70 feet) recovery wells supply the treatment system.

3.1.3 OU No. 4 (Site 74 and 41)

Description—OU No. 4 consists of Site 41, Camp Geiger Dump Near the Former Trailer Park and Site 74, the Mess Hall Grease Pit Disposal Area.

Site 41 is approximately 30 acres in area and is situated on a topographical high. From 1946 to 1970, this site was used as an open burn dump. Construction debris; petroleum, oil, and lubricant (POL) wastes; pesticides; solvents; batteries; and ordnance, possible unexploded, were disposed of at the site. Other chemicals may have also been dumped there (Baker Environmental, June 1995).

Site 74 was used to dispose of grease from the mess hall from the early 1950s to 1960. The grease may also have been ignited, using a volatile substance. Drums containing PCBs and "pesticide soaked bags" were also reported to be disposed of in the trenches at the site, which is approximately 5 acres in size. Another area at Site 74 , known as the former pest control area, is less than an acre in size and is located approximately one-quarter mile from the grease disposal area. This site once housed a building thought to be used for storing and mixing pesticides (Baker Environmental, June 1995).

Regulatory Framework—The OU No. 4 ROD was finalized in June 1995. The final remedy for Sites 41 and 74 included institutional controls for soils and landfill material and institutional controls and semiannual monitoring for groundwater and surface seeps (Site 41 only). The major components of the selected remedies for OU No. 4 are listed in Table 3-2.

The criterion for stopping monitoring at OU No. 4 is three rounds of ND data. If contaminant concentrations at a site approach action levels but do not further decrease, a risk-based approach may be used to close the site (personal communication, Mick Senus, Camp Lejeune Activities, October 13, 1998).

Activity Status—The LTM program at OU No. 4 began in 1997. Site 74 will be discontinued from the program because of several rounds of ND data, following analysis of the July 1998 data. With only Site 41 remaining in the LTM program, the number of wells monitored for this OU will be decreased from nine to five. Eight surface water and sediment samples are also collected from various ditches and natural drainage ways at the site. The sampling points for Site 41 are shown in Figure 3-3.

3.1.4 OU No. 5 (Site 2)

Description—OU No. 5 covers an area of approximately 5 acres in the northern part of the Base and contains only Site 2. There are two main areas of concern within this site: the area around Building 712 and the Former Storage Area. The area around Building 712 is further broken down into the Lawn Area and the Mixing Pad Area.

From 1945 to 1958, Building 712 was used for storing, handling, and

Figure 3-2. Sample Location Map for OU No. 2, Sites 6 and 82

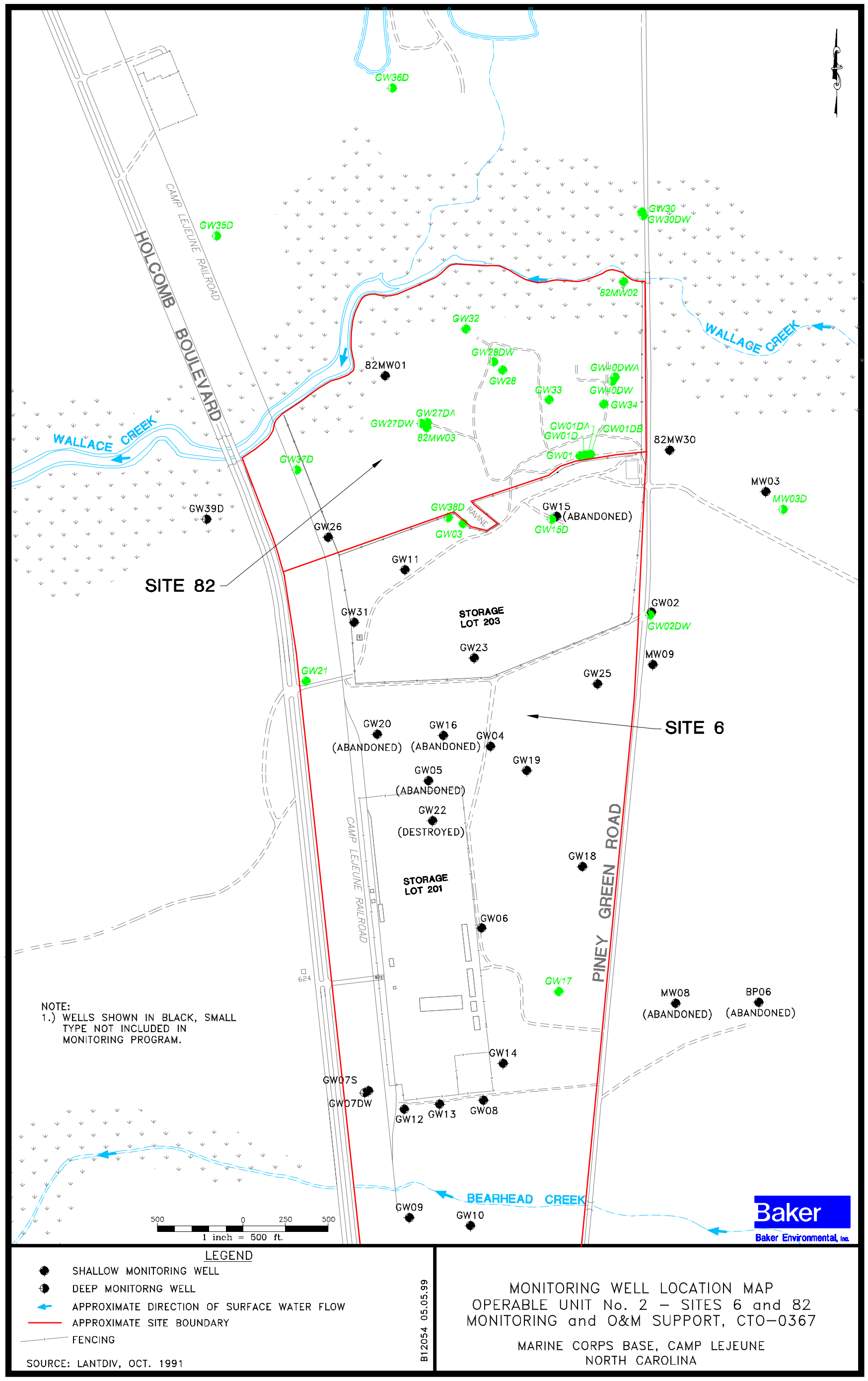
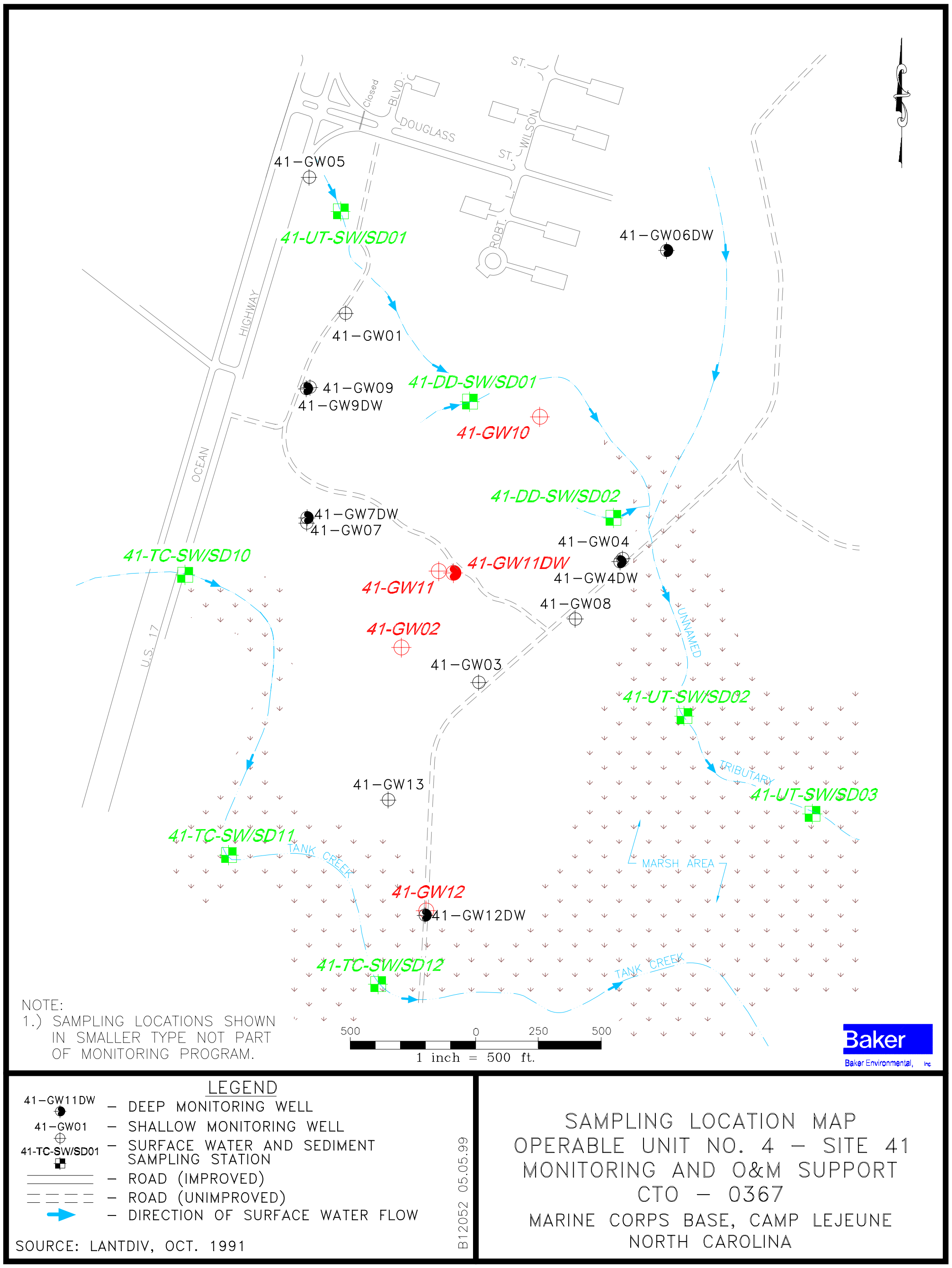


Figure 3-3. Sample Location Map for OU No. 4, Site 41



dispensing pesticides. It was later used as a children's day care center and currently houses administrative offices.

Several pesticides have been handled at the site. Contamination at the site is a result of pesticide handling, equipment washing, and disposal. The Mixing Pad Area and the railroad drainage ditch adjacent to it are two of the areas suspected of being affected by this contamination (Baker Environmental, September 1994b).

Regulatory Framework—The OU No. 5 ROD was completed in September 1994. The selected remedy components for this OU are listed in Table 3-2. The criteria for stopping monitoring at OU No. 5 are the same as described for OU No. 4.

Activity Status—A time-critical removal action was conducted at OU No. 5 in 1993, leaving only one hotspot of toluene and ethylbenzene associated with the pesticide plant. Quarterly sampling began at the OU in July 1996. Sampling was decreased to semiannual in late January 1997. Currently, seven shallow wells and one intermediate well are sampled as part of the LTM program. These monitoring points are shown in Figure 3-4.

3.1.5 OU No. 7 (Sites 1, 28, and 30)

Description—OU No. 7 is located in the eastern portion of the Base, near the New River and south of the HPIA. This OU is made up of three sites: Site 1, the French Creek Liquids Disposal Area; Site 28, the Hadnot Point Burn Dump; and Site 30, the Sneads Ferry Road Fuel Tank Sludge Area. These sites are grouped together because of their proximity and similar wastes.

Site 1 is divided into two suspected disposal areas, the northern and southern. Each of these areas is broken down into numerous potential source areas, including hazardous material storage areas, machine and maintenance shops, equipment wash areas, ASTs, and oil/water separators.

Site 28 is located near the Hadnot Point Sewage Treatment Plant and occupies approximately 23 acres. Contamination associated with the reported burn dump at this site includes metals and SVOCs. Much of the area around this site is used for recreation and physical training exercises. Picnic and playground areas, as well as a stocked fish pond, are located within the site.

Site 30 is a suspected sludge disposal area, located in the southern part of OU No. 7. The site is adjacent to training areas and artillery ranges.

Regulatory Framework—The ROD for OU No. 7, submitted in December 1995, lists the final remedies for Sites 1, 28, and 30 (Baker Environmental, December 1995). The final remedies for these sites are listed in Table 3-2. The criteria for stopping monitoring at OU No. 7 are the same as described for OU Nos. 4 and 5.

Activity Status—A semiannual groundwater LTM program was begun in July of 1998 for Sites 1 and 28. It is expected that Site 1 will be eliminated from the LTM program sometime during the 1999 calendar year. It is also likely that Site 28 can be eliminated from the program during 1999. Current sampling activities, as specified in the ROD for this OU, include collecting groundwater samples at seven shallow wells and one deep well at Site 1, and five shallow wells and two deep wells at Site 28. Sediment and surface water samples are also collected from three locations along the New River. The Site 1 sampling points are shown in Figure 3-5, and Site 28 sampling points are shown in Figure 3-6.

3.1.6 OU No. 12 (Site 3)

Description—OU No. 12 consists only of Site 3, the Old Creosote Plant. Located in the northern portion of the Base near OU Nos. 4 and 5, it occupies approximately 5 acres.

Figure 3-4. Sample Location Map for OU No. 5, Site 2

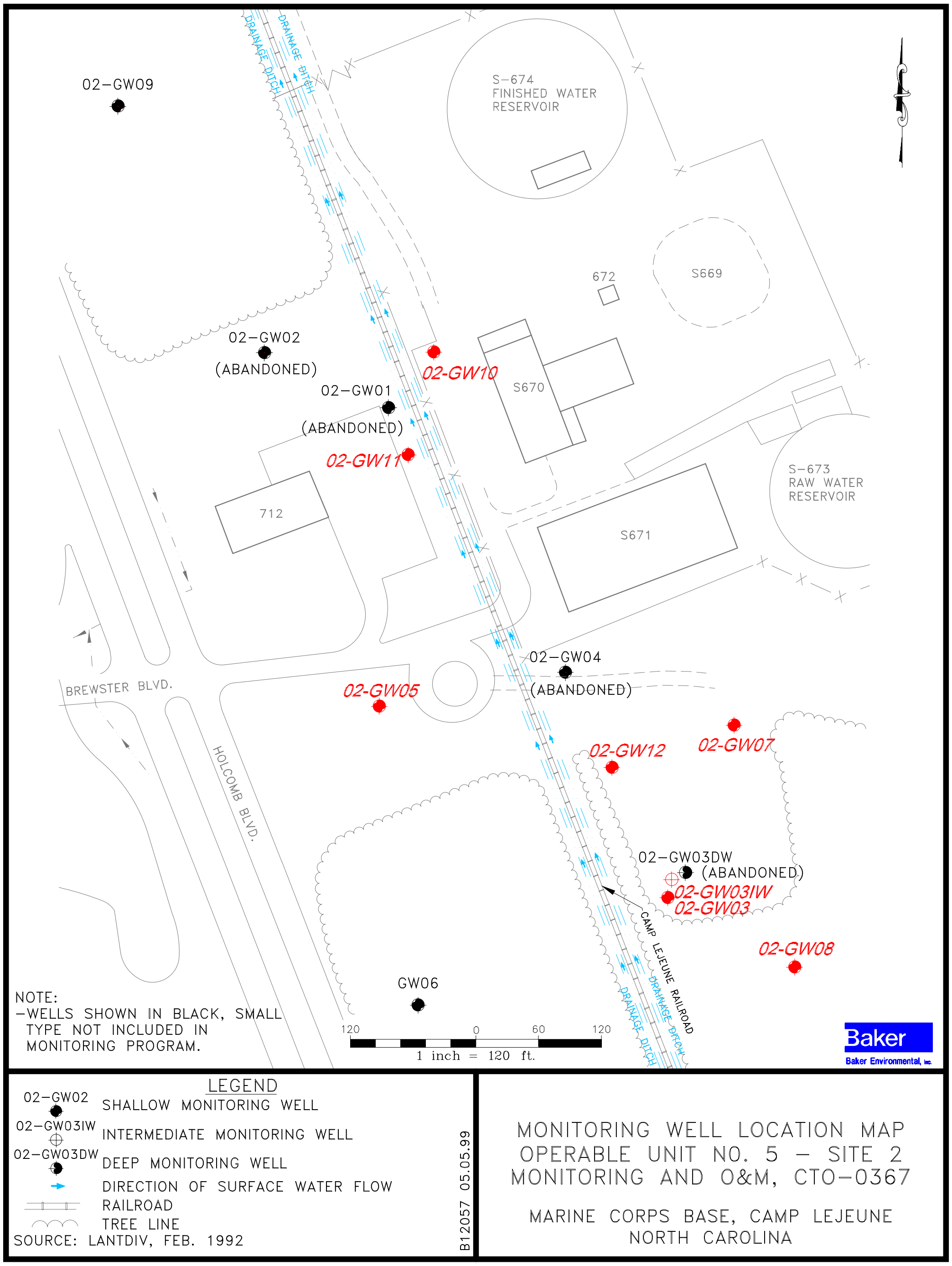


Figure 3-5. Sample Location Map for OU No. 7, Site 1

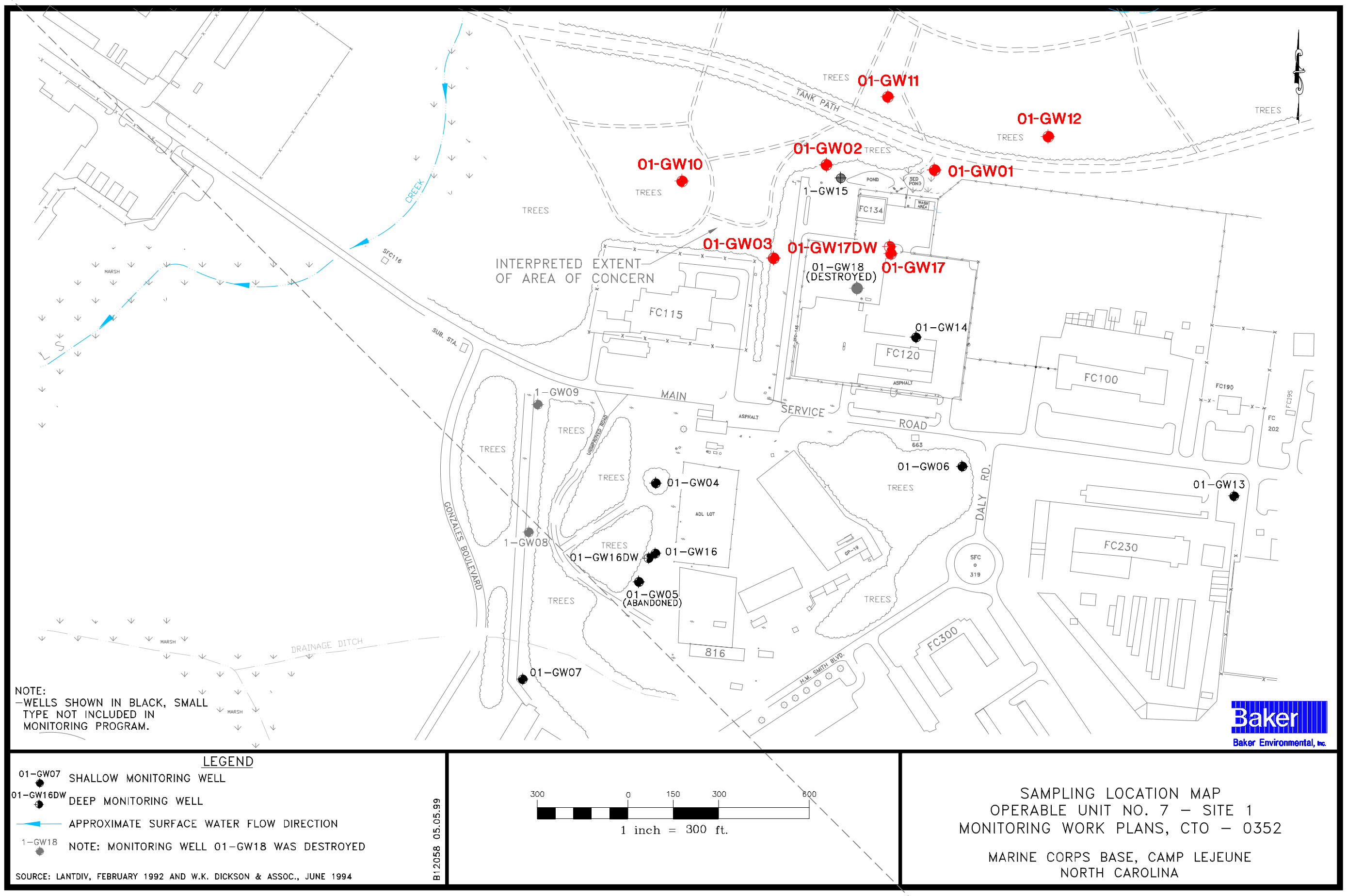
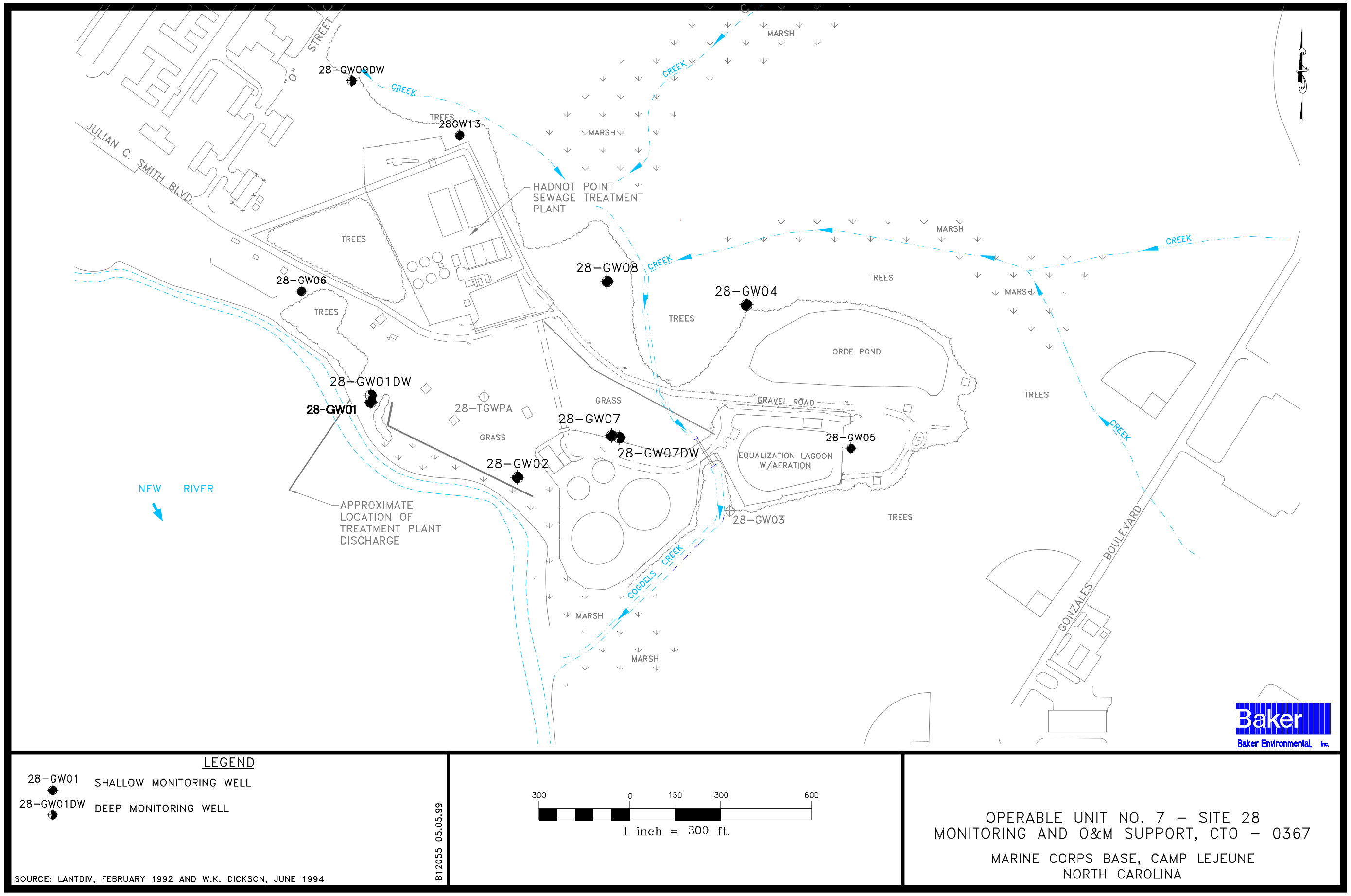


Figure 3-6. Sample Location Map for OU No. 7, Site 28



Site 3 was active from 1951 to 1952 and was used to supply treated lumber during construction of the Base railroad. An onsite sawmill was used to cut logs into railroad ties. The ties were then treated with hot creosote in pressure cylinder chambers. Creosote was reportedly stored for reuse in a railroad tank car. A railroad spur may have been located at this site.

Regulatory Framework—The OU No. 12 ROD was submitted in January 1997 (Baker Environmental, January 1997). The selected remedy detailed in the ROD is given in Table 3-2. No Applicable or Relevant and Appropriate Requirements (ARARs) were identified for soil at OU No. 12. Federal soil screening levels have been identified as chemical specific “to-be-considered” standards (TBCs).

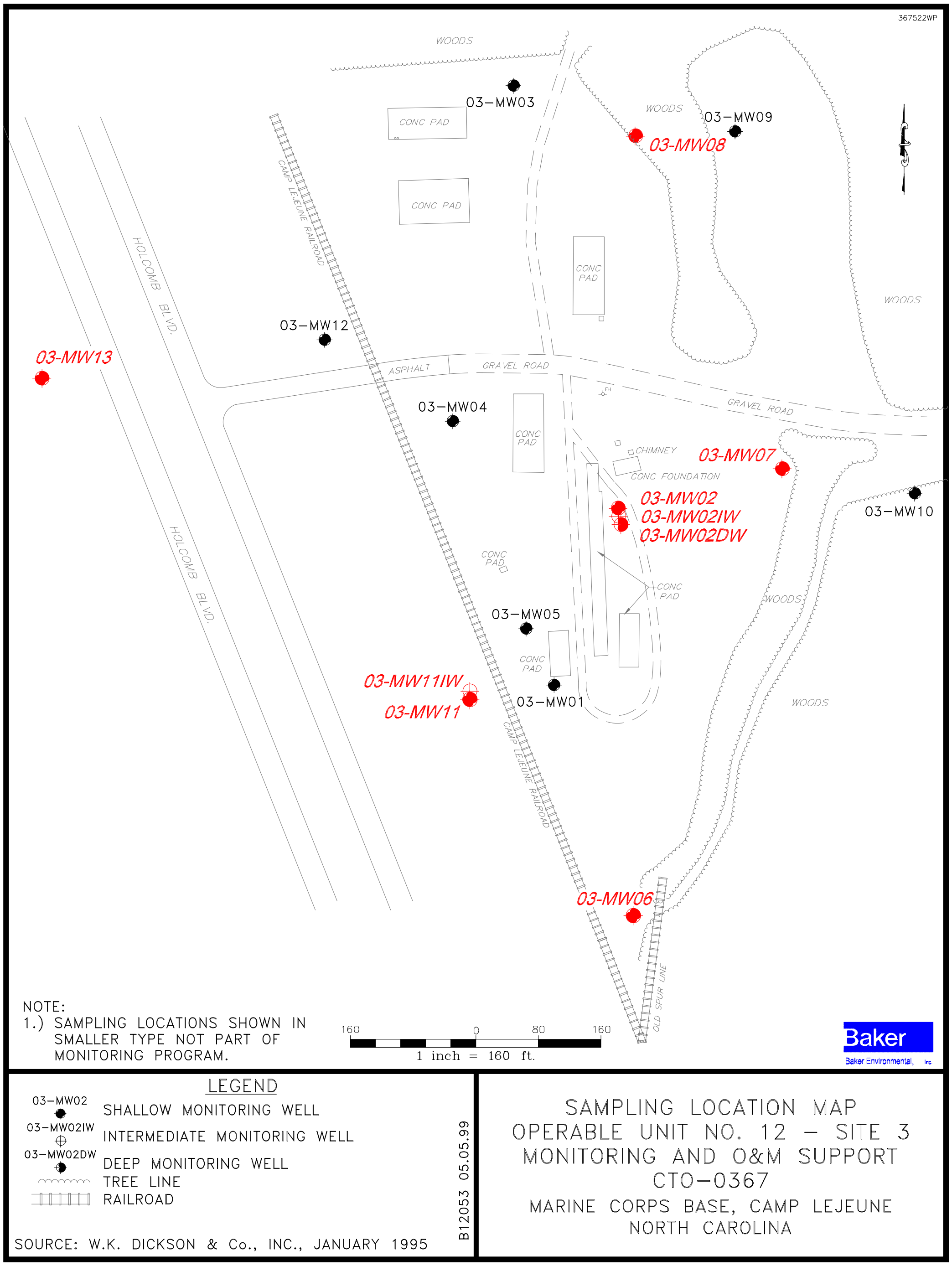
Activity Status—Soil is the main media of concern at OU No. 12; however, a semiannual groundwater monitoring program was begun in January of 1998 in anticipation of an upcoming soil removal action. The groundwater monitoring program will allow investigators to assess the effectiveness of the removal action. Currently, five shallow, two intermediate, and one deep monitoring well are included in the monitoring program for OU No. 12. These sampling locations are shown in Figure 3-7.

3.2 Best Practices Already in Place

The IRP at MCB Camp Lejeune is effectively conducted by a staff of professionals whose objectives are to achieve closeout of sites as efficiently as possible, reduce costs, and protect human health and the environment. There are several examples of practices that Camp Lejeune has already put in place to optimize their LTM program. The following items may be evaluated by other installations seeking to reduce costs associated with LTM:

- Camp Lejeune has decision criteria in place to remove sites from the LTM program. They have successfully removed Site 24 and have proposed Site 74 for removal. They anticipate removing Sites 1 and 28 from the program during the 1999 fiscal year.
- Camp Lejeune has a detailed work plan for their entire LTM program that has been implemented for over 1 year.
- The Base regularly analyzes LTM data, performs trend analysis, and contours the data to make recommendations for program improvements (e.g., monitoring point and sampling frequency reductions).
- Regular inspections of monitoring wells are conducted, and wells that are in deteriorating condition are properly abandoned to prevent further contamination of the groundwater.
- The entire LTM program has been reduced to semiannual (or less) periodic monitoring versus quarterly.
- The Base has eliminated “double sampling” of supply wells, which are already sampled on a regular basis by Camp Lejeune water resource personnel.
- Camp Lejeune has an excellent “team approach” with the regulators and the community. They have bimonthly meetings with the regulators to review the LTM data at each OU and make consensus recommendations for changes and improvements.
- They have implemented a streamlined reporting process. Semiannual reports are inserted into a binder assigned to each OU as they are produced. Generally, only one draft of each report is issued.
- Camp Lejeune is handling IRP data electronically and has written specifications in place for contractors to follow when providing these data.

Figure 3-7. Sample Location Map for OU No. 12, Site 3



4.0 PROGRAM OPTIMIZATION RECOMMENDATIONS

The following sections present recommendations for optimizing overall site strategy and monitoring programs at MCB Camp Lejeune.

4.1 Site Strategy Considerations

In preparation for the 5-year review scheduled for 1999 and eventual site closeout, there are several site strategies that should be considered. These strategies include assessing the role of natural attenuation at the LTM OUs, tracking cost and performance data for the pump and treat systems, and pursuing a technical impracticability waiver for the OU No. 2 plume. The following paragraphs outline these strategies and give recommendations for implementing them.

4.1.1 Natural Attenuation Data

Currently, there is no formal application or monitoring for natural attenuation at the Camp Lejeune LTM OUs. However, the Base is pursuing monitored natural attenuation (MNA) as part of feasibility studies being conducted at other sites. Upcoming RODs for sites at OU No. 6 and OU No. 14 are under negotiation and propose MNA as the final remedy. These RODs are expected to be signed early in calendar year 1999. MCB Camp Lejeune should use this opportunity to pursue MNA for the current LTM OUs as well.

Implementing natural attenuation as part of the LTM program may lead to earlier shutdown of active remedial systems and eventual site closeout. Camp Lejeune should consider developing an MNA work plan for the LTM OUs. This work plan could be presented for approval as part of the upcoming 5-year review in calendar year 1999.

4.1.2 Technical Impracticability Waiver

The OU No. 2 plume has concentrations exceeding 100 parts per million (ppm) of chlorinated solvents, which indicates the presence of dense non-aqueous phase liquids (DNAPL) in the groundwater. The average influent concentration levels for the 300 gallon per minute (gpm) pump and treat system is 21 ppm, and the 10 ppm portion of the plume is estimated to be 200 yards in length. On the basis of overall site conditions and current remedial action status, and a comparison with the criteria specified in EPA Directive 9234.2-25, *"Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration*" (September 1993), it appears unlikely that MCLs will be achieved at OU No. 2. The referenced EPA guidance was written to acknowledge and address the problematic nature of groundwater restoration at sites with significant DNAPL contamination in the subsurface. To date, there are no documented examples where groundwater has been remediated to MCLs through the application of pump and treat methods where DNAPL is present. In these cases, plume containment is the primary goal.

An appropriate remedial strategy at DNAPL sites should address the DNAPL zone and the "dissolved phase" portion of the plume with separate, but integrated, approaches. Typically, this includes aggressive source removal and containment in the DNAPL zone, along with active and/or passive treatment of the "dissolved phase" portion of the plume. A Technical Impracticability (TI) waiver can be applied to the DNAPL portion of the plume, recognizing that complete restoration of water quality is not generally achievable with current technologies, while the more stringent MCL cleanup requirements would be maintained for the "dissolved phase" (EPA, September 1993).

4.1.3 Cost and Performance Tracking

Camp Lejeune is just beginning to evaluate cost and performance data for the pump and treat systems at OU Nos. 1 and 2. To date, performance metrics such as cumulative mass removed over time and cost per pound extracted have not been calculated or tracked graphically. In order to prepare for the 5-year review and a potential technical impracticability waiver for OU No. 2, monthly performance data for the pump and treat systems should be tracked and presented graphically as part of the LTM reporting process. At a minimum, influent contaminant concentration versus time and cost per pound removed versus time should be tracked. Figure 4-1 shows examples of common cost and performance evaluation plots. Data used for these plots do not reflect conditions at any Camp Lejeune sites.

4.1.4 Contracting

Camp Lejeune currently utilizes two separate contractors for the LTM program and the operation and maintenance (O&M) of the pump and treat systems. This has sometimes resulted in inadequate coordination and integration of the monitoring program with the treatment systems being monitored. One possible solution is to formalize the process for incorporating the O&M cost and performance data into the periodic monitoring reports for OU Nos. 1 and 2. In addition, the two contractors should meet regularly (e.g., during the semiannual reporting process) to discuss recommendations to optimize system performance. These recommendations should also be incorporated into the monitoring reports.

4.2 LTM Program Recommendations

The following section outlines both general and site-specific recommendations for optimizing the LTM program at MCB Camp Lejeune. These suggestions are based on the optimization strategy summarized in Section 1.3 of this case study. A summary of the recommendations is given in Table 4-1. It is important to note that, in evaluating these suggestions, regulator and community approval must also be considered.

4.2.1 Monitoring Point Reduction

One of the most effective ways to reduce LTM costs is to reduce the number of wells sampled. This not only saves labor in the field, it reduces analytical, data management, and reporting costs. The LTM program at Camp Lejeune includes a reasonable number of monitoring wells to achieve program objectives at each site. However, there are a few wells that may be considered for elimination from the program without compromising quality.

Elimination of Monitoring Points—In the most recent semiannual monitoring report for OU No. 2, the LTM contractor makes a recommendation to eliminate four wells from the LTM program (Baker Environmental, 1998a). These wells, GW02DW, GW21, GW30DW, and GW40DA, have shown no evidence of contamination due to site activities. In addition, they are upgradient, sidegradient, or too deep with respect to site contaminants to become affected in a realistic time frame. It is reasonable to eliminate these wells from the LTM program at OU No. 2.

In addition to these wells, GW30 should be considered for elimination from the program. This shallow well is on the opposite side of Wallace Creek from the rest of the site. If shallow groundwater discharges to Wallace Creek, as appears to be the case based on the potentiometric surface at the site, the creek forms a hydraulic barrier effectively preventing the migration of site contaminants any further north. The contaminants moving north from the site with shallow groundwater will discharge into Wallace Creek, and continue downstream carried by surface water.

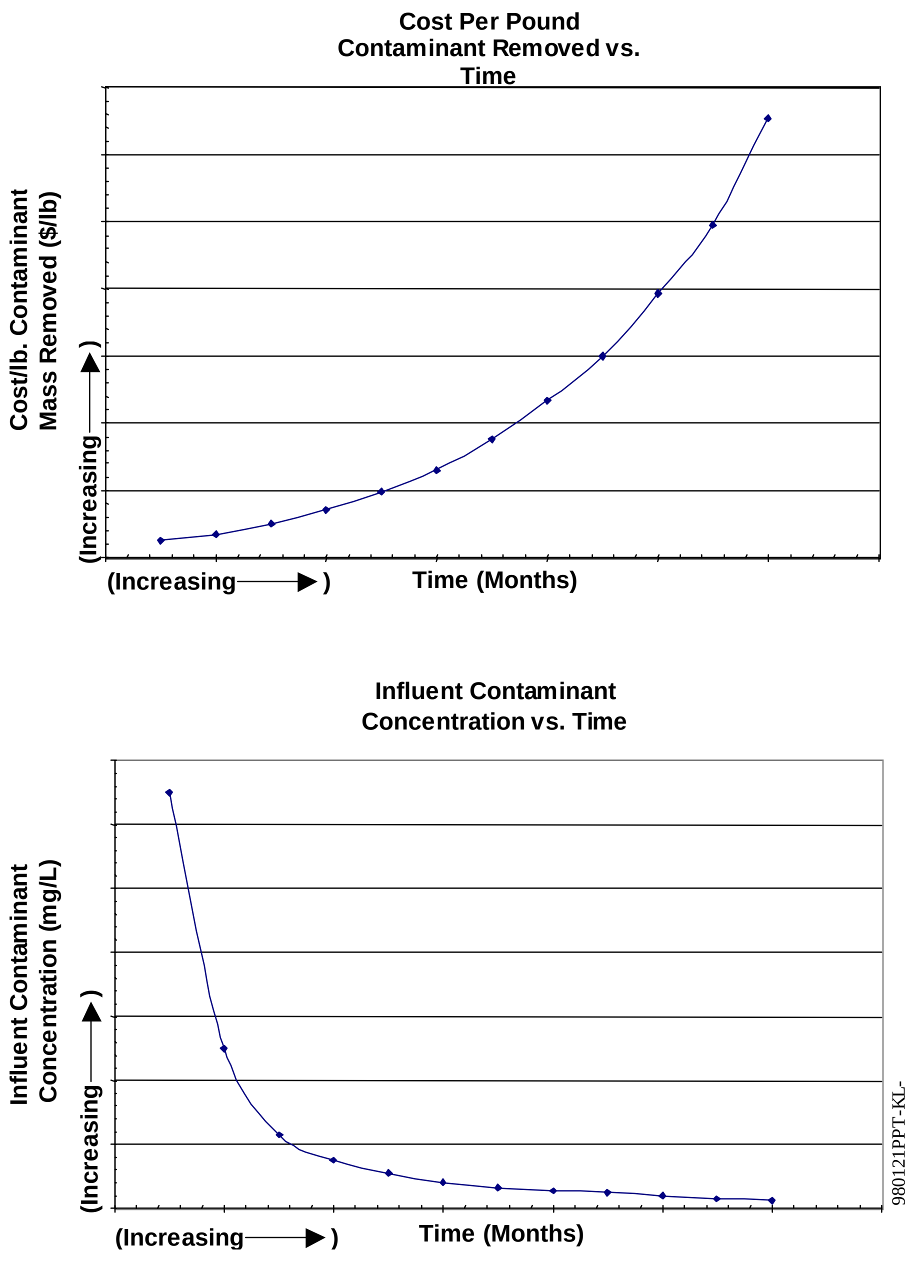


Figure 4-1. Common Cost and Performance Evaluation Plots

Table 4-1. Summary of Recommendations for the MCB Camp Lejeune LTM Program

Strategy	General Recommendations	Site-Specific Recommendation(s)	Potential Cost Savings/Benefits
Monitoring Point Reduction	Continue program of assessment of well condition and abandonment of deteriorating wells[a].	**OU No. 2—**Eliminate GW02DW, GW21, GW30DW, GW40DA[a] and GW30 from the LTM program. **OU No. 4—**Eliminate surface water samples 41-UT-SW02 and 41-TC-SW11 and sediment samples 41-UT-SD02 and 41-TC-SD11 from the LTM program. **OU No. 12—**Abandon monitoring wells 03-MW08 (if damaged) and 03-MW03 once debris removal has taken place.	1. Continuing the effort of abandoning wells will help eliminate further contamination of the aquifer, decrease maintenance and sampling costs, and improve overall data quality. For every well eliminated from the monitoring program, an average of $200 in analytical costs are saved per sampling round. 2. Eliminating sampling points at a given site will decrease analytical costs proportionately. For example, eliminating 5 wells from the OU No. 2 program will save approximately 18%, or nearly $2000 annually, of the OU analytical budget. Eliminating 2 surface water and sediment samples at Site 41 (OU No. 4) saves 19%, or approximately $1700 of the site's annual analytical budget. These estimates do not include savings associated with field, data management, or reporting labor.
Duration and Frequency Reduction	1. Conduct a Basewide background metals study. 2. Consider sampling upgradient or background wells annually. 3. Consider sampling deep wells that have not yet been affected by site contaminants annually.	**OU No. 1—**Reduce monitoring of 78-GW09-3 and 78-GW24-3 to annually. **OU No. 2—**Reduce monitoring of GW04 and MW03D to annually. **OU No. 4—**Conduct a Basewide background metals study. Reduce monitoring of 41-GW07 to annually. **OU No. 5—**Reduce monitoring of 02-GW08 to annually. **OU No. 7—**Conduct a Basewide background metals study (not important for this OU if LTM is successfully stopped at Site 28 during 1999). **OU No. 12—**Reduce monitoring of 03-MW07 and 03-MW02DW to annually. Discontinue monitoring at this OU once any effects of the soil removal action have passed.	1. Although a Basewide background study would require an initial expenditure, it could easily pay for itself if the results enabled the closeout of sites at OU No. 4 or 7 a year or more ahead of schedule. A cost of approximately $50,000, including analytical, labor, and reporting, should cover a background study of approximately 20 wells, based on current monitoring program costs. 2. A reduction to annual sampling of the listed monitoring wells would eliminate a total of 8 samples annually, for a savings of approximately 4%, or $1400, of the annual analytical budget. Additional savings can be expected in field labor.

Table 4-1. Summary of Recommendations for the MCB Camp Lejeune LTM Program (Continued)

Strategy	General Recommendations	Site-Specific Recommendation(s)	Potential Cost Savings/Benefits
Field Procedures and Equipment Efficiency Improvements	Investigate the potential for using dedicated micropurging techniques to reduce labor and improve sample quality.	NA	Implementing a dedicated bladder pump system would cost approximately $60,000 to $85,000. Assuming a 50% reduction in field labor (from $60,000 down to $30,000 per year), this system could be paid off in four sampling rounds (2 years). This does not reflect other savings, such as decreased purge water handling.
Reducing the Number of Analytes	1. Consider eliminating any analytes that have not been detected in four rounds of sampling, including analytes detected below the sample specific detection limit or attributable to laboratory contamination. 2. Consider adding at least one equipment blank per round of sampling where non-dedicated equipment is used.	**OU No. 2—**Eliminate CLP metals and total and suspended solids from the analyte list[a]. **OU No. 5—**Reduce analyte list to BTEX.	1. Eliminating all but the most representative analytes may not only save a significant amount of the analytical budget, but will decrease costs associated with data management and reporting. It will also result in clearer, more concise LTM reports. Eliminating metals from the analyte list at OU No. 2 will save approximately $700 in analytical costs annually. 2. The recommendation to add an equipment blank will only add 2 samples per year (an approximate 1%, or $400 increase in analytical budget), and will improve data defensibility.
Data Analysis Tools	Camp Lejeune should continue on its course of coordinating the LTM data with the GIS system already in place. Priority should be given to linking more recent data from currently active sites so that concentration over area tracking may begin as soon as possible.	NA	Benefits of this approach may include expedited regulator buy-in and, potentially, expedited site closeout. The more ways there are to visualize the data, the better the decisions that can be made using it.
Report Streamlining	Continue focusing on graphical and tabular formats and further decrease the amount of text submitted. Highlight important data in tables and combine site maps to the extent possible.	NA	Further streamlining the reporting procedure will save labor costs for both reporting and reviewing documents. Based on the current LTM budget, it appears that reporting and data management costs make up a significant portion (50% or more) of the monitoring program costs. Copying and material costs will also be reduced. In addition, the clarity of site data should be enhanced.

[a]Recommendation made by LTM contractor.

The LTM program for Site 41 at OU No. 4 includes five groundwater, eight sediment, and eight surface water samples. It is probable that some of these sampling points can be eliminated without diminishing the quality of the program. Priority should be given to those samples that indicate the quality of the surface water as it enters the site, and as it leaves the site. Samples collected on site, or along intervals from the same drainage way, may be reduced to save labor, analytical, and reporting costs. The elimination of two sediment and two surface water samples will reduce analytical costs for the site by approximately 19% (4 out of 21 samples) and labor, reporting, and data management costs by a lesser percent.

For example, surface water and sediment samples 41-UT-SW/SD02 and -SW/SD03 are both collected from the unnamed tributary (see Figure 3-3). The SW/SD03 samples are collected approximately 500 feet downstream of the SW/SD02 samples, and the surface water and sediment data are very similar for these two locations. Since it is more important to look at what may be leaving the site, it would be reasonable to propose the elimination of 41-UT-SW/SD02 from the sampling program.

The same logic can be applied to samples 41-TC-SW/SD11 and -SW/SD12, located on Tank Creek. Again, the data are similar and eliminating the upstream sample location (41-TC-SW/SD11) will not compromise knowledge of potential off-site migration of contaminants in surface water and sediments.

Monitoring Well Abandonment— As a general recommendation, the Base should continue its regular inspection and abandonment of wells determined to be in deteriorating condition. The site map figures presented in Section 3 of this case study specify those wells that have already been abandoned or destroyed.

The semiannual monitoring reports for the first half of 1998 for OU Nos. 2, 4, 5, 7, and 12 cite wells installed in the mid-1980s for confirmation studies as those most likely to be in deteriorating condition (Baker Environmental, 1998a, May 1998, August 1998, 1998b, 1998c). These wells are beginning to incur maintenance costs to keep them painted and rust-free. Higher turbidity in these wells may be resulting in compromised sample quality. The LTM contractor is recommending abandonment of many of these wells, and should continue to pursue this.

Monitoring well 03-MW08 is supposed to be included in the monitoring program for OU No. 12. However, this well has been buried under branches, brush, and other debris resulting from recent activity at the OU. This well is located sidegradient to the bulk of site contamination, centered on 03-MW02, where it is assumed that the soil removal action will take place. This well should be considered for permanent elimination from the monitoring program for this OU, and properly abandoned upon removal of the debris. Monitoring well 03-MW03 has also been buried, and as this is not a well that is actively being sampled as part of the monitoring program for the OU, it should also be properly abandoned once uncovered.

4.2.2 Duration and Frequency Reduction

Another important approach to decreasing LTM program costs is decreasing the number of samples through reductions in sampling duration and/or frequency.

Duration Reduction—Although there is a 5-year review period for the LTM program at Camp Lejeune, the Base has initiated decision criteria for determining when a site may be discontinued prior to the end of the review period. These decision criteria state that monitoring may be stopped if three rounds of ND data are collected. Risk-based levels may also be used if contaminant concentrations at the site approach action levels but do not further decrease. This approach has allowed the Base to eliminate sites from the LTM program before the end of the review period. *This is an excellent approach that should be continued for all current and future LTM sites at Camp Lejeune.*

OU No. 12 is undergoing groundwater monitoring in preparation for an upcoming soil removal action. Once the removal action has taken place, and groundwater monitoring results indicate that the removal action either has not affected groundwater or that the effects have passed, the monitoring program at the OU should be eliminated and Site 3 closed out.

Site 41 at OU No. 4 is a metal-contaminated site with elevated concentrations of iron and manganese, in particular. These metals are expected to occur naturally at higher concentrations in the coastal plain environment. By gaining a better understanding of the natural levels of metals occurring in groundwater at Camp Lejeune, a case may be made for stopping LTM sooner at this site. It is anticipated that the LTM program at Site 28, OU No. 7**,** will be stopped during the 1999 calendar year. This site is being monitored for metals only. If there is any hesitation on the part of regulators to allow this site to be closed out, it may also benefit from a better definition of naturally occurring metal concentrations. *Thus, the implementation of a background groundwater study is recommended to decrease the duration of LTM at metal-contaminated sites.*

Because the geology and hydrogeology of the Base is fairly uniform, a background study may be designed to determine Basewide background metals concentrations in groundwater. This can be done by identifying monitoring or other wells throughout the entire installation that are not thought to be affected by site contamination. These wells should be categorized by the aquifer in which they are completed. After sampling these wells and analyzing for a suite of metals, upper tolerance limits (UTLs) should be determined for each metal in both the shallow water-bearing unit and the Castle Hayne Aquifer. These UTLs can be used to assess the significance of metal detections in groundwater at Camp Lejeune

Frequency Reduction—*MCB Camp Lejeune has done an excellent job of assessing the LTM program and making reductions to sampling frequency. Currently, all of the OUs are on a semiannual, or less, sampling frequency.* Some of the deeper wells at OU No. 2 have recently been reduced to an annual frequency, based on the distribution of contaminants in shallower wells. There are other wells within the Camp Lejeune LTM program that may be considered for reduction to annual monitoring.

The purpose of a well should be taken into account when determining the frequency it needs to be sampled. Downgradient, plume edge wells require more frequent sampling than an upgradient or background well. Upgradient wells that may be considered for annual sampling include:

- **OU No. 2—**GW04 and MW03D
- **OU No. 4—**41-GW07
- **OU No. 5—**02-GW08
- **OU No.12—**03-MW07

The deep well at OU No. 12, monitoring well 03-MW02DW, should be considered for annual sampling. This deep well is co-located with an intermediate and shallow well. Although site contamination is centered on the shallow well at this location (03-MW02), very little of this contamination has reached the intermediate well (03-MW02IW). The deep well is screened another 70 feet below the intermediate well. Therefore, annual sampling of this well should be adequate to track the vertical movement of site contaminants.

Two deep wells at OU No. 1, 78-GW09-3 and 78-GW24-3, may also be considered for annual sampling for the same reasons given above.

4.2.3 Field Procedures and Equipment Efficiency Improvements

Based on a review of the LTM contractor's current work plans, it may be possible to improve the efficiency of some of the field procedures in order to save money on sampling labor.

The LTM contractor currently applies low-flow purging (approx. 1 L/min) techniques using nondedicated pumps. However, three well casing volumes are removed prior to sampling. This is an unnecessarily conservative approach, as there is no volume-related criteria when using the low-flow purging technique (Puls and Barcelona, 1995). An effort should be made to determine if the LTM OUs are appropriate for true low-flow (or "micropurging") techniques. The primary question is whether all of the wells that are essential to the LTM program at a specific site have adequate recharge rates to support true low-flow purging. *The following discussion on micropurging has relevance to all other current and future groundwater monitoring programs at the Base, and is, therefore, presented in significant detail.*

The goal of this technique is to eliminate vertical movement of groundwater within the well casing during purging. In doing this, the well may be purged from one small section of the screened interval, without the mixing of stagnant casing water and fresh formation water. Therefore, purge times and volumes are significantly decreased. Wells are purged only until water quality parameters such as pH, conductivity, temperature, and dissolved oxygen, have stabilized. This is typically accomplished after just a few liters.

To determine if the wells being sampled are candidates for low flow purging, a pump capable of rates less than 0.5 L/min should be used. Pumps should be lowered gently into the well to approximately the middle of the screened interval, and the water column should be allowed to stabilize prior to the start of purging. During purging, water levels should be monitored and the pump rate adjusted so that drawdown does not exceed 0.3 feet. If it is not possible to accomplish this at rates of between 0.5 and 0.1 L/min, the well is probably not a candidate for low-flow purging.

Although dedicated bladder pumps are the preferred equipment for successfully applying low-flow purging (Puls and Barcelona, 1995), the appropriateness of this technique for the MCB Camp Lejeune LTM program should be determined prior to considering an investment in dedicated equipment. The cost of installing such a system is approximately $1000/well, plus $1000 for a pump controller that can be moved from well to well. Based on this estimate, a dedicated sampling system for Camp Lejeune's current LTM program would cost approximately $85,000. However, through anticipated reductions in the program, such as the elimination of Sites 1 and 28, the cost of the system should be reduced to approximately $60,000. If the duration of each sampling event can be reduced from 30 to 15 days, a semiannual savings of $15,000 may be realized, based on a 2-person sampling crew working 10-hour days at $50/hour per person.

At this rate, a dedicated pump system should pay for itself in approximately four sampling rounds. This estimate does not include cost savings associated with purge water handling, travel, reporting, etc. When monitoring has been terminated at a site, the dedicated pumps can be decontaminated and reinstalled in other wells or at other sites in order to increase the economy of the program.

Another potential cost avoidance and sample quality benefit that may result from low-flow purging is the decrease in metal concentrations that usually results from this technique. Metal and other contaminant concentrations may be decreased by decreasing turbidity associated with traditional purging methods. However, since purging is already being conducted at such a low rate at Camp Lejeune, this benefit has likely already been realized.

If a dedicated system is not deemed economically feasible, but the micropurging technique is appropriate for the site, renting two nondedicated pumps should be considered. With two pumps, one can be placed in a well and allowed to stabilize while purging, sampling, and decontamination of another well is taking place. An equipment blank is recommended for any sampling conducted with non-dedicated equipment.

4.2.4 Simplification of Analyses

Since analytical costs make up a significant portion of LTM program expenses, streamlining the analytical approach is a viable way to cut overall LTM program costs. Reducing the number of analytes at a site, eliminating overlapping analytical methods, and reducing quality assurance/quality control (QA/QC) samples to the minimum required are examples of ways to streamline the LTM analyses.

Reducing the Number of Analytes—Reducing the number of analytes reported for a site not only reduces analytical costs, it reduces data management, validation, interpretation, and reporting costs. Eliminating unnecessary analytes results in clearer, more concise reports.

At most of the LTM sites at Camp Lejeune, target compound list (TCL) VOCs or SVOCs are being analyzed. This usually results in several analytes that have never been detected at the site. Eliminating these undetected compounds and reporting data only for the contaminants of concern at a site will streamline the entire data handling and reporting process. Consideration should be given to eliminating any analytes that have not been detected for four rounds of sampling. This includes analytes that were detected at concentrations less than the sample-specific detection limit and those that have been detected at concentrations similar to laboratory blanks. Specific examples of analytes that may be eliminated are given below.

The LTM contractor has recommended the elimination of Contract Laboratory Protocol (CLP) metals and total and suspended solids at OU No. 2. This recommendation is made based on the fact that many metals occur naturally at high concentrations in the area, and that the metals data were not necessary in tracking the contaminants of concern (VOCs) at the OU. This is an excellent recommendation that will save a significant amount of money, as CLP metals is an expensive method and nearly 30 wells are included in the OU No. 2 LTM program. A Basewide background metals study, recommended in Section 4.2.2, may also help to eliminate metals from site analyte lists.

The analyte list could be reduced to BTEX for OU No. 5. The analyses for this OU can still be done by SW8260, although with a significantly reduced compound list. Although there are less expensive analytical methods available for BTEX, such as SW8020, ensuring that data collected at the OU are comparable to past sampling rounds is more important. In addition, many analytical laboratories have stopped offering SW8020.

Eliminating Overlapping Methods—Eliminating overlapping methods saves money and simplifies data interpretation. However, it does not appear the Camp Lejeune LTM program includes any overlapping methods.

Evaluating QA/QC Samples— Currently, the only QA/QC samples collected as part of the Camp Lejeune LTM program are trip blanks. It is not likely that any streamlining can be achieved in this area. In fact, it is recommended that some additional QA/QC samples be considered, to increase the defensibility of LTM data. Although most of the samples are collected using dedicated or disposable tubing and a peristaltic pump, there are some wells in the program that cannot be sampled in this manner. These are wells with static water levels of greater than 20 ft bgl, including:

- **OU No. 2—**06-GW01D, 06-GW01DA, 06-GW28DW, and 06-GW27DW
- **OU No. 5—**02-GW03IW
- **OU No. 12—**03-MW02IW, 03-MW02DW, 03-MW11, and 03-MW11IW

These wells are sampled using a nondedicated submersible electric pump. It is recommended that at least one equipment blank be collected for each sampling round that nondedicated equipment is used.

Trip blanks, which are submitted with each shipment containing samples for volatile parameters, may be decreased by decreasing the number of coolers packed with these types of samples. This may be accomplished by consolidating VOC samples in one cooler and shipping every other day of the sampling round, provided analytical hold times are not approached.

4.2.5 Report Streamlining

MCB Camp Lejeune has already done an excellent job of streamlining their semiannual monitoring reports. The reports are generally submitted in only one draft and they are inserted into a binder dedicated to a specific OU.

The inclusion of recommendations for streamlining and otherwise improving the LTM program at Camp Lejeune within the monitoring reports is an excellent idea. This, and the tracking of those recommendations that have been adopted, should be continued. Other discussion within the text could be further reduced, however, by allowing the tables and figures to present the data.

The LTM contractor has focused on tabular and graphic presentation styles to help cut down on review time. Data tables within the report body currently present only analytes that have been detected in at least one well. This is an excellent approach. Readability of the tables may be improved by shading or otherwise delineating hits, either above the detection limit or some standard such as an MCL. This will also decrease the overall number of tables, by eliminating those that show data above screening standards. Appendix B gives an example.

Sample location maps currently included in the semiannual monitoring reports may be consolidated by showing groundwater sampling locations along with the potentiometric surface on one map, and contaminant concentration information on another.

It should also be evaluated whether detailed information, such as chain-of-custody forms, is necessary for inclusion in the reports. Having the original forms on file may be determined to be adequate in case of need.

4.2.6 Data Analysis Tools

There are several data analysis tools that will assist in interpreting and tracking the behavior of contaminants at Camp Lejeune's LTM OUs in preparation for the 5-year review. Use of these tools, such as geographic information systems (GIS) and other graphics packages, increase the visual impact of large amounts of data.

Camp Lejeune has a database in place to handle all of their data electronically. This database is in the process of being linked to a GIS package so that data can be spatially displayed and analyzed. The Base currently has great potential for putting together interactive data presentations, and should continue pursuing the coordination of LTM data with the central GIS. This in turn could be accessible to all environmental personnel via a central server, and ideally the Base Intranet.

Once in place, a GIS package will help display data spatially and can also be used to construct and track plume or other types of "concentration over area" maps. Examples of screen shots, taken from a GIS package that has applicability to the program at Camp Lejeune, are shown in Appendix B.

Presentations to State regulators and the community can be greatly enhanced by using such a system. Regulator buy-in may be obtained during a data visualization meeting, rather than awaiting comments on bulky documents. These applications can usually be linked directly to a database to further streamline data handling and reduce errors associated with redundancy.

Camp Lejeune currently tracks concentration over time for contaminants of concern at several of the OUs and tracks contaminant plumes at the two OUs with pump and treat systems. These are good practices that will prepare the Base for the upcoming 5-year review. Examples of the graphs and figures currently submitted with the semiannual monitoring reports are given in Appendix B. Similar data tracking is planned for the treatment systems (i.e., performance over time, and cost per pound of contaminant removed), and will be included in upcoming monitoring reports. These types of information are crucial to planning the timely and efficient shutdown of active treatment systems and eventual site closeout.

5.0 EVALUATION OF OPTIMIZATION

Evaluation of the optimization suggestions includes two aspects: 1) the estimate of total cost reduction, and 2) the potential effects on data quality. Following is a brief discussion of each aspect.

5.1 Impact on Data Quality

The strategies and recommendations for LTM optimization discussed in Section 4 must be applied in such a way that monitoring data quality is not compromised. If only sampling points that do not contribute to the monitoring goals or that already have well-defined trends are eliminated or their monitoring frequency reduced, the program quality will not be adversely affected.

Some recommendations may actually improve the quality of the monitoring program. Implementing the recommendation to install a dedicated bladder pump system for low-flow purging may actually improve data quality, via lower turbidity levels, increased sample representativeness, and lower likelihood of cross contamination. Likewise, eliminating wells that are in poor condition from the monitoring program, via abandonment, should also contribute to an overall increase in sample quality.

Other recommendations that should result in an increase in monitoring program quality include those to further streamline reporting and implement additional data analysis tools. Implementing these suggestions should improve the conciseness and clarity of monitoring reports and data presentations.

5.2 Estimate of Total Cost Reduction

The total 1998 monitoring budget for the six OUs listed in this case study is approximately $380,000. It is estimated that somewhere between one-quarter and one-third of this budget is spent on analytical and field labor costs.

By implementing the suggestions outlined in Table 4-1, a significant cost savings could be realized. It is estimated that the analytical budget could be decreased by approximately 18%, or $6000, through reductions in monitoring points, monitoring frequency, and site analyte lists. Additional savings could be realized for field labor, although mobilization costs would remain the same. The elimination of non-essential analytes would further reduce reporting and data management costs.

Although a few of the recommendations would initially increase program costs, it is anticipated that the resulting improvements would pay for themselves within a reasonable time frame. Implementation of a dedicated bladder pump system may cost $60,000 or more; however, it is estimated that it would take only four sampling rounds using micropurging techniques to pay for the system. This was calculated assuming a 50%, or $15,000, reduction in sampling labor each round. It is important to note that it is not necessary to invest in dedicated bladder pumps to realize these cost savings; nondedicated rental equipment may also be used to implement micropurging techniques.

A Basewide background metals study would require an initial investment of up to $50,000. However, the closeout of any one OU by as little as 1 year ahead of schedule should cover the costs of sample collection, analysis, and reporting for the background study.

6.0 LIST OF REFERENCES

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Appendix A

Cleanup Objectives for OU Nos. 1 and 2 at MCB Camp Lejeune

TABLE A-1

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN AT OU-1 (Sites 24 and 78) MCB CAMP LEJUNE, NORTH CAROLINA

Media	Contaminant of Concern	Remediation Goal	Units [1]
Groundwater	Benzene	1.0	ug/L
	1,2-Dichloroethene (total)	70	ug/L
	Ethylbenzene	29	ug/L
	Heptachlor Epoxide	0.2	ug/L
	Tetrachloroethene	0.7	ug/L
	Toluene	1,000	ug/L
	Trichloroethene	2.8	ug/L
	Vinyl Chloride	0.015	ug/L
	Xylenes (total)	400	ug/L
	Arsenic	50	ug/L
	Barium	1,000	ug/L
	Beryllium	4	ug/L
	Chromium	50	ug/L
	Manganese	50	ug/L
	Vanadium	110	ug/L
Soil	PCBs (total)	370	ug/kg
	4,4'-DDD	12,000	ug/kg
	4,4'-DDT	8,400	ug/kg
	Chlordane (total)	2,200	ug/kg

[1] **ug/L = microgram per liter**
ug/kg = microgram per kilogram

TABLE A-2

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN AT OU-2 (Sites 6 and 82) MCB CAMP LEJUNE, NORTH CAROLINA

Media	Contaminant of Concern	Remediation Goal	Units [1]
Groundwater	1,2-Dichloroethene	0.38	ug/L
	Trans-1,2-Dichloroethene	70	ug/L
	Ethylbenzene	29	ug/L
	Tetrachloroethene	0.7	ug/L
	Trichloroethene	2.8	ug/L
	Vinyl Chloride	0.015	ug/L
	Arsenic	50	ug/L
	Barium	1,000	ug/L
	Beryllium	4	ug/L
	Chromium	50	ug/L
	Lead	15	ug/L
	Manganese	50	ug/L
	Mercury	1.1	ug/L
	Vanadium	80	ug/L
Soil	PCBs (total)	10,000	ug/kg
	4,4'-DDT	60,000	ug/kg
	Benzene	5.4	ug/kg
	Trichlorethene	32.2	ug/kg
	Tetrachloroethene	10.5	ug/kg
	Arsenic	23,000	ug/kg
	Cadmium	39,000	ug/kg
	Manganese	390,000	ug/kg

[1] ug/L = microgram per liter
ug/kg = microgram per kilogram

Appendix B

Examples of Tabular and Graphic Formats

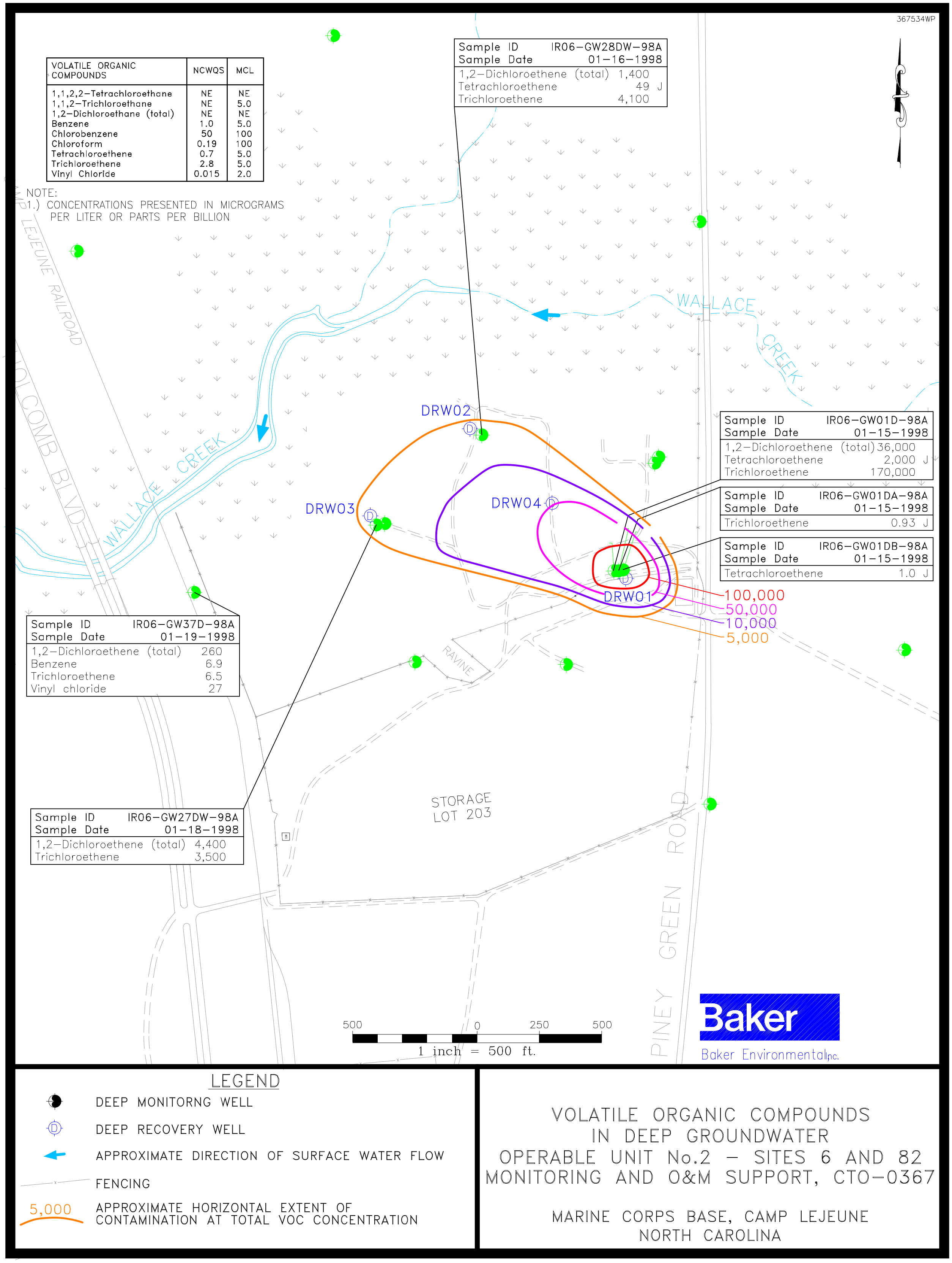
Tank Farm Groundwater Data—Round 3

Analyte	Method (units)	Screening Criteria	Location ID						
			05-MW-02	05-MW-03	05-MW-04	05-MW-05	05-MW-06	05-MW-07	05-MW-11
Gasoline Range Organics	AK101 (ug/L)	NA	ND (50)[a]	17,000 (50)	110,000 (50)	130,000 (50)	ND (50)	97,000 (50)	1,200 (50)
Diesel Range Organics	AK102 (ug/L)	NA	40 J (100)	2,100 (100)	13,000 (100)	6,900 (100)	53 J (100)	8,700 (100)	1,200 (100)
Acetone	SW8260 (ug/L)	3,700 RN	5.01 B (2.09)	14.4 (2.09)	745 (522)	54.2 (31.4)	2.49 B (2.09)	56.4 (31.4)	7.94 (2.09)
Benzene		5 M	0.0300 BJ (0.0307)	4,530[b] (3.07)	27,200 (30.7)	41,000 (30.7)	0.0700 B (0.0307)	24,400 (15.4)	10.4 (0.0307)
Chloromethane		1.4 RC	0.240 B (0.155)	ND (0.155)	222 (38.8)	2.85 (2.32)	ND (0.155)	ND (2.32)	ND (0.155)
Dibromochloromethane		0.13 RC	ND (0.0283)	ND (0.0283)	ND (7.08)	ND (0.424)	ND (0.0283)	ND (0.424)	ND (0.0283)
1,2-Dichloroethane		5 M	0.710 (0.0791)	0.840 (0.0791)	ND (19.8)	35.1 (1.19)	ND (0.0791)	59.2 (1.19)	0.450 (0.0791)
1,1-Dichloroethene		7 M	ND (0.0806)	ND (0.0806)	17.5 J (20.2)	ND (1.21)	ND (0.0806)	ND (1.21)	ND (0.0806)
Trans-1,3-Dichloropropene		0.077 RC	ND (0.0829)	ND (0.0829)	ND (20.7)	ND (1.24)	ND (0.0829)	ND (1.24)	ND (0.0829)
Ethylbenzene		700 M	ND (0.110)	330 (3.30)	810 (27.5)	741 (1.65)	ND (0.110)	649 (1.65)	0.0900 J (0.110)
Methylene chloride		5 M	0.210 B (0.151)	0.930 B (0.151)	398 (37.8)	20.2 (2.26)	0.160 B (0.151)	3.60 (2.26)	0.130 BJ (0.151)
4-Methyl-2-Pentanone (MIBK)		2,900 RN	ND (0.501)	2.81 (0.501)	ND (125)	46.2 (7.52)	ND (0.501)	ND (7.52)	2.21 (0.501)
1,1,2,2-Tetrachloroethane		0.052 RC	ND (0.170)	ND (0.170)	ND (42.5)	ND (2.55)	ND (0.170)	ND (2.55)	ND (0.170)
Toluene		1,000 M	ND (0.0336)	2,200 (3.36)	13,400 (33.6)	19,100 (33.6)	0.0500 (0.0336)	20,200 (16.8)	2.64 (0.0336)
Trichloroethene		5 M	ND (0.0439)	ND (0.0439)	ND (11.0)	4.50 (0.658)	ND (0.0439)	ND (0.658)	ND (0.0439)
Total Xylenes		10,000 M	ND (0.489)	1,100 (14.7)	2,250 (122)	2,560 (93.1)	ND (0.489)	3,090 (93.0)	0.610 (0.489)

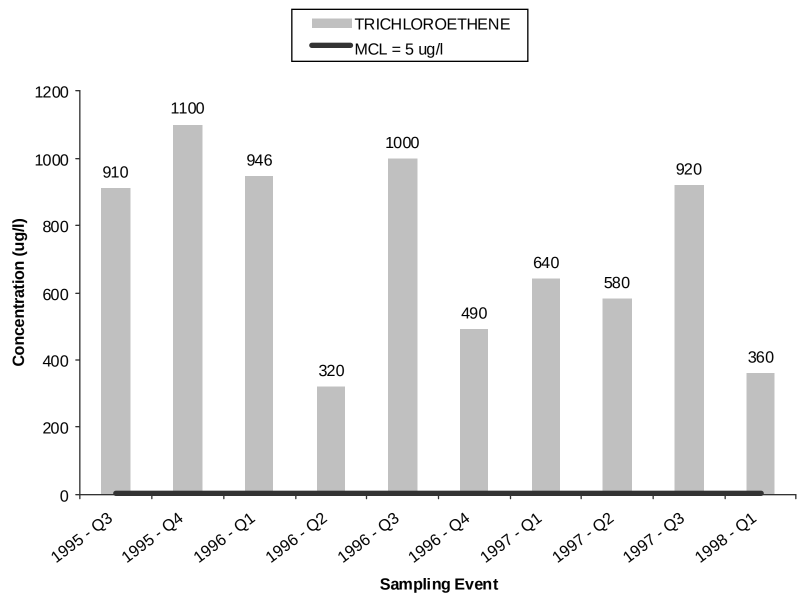
[a]Numbers in parentheses are sample-specific quantitation limits.
[b]Shaded results exceed the screening criteria.

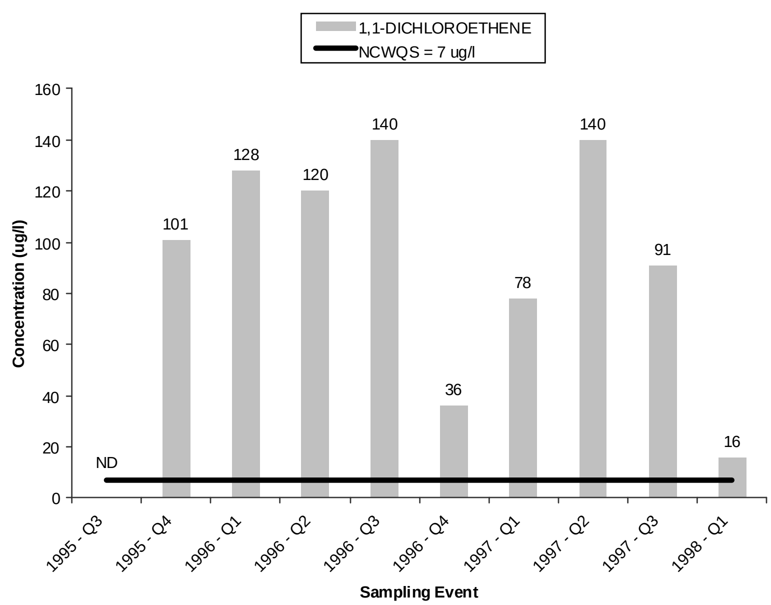
M = Maximum Contaminant Level (MCL).
RC = EPA Region III risk-based criteria, carcinogenic level.
RN = EPA Region III risk-based criteria, non-carcinogenic level.
ND = Not detected at the specified quantitation limit.
J = Detected at a concentration less than the specified detection limit.
B = Detected at concentrations indistinguishable from those detected in laboratory blanks.

Example 1. Tabular Format with Highlighted Results
(NOTE: these are sample data and do not reflect site conditions at any MCB Camp Lejeune site)



Example 2. Contaminant Plume Contouring Figures Presented in Camp Lejeune's Semiannual Monitoring Reports





Example 3. Concentration Tracking Graphs Presented in Camp Lejeune's Semiannual Monitoring Reports—Trichloroethene and 1,1-Dichloroethene from Monitoring Well 78-GW09 Site 78, OU No. 1

B.0 GIS NOTES

Example GIS Application Features

The following two pages illustrate screen shots of a GIS application that allows the user to generate plume maps using data from a monitoring program. By selecting an Operable Unit, a contaminant of concern, and a sampling round, a custom query is generated. The concentration data from the query are subsequently contoured and displayed on the screen. A table containing the query data is also displayed.

By clicking on a well, building, source area or other feature in the GIS display, the user can bring up specific data regarding the chosen feature. For example, clicking on a specific well may enable the user to bring up well construction, water level, or contaminant concentration data. Clicking on a site or Operable Unit may bring up pertinent information such as contaminants of concern, site activities, and dates of operation.

Standard GIS functions include the ability to pan, zoom in, zoom out, and other standard navigation tools. All of these and the above features can be used to give an effective presentation, with the ability to provide real-time responses to any data requests the audience may have.

Example GIS Applications to LTM Programs

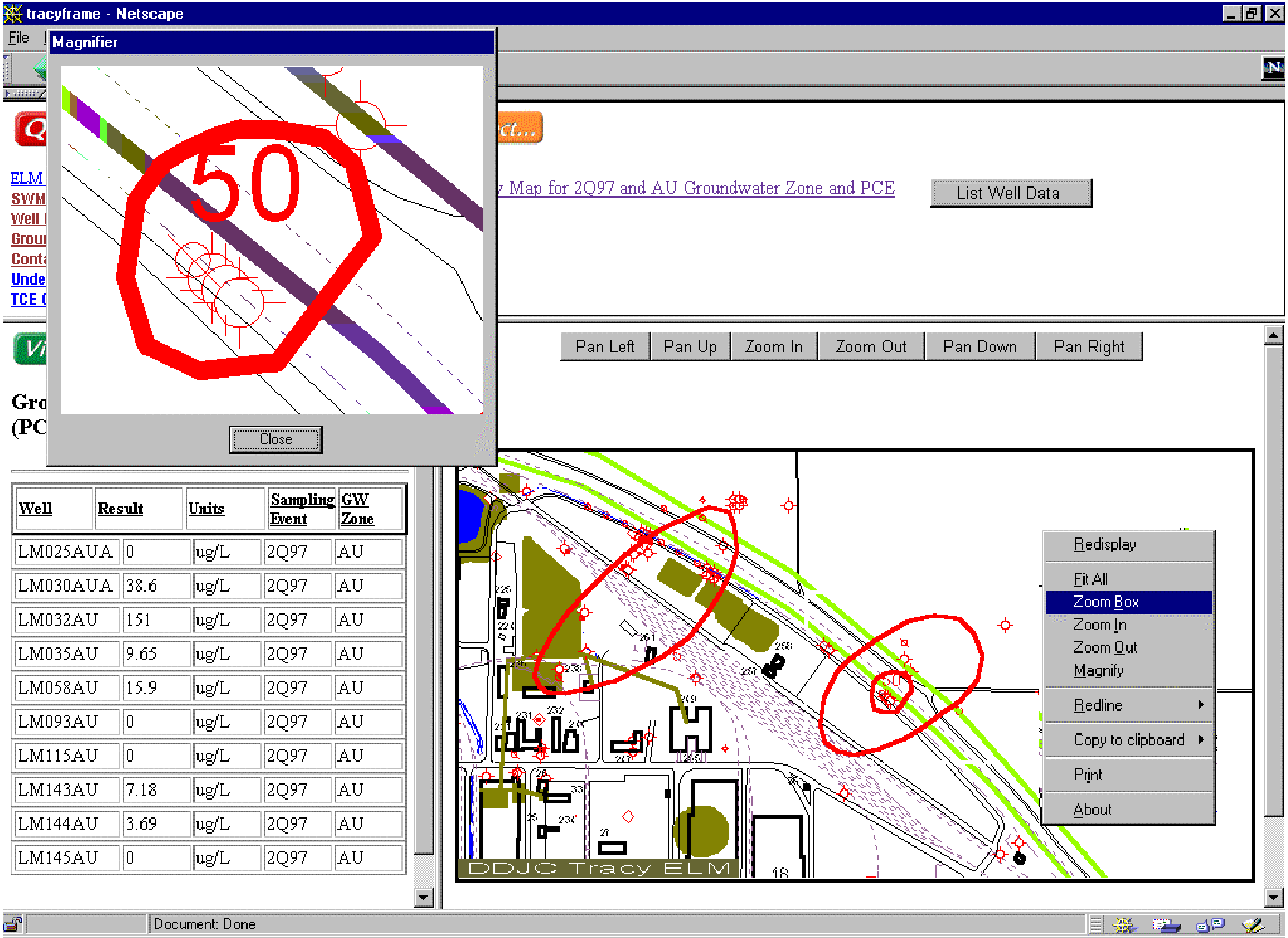
These types of applications have many uses within an LTM program. By being able to continuously track a plume's size and shape, decisions regarding which wells to sample and when to shut down active remediation systems can be made. For instance;

- If a plume is determined to be shrinking, wells once within the plume may become downgradient wells. Further downgradient wells may be eliminated from monitoring.
- If changes to plume size and contaminant concentrations become insignificant over time, consideration may be given to shutting down active remediation and allowing natural attenuation to take place.
- If a plume appears to be growing, additional wells may need to be identified or installed to track the plume edge. In addition, changes may need to be made to the remediation system to prevent offsite migration of contaminants.

Additional uses of this type of system involve tracking of individual monitoring points over time. By querying out several rounds of data for a single monitoring point, either in tabular or graphic format, decisions can be made regarding that monitoring point:

- If contaminant concentrations appear to be decreasing, the well may be eliminated from the program, depending upon its location, or monitored less frequently.
- If contaminant concentrations have leveled off, the well may be proposed for less frequent monitoring.
- If contaminant concentrations appear to be increasing, the well should be kept in the LTM program and monitored at the current frequency.

By querying several rounds of analytical data for an entire site, decisions regarding analytical methods may be made. If a given analyte has not been detected in four sampling rounds, it should be proposed for elimination from the LTM program for that site. If no analytes of concern have been detected at concentrations above action levels for two or more rounds, it may be reasonable to propose the entire site for closeout.



Well	Result	Units	Sampling Event	GW Zone
LM025AUA	0	ug/L	2Q97	AU
LM030AUA	38.6	ug/L	2Q97	AU
LM032AU	151	ug/L	2Q97	AU
LM035AU	9.65	ug/L	2Q97	AU
LM058AU	15.9	ug/L	2Q97	AU
LM093AU	0	ug/L	2Q97	AU
LM115AU	0	ug/L	2Q97	AU
LM143AU	7.18	ug/L	2Q97	AU
LM144AU	3.69	ug/L	2Q97	AU
LM145AU	0	ug/L	2Q97	AU

tracyframe - Netscape

File Edit View Go Communicator Help

Query...

ELM Help
ELM Home
SWMUs
Well Inventory
Groundwater Elevations
Contaminant Concentrations
Underground Storage Tanks
TCE Comparison Map (1995-96)

Select...

Draw Map for 2Q97 and AU Groundwater Zone and PCE

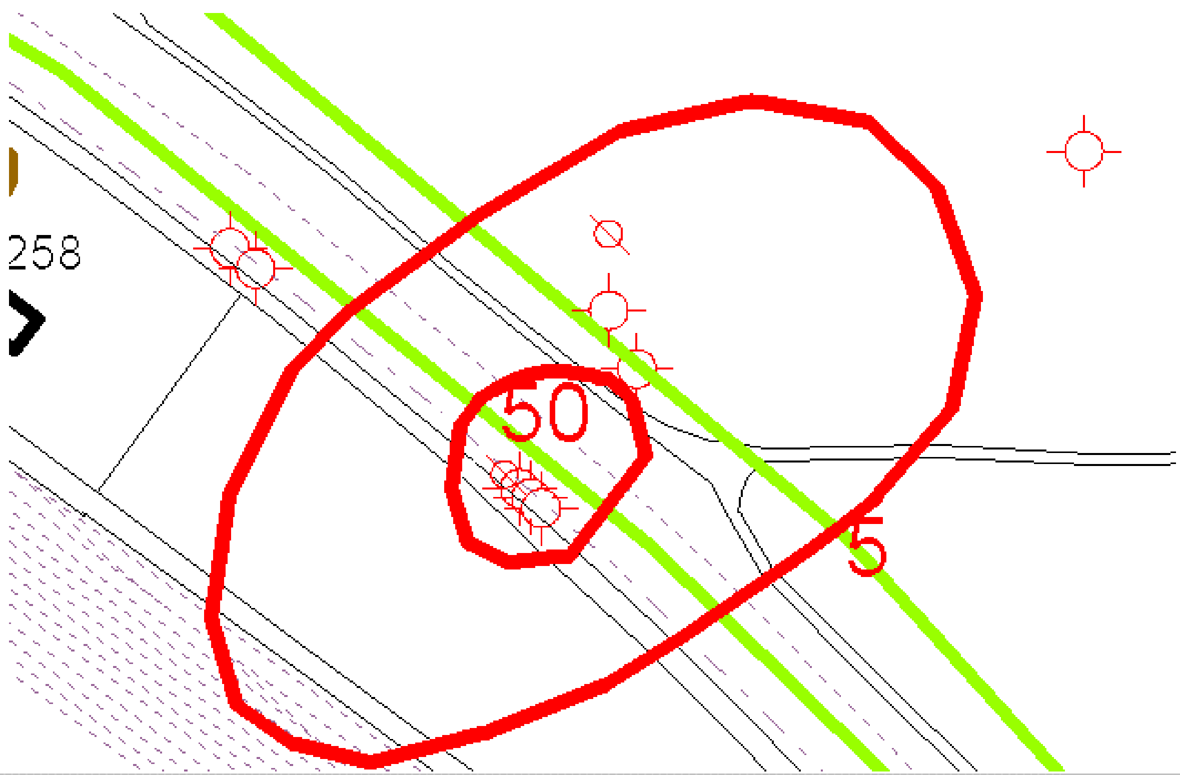
List Well Data

View...

Groundwater Contamination Inventory (PCE)

Well	Result	Units	Sampling Event	GW Zone
LM025AUA	0	ug/L	2Q97	AU
LM030AUA	38.6	ug/L	2Q97	AU
LM032AU	151	ug/L	2Q97	AU
LM035AU	9.65	ug/L	2Q97	AU
LM058AU	15.9	ug/L	2Q97	AU
LM093AU	0	ug/L	2Q97	AU
LM115AU	0	ug/L	2Q97	AU
LM143AU	7.18	ug/L	2Q97	AU
LM144AU	3.69	ug/L	2Q97	AU
LM145AU	0	ug/L	2Q97	AU

Pan Left | Pan Up | Zoom In | Zoom Out | Pan Down | Pan Right



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