06.07-07/01/99-02335

WORK PLANS
FOR
LONG TERM MONITORING
AND
NATURAL ATTENUATION MONITORING

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Submission Date:

JULY 1999

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

PREFACE

These plans document the objectives and actions required to comply with the monitoring of Installation Restoration (IR) sites located throughout Marine Corps Base (MCB), Camp Lejeune, North Carolina. Sites are grouped into 18 operable units (OU). Sites for which monitoring has been proposed are presented in Figure P-1.

Monitoring sites fall into two categories: Long Term Monitoring (LTM) sites and Natural Attenuation (NA) Monitoring sites. LTM sites include: OU 1 (Site 78); OU 2 (Sites 6 and 82); OU 3 (Site 21); OU 5 (Site 2); OU 7 (Sites 1 and 28); and OU 12 (Site 3). NA Monitoring Sites include: OU 6 (Sites 36, 54, and 86); OU 10 (Site 35); OU 14 (Site 69); OU 15 (Site 88); and OU 16 (Sites 89 and 93).

In the case of LTM sites, the Department of the Navy (DoN) Naval Facilities Engineering Command, Atlantic Division; MCB, Camp Lejeune; USEPA Region IV (USEPA); and the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) have agreed upon the selected remedial alternative for each site, as stipulated in Records of Decision (RODs) for each OU. The RODs provide specifications to perform the environmental sampling portion of the LTM initiative, including sampling frequency, sample locations, sample collection methods, and analytical requirements. The Work Plans (WPs) for LTM sites provide a general description of each OU, a brief review of the original RODs, a chronology of approved changes to the monitoring program that have occurred since the ROD's acceptance, and a detailed outline of activities that are currently being implemented under the monitoring program.

In the case of NA Monitoring sites, RODs are forthcoming. Based on the nature of contamination revealed by data from past investigations, these sites are candidates for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Monitoring at these sites is being implemented to provide additional data necessary to support NA as a remedial alternative. The Work Plans for NA sites provide a general description of each OU, describe the original monitoring program and any amendments implemented since its inception, and outline upcoming activities to be implemented under the monitoring program.

The plans provided in this document will be subject to revision during the period of performance, prior to five year regulatory review. All approved and recommend additions and modifications to the monitoring program at MCB, Camp Lejeune, will be presented in detail in monitoring reports for each OU.

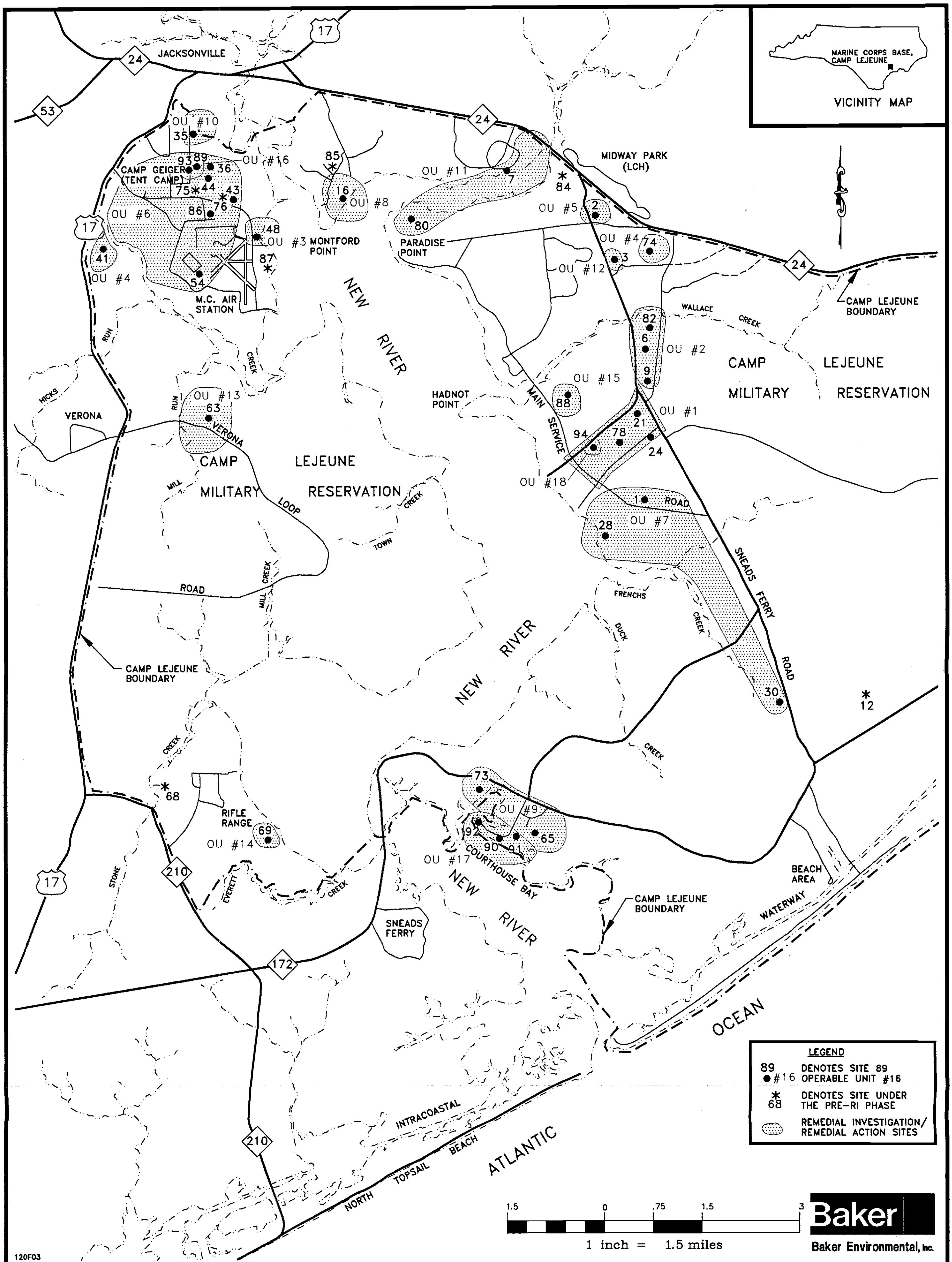


FIGURE P-1

OPERABLE UNIT AND SITE LOCATION MAP
LONG TERM AND NATURAL ATTENUATION MONITORING WORK PLAN

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02335 II 01Z

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 1 (SITE 78)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

The Record of Decision (ROD) for Operable Unit (OU) No. 1 (Sites 21, 24, and 78), Marine Corps Base (MCB), Camp Lejeune, North Carolina, was formulated in response to findings of previous investigations, and was signed on September 15, 1994. The ROD outlines remedial actions to be implemented at OU 1. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this work plan is to address the continuation of those monitoring activities at OU 1, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first provides a general description of the investigative area, including its location and history of operation. The second is a brief review of the original ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities that are currently being implemented and are planned to continue under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 1

The study area, OU 1, is one of 18 operable units within MCB, Camp Lejeune. OU 1 is in the midst of an industrial area at Hadnot Point. It covers an area of approximately 690 acres. OU 1 is located approximately one mile east of the New River and two miles south of State Route 24 (Figure P-1). The operable unit is bordered by Holcomb Boulevard to the northwest, Sneads Ferry Road to the northeast, Main Service Road to the southwest, and woodlands and Cogdels Creek to the southeast.

2.1.1 Site 21

Site 21, which is identified as Transformer Storage Lot 140, is located within the northwest section of Site 78. The site has had a history of pesticide usage and reported transformer oil disposal. One portion of the site was used as a pesticide mixing area and as a cleaning area for pesticide application equipment from 1958 to 1977. This area, the Former Pesticide Mixing/Disposal Area, appears to be located throughout the southern portion of the site.

2.1.2 Site 24

Site 24, which is referred to as the Industrial Fly Ash Dump, is located adjacent to the southeast portion of Site 78. The site was used for the disposal of fly ash, cinders, solvent, used paint stripping compounds, sewage sludge, and water treatment spiractor sludge from the later 1940s to 1980. Spiractor sludge from the wastewater treatment plant and sewage sludge from the sewage treatment plant were reportedly disposed at the site in the 1960s. During 1972 to 1979, fly ash and cinders were dumped on the ground surface, and solvents used to clean out the boilers were poured onto these piles. Furniture stripping wastes were also reported to be disposed in this area. Additionally, there are two buried metal areas within Site 24.

2.1.3 Site 78

Site 78, which is referred to as the Hadnot Point Industrial Area (HPIA) is located adjacent to the northwest portion of Site 24 and houses the industrial area of MCB, Camp Lejeune. The HPIA was the first developed area at MCB, Camp Lejeune. It was comprised of approximately 75 buildings and facilities including maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, and storage yards. Due to the industrial nature of the site, many spills and leaks have consisted of petroleum-related products and solvents from underground storage tanks (USTs), drums, and uncontained waste storage areas.

2.2 Record of Decision for Operable Unit No. 1

This section indicates previous investigations at OU 1 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Sites 21, 24, and 78 were approved by representatives of the following:

- Naval Facilities Engineering Command, Atlantic Division
- Marine Corps Base Camp Lejeune
- U.S. Environmental Protection Agency - Region IV
- North Carolina Department of Environment, Health, and Natural Resources

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the recommended remedial actions. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 1 began in 1983 with an Initial Assessment Study. Additional documents that are relevant to the accepted remedial alternatives for Sites 21, 24, and 78 include the following:

- Confirmation Studies, 1984-87
- Site Summary Report, 1990
- Groundwater Study at Hadnot Point Fuel Farm
- Remedial Investigation for Shallow Soils and Castle Hayne Aquifer, 1991
- Interim Remedial Action Remedial Investigation and Feasibility Study, 1992
- Corrective Action Plan, February 1994
- Final Remedial Investigation Report, June 1994
- Final Feasibility Study, July 1994
- Final Proposed Remedial Action Plan, July 1994
- Final Record of Decision, September 1994

Pertinent findings are summarized in the Final ROD for OU 1. As documented in the ROD, several areas of concern (AOC) were identified within OU 1:

- VOC-contaminated plume located near the 900-Series Building area within Site 78 (referred to as Groundwater AOC1).
- Three small areas of groundwater contamination (PCE only) located throughout Site 78 (Groundwater AOCs 2,3, and 8).
- A feul-contaminanted plume located near the Hadnot Point Fuel Farm (Groundwater AOC 3).
- A VOC-contaminated plume located near the 1600 and 1700 Series Building area of Site 78 (Groundwater AOC 5).
- Two areas of groundwater contamination located within Site 24 (heptachlor epoxide only) (Groundwater AOCs 6 and 7).
- Northern portion of Site 21 with elevated levels of PCBs in soil (Soil AOC 1).
- Southwest portion of Site 21 with elevated PCB concentrations in surface soil (Soil AOC 2).
- Southwest portion of Site 21 with elevated pesticide concentrations in surface soil (Soil AOC 3).
- Northeastern edge of Building 1502 within Site 78 with elevated levels of pesticides in surface soil (Soil AOC 4).

2.2.2 Selected Remedial Actions

This section describes the Selected Remedial Actions as originally outlined in the accepted ROD. The primary objective of the remedial action at OU 1 is to contain the migration of two shallow groundwater plumes located within Site 78 (AOCs 1 and 5). The Selected Remedial Action for OU 1, as provided in the ROD, included source control of groundwater through an interim action pump and treat system, institutional controls, off-site treatment/disposal of contaminated soil from all Soil AOCs, and a long term groundwater monitoring program.

Institutional controls under the interim action included placing aquifer-use restrictions on the shallow aquifer, deed restrictions on the placement of additional water supply wells within OU 1, and keeping closed water supply wells out of service.

The long term monitoring program, as originally described in the ROD, consisted of the sampling of 20 monitoring wells for Volatile Organic Compounds (VOCs) and total metals on a quarterly basis. The monitoring wells sampled included 16 shallow monitoring wells, two intermediate monitoring wells, and two deep monitoring wells located within Site 78. Additionally, five shallow monitoring wells (within Sites 78 and 24), two active water supply wells, and six inactive water supply wells were sampled semi-annually for Target Compound List (TCL) VOCs, Target Analyte List (TAL) metals, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS). Water supply wells are located within or in the vicinity of Site 78. No monitoring wells are located within Site 21.

No additional remedial actions, other than long term monitoring, were performed for Groundwater AOCs 2, 4, 6, 7, and 8 based on low contaminant concentrations and no apparent sources in these areas. A fuel recovery system is not being implemented at groundwater AOC 3. Groundwater treatment is currently operating at this site under the UST Program. Long term groundwater monitoring will continue until remediation levels have been obtained. The remediation levels for the groundwater contaminants of concern (identified in the ROD) are listed in Table 1.

Remedies provided within the ROD for OU 1 are permanent, long term solutions because groundwater contaminants at this OU are either being actively treated or permitted to naturally degrade. Periodic sampling is a reliable means of monitoring contaminant persistence and migration.

2.3 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Sites 24 and 78 that have been implemented since the signing of the ROD. These modifications are presented in detail in the Monitoring Reports for OU 1. All future recommendations to modify the monitoring program for OU 1 will also be presented in the monitoring reports.

2.3.1 Third Quarter 1996 – Start of LTM Program

The LTM Program at Sites 24 and 78 began in the third quarter (July) of 1996 and was to continue on a quarterly basis. Groundwater samples were collected from three monitoring wells at Site 24 (24-GW08, 24-GW09, and 24-GW10) and were analyzed for TCL VOCs, TAL Metals, Oil and Grease, TDS, and TSS. Groundwater samples from 23 monitoring wells and five recovery wells at Site 78 were collected and analyzed for these same parameters (TCL VOCs, TAL Metals, Oil and Grease, TDS, and TSS). Recovery wells at Site 78 are RW-1, RW-2, RW-3, RW-4, and RW-9. Monitoring wells at Site 78 include 18 shallow wells, two intermediate wells, and three deep wells, listed below:

Shallow Wells (18):		Intermediate Wells (2):	Deep Wells (3):
78-GW01	78-GW17-1	78-GW09-2	78-GW09-3
78-GW04-1	78-GW19	78-GW24-2	78-GW24-3
78-GW05	78-GW21		78-GW31-3
78-GW08	78-GW22		
78-GW09-1	78-GW22-1		
78-GW10	78-GW23		
78-GW11	78-GW24-1		
78-GW14	78-GW25		
78-GW15	78-GW39		

2.3.2 Fourth Quarter 1996

No changes occurred during this quarter.

2.3.3 First Quarter 1997

Site 24 Sample Analyses

Target Compound List Pesticide analyses were added to the sampling program at Site 24. Groundwater samples from both monitoring and water supply wells at OU 1 had been collected quarterly and analyzed for VOCs, total metals, TSD and TSS. The contaminant of concern in groundwater at Site 24, however, was identified during the Remedial Investigation (RI) as heptachlor epoxide. This pesticide was detected in groundwater samples collected from shallow monitoring wells 24-GW08, 24-GW09, and 24-GW10. These same wells were identified in the ROD for inclusion in the monitoring program at OU 1. Heptachlor epoxide was detected in each of the three wells at concentrations exceeding the North Carolina Water Quality Standards (NCWQS) of 0.004 micrograms per liter (µg/L), but less than the Federal Maximum Contaminant Level (MCL) of 0.2 µg/L. Until it can be determined that pesticides are no longer a concern at this site, samples will be obtained from monitoring wells 24-GW08, 24-GW09, and 24-GW10 and submitted for pesticide analyses.

Site 78 Sample Analyses

Oil and grease analyses were removed from the sampling program at Site 78. The ROD stipulates only that samples be collected and analyzed for VOCs, total metals, TDS, and TSS. Oil and grease analyses were added to the monitoring program in response to engineering requirements of the groundwater treatment system. However, only treatment plant influent and effluent need be submitted for oil and grease analyses as an indictor of oil and water separator efficiency. In addition, concentrations of oil and grease compounds have not been detected among any samples collected during the most recent sampling events. Analytical results from previous monitoring events at Site 78 suggest that oil and grease compounds have been detected infrequently and at concentrations less than 15 mg/L. Based upon this information, groundwater samples were no longer submitted for oil and grease analyses.

Total metal, TDS, and TSS analyses were also eliminated from the sampling program. Although positive detections of metals and TDS had been greater than applicable NCWQS, these analyses are not required to determine or monitor VOC contaminant migration. In addition, there is no history or evidence to suggest that metal disposal activities may have occurred at Site 78. The sediments of North Carolina's coastal plain are naturally rich in metals, particularly iron and manganese. It is not uncommon to detect total metal concentrations in groundwater at MCB, Camp Lejeune that are greater than the applicable water quality standards.

Sampling Inactive Recovery Wells

Recovery wells RW-1 through RW-4, and RW-9 were removed from the sampling program at Site 78. These wells were deactivated as a result of low influent contaminant concentrations and were not actively extracting groundwater for treatment. Sampling results obtained since the inception of the monitoring program activities at Site 78 had suggested that little to no contamination had been present within samples obtained from these recovery wells. Additionally, samples collected from the recovery wells via the low-flow sampling method were suspected of not accurately reflecting true contaminant concentrations in the groundwater as this method does not remove a sufficient volume of groundwater at the minimum required flow rate from the larger diameter recovery wells.

Sampling Select Monitoring Wells

Monitoring well 78-GW22-1 was removed from the sampling program. This well was located within the former fuel farm area and petroleum-related contaminants were consistently detected at concentrations exceeding applicable water quality standards. The former fuel farm is being addressed as part of the Underground Storage Tank (UST) Program at MCB, Camp Lejeune and an active product recovery system is in operation within 250 feet of monitoring well 78-GW22-1.

Monitoring wells 78-GW05 and 78-GW19 were removed from the monitoring program. These two wells are situated adjacent to other unrelated areas of concern. Monitoring well 78-GW05 is located within 200 feet of Installation Restoration (IR) Site 94 and well 78-GW19 is situated near a UST site associated with Building 1115. Samples collected from both monitoring wells had exhibited concentrations of organic compounds below 2 µg/L. Site 94 and the former UST at Building 1115, however, were being or were planned to be addressed under separate investigations. Therefore, groundwater samples from wells 78-GW05 and 78-GW19 were removed from the monitoring program at Site 78.

Deep monitoring well 78-GW31-3 was also removed from the sampling program at Site 78. Samples that had been obtained from this well had exhibited little to no contamination during the previous six monitoring events. Toluene was the only organic compound detected among the samples obtained from 78-GW31-3. During the second quarter of 1996, toluene was detected at a concentration of 1.1 µg/L. The NCWQS for toluene is 1,000 µg/L.

Shallow Monitoring Well Abandonment

Monitoring well 78-GW22-1 was abandoned according to accepted procedures. Recorded field observations suggested that this shallow monitoring well had begun to deteriorate or was poorly constructed during the 1986 Confirmation Study. Soil particles from the surrounding undifferentiated formation were entering the well, most likely bypassing the screen and sandpack. Sediments, as a result, were introduced into groundwater samples obtained from 78-GW22-1, and may have biased total metal analytical results. Additionally, this well was located within an area being addressed as part of the UST Program at MCB, Camp Lejeune. Several monitoring wells are located within close proximity of well 78-GW22-1.

2.3.4 Second Quarter 1997

No changes occurred during this quarter.

2.3.5 Third and Fourth Quarters 1997

Sampling Frequency Modified

The frequency of sampling at OU 1 was reduced from quarterly to semi-annually. Groundwater samples obtained from Site 78 during previous sampling periods had exhibited similar concentrations of the same VOCs. In fact, several laboratory results had remained nearly constant throughout the monitoring program. Although groundwater continues to be actively extracted and treated, none of the groundwater recovery wells have monitoring wells within their expected capture zones. Without means to monitor the progress of active treatment systems, groundwater samples currently being obtained served only to confirm the presence of site contaminants. Based upon this information, a reduction in the number of yearly sampling events from four to two was implemented. Semi-annual sampling will sufficiently monitor site contaminants in groundwater at Site 78, given current treatment system components.

Horizontal Extent of Contamination Further Defined

A network of 23 temporary monitoring wells within the northern and southern contaminant plume areas were installed and sampled during this quarter. Three monitoring wells installed as part of an unrelated UST investigation were also employed to better define the horizontal extent of the two suspected groundwater contaminant plumes. The additional sampling data acquired from a supplemental investigation will aid in the placement of future recovery wells.

2.3.6 First and Second Quarters 1998

Site 24 Groundwater Sampling Discontinued

Site 24 was eliminated from the OU 1 monitoring program as of July 1998. Although a few total metal detections exceeded applicable NCWQS, the metal analyses were not necessary to determine the presence of heptachlor epoxide; the contaminant of concern identified in the ROD. In addition, VOCs were not detected during any of the four monitoring events. Analytical results from soil samples collected throughout Site 24 during the Remedial Investigation (RI) confirmed the presence of pesticides. The pesticides among soil samples were detected at concentrations reflective of their base-wide application and use. In general, pesticides have a tendency to adhere to soil material. Suspended soil particles, or colloids, in the groundwater samples from Site 24 were likely to have been the cause of the detected pesticide contaminant during the 1993 RI. A low-flow purge method was used during more recent sample collection activities to reduce the amount of suspended material in samples and more accurately reflect true aquifer conditions. As a result, the lack of groundwater pesticide contamination at Site 24 was confirmed by four consecutive sampling events.

Horizontal Extent of Contamination Further Defined

Based upon the results of the previous quarter's supplemental investigation, three permanent and three temporary monitoring wells were installed in January of 1998. Permanent shallow wells 78-GW40, 78-GW41, and 78-GW42 were installed to provide groundwater monitoring points within the plume areas. The additional sampling data acquired from the supplemental investigation will aid in the placement of future recovery wells.

2.3.7 Third and Fourth Quarters 1998

Four additional recovery wells, supplementing the eleven already existing recovery wells (RW-1 through RW-11) were installed as part of the selected remedy for OU 1. Recovery wells will not be sampled as part of the groundwater monitoring program. However, with the exception of RW-14, recovery wells were installed near existing monitoring wells that can be employed to roughly determine the capture zone (i.e., radius of influence) of the recovery well and monitor contaminant concentrations as treatment activities continue.

2.3.8 First and Second Quarters 1999

No changes occurred during this quarter.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 1, Site 78. As presented in the ROD, Site 21 does not require any further monitoring or remedial activities. Subsequent to the signing of the ROD, Site 24 was removed from the monitoring program as per approved additions and modifications documented in Monitoring Reports for OU 1. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Groundwater samples will be collected semi-annually from 18 shallow monitoring wells, two intermediate wells, and two deep wells. All groundwater samples will be analyzed for VOCs. Shallow monitoring wells 78-GW21, 78-GW22A, 78-GW23, 78-GW24-1, 78-GW25, 78-GW40, and 78-GW41 are located within the northern portion of the study area. Deep monitoring well 78-GW24-3 and intermediate monitoring well 78-GW24-2 are also located within the northern portion of Site 78. Shallow monitoring wells 78-GW14, 78-GW15, and 78-GW17-1 are located within the central portion of the study area. Shallow monitoring wells 78-GW01, 78-GW04-1, 78-GW08, 78-GW09-1, 78-GW10, 78-GW11, and 78-GW42 are located within the southern portion of the study area. Deep monitoring well 78-GW09-3 and intermediate monitoring well 78-GW09-2 are also located within the southern portion of Site 78. An additional shallow monitoring well, 78-GW39, is located south of the Site 78. The shallow and intermediate wells will be employed to monitor conditions within the surficial aquifer. Samples obtained from the two deep monitoring wells will be representative of conditions within the deeper, Castle Hayne, aquifer.

Table 2 provides construction details for each of the monitoring wells included in the monitoring program, while Table 3 provides the sampling and analysis program for groundwater samples obtained at Site 78. The locations of monitoring wells throughout Site 78 are depicted in Figure 1. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 78.

3.2 Sample Designations

In order to identify and accurately track the various samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, site, sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e. Installation Restoration Program)
Site Number	Monitoring activities will be conducted at Site 78.
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number.
QA/QC	TB = Trip Blank
Year	The number will reference the calendar year the sample was obtained (e.g., 00 would represent 2000).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR78-GW09DW-99A refers to:

IR78-GW09DW-99A	Installation Restoration
IR78-GW09DW-99A	Site 78
IR78-GW09DW-99A	Groundwater sample
IR78-GW09DW-99A	Monitoring well number 09
IR78-GW09DW-99A	Deep monitoring well
IR78-GW09DW-99A	Year 1999
IR78-GW09DW-99A	First quarter

Under this sample designation format the sample number IR78-TB01-00A refers to:

IR78-TB01-00A	Installation Restoration
IR78-TB01-00A	Site 78
IR78-TB01-00A	Trip Blank
IR78-TB01-00A	Sequential number, in order of collection. The total number will depend upon how many trip blanks are required.
IR78-TB01-00A	Year 2000
IR78-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 78. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged into the groundwater treatment plant at Site 78.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for volatile organic analysis (VOCs) will be collected first, followed by metals. Sample containers will be labeled and referenced on a laboratory chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 3 defines the sampling and analysis program for the groundwater monitoring wells at Site 78.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for volatile analyses.

Equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Record of Decision, Operable Unit No. 1 (Sites 21, 24, and 78) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. September 1994.

Baker Environmental, Inc. Quarterly Monitoring Reports, Unit No. 1 (Sites 24 and 78) for MCB Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. Ongoing submittals starting in November 1996.

TABLES

TABLE 1

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN IN GROUNDWATER
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 1 – SITE 78
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Remediation Goal (1) (µg/L)
Benzene	1.0
1,2-Dichloroethene (total)	70
Ethylbenzene	29
Heptachlor Epoxide	0.2
Tetrachloroethene	0.7
Toluene	1,000
Trichloroethene	2.8
Vinyl Chloride	0.015
Xylenes (total)	400
Arsenic	50
Barium	1,000
Beryllium	4
Chromium	50
Manganese	50
Vanadium	110

(1) Baker Environmental, Inc. (1994) Final Record of Decision For Operable Unit No. 1 (Sites 21, 24, and 78)

µg/L = microgram per liter

TABLE 2

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 1 - SITE 78
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)	Stick-Up (feet, ags)
78-GW01	1986	NA	NA	27.0	25.0	5.0-25.0	3.0	2.0	1.80
78-GW04-1	1986	31.63	28.90	27.0	24.5	4.5-24.5	3.0	2.0	2.60
78-GW08	1986	28.72	26.30	27.0	25.0	5.0-25.0	3.0	2.0	3.12
78-GW09-1	1987	NA	NA	27.0	25.0	5.0-25.0	3.0	2.0	2.35
78-GW09-2	1987	27.60	25.40	152	150	130-150	105	100	1.92
78-GW09-3	1986	26.97	24.70	152	150	130-150	105	10.0	2.25
78-GW10	1986	28.13	25.70	27.0	25.0	5.0-25.0	3.0	2.0	2.22
78-GW11	1986	28.22	25.50	25.5	25.0	5.0-25.0	3.0	2.0	2.49
78-GW14	1986	27.32	25.00	25.5	25.0	5.0-25.0	3.0	2.0	1.92
78-GW15	1986	27.03	26.80	25.5	25.0	5.0-25.0	3.0	2.0	0.08
78-GW17-1	1986	30.00	27.50	25.5	25.0	5.0-25.0	3.0	2.0	2.16
78-GW21	1986	33.51	31.20	25.0	25.0	5.0-25.0	3.0	2.0	NA
78-GW22A	1986	32.36	30.40	25.0	25.0	5.0-25.0	3.0	2.0	NA
78-GW23	1986	32.08	30.00	25.5	25.0	5.0-25.0	3.0	2.0	1.82
78-GW24-1	1986	32.84	30.50	25.5	25.0	5.0-25.0	3.0	2.0	1.55
78-GW24-2	1987	33.73	30.40	80.0	76.6	56.6-76.6	51.6	48.6	2.88
78-GW24-3	1987	32.32	30.50	155	148	128-148	90.0	84.0	2.24
78-GW25	1986	32.58	30.10	25.5	25.0	5.0-25.0	5.0	3.0	2.17
78-GW39	1993	19.44	16.80	20.0	20.0	10.0-20.0	8.0	6.0	19.44
78-GW40	1998	NA	NA	24.6	24.6	4.4-24.0	3.0	1.5	2.0
78-GW41	1998	NA	NA	24.5	24.0	4.5-23.8	3.0	1.5	0.0
78-GW42	1998	NA	NA	24.0	23.0	3.9-23.2	3.0	1.5	0.0

Notes:

ags = Above ground surface

bgs = Below ground surface

msl = Mean sea level

NA = Information not available

TABLE 3

SAMPLE SUMMARY
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 1 - SITE 78
MCB, CAMP LEJEUNE, NORTH CAROLINA

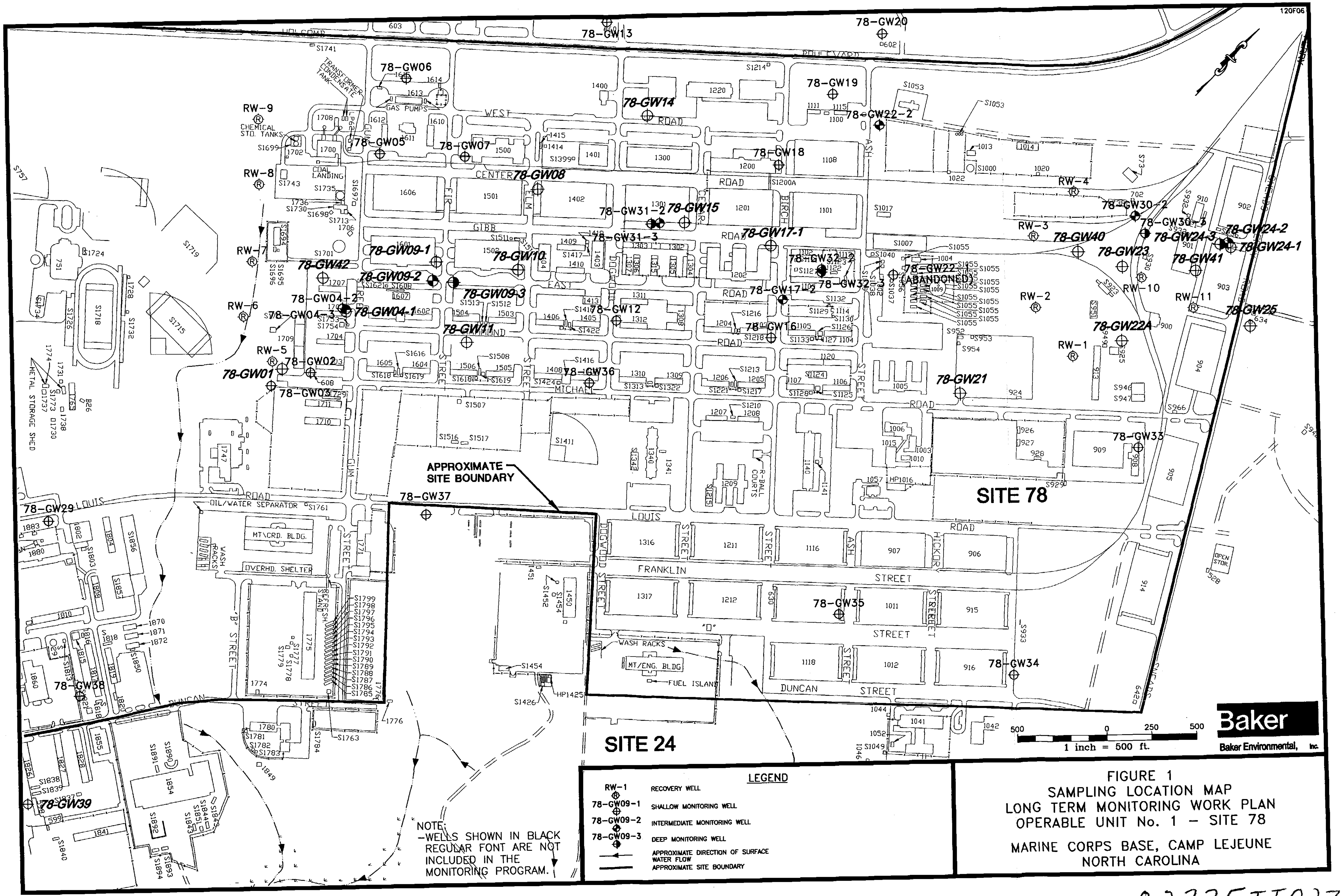
Location	Media	TCL Volatiles(1)	Sample Designations
78-GW01	GW	X	IR78-GW01-**
78-GW04-1	GW	X	IR78-GW04-**
78-GW08	GW	X	IR78-GW08-**
78-GW09-1	GW	X	IR78-GW09-**
78-GW09-2	GW	X	IR78-GW09IW-**
78-GW09-3	GW	X	IR78-GW09DW-**
78-GW10	GW	X	IR78-GW10-**
78-GW11	GW	X	IR78-GW11-**
78-GW14	GW	X	IR78-GW14-**
78-GW15	GW	X	IR78-GW15-**
78-GW17-1	GW	X	IR78-GW19-**
78-GW21	GW	X	IR78-GW21-**
78-GW22	GW	X	IR78-GW22A-**
78-GW23	GW	X	IR78-GW23-**
78-GW24-1	GW	X	IR78-GW24-**
78-GW24-2	GW	X	IR78-GW24IW-**
78-GW24-3	GW	X	IR78-GW24DW-**
78-GW25	GW	X	IR78-GW25-**
78-GW39	GW	X	IR78-GW39-**
78-GW40	GW	X	IR78-GW40-**
78-GW41	GW	X	IR78-GW41-**
78-GW42	GW	X	IR78-GW42-**

Notes:

(1) Target Compound List Volatile Organic Compounds

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which groundwater sample is obtained.

FIGURES



LEGEND

RW-1	RECOVERY WELL
78-GW09-1	SHALLOW MONITORING WELL
78-GW09-2	INTERMEDIATE MONITORING WELL
78-GW09-3	DEEP MONITORING WELL
→	APPROXIMATE DIRECTION OF SURFACE WATER FLOW
—	APPROXIMATE SITE BOUNDARY

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

FIGURE 1
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 1 - SITE 78

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 2 (SITES 6 AND 82)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

The Record of Decision (ROD) for Operable Unit (OU) No. 2 (Sites 6, 9, and 82), Marine Corps Base (MCB), Camp Lejeune, North Carolina, was formulated in response to findings of previous investigations, and was signed on September 24, 1993. The ROD outlines remedial actions to be implemented at OU 2. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this work plan is to address the continuation of those monitoring activities at OU 2, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first provides a general description of the investigative area, including its location and past history of operation. The second is a brief review of the original ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities that are currently being implemented and are planned to continue under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 2

The study area, OU 2, is one of 18 operable units within MCB, Camp Lejeune. OU 2 consists of three Sites: 6, 9, and 82. It is located approximately two miles east of the New River and two miles south of State Route 24 (Figure P-1). It is bordered to the north by Wallace Creek, to the west by Holcomb Boulevard, to the east by Piney Green Road, and to the south by Sneads Ferry Road.

2.1.1 Site 6

Site 6 is comprised of two open storage lots, a ravine, and the wooded areas that surround the storage lots. Open Storage Lot 201 is a fenced lot located in the south-central portion of Site 6. This lot is currently used to store military equipment and vehicles, lumber, hydraulic oils and lubricants, non-polychlorinated biphenyls (PCB) transformers, and other supplies. Open Storage Lot 203 is a fenced lot situated in the northern portion of Site 6, bordering Site 82 to the south. Storage Lot 203 is no longer used as an active storage area.

Site 6 has a history of various uses, including the disposal and storage of wastes and supplies. Pesticides have reportedly been stored in the northeast and southeast portions of Lot 201. Transformers containing PCBs were reportedly stored in the southwest portion of Lot 201. Open Storage Lot 203 previously served as a waste disposal and storage area from as early as the 1940s to the late 1980s. Reports detailing disposal activities within Lot 203 are vague; there is little indication as to the types and quantities of material disposed of throughout the lot, with the exception of pesticides. Pesticides were reported to have been stored in a trailer on Lot 203 as well as in the southeast portion of the lot. Former employees at Lot 203 have reported disposal of various chemicals including PCBs, cleaning solvents, electrolytes from used batteries, and waste oils.

2.1.2 Site 9

Site 9, the Fire Fighting Training Pit at Piney Green Road, is bounded by Holcomb Boulevard on the west, Bear Head Creek approximately 500 feet to the north, Piney Green Road on the east, Sneads Ferry Road on the south, and Site 6 to the north. Site 9 consists of an asphalt-lined fire training pit, an oil/water separator, four aboveground storage tanks (ASTs), three propane tanks, and a fire tower (smoke house). Site 9 has been used for fire fighting training exercises from the early 1960s to the present. Until 1981, training exercises were conducted in an unlined pit. The pit is currently asphalt lined. Flammable liquids including used oil, solvents, and contaminated fuels (unleaded) were used as accelerants during training exercises. Approximately 30,000 to 40,000 gallons of JP-4 and JP-5 fuels were also burned in the fire training pit.

2.1.3 Site 82

Site 82, the Piney Green Road Volatile Organic Compound (VOC) Site, is located directly north and adjacent to Site 6. The site is predominantly covered by woodlands and is randomly littered with debris such as communication wire, spent ammunition casings, and empty or rusted drums. No organized operations are documented for Site 82. It appears that the site area was used for disposal of miscellaneous debris from Lot 203, since similar items were identified at both sites.

2.2 Record of Decision for Operable Unit No. 2

This section indicates previous investigations at OU 2 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Sites 6, 9, and 82 were approved of by representative of the following:

- Naval Facilities Engineering Command, Atlantic Division (LANTDIV)
- Marine Corps Base Camp Lejeune, North Carolina
- U.S. Environmental Protection Agency (USEPA) - Region IV
- North Carolina Department of Environment and Natural Resources (NC DENR)

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the selected remedial alternatives. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 2 began in 1983 with an Initial Assessment Study. Additional documents that are relevant to the accepted remedial alternatives for Sites 6, 9, and 82 include the following:

- Confirmation Study - 1984-87
- Site Summary Report - 1990
- Soil Gas Survey at Lot 203 - February, 1989
- Site Assessment Report for Site 6 - March 1992

- Final Remedial Investigation Report - August, 1993
- Final Feasibility Study - August, 1993
- Final Proposed Remedial Action Plan - August, 1993

Pertinent findings are summarized in the Final ROD for OU 2. As a result of the various environmental investigations at OU 2, several areas of concern (AOCs) were identified as follows:

- VOC-contaminated groundwater plume (shallow and deep) originating from Site 82

- Four small areas of groundwater contamination south and west of Open Storage Lot 203

- Source of groundwater VOC contamination at Site 82 ("Soil AOC1")

- Upper portion of the ravine at Site 6 with elevated levels of polyaromatic hydrocarbons (PAHs), PCBs, and metals in soil and sediment (Soil AOC2). This may be a source of contamination to Wallace Creek

- Northcentral portion of Lot 203 with elevated levels of PCBs in soil (Soil AOC3).

- Northwestern portion of Lot 203 with elevated levels of PCBs in soil (Soil AOC4).

- Northeastern corner of Lot 201 with elevated levels of pesticides in soil (Soil AOC5).

- Wooded area east of Lot 201 and adjacent to Piney Green Road with elevated levels of PCBs in soil (Soil AOC6)

No AOCs were identified within Site 9.

Various drums, containers, and ASTs were noted throughout Sites 6 and 82. All surficial drums/containers and known buried drums were to be removed from OU 2 through a Time Critical Removal Action conducted prior to implementing additional remedial actions at OU 2.

2.2.2 Selected Remedial Actions

The primary objectives of the Selected Remedial Actions are: (1) to prevent current or future exposure to the contaminated groundwater and contaminated soils; (2) to remediate groundwater contamination for future potential use of the aquifer; and (3) to treat or remove contaminated soils from designated areas of concern. The selected remedy, as provided in the ROD, was a combination of institutional controls, intensive groundwater extraction and treatment, and on-site treatment and off-site disposal of soil. Because no areas of concern were located within Site 9, the selected remedy for Site 9 involved taking no further remedial action.

An active groundwater remediation system was installed and is currently maintained and operated at Sites 6 and 82. Extracted groundwater is treated for organics and inorganics before being discharged into Wallace Creek. Institutional controls restrict the use of existing water supply wells and the installation of any new water supply wells within OU 2. Soil treatment included in situ treatment of VOC contaminated soils and excavation and off-site disposal of PCB and pesticide contaminated soils.

A long term groundwater monitoring program was implemented to monitor the effectiveness of the groundwater remedy and to monitor the nearby water supply wells that are currently active. Groundwater from 21 existing monitoring wells and three nearby water supply wells were collected on a semi-annual basis and analyzed for Target Compound List (TCL) volatiles. Long term groundwater monitoring is ongoing and will continue until remediation levels have been met. The remediation levels for the groundwater contaminants of concern (identified in the ROD) are listed in Table 1.

The remedy provided within the ROD for OU 2 is a permanent, long term solution because contaminant sources are being removed and groundwater contaminants are being actively treated. Periodic sampling is a reliable means of monitoring contaminant persistence and migration.

2.3 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Sites 6 and 82 that have been implemented since the signing of the ROD. These modifications are presented in detail in the Monitoring Reports for OU 2. All future recommendations to modify the monitoring program for OU 2 will also be presented in the monitoring reports.

2.3.1 Third Quarter 1997 – Start of LTM Program

The LTM Program at Sites 6 and 82 began in the third quarter (July) of 1997. Groundwater samples collected from 28 groundwater monitoring wells were analyzed for VOCs, metals, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS). Monitoring was to continue on a quarterly basis. The following monitoring wells were sampled during the initial monitoring event:

Shallow Monitoring Wells (12):
06-GW01
06-GW03
06-GW16
06-GW17
06-GW21
06-GW28
06-GW30
06-GW32
06-GW33
06-GW34
82-MW02
82-MW03

Deep Monitoring Wells (16):
06-GW01D
06-GW01DA
06-GW01DB
06-GW02D
06-MW03D
06-GW15D
06-GW27DA
06-GW27DW
06-GW28DW
06-GW30DW
06-GW35D
06-GW36D
06-GW37D
06-GW38D
06-GW40DW
06-GW40DWA

2.3.2 Fourth Quarter 1997

The locations of a select number of monitoring wells and all recovery wells were field verified using a global positioning system (GPS). Although only accurate to within roughly a meter, the GPS system was employed to verify that the original survey coordinates were correct. As a result of the field verification, survey coordinates of three suspect monitoring wells were updated. In addition to monitoring and recovery wells, a limited amount of supplemental survey information was also obtained from the site. During the period from 1992 through 1996 several new structures, unimproved roads, utilities, and fences were added to the study area. The GPS system was employed to supplement existing survey information with the significant changes that have occurred.

2.3.3 First Quarter 1998

No changes occurred during this quarter.

2.3.4 Second Quarter 1998

Ten recovery wells were added to the monitoring program for quarterly sampling of VOCs. Shallow recovery wells include 06-SRW01, 06-SRW02, 06-SRW03, 06-SRW04, 06-SRW05, and 06-SRW06. Deep recovery wells include 06-DRW01, 06-DRW02, 06-DRW03, and 06-DRW04. Monitoring well 06-SRW06 is inoperable, but will be sampled once it becomes operable. A permanent sampling port, capable of limiting the flow of groundwater from the pressurized system, was installed at each recovery well so that representative samples can be obtained. Contaminant concentrations detected from recovery wells provide a measure of recovery well efficiency.

2.3.5 Third Quarter 1998

Sample analyses were modified to exclude metal, TSS, and TDS analyses. Although a few select metals and dissolved solids had been detected at concentrations that exceeded either North Carolina Water Quality Standards (NCWQS) or Federal Maximum Contaminant Levels (MCL), the mentioned analyses are not required to monitor the nature, migration, or persistence of VOCs in groundwater.

Based upon analytical data accumulated during four previous sampling initiatives, monitoring wells 06-GW02DW, 06-GW21, 06-GW30DW, and 06-GW40DWA were eliminated from the monitoring program. No VOCs had been detected among samples obtained from these five monitoring wells during three consecutive monitoring events.

Based upon relative locations and total depths, the sampling frequency of nine deep monitoring wells was switched from quarterly to annually. Monitoring wells 06-GW01DA, 06-GW01DB, 06-MW03D, 06-GW15D, 06-GW27DA, 06-GW35D, 06-GW36D, 06-GW38D, and 06-GW40DW are situated either below or adjacent to known groundwater contamination. However, very low concentrations or no VOCs were detected among samples obtained from these wells during the monitoring program. Annually sampling of these wells was to commence during the second quarter of 1999.

Monitoring well 06-GW16, along with two nearby monitoring wells, was abandoned prior to commencement of a construction project between Lots 201 and 203. As indicated in the monitoring reports, groundwater samples obtained from 06-GW16 had exhibited total VOCs at concentrations greater then 1,000 mg/L during previous sampling initiatives. Monitoring well 06-GW17 was destroyed as a result of construction activities. Two additional shallow monitoring wells, 06-GW41 and 06-GW42, were installed to more accurately define the leading edge of the horizontal extent of shallow groundwater contamination in the central portion of Site 82.

2.3.6 Fourth Quarter 1998

The sampling frequency of twelve shallow and four deep monitoring wells was switched from quarterly to semi-annually. These wells are 06-GW01, 06-GW03, 06-GW17, 06-GW28, 06-GW30, 06-GW32, 06-GW33, 06-GW34, 06-GW41, 06-GW42, 82-MW02, 82-MW03, 06-GW01D, 06-GW27DW, 06-GW28DW, and 06-GW37D.

Details regarding these changes will be provided in the next scheduled submittal of the Monitoring Report.

2.3.7 First Quarter 1999

A new shallow monitoring well, 06-GW16, was installed to replace the original well 06-GW16 that had been destroyed during construction activities in mid-1998. This monitoring well will be sampled semi-annually for VOCs.

Details regarding these changes will be provided in the next scheduled submittal of the Monitoring Report.

2.3.8 Second Quarter 1999

No changes occurred during this quarter.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 2, Sites 6 and 82 as of July 1999. As stated above, Site 9 does not require any monitoring or remedial activities. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

All samples collected during the monitoring program at Sites 6 and 82 will be analyzed for volatile organic compounds. Sampling will be staggered such that some wells will be sampled quarterly, some semiannually, and some annually. Ten recovery wells, which are part of the groundwater treatment system, will be sampled quarterly: 06-SRW01, 06-SRW02, 06-SRW03, 06-SRW04, 06-SRW05, 06-SRW06, 06-DRW01, 06-DRW02, 06-DRW03, and 06-DRW04. Figure 1 depicts the location of recovery wells. Twelve shallow and four deep monitoring wells will be sampled semi-annually: 06-GW01, 06-GW01D, 06-GW03, 06-GW16, 06-GW27DW, 06-GW28S, 06-GW28DW, 06-GW30, 06-GW32, 06-GW33, 06-GW34, 06-GW37D, 06-GW41, 06-GW42, 82-MW02, and 82-MW03. Nine deep monitoring wells will be sampled annually: 06-GW01DA, 06-GW01DB, 06-MW03D, 06-GW15D, 06-GW27DA, 06-GW35D, 06-GW36D, 06-GW38D, 06-GW40DW. Monitoring well locations are shown in Figure 2. Shallow wells will be employed to monitor conditions within the uppermost portion of the surficial aquifer. Samples obtained from deep monitoring wells will be representative of conditions within the deeper, Castle Hayne, aquifer.

Table 2 provides available construction details for each of the monitoring wells at OU 2, while Table 3 provides the sampling and analysis program for groundwater samples obtained at Sites 6 and 82. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Sites 6 and 82.

3.2 Sample Designations

In order to identify and accurately track the various samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e. Installation Restoration Program)
Site Number	Monitoring activities will be conducted at Sites 6 and 82.
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a zero (e.g., 06-GW03).
QA/QC	TB = Trip Blank
Year	The number will reference the calendar year in which the sample was obtained (e.g., 00 would represent 2000).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample is collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR06-GW01D-00A refers to:

IR06-GW01D-00A	Installation Restoration Program
IR06-GW01D-00A	Site 6
IR06-GW01D-00A	Groundwater sample
IR06-GW01D-00A	Monitoring well number 01

IR06-GW01D-00A	Deep monitoring well. A "DW" or "DWA" designation may also be employed in the case of more than one deep monitoring well.
IR06-GW01D-00A	Year 2000
IR06-GW01D-00A	First quarter

Under this sample designation format the sample number IR06-TB01-99A refers to:

IR06-TB01-99A	Installation Restoration Program
IR06-TB01-99A	Site 6
IR06-TB01-99A	Trip Blank
IR06-TB01-99A	Sequential number, in order of collection. Trip blanks are included with every shipment to be analyzed for volatile organic compounds. The total number will depend upon how many trip blanks are required.
IR06-TB01-99A	Year 1999
IR06-TB01-99A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Sites 6 and 82. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected for shallow monitoring wells. Deep monitoring wells are expected to have quicker flow rates of 2 to 3 gallons per minute (GPM).

6. Investigative Derived Waste (IDW) (i.e., purge water) will be temporarily containerized and then discharged directly into the on-site groundwater treatment plant currently in operation.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Metric Turbidity units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOC analyses will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 3 defines the sampling and analysis program for the groundwater monitoring wells at Sites 6 and 82.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks. Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for volatile organic compounds. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC analyses.

Equipment rinsates, field blanks, field duplicates, and matrix spike and matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Record of Decision, Operable Unit No. 2 (Sites 6, 9, and 82) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. September 1993.

Baker Environmental, Inc. Monitoring Report, Operable Unit No. 2 (Sites 6, 9, and 82) MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Ongoing submittals starting in July 1996.

TABLES

TABLE 1

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN IN GROUNDWATER
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 2 – SITES 6 AND 82
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Contaminant of Potential Concern	Remediation Goal (1)
Groundwater (μg/L)	1,2-Dichloroethane	0.38
	Trans-1,2-Dichloroethene	70
	Ethylbenzene	29
	Tetrachloroethene	0.7
	Trichloroethene	2.8
	Vinyl Chloride	0.015
	Arsenic	50
	Barium	1,000
	Beryllium	4
	Chromium	50
	Lead	15
	Manganese	50
	Mercury	1.1
	Vanadium	80

(1) Baker Environmental, Inc. (1993) Final Record of Decision For Operable Unit No. 2 (Sites 6, 9, and 82)

μg/L = microgram per liter

TABLE 2

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING PLAN
OPERABLE UNIT NO. 2 - SITES 6 AND 82
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Stick-Up (feet, ags)
06-GW01	10-21-86	35.18	32.7	25.0	25.0	5.0 - 25.0	3.0 - 25.0	2.0 - 3.0	2.48
06-GW01D	11-07-92	35.31	32.8	117.0	112.5	102.7 - 111.7	99.5 - 117.0	96.0 - 99.5	2.51
06-GW01DA	04-03-93	35.23	32.7	230.0	230.0	220.0 - 230.0	215.0 - 230.0	190.0 - 230.0	2.53
06-GW01DB	09-10-93	NA	NA	263.0	262.0	247.0 - 262.0	240.0 - 263.0	234.0 - 240.0	2.50
06-GW03	10-24-86	31.32	28.8	25.5	25.0	5.0 - 25.5	3.0 - 25.5	2.0 - 3.0	2.52
06-MW03D	03-31-93	35.18	34.2	201.5	118.0	97.6 - 117.6	94.0 - 118.0	898.0 - 94.0	0.98
06-GW15D	04-06-93	28.0	25.2	160.0	155.0	145.0 - 155.0	141.0 - 155.0	139.0 - 141.0	2.80
06-GW16	11-07-92	27.63	24.9	20.0	20.0	5.4 - 19.8	3.0 - 20.0	1.6 - 3.0	2.73
06-GW27DW	10-12-92	24.47	22.5	112.0	110.0	100.1 - 109.1	97.0 - 112.0	94.5 - 97.0	1.97
06-GW27DA	08-13-93	NA	NA	236.0	236.0	226.0 - 236.0	224.0 - 236.0	100.0 - 224.0	2.5
06-GW28S	10-10-92	30.20	27.6	32.5	32.0	17.5 - 31.7	15.0 - 32.5	13.3 - 15.0	2.60
06-GW28DW	10-20-92	31.74	28.7	115.0	114.5	104.7 - 113.6	99.0 - 115.0	95.0 - 99.0	3.04
06-GW30	11-07-92	12.60	9.9	21.0	20.0	5.3 - 19.7	3.0 - 21.0	1.5 - 3.0	2.70
06-GW32	04-01-93	21.79	19.6	27.0	27.0	11.0 - 26.0	10.0 - 27.0	7.0 - 10.0	2.19
06-GW33	04-01-93	22.42	20.0	22.0	22.0	6.0 - 21.0	4.5 - 22.0	3.0 - 4.5	2.42
06-GW34	03-05-93	32.01	29.0	36.0	35.0	19.0 - 34.0	17.5 - 35.0	15.0 - 17.5	3.01
06-GW35D	03-07-93	14.29	12.0	201.0	105.0	95.0 - 105.0	90.0 - 105.0	87.0 - 90.0	2.29
06-GW36D	04-01-93	17.61	15.6	201.5	95.0	75.0 - 95.0	66.0 - 95.0	62.0 - 66.0	2.01
06-GW37D	04-01-93	15.96	14.0	111.5	95.0	75.0 - 95.0	73.0 - 95.0	70.0 - 73.0	1.96
06-GW38D	08-28-93	NA	NA	277.0	275.0	255.0 - 275.0	253.0 - 277.0	248.0 - 253.0	2.50
06-GW40DW	12-04-94	NA	NA	250.0	246.0	230.0 - 245.0	225.0 - 250.0	198.0 - 225.0	2.50
06-GW41	11-16-98	NA	NA	23.0	23.0	8.0 - 23.0	6.0 - 23.0	4.0 - 6.0	2.91
06-GW42	11-16-98	NA	NA	32.0	32.0	17.0 - 32.0	15.0 - 32.0	13.0 - 15.0	2.88

TABLE 2 (Continued)

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING PLAN
OPERABLE UNIT NO. 2 - SITES 6 AND 82
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Stick-Up (feet, ags)
82-MW02	06-17-91	6.28	3.71	13.2	13.0	3.0 - 13.0	2.0 - 13.0	2.0 - 1.0	2.57
82-MW03	06-18-91	24.57	21.98	21.5	21.0	11.0 - 21.0	9.0 - 21.5	7.0 - 9.0	2.59

Notes:

ags = above ground surface
bgs = below ground surface
msl = mean sea level
NA = Information not available

TABLE 3

SAMPLING SUMMARY
LONG TERM MONITORING PLAN
OPERABLE UNIT NO. 2 - SITES 6 AND 82
MCB, CAMP LEJEUNE, NORTH CAROLINA

Location	Media	TCL Volatiles[1]	Sample Designation	Sampling Frequency
06-SRW01	Groundwater	X	IR06-SRW01-**	Quarterly
06-DRW01	Groundwater	X	IR06-DRW01-**	
06-SRW02	Groundwater	X	IR06-SRW02-**	
06-DRW02	Groundwater	X	IR06-DRW02-**	
06-SRW03	Groundwater	X	IR06-SRW03-**	
06-DRW03	Groundwater	X	IR06-DRW03-**	
06-SRW04	Groundwater	X	IR06-SRW04-**	
06-DRW04	Groundwater	X	IR06-DRW04-**	
06-SRW05	Groundwater	X	IR06-SRW05-**	
06-SRW06	Groundwater	X	IR06-SRW06-**	
06-GW01	Groundwater	X	IR06-GW01-**	Semiannually
06-GW01D	Groundwater	X	IR06-GW01D-**	
06-GW03	Groundwater	X	IR06-GW03-**	
06-GW16	Groundwater	X	IR06-GW16-**	
06-GW27DW	Groundwater	X	IR06-GW27DW-**	
06-GW28S	Groundwater	X	IR06-GW28S-**	
06-GW28DW	Groundwater	X	IR06-GW28DW-**	
06-GW30	Groundwater	X	IR06-GW30-**	
06-GW32	Groundwater	X	IR06-GW32-**	
06-GW33	Groundwater	X	IR06-GW33-**	
06-GW34	Groundwater	X	IR06-GW34-**	
06-GW37D	Groundwater	X	IR06-GW37D-**	
06-GW41	Groundwater	X	IR06-GW41-**	
06-GW42	Groundwater	X	IR06-GW42-**	
82-MW02	Groundwater	X	IR06-82GW02-**	
82-MW03	Groundwater	X	IR06-82GW03-**	
06-GW01DA	Groundwater	X	IR06-GW01DA-**	Annually
06-GW01DB	Groundwater	X	IR06-GW1DB-**	
06-MW03D	Groundwater	X	IR06-GW03D-**	
06-GW15D	Groundwater	X	IR06-GW15D-**	
06-GW27DA	Groundwater	X	IR06-GW27DA-**	
06-GW35D	Groundwater	X	IR06-GW35D-**	
06-GW36D	Groundwater	X	IR06-GW36D-**	
06-GW38D	Groundwater	X	IR06-GW38D-**	
06-GW40DW	Groundwater	X	IR06-GW40DW-**	

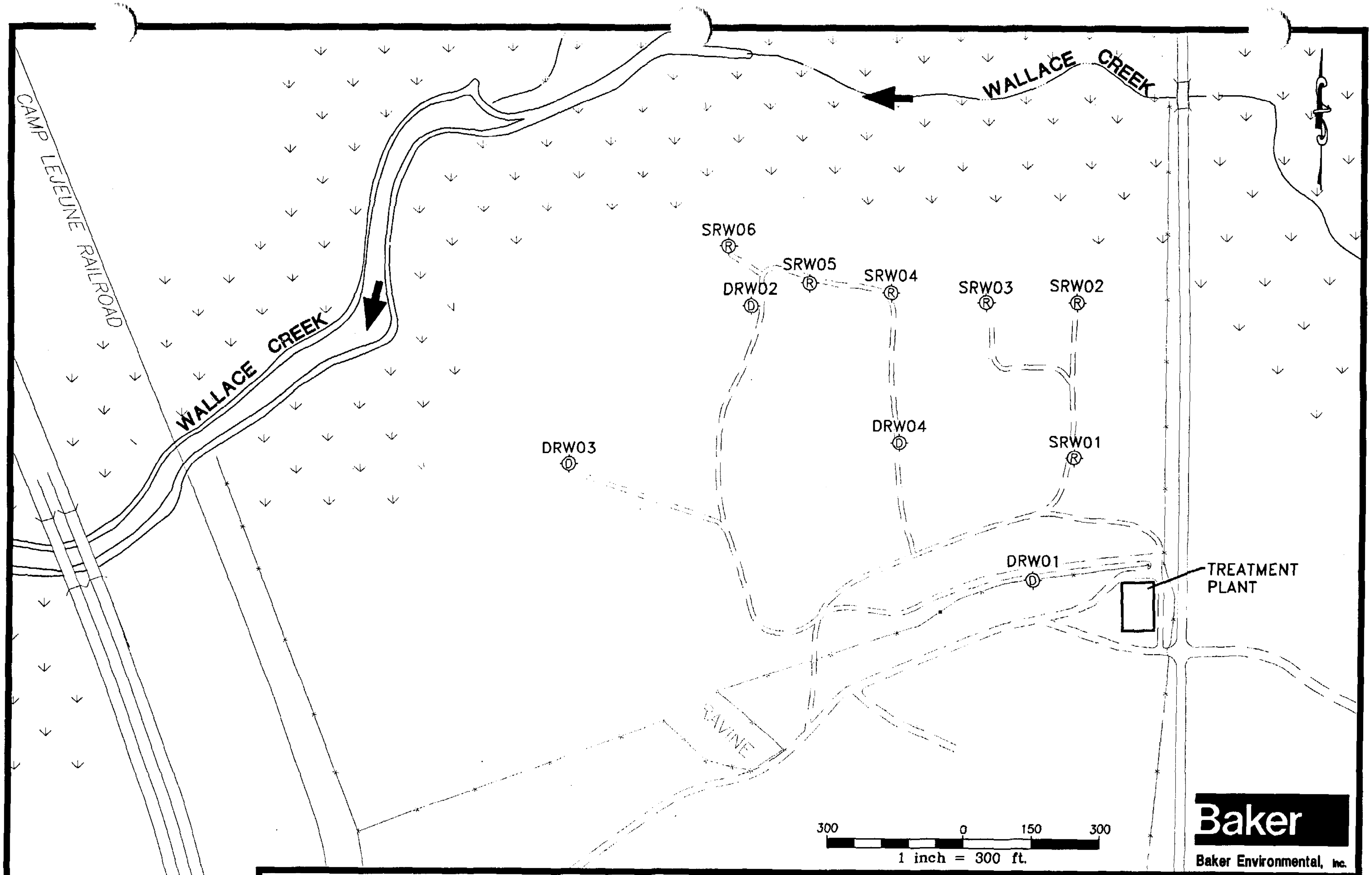
Notes:

[1] Target Compound List Organic Compounds

X = Requested analysis

** = Year (e.g., 00 for 2000) and Quarter (e.g., A for January through March) in which sample is obtained.

FIGURES

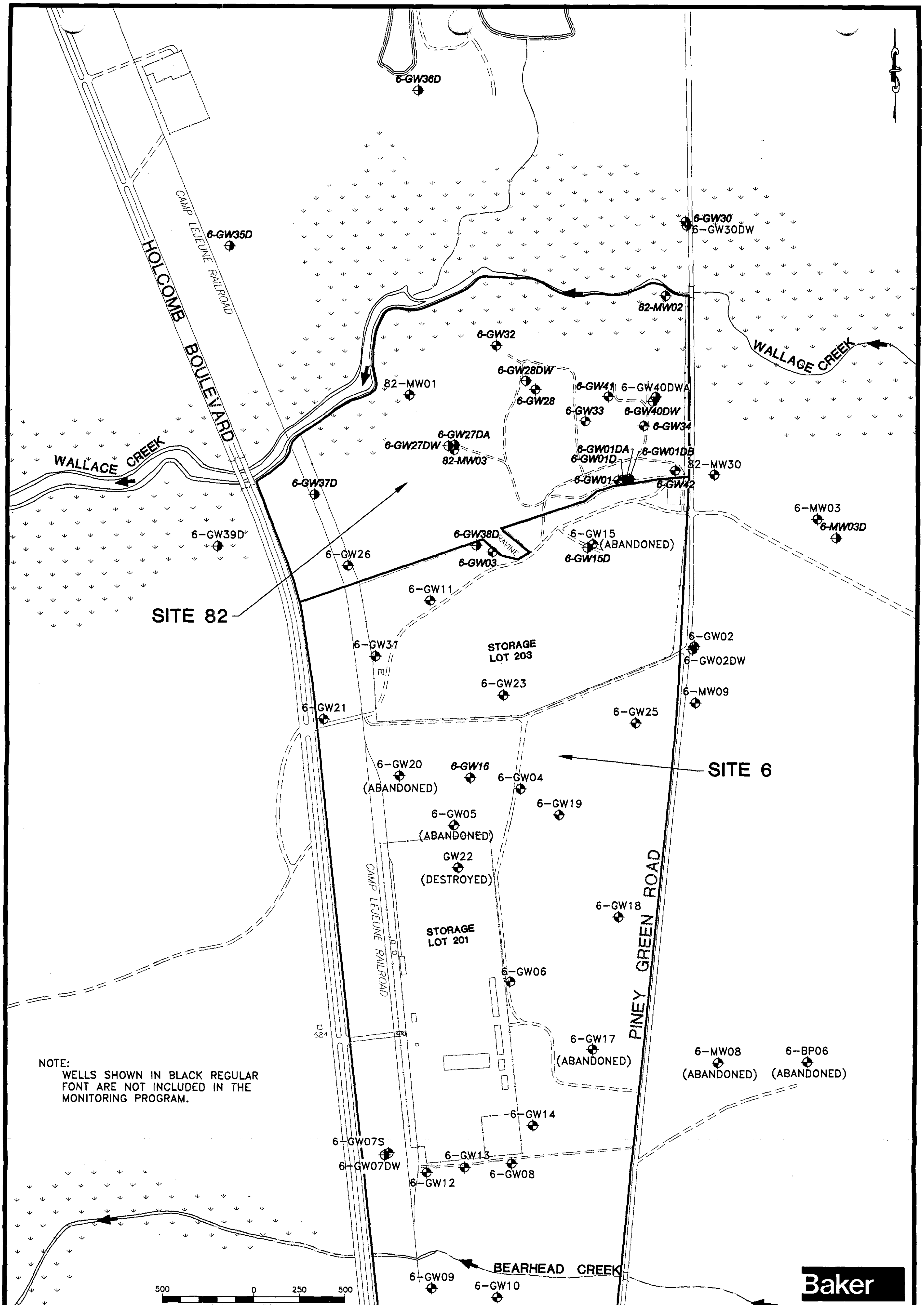


LEGEND

- Ⓓ DEEP RECOVERY WELL
- Ⓡ SHALLOW RECOVERY WELL
- ← APPROXIMATE DIRECTION OF SURFACE WATER FLOW
- —×— FENCING
- ⁔ APPROXIMATE HORIZONTAL EXTENT OF CONTAMINATION WITH TOTAL VOC CONCENTRATION

FIGURE 1
SAMPLING LOCATION MAP–RECOVERY WELLS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 2 – SITES 6 and 82
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

387401WP



LEGEND

⊕ SHALLOW MONITORING WELL
⊕ DEEP MONITORNG WELL
← APPROXIMATE DIRECTION OF SURFACE WATER FLOW
— APPROXIMATE SITE BOUNDARY
—x— FENCING

SOURCE: LANTDIV, OCT. 1991

FIGURE 2

SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 2 - SITES 6 and 82

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02335II032

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 4 (SITE 41)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVES

The Record of Decision (ROD) for Operable Unit (OU) No. 4 (Sites 41 and 74), Marine Corps Base (MCB), Camp Lejeune, North Carolina, was formulated in response to findings of previous investigations, and was signed on December 5, 1995. The ROD outlines remedial actions to be implemented at OU 4. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this work plan is to address the continuation of those monitoring activities at OU 4, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first provides a general description of the investigative area, including its location and past history of operation. The second is a brief review of the original ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities that are currently being implemented and are planned to continue under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow Country, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 4

The study area, OU 4, is one of 18 operable units within MCB, Camp Lejeune. OU 4 consists of Sites 41 and 74. These two sites were grouped into OU 4 because both have a reported history of chemical warfare material (CWM) disposal. Both sites are heavily wooded. Figure P-1 shows the location of OU 4 within MCB, Camp Lejeune.

2.1.1 Site 41

Site 41, Camp Geiger Dump Near the Former Trailer Park, is located east of Highway 17 within the Camp Geiger area of MCB, Camp Lejeune. From 1946 to 1970, Site 41 was used as an open burn dump. The dump received construction debris, petroleum, oil, and lubricant (POL) wastes, mirex (a pesticide), solvents, batteries, and ordnance. The ordnance may have been burned prior to disposal, but may also be present as unexploded ordnance (UXO). CWM, suspected to be chemical agent identification sets (CAIS), was reportedly taken to Site 41 for disposal as well.

2.1.2 Site 74

Site 74, Mess Hall Grease Pit Disposal Area, is located approximately one-half mile east of Holcomb Boulevard in the northeast section of MCB, Camp Lejeune. Site 74 consists of two areas in a remote region of the base: the former grease pit disposal area and a former pest control area. The former grease pit disposal area was used as a disposal area from the early 1950s until 1960. Grease was reportedly disposed of in trenches. It was reported that a volatile substance was sometimes used to ignite the grease. Drums containing polychlorinated biphenyls (PCBs) and "pesticide soaked bags" were also reportedly disposed of in the trenches. The former pest control area is believed to have been used for the storage and handling of pesticides for pest control. There are no known disposal activities associated with the former pest control area at Site 74.

2.2 Record of Decision for Operable Unit No. 4

This section indicates previous investigations at OU 4 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Sites 41 and 74 were approved by representatives of the following:

- Naval Facilities Engineering Command, Atlantic Division
- Marine Corps Base Camp Lejeune
- USEPA, Region IV
- North Carolina Department of Environment, Health, and Natural Resources

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the recommended remedial actions. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 4 began in 1983 with an Initial Assessment Study prepared by Water and Air Research. Additional documents that are relevant to the accepted remedial alternative for Sites 41 and 74 include the following:

- Confirmation Studies, 1984-1987
- Site Summary Report, 1990
- Pre-Remedial Investigation, 1992
- Final Remedial Investigation, 1995
- Final Feasibility Study , 1995
- Final Proposed Remedial Action Plan, 1995

Pertinent findings in these investigations are summarized in the revised Final ROD for OU 4. As a result of these findings, areas of concern (AOCs) at OU 4 are identified as Site 41, and the Grease Pit Disposal Area and Pest Control Area at Site 74.

2.2.2 Selected Remedial Actions

This section describes the Selected Remedial Actions as originally outlined in the accepted ROD. The objectives of the remedial action at OU 4 are the following:

- Prevent future potential exposure to buried contaminated soil and waste, (Sites 41 and 74)
- Prevent future potential exposure to contaminated groundwater, (Site 41)

- Protect ecological receptors from future potential exposure to contaminated surface water, (Site 41)
- Prevent future potential use of the shallow groundwater, (Site 74)
- Cost effectiveness, (Sites 41 and 74)

The Selected Remedial Action for the soil/landfill material at Sites 41 and 74, as provided in the ROD, was the implementation of institutional controls. These controls included the designation of Sites 41 and 74 as restricted areas, and the control of future site use via a designation in the Base Master Plan prohibiting invasive construction and residential use. This selected remedy was anticipated to reduce the future invasive construction risks, and provide a long-term solution for restricted site use.

The selected remedy for groundwater and seep surface water at Site 41, as provided in the ROD, included the implementation of institutional controls including restricted groundwater usage in the vicinity of Site 41 and a designation in the Base Master Plan prohibiting installation of potable water supply wells within 500 feet of the boundary of the site. Additionally, a groundwater, surface water, and sediment sampling program was initiated. Sampling was initially conducted semi-annually.

The selected remedy for groundwater at Site 74 was the implementation of institutional controls restricting groundwater usage in the vicinity of the site. The Base Master Plan for Site 74 officially designated a groundwater use category prohibiting installation of potable water supply wells on site. Additionally, a periodic groundwater monitoring program was implemented, initially on a semi-annual basis. Sampling was to be reduced to an annual basis once a stable or decreasing trend in contaminant levels was observed. Long term groundwater monitoring will continue until remediation levels have been obtained. The remediation levels for the groundwater contaminants of concern identified in the ROD are listed in Table 1.

Remedies provided within the ROD for OU 4 are permanent, long term solutions because contaminant levels are marginal and are contaminants are being permitted to naturally degrade. Periodic sampling is a reliable means of tracking contaminant persistence and migration.

2.3 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Sites 41 and 74 that have been implemented since the signing of the ROD. These modifications are presented in detail in the Monitoring Reports for OU 4. All future recommendations to modify the monitoring program for OU 4 will also be presented in the monitoring reports.

2.3.1 First Half 1997 – Start of LTM Program

OU 4 is comprised of Sites 41 and 74. The initial monitoring at Site 41 consisted of the sampling of four shallow monitoring wells: 41-GW02, 41-GW10, 41-GW11, and 41-GW12; one deep monitoring well identified as 41-GW11DW; and eight surface water\sediment samples: 41-UT-SW\SD01, 41-UT-SW\SD02, 41-UT-SW\SD03, 41-TC-SW\SD10, 41-TC-SW\SD11, 41-TC-SW\SD12, 41-DD- SW\SD01, and 41-DD-SW\SD02. Groundwater and surface water samples were collected on a semi-annual basis and analyzed for Contract Laboratory Procedure (CLP) Volatile Organic Compounds (VOC), Target Analyte List (TAL) Metals, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS). Sediment samples were analyzed for CLP Volatiles and TAL Metals.

The initial monitoring of Site 74 consisted of the sampling of four shallow monitoring wells: 74-GW01, 74-GW02, 74-GW03A, and 74-GW07. Groundwater samples were collected on a semi-annual basis and analyzed for TAL Metals, TSS, and TDS.

2.3.2 Second Half 1997

No changes occurred during this quarter.

2.3.3 First Half 1998

No changes occurred during this quarter.

2.3.4 Second Half 1998

Monitoring activities at Site 74 were discontinued because detected metal concentrations are indicative of naturally occurring metals in the presence of acidic soils. The coastal plain environment of North Carolina is naturally rich in metals. As a result, aluminum, iron, lead, and manganese had consistently been detected at concentrations in excess of either state or federal screening criteria among many of the groundwater samples obtained during the monitoring program. Iron and manganese had routinely been detected above applicable standards among groundwater samples obtained throughout MCB, Camp Lejeune. The recorded concentrations of iron and manganese, and to a lesser extent, aluminum and lead in groundwater at Site 74, are due to geologic conditions (i.e., naturally occurring metals bound to unconsolidated soil particles) and sample acquisition methods, and not mobile metal concentrations in the aquifer.

2.3.5 First Half 1999

Wet chemistry analysis, including TDS and TSS, were eliminated from the sampling program at Site 41. Wet chemistry analyses was initially included in the monitoring program to correlate with total metal results. Although the amount of suspended material corresponds with the concentration of metals detected in groundwater samples, the additional information is superfluous. The relative amount of suspended material in each sample can be surmised from turbidity readings recorded during sample collection. Other water quality parameters, including pH and conductivity, may also be employed to supplement information regarding total metal concentrations. Finally, North Carolina has no provisions that account for TDS and TSS when evaluating total metals.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 4, Site 41. This work plan describes groundwater, surface water, and sediment monitoring activities to be performed at Site 41 as of July 1999. Subsequent to the signing of the ROD, Site 74 was removed from the Monitoring Program. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Five groundwater monitoring wells at Site 41 will be sampled semi-annually as part of the monitoring program. The selected wells include 41-GW02, 41-GW10, 41-GW11, 41-GW11DW, and 41-GW12, presented on Figure 1. Samples will be analyzed for VOCs, metals, TSS, and TDS. Table 2 provides construction details for each of the monitoring wells included in the monitoring program. Table 3 summarizes analyses to be performed. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 78.

Surface water and sediment samples will be collected semi-annually from eight locations at Site 41, as shown on Figure 1. These locations include the following:

Location	Surface Water	Sediment
• Unnamed Tributary:	IR41-UT-SW01	IR41-UT-SD01
	IR41-UT-SW02	IR41-UT-SD02
	IR41-UT-SW03	IR41-UT-SD03
• Tank Creek:	IR41-TC-SW10	IR41-TC-SD10
	IR41-TC-SW11	IR41-TC-SD11
	IR41-TC-SW12	IR41-TC-SD12
• Drainage Ditches	IR41-DD-SW01	IR41-DD-SD01
	IR41-DD-SW02	IR41-DD-SD02

Surface water and sediment samples will be analyzed for VOCs and metals. Table 3 summarizes analyses to be performed.

3.2 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including quality assurance and quality control (QA/QC) samples, will be designated with a unique number. The sample number will serve to identify the investigation, site, sample media, sampling location, QA/QC qualifiers, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site #-Surface Water Body (optional)-Media and Station # or QA/QC-Year and event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Site 41
Surface Water Body	TC = Tank Creek UT = Unnamed Tributary DD = Drainage Ditch
Media	GW = Groundwater SW = Surface Water SD = Sediment
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a 0 (i.e., 41-GW02)
QA/QC	(TB) = Trip Blank
Year	The number will reference the calendar year the sample was obtained. For example: 99 = 1999 00 = 2000
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR41-GW11DW-00A refers to:

IR41-GW11DW-00A	Installation Restoration
IR41-GW11DW-00A	Site 41
IR41-GW11DW-00A	Groundwater sample
IR41-GW11DW-00A	Monitoring well #11
IR41-GW11DW-00A	Deep monitoring well
IR41-GW11DW-00A	Year 2000
IR41-GW11DW-00A	First quarter

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Site 41.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 3 defines the sampling and analysis program for the groundwater monitoring wells at Site 41.

Surface water samples will be collected from eight discrete locations at Site 41. The following is the sampling method to be used to obtain the surface water samples:

1. Surface water samples will be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted.

2. Samples will be collected by dipping the sample bottles directly into the water. An unpreserved, laboratory-decontaminated transfer bottle will be used to fill preserved bottles. Additionally, a transfer bottle will be used to fill all bottles if surface water is too shallow. Care will be taken when collecting samples for VOCs to avoid excessive agitation that could result in the loss of volatiles. Samples will be collected in the following order: volatile organics, then metals. Sample containers will be labeled prior to collection.

3. If sample containers do not contain preservative they will be rinsed at least once with the sample water prior to the final sample collection. In addition, the sampling container used to transfer the surface water into the sample bottles containing preservative will be rinsed once with the sample water.

4. Temperature, pH, specific conductance, and dissolved oxygen will be measured in the field at each sampling station immediately following sample collection.

5. The sample containers will be stored in a cooler with ice until laboratory shipment.

One sediment sample will be collected from each of eight discrete locations at Site 41. The following is the sampling method to be used to obtain the sediment samples:

1. At each station the sediment sample will be collected after the surface water sample has been collected.

2. Sediment samples will be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted.

3. The sediment sample interval at each station will be collected with a stainless steel hand-held coring instrument (sediment sleeve). A disposable clear plastic liner tube, fitted with an eggshell catcher to prevent sample loss, will be used at each station.

4. The coring sleeve will be pushed into the sediment to a depth of 6-inches or until refusal, which ever is encountered first. The sediment sample will be extruded from the liner with a decontaminated extruder and homogenized prior to being transferred to the laboratory containers. Samples for VOCs will not be homogenized.

5. Sediment for VOCs will be placed directly into the sample container. The sample container will be filled completely, without headspace, to minimize volatilization. The remaining sediment will be placed into a decontaminated stainless steel bowl and thoroughly mixed utilizing stainless steel spoons. The sample containers for the metal analysis will then be filled. Sample jars will be labeled prior to sample collection.

6. The sample containers will be stored in a cooler with ice until laboratory shipment.

Under this sample designation format the sample number IR41-UT-SW08-00A refers to:

IR41-UT-SW08-00A	Installation Restoration
IR41-UT-SW08-00A	Site 41
IR41-UT-SW08-00A	Unnamed Tributary
IR41-UT-SW08-00A	Surface Water sample
IR41-UT-SW08-00A	Sampling Station #8
IR41-UT-SW08-00A	Year 2000
IR41-UT-SW08-00A	First quarter

Under this sample designation format the sample number IR41-UT-SD08-00A refers to:

IR41-UT-SD08-00A	Installation Restoration
IR41-UT-SD08-00A	Site 41
IR41-UT-SD08-00A	Unnamed Tributary
IR41-UT-SD08-00A	Sediment sample
IR41-UT-SD08-00A	Sampling Station #8
IR41-UT-SD08-00A	Year 2000
IR41-UT-SD08-00A	First quarter

Under this sample designation format the sample number IR41-TB01-00A refers to:

IR41-TB01-00A	Installation Restoration
IR41-TB01-00A	Site 41
IR41-TB01-00A	Trip Blank
IR41-TB01-00A	Sequential number
IR41-TB01-00A	Year 2000
IR41-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 41. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

The SOPs for surface water and sediment sampling are located in the SOP section of this document. All sample locations will be displayed by placing a pin flag at the nearest bank or shore. The sample number will be marked on the pin flag with indelible ink.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirements for this long-term monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for volatile organic compounds. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC analysis.

Equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates will not be collected during the long-term monitoring program. The samples collected during the program will be considered confirmatory only; therefore, the above QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Record of Decision, Operable Unit No. 4 (Sites 41 and 74) for Marine Corps Base, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. December 1995.

Baker Environmental, Inc. Semi-annual Monitoring Reports, Operable Unit No. 4 (Sites 41 and 74) for Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Ongoing submittals starting in January 1997.

TABLES

TABLE 1

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN IN GROUNDWATER
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 4 – SITE 41
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Remediation Goal [1] (µg/L)
Arsenic	50
Beryllium	4
Cadmium	5
Chromium	50
Lead	15
Nickel	100

(1) Baker Environmental, Inc. (1995) Revised Final Record of Decision For Operable Unit No. 4 (Sites 41 and 74)

µg/L = microgram per liter (ppb)

TABLE 2

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 4 - SITE 41
MCB, CAMP LEJEUNE, NORTH CAROLINA

Site 41 Well No.	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Stick-Up (feet, ags)
41-GW02	NA	NA	NA	NA	NA	NA	NA	NA	NA
41-GW10	1994	13.93	12.1	14.0	13.0	3.0 - 13.0	1.5 - 14.0	0.5 - 1.5	1.8
41-GW11	1994	24.69	21.5	16.0	15.0	5.0 - 15.0	3.0 - 16.0	0.5 - 3.0	3.2
41-GW11DW	1994	23.63	21.5	52.0	50.0	40.0 - 50.0	37.0 52.0	35.0 - 37.0	2.1
41-GW12	1994	8.41	6.4	17.0	16.0	6.0 - 16.0	4.0 - 17.0	2.0 - 4.0	2.0

Notes:

ags = above ground surface
bgs = below ground surface
msl = mean sea level
NA = Information not available

TABLE 3

SAMPLE SUMMARY
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 4 - SITE 41
MCB, CAMP LEJEUNE, NORTH CAROLINA

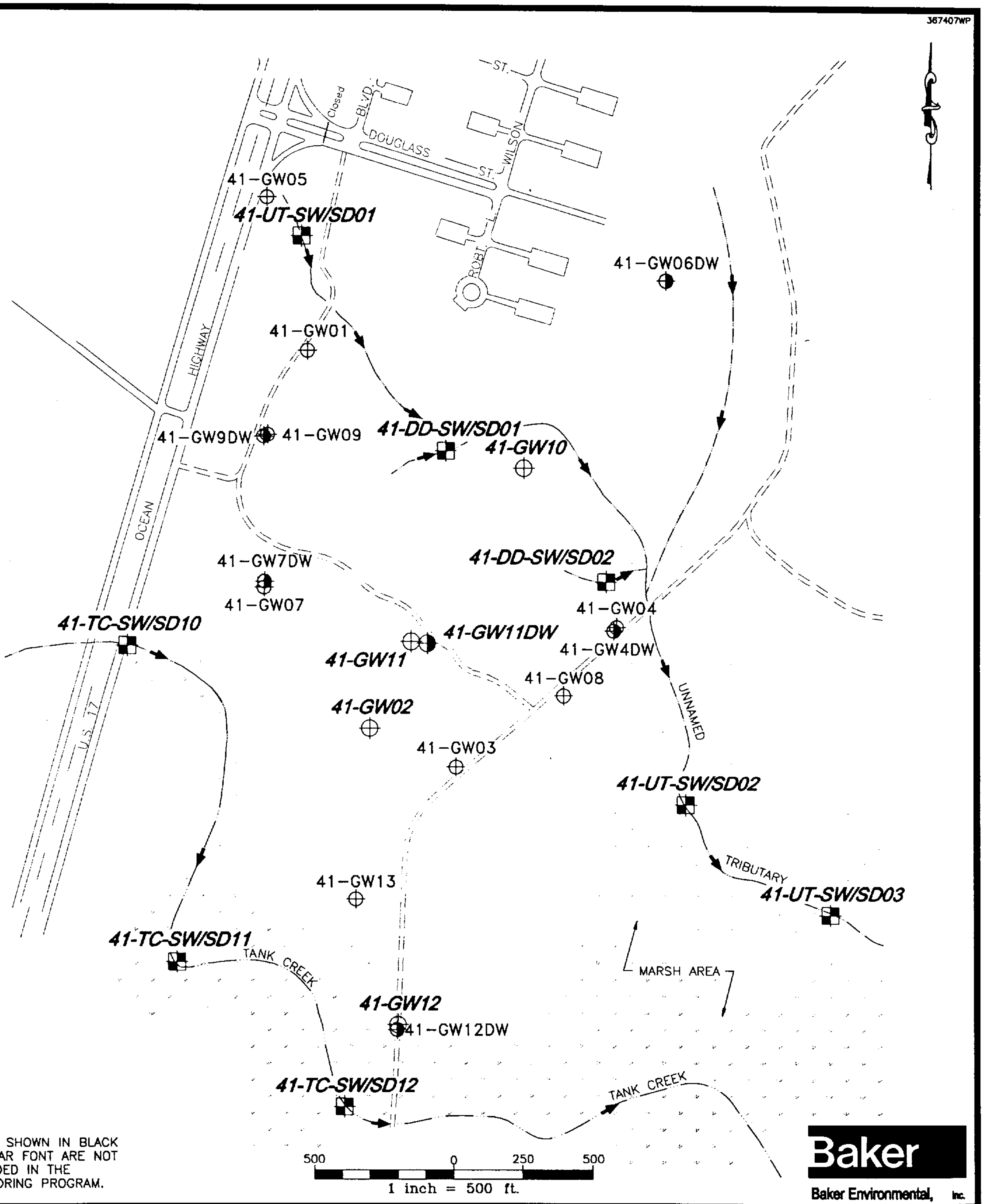
Location	Media	VOC(1)	Metals (2)	Sample Designation
41-GW02	GW	X	X	IR41-GW03-**
41-GW10	GW	X	X	IR41-GW10-**
41-GW11	GW	X	X	IR41-GW11-**
41-GW11DW	GW	X	X	IR-GW11DW-**
41-GW12	GW	X	X	IR41-GW12-**
41-UT-SW01	SW	X	X	IR41-UT-SW01-**
41-UT-SW02	SW	X	X	IR41-UT-SW02-**
41-UT-SW03	SW	X	X	IR41-UT-SW03-**
41-TC-SW10	SW	X	X	IR41-TC-SW10-**
41-TC-SW11	SW	X	X	IR41-TC-SW11-**
41-TC-SW12	SW	X	X	IR41-TC-SW12-**
41-DD-SW01	SW	X	X	IR41-DD-SW01-**
41-DD-SW02	SW	X	X	IR41-DD-SW02-**
41-UT-SD01	SD	X	X	IR41-UT-SD01-**
41-UT-SD02	SD	X	X	IR41-UT-SD02-**
41-UT-SD03	SD	X	X	IR41-UT-SD03-**
41-TC-SD10	SD	X	X	IR41-TC-SD10-**
41-TC-SD11	SD	X	X	IR41-TC-SD11-**
41-TC-SD12	SD	X	X	IR41-TC-SD12-**
41-DD-SD01	SD	X	X	IR41-DD-SD01-**
41-DD-SD02	SD	X	X	IR41-DD-SD02-**

Notes:

(1) Target Compound List Volatile Organic Compounds
(2) Target Analyte List Metals

GW = Groundwater
SW = Surface water
SD = Sediment
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which groundwater sample is obtained.

FIGURES



NOTE:
- WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

Baker

Baker Environmental, Inc.

LEGEND

41-GW11DW ⊕ – DEEP MONITORING WELL
41-GW01 ⊕ – SHALLOW MONITORING WELL
41-TC-SW/SD01 ▨ – SURFACE WATER AND SEDIMENT SAMPLING STATION
==== – ROAD (UNIMPROVED)
➡ – DIRECTION OF SURFACE WATER FLOW

SOURCE: LANTDIV, OCT. 1991

FIGURE 1
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 4 – SITE 41

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 5 (SITE 2)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

The Record of Decision (ROD) for Operable Unit (OU) No. 5 (Site 2), Marine Corps Base (MCB), Camp Lejeune, North Carolina was formulated in response to findings of previous investigations, and was signed on September 15, 1994. The ROD outlines remedial actions to be implemented at OU 5. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this Work Plan is to address the continuation of those monitoring activities at OU 5, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first provides a general description of the investigative area including its location and its past history of operation. The second is a brief review of the original signed ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities that are currently being implemented and are planned to continue under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 5

The study area, OU 5, is one of 18 operable units within MCB, Camp Lejeune. OU 5, which covers an area of approximately 5 acres, is made up solely of Site 2. The site is located at the intersection of Holcomb Boulevard and Brewster Boulevard (Figure P-1). OU 5 is bordered to the north by a wooded area; to the west by Holcomb Boulevard; and to the east by a water treatment plant.

Within the site, there are two main areas of concern: the area around Building 712 [including the Lawn Area (LA) and the Mixing Pad Area (MPA)]; and the Former Storage Area (FSA), which is located at the southern portion of the site across the railroad tracks. From 1945 to 1958, Building 712 was used for the storing, handling, and dispensing of pesticides. Contamination is believed to have occurred as a result of small spills, washout, and excess product disposal. Building 712 was later used as a childrens' day care center. The building is currently used for administrative offices. The FSA was used to store bulk materials and vehicles.

2.2 Record of Decision for Operable Unit No. 5

This section indicates previous investigations at OU 5 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Site 2 were approved by representatives of the following:

- Naval Facilities Engineering Command, Atlantic Division (LANTDIV)
- Marine Corps Base, Camp Lejeune, North Carolina
- U.S. Environmental Protection Agency (EPA) - Region IV
- North Carolina Department of Environment and Natural Resources (NC DENR)

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the selected remedial alternatives. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 5 began in 1983 with an Initial Assessment Study. Additional documents relevant to the accepted remedial alternatives for Site 2 include the following:

- Confirmation Study - 1984 to 1990
- Site Summary Report - 1990
- Final Remedial Investigation Report - June, 1994
- Final Feasibility Study - June, 1994
- Final Proposed Remedial Action Plan - June, 1994
- Final Record of Decision - September, 1994
- Corrective Action Plan - March, 1995

Pertinent findings are summarized in the Final ROD for OU 5. As a result of these findings, a Time Critical Removal Action was immediately initiated, following the 1994 Remedial Investigation (RI), to remove contaminated soil and sediment from the site. Therefore, only Volatile Organic Compounds (VOCs) in groundwater remained as potential contaminants of concern. Areas of concern (AOCs) at OU 5 are identified as the area around Building 712 (including the Lawn Area and the Mixing Pad Area), and the Former Storage Area.

2.2.2 Selected Remedial Action

This section describes the Selected Remedial Actions as they were originally outlined in the accepted ROD. The primary objectives of the remedial action at OU 5 are: (1) to prevent future human exposure to the contaminated groundwater; and (2) to insure, through monitoring, that there is no human or environmental exposure due to migration of the contaminant plume off site. This work plan does not provide remedial goals for groundwater contaminants because the remedial objective specified in the ROD focuses on monitoring contaminant migration, not chemical-specific concentrations. The Selected Remedial Action for OU 5, as provided in the ROD, included institutional controls restricting the installation of new potable water supply wells in the vicinity of Site 2, and long term groundwater monitoring. Long term monitoring will identify any potential off-site migration of groundwater contaminants.

The LTM program originally consisted of quarterly sampling and analysis of 12 monitoring wells and three nearby operational water supply wells. Groundwater samples were analyzed for VOCs, barium, beryllium, cadmium, chromium, lead, manganese, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS).

Remedies provided within the ROD for OU 5 are permanent, long term solutions because groundwater contaminants at this OU are being permitted to naturally degrade. Periodic sampling is a reliable means of monitoring contaminant persistence and migration.

2.3 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Site 2 that have been implemented since the signing of the ROD. These modifications are presented in detail in the Monitoring Reports for OU 5. All future recommendations to modify the monitoring program for OU 5 will also be presented in the monitoring reports.

2.3.1 Third Quarter 1996 – Start of LTM

The initial monitoring at Site 2 consisted of 11 shallow monitoring wells: 02-GW01, 02-GW02, 02-GW03, 02-GW04, 02-GW05, 02-GW06, 02-GW07, 02-GW08, 02-GW09, 02-GW10, 02-GW11; one deep monitoring well, 02-GW03DW; and three water supply wells HP-616, HP-646, and HP-647. Groundwater samples were collected on a quarterly basis and were analyzed for Target Compound List (TCL) VOCs, selected Target Analyte List (TAL) Metals, TSS, and TDS.

2.3.2 Fourth Quarter 1996

No changes occurred during this quarter.

2.3.3 First Half 1997

Supply Well Sampling

Supply wells HP-616, HP-646, and HP-647 were eliminated from the monitoring program at Site 2. The three potable water supply wells are located more than 1,200 feet from the study area and had been sampled over six consecutive quarters with only one positive detection of a VOC (methylene chloride). Methylene chloride was detected in a sample obtained from HP-616 at a concentration of 1.0 microgram per liter (μg/L) during the third quarter of 1996. This compound is a common laboratory contaminant that is often introduced to the sample during preparation or analysis of the environmental samples. None of the VOC and Total Metal detections among any of the groundwater samples obtained from the supply wells exceeded applicable water quality standards. In addition, supply wells at MCB, Camp Lejeune are currently sampled as part of an on going monitoring program administered by MCB, Camp Lejeune. Based on this information, the identified water supply wells were eliminated from the sampling program.

Shallow Monitoring Well Sampling

Monitoring wells 02-GW06 and 02-GW09 were eliminated from the sampling program for Site 2. As depicted in Figure 1, the two monitoring wells are not positioned hydraulically down gradient of known contamination at Site 2. Methylene chloride and chloroform, contaminants believed to be the result of laboratory sample preparation, had each been detected twice among samples obtained from 02-GW06 during the previous six quarters of sampling. No other VOCs had been detected in samples obtained from 02-GW06 and 02-GW09 during the six sampling events that had taken place at Site 2. Additional information gained from monitoring wells 02-GW06 and 02-GW09 was not expected to provide relevant data in support of the decision making process. As a result, the identified monitoring wells were eliminated from the sampling program.

To address the need for down gradient monitoring of the known contamination at Site 2, well 02-GW12 was added to the monitoring program. Information gained from monitoring well 02-GW12 is expected to provide relevant data in support of the decision making process.

Sampling Frequency

The majority of groundwater samples obtained from Site 2 had exhibited little or no contamination during the previous six quarterly sampling events. Only two contaminants, ethylbenzene and xylenes, were consistently detected above state water quality standards. Ethylbenzene and xylenes were detected in the same well, 02-GW03, and at similar concentrations during the 1993 Remedial Investigation (Baker, 1994). Ethylbenzene was also detected in shallow monitoring well 02-GW03 during the 1984 Confirmation Study (ES&E, 1990). In addition, there is little evidence to suggest that contaminants have migrated from the area immediately surrounding 02-GW03. Based upon this information, the number of yearly sampling events was reduced from four to two. Semi-annual sampling will sufficiently monitor the groundwater conditions at Site 2.

Sample Analyses

The sampling program for Site 2 was modified such that Total Metal, TDS, and TSS analyses were eliminated from the program. Although, concentrations of metals and TDS were detected at concentrations that exceeded applicable North Carolina standards, these analyses were not necessary data requirements. There was no history or evidence to suggest that metal disposal activities may have occurred at Site 2. Soils of the North Carolina coastal plain tend to be naturally rich in metals, especially iron and manganese. It is not uncommon to detect Total Metal concentrations in groundwater at MCB, Camp Lejeune that exceed applicable water quality standards. In addition, the analyses were eliminated because the results were not required to determine VOC migration throughout Site 2.

Monitoring Well Abandonment and Installation

Deep monitoring well 02-GW03DW was situated adjacent to shallow monitoring well 02-GW03. The screened portion of 02-GW03DW was below a semi-confining unit that separates the surficial and Castle Hayne aquifers. Both ethylbenzene and total xylenes were detected at concentrations exceeding applicable water quality standards in shallow monitoring well 02-GW03. Although ethylbenzene and total xylenes were detected at concentrations below 1.0 µg/L in samples obtained from 02-GW03DW during a previous monitoring event, their presence had not been confirmed. Field observations suggested that bentonite clay, installed during well construction, had begun to enter the screen and sandpack of deep monitoring well 02-GW03DW. The sandpack was presumably clogged with bentonite, limiting the ability of groundwater to enter the well screen. Bentonite clay, as a result, may also have been introduced into groundwater samples obtained from the deep monitoring well causing total dissolved solids and metal concentrations to be detected above the North Carolina standards. The bentonite may have falsely biased total metal and total dissolved solid results. The results could have reflected naturally occurring metals from the surrounding formation that had adhered to the clay particles by a weak ionic bond.

Based on this information, well 02-GW03DW was abandoned according to accepted procedures. An intermediate monitoring well, set immediately above the semi-confining unit, was then installed to replace the deep monitoring well. The intermediate monitoring well was situated adjacent to shallow monitoring well 02-GW03 and installed to a depth of approximately 60 feet below ground surface. Groundwater samples collected above the semi-confining layer will be employed to determine if contaminants have migrated from the upper portion of the surficial aquifer to the lower portion of the surficial aquifer.

Recorded field observations suggested that three of the five shallow monitoring wells installed at Site 2 during 1984 had begun to deteriorate and were clogged with fine-grained material from the surrounding formation. During redevelopment, monitoring wells 02-GW01 and 02-GW04 did not recharge adequately and often the extracted groundwater appeared extremely turbid. Well 02-GW02 could not be redeveloped due to an insufficient amount of groundwater in the screened portion of the well casing. As a result of deterioration or obstruction, environmental samples were likely to have been obtained from only a limited interval of the surficial aquifer where groundwater was permitted to enter the well screen; possibly misrepresenting true groundwater conditions. Based upon this information, monitoring wells 02-GW01, 02-GW02, and 02-GW04 were abandoned according to accepted procedures.

2.3.4 Fourth Quarter 1997 & First Quarter 1998

No changes occurred during this quarter.

2.3.5 Second Quarter and Third Quarter 1998

No changes occurred during this quarter.

2.3.6 Fourth Quarter 1998 & First Quarter 1999

No changes occurred during this quarter.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 5, Site 2 as of July 1999. Sampling locations, sample analyses, and sample designations are included within this section.

3.1 Sampling

Groundwater from six shallow monitoring wells and one intermediate monitoring well will be sampled as part of the monitoring program at Site 2. Shallow monitoring wells 02-GW03, 02-GW07, 02-GW08, and 02-GW12 are located within the southern portion of the study area. Intermediate monitoring well 02-GW03IW is also located within the southern portion of Site 2. Shallow monitoring wells 02-GW05 and 02-GW10 are located adjacent to or downgradient of the known groundwater contamination. The six shallow wells will be employed to monitor conditions within the uppermost portion of the surficial aquifer. Samples obtained from intermediate monitoring well 02-GW03IW will be representative of conditions within the deeper portion of the surficial aquifer.

Table 1 provides available construction details for monitoring wells at Site 2. The locations of monitoring wells throughout Site 2 are depicted in Figure 1. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 2.

3.2 Sample Designations

In order to identify and accurately track the groundwater samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Site 2
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a zero (e.g., 02-GW05).
QA/QC	TB = Trip Blank
Year	The number will reference the calendar year in which the sample was obtained (e.g., 99 would represent 1999).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR02-GW03IW-99A refers to:

IR02-GW03IW-99A	Installation Restoration
IR02-GW03IW-99A	Site 2
IR02-GW03IW-99A	Groundwater sample
IR02-GW03IW-99A	Monitoring well number 03
IR02-GW03IW-99A	Intermediate monitoring well

IR02-GW03IW-99A	Year 1999
IR02-GW03IW-99A	First quarter

Under this sample designation format the sample number IR02-TB01-00A refers to:

IR02-TB01-00A	Installation Restoration
IR02-TB01-00A	Site 2
IR02-TB01-00A	Trip Blank
IR02-TB01-00A	Sequential number, in order of collection. The total number will depend upon how many trip blanks are required.
IR02-TB01-00A	Year 2000
IR02-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 2. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Site 2.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOC analyses will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 2 defines the sampling and analysis program for the groundwater monitoring wells at Site 2.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for volatile organic compounds. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC analyses.

Equipment rinsates, field blanks, field duplicates, and matrix spike and matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Remedial Investigation Report, Operable Unit No. 5 (Site 2) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. June 1994.

Baker Environmental, Inc. Record of Decision, Operable Unit No. 5 (Site 2) for Marine Corps Base, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. September 1994.

Baker Environmental, Inc. Semi-annual Monitoring Reports, Operable Unit No. 5 (Site 2) for Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Ongoing submittals starting in July 1996.

Environmental Science and Engineering, Inc. (ES&E) Site Summary Report. Final. Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. ESE project No. 49-0236. 1990.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 5 - SITE 2
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)	Stick-Up (feet, ags)
02-GW03	1984	35.40	33.00	NA	25.0	10.0 to 25.0	NA	NA	NA
02-GW03IW	1997	NA	NA	70.0	60.0	50.0 to 60.0	45.0	34.0	3.0
02-GW05	1984	33.72	31.80	NA	25.0	10.0 to 25.0	NA	NA	NA
02-GW07	1993	34.03	31.6	16.0	13.0	3.0 to 13.0	2.0	1.0	2.4
02-GW08	1993	34.92	31.90	12.5	12.5	2.5 to 12.5	1.5	0.5	3.0
02-GW10	1994	32.28	32.47	15.0	13.5	3.5 to 13.5	2.5	1.5	3.5
02-GW12	1997	NA	NA	31.0	23.0	3.0 to 23.0	2.0	1.5	3.0

Notes:

ags = Above ground surface
bgs = Below ground surface
msl = Mean sea level
NA = Information not available

TABLE 2

SAMPLE SUMMARY
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 5 - SITE 2
MCB, CAMP LEJEUNE, NORTH CAROLINA

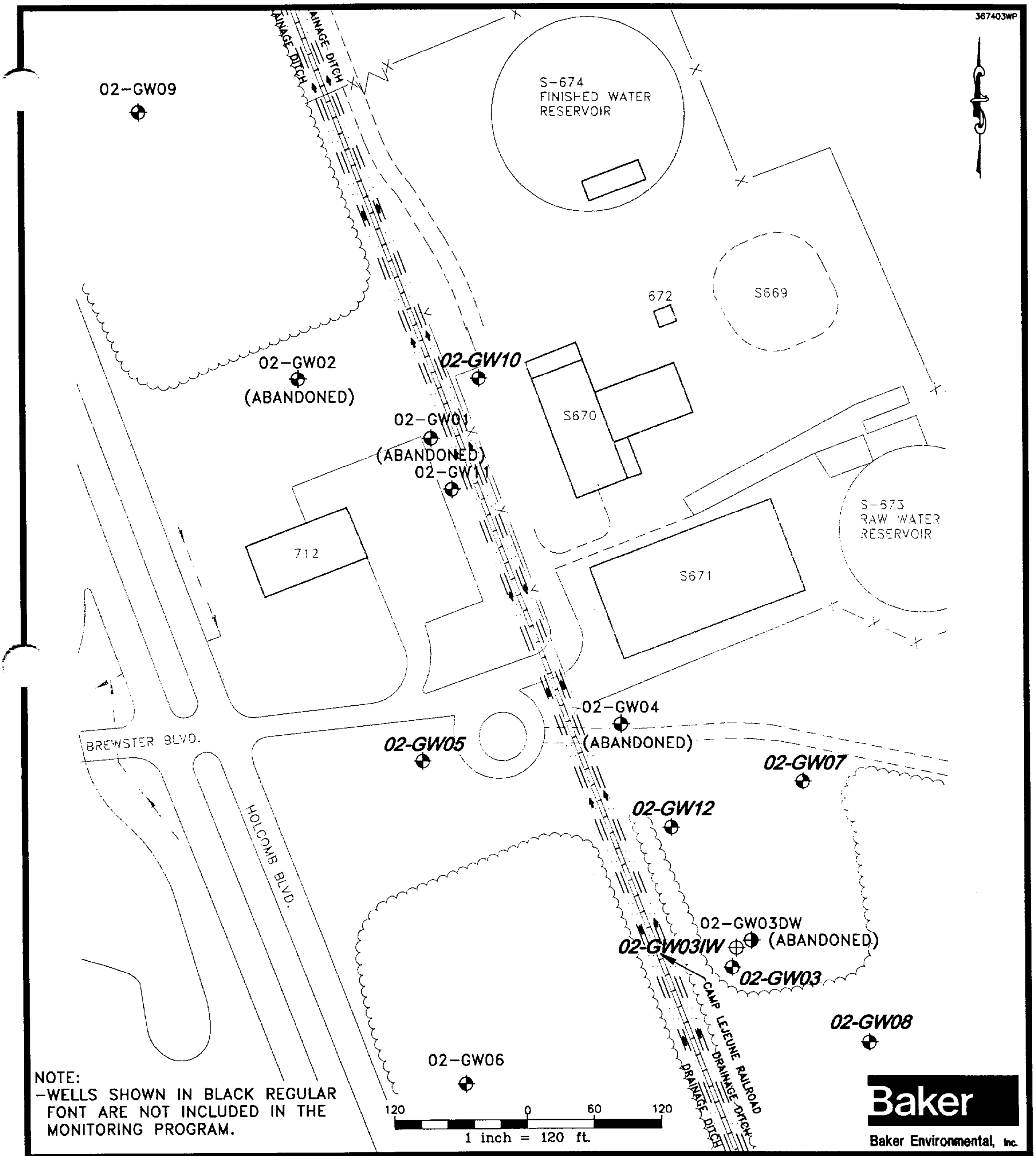
Sample Location	Media	TCL Volatiles[1]	Sample Designation
02-GW03	GW	X	IR02-GW03-**
02-GW03IW	GW	X	IR02-GW03IW-**
02-GW05	GW	X	IR02-GW05-**
02-GW07	GW	X	IR02-GW07-**
02-GW08	GW	X	IR02-GW08-**
02-GW10	GW	X	IR02-GW10-**
02-GW12	GW	X	IR02-GW12-**

Notes:

(1) Target Compound List Volatile Organic Compounds

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

Baker

Baker Environmental, Inc.

LEGEND

02-GW02 ⊕ SHALLOW MONITORING WELL

02-GW03IW ⊕ INTERMEDIATE MONITORING WELL

2-GW03DW ⊕ DEEP MONITORING WELL

→ DIRECTION OF SURFACE WATER FLOW

SOURCE: LANTDIV, FEB. 1992

FIGURE 1
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 5 – SITE 2

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 7 (SITES 1 AND 28)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

The Record of Decision (ROD) for Operable Unit (OU) No.7 (Sites 1 and 28), Marine Corps Base (MCB), Camp Lejeune, North Carolina, was formulated in response to findings of previous investigations and was signed on May 16, 1996. The ROD outlines remedial actions to be implemented at OU 7. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this work plan is to address the continuation of those monitoring activities at OU 7, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first area is a general description of the investigative area, including its location and history of operation. The second is a brief review of the original ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities which are currently being implemented and are planned to continued under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base (MCB), Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 7

The study area, OU 7, is one of 18 operable units within MCB, Camp Lejeune. OU 7 consists of three Sites: 1, 28, and 30. It is located on the eastern portion of the base, situated between the New River and Sneads Ferry Road, south of the Hadnot Point Industrial Area (HPIA) (Figure P-1).

2.1.1 Site 1

Site 1, the French Creek Liquids Disposal Area, is the northern most site located within OU 7. Site 1 consists of two suspected disposal areas: the northern disposal area and the southern disposal area. Site 1 had been used by several different mechanized, armored, and artillery units since the 1940s. Reportedly, liquid wastes generated from vehicle maintenance were routinely poured onto the ground surface. During motor oil changes, vehicles were driven to a disposal point and drained of used oil. In addition, acid from dead batteries was reportedly hand carried from maintenance buildings to disposal points. At times, holes were reportedly dug for waste acid disposal and then immediately backfilled. Thus the disposal areas at Site 1 are suspected to contain petroleum, oil, and lubricants (POL) and battery acid.

2.1.2 Site 28

Site 28, the Hadnot Point Burn Dump, is the western most site located within OU 7. The site is located along the eastern bank of the New River and is approximately one mile south of the HPIA on the mainside portion of MCB, Camp Lejeune. Site 28 operated from 1946 to 1971 as a burn area for a variety of solid wastes generated on the base. Reportedly, industrial waste, trash, oil-based paint, and construction debris were burned then covered with soil. In 1971, the burn dump ceased operations and was graded and seeded with grass.

2.1.3 Site 30

Site 30, the Sneads Ferry Road Fuel Tank Sludge Area, is the southern most site located within OU 7. The site is situated along a tank trail that intersects Sneads Ferry Road from the west, approximately 1 mile south of the intersection with Marines Road, and roughly 4-1/2 miles south of the HPIA. Site 30 was reportedly used by a private contractor as a cleaning area for emptied fuel storage tanks from other locations. The tanks were used to store leaded gasoline that contained tetraethyl lead and related compounds. Since fuel residuals remaining in the emptied tanks were reportedly washed out at Site 30, the disposal area is suspected to contain fuel sludge and wastewater from the washout of the tanks.

2.2 Record of Decision for Operable Unit No. 7

This section indicates previous investigations at OU 7 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Sites 1 and 28 were approved by representatives of the following:

- Naval Facilities Engineering Command, Atlantic Division
- Marine Corps Base Camp Lejeune
- U.S. Environmental Protection Agency - Region IV
- North Carolina Department of Environment, Health, and Natural Resources

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the recommended remedial actions. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 7 began in 1983 with an Initial Assessment Study. Additional documents that are relevant to the accepted remedial alternatives for Sites 1, 28, and 30 include the following:

- Confirmation Study, 1984-87
- Soil Assessment at Site 1, 1991
- Aerial Photographic Investigation, 1992
- Surface Water and Sediment Investigation, 1993
- Additional Groundwater Investigation, 1993
- Remedial Investigation, 1994

Pertinent findings are summarized in the Final ROD for OU 7.

2.2.2 Selected Remedial Action

This section describes the Selected Remedial Actions as originally outlined in the accepted ROD for OU 7. The objectives of the remedial actions at Sites 1, 28 and 30 are as follows:

Site 1

The primary objective of the remedial action at Site 1 is to address trichloroethene (TCE) contamination in the shallow groundwater aquifer. Institutional controls include aquifer use restrictions that prohibit the future use of the aquifer as a potable water source. Deed restrictions will limit the future use of the land at the site, including placement of wells. These restrictions will be implemented via the Base Master Plan. A long term groundwater monitoring plan will be implemented to monitor contaminant concentrations and migration. Eight wells are to be sampled semi-annually and the samples analyzed for Volatile Organic Compounds (VOCs). The remediation level for TCE in groundwater is 5.0 µg/L, based on the North Carolina Water Quality Standard (NCWQS).

Site 28

The objective of the remedial action at Site 28 is to address manganese and lead contamination in the groundwater. Institutional controls include aquifer use restrictions that will prohibit the future use of the aquifer as a potable water source. Deed restrictions will limit the future use of land at the site, including placement of wells. These restrictions will be implemented via the Base Master Plan. A long term groundwater monitoring plan will be implemented to monitor contaminant concentrations and migration. Six monitoring wells will be sampled semi-annually and the samples will be analyzed for lead and manganese. The remediation levels for lead and manganese in groundwater are 15 µg/L and 50 µg/L, respectively, based on North Carolina Water Quality Standards. In the case of manganese in the groundwater, the remediation level will probably never be achieved because this inorganic appears to occur naturally at high levels at MCB, Camp Lejeune.

Site 30

The objective of the remedial action at Site 30 is to address site conditions that already appear to be protective of human health and the environment. As presented in the ROD, no further action will be taken at Site 30.

Remedies provided within the ROD for OU 5 are permanent, long term solutions because groundwater contaminants at this OU are being permitted to naturally degrade. Periodic sampling is a reliable means of monitoring contaminant persistence and migration.

2.3 Monitoring Timeline

Additions and modifications to the monitoring program have been implemented since the signing of the ROD. These modifications are presented in the Monitoring Reports for OU 7. In addition, all future recommendations to modify the monitoring program for OU 7 will be presented in the monitoring report. The following is a brief chronology of monitoring events for both Site 1 and Site 28.

2.3.1 Site 1

Second Half 1996 – Start of LTM Program

The initial groundwater sampling of Site 1 consisted of eight shallow and one deep monitoring well. These nine monitoring wells included: 01-GW01, 01-GW02, 01-GW03, 01GW10, 01-GW11, 01-GW12, 01-GW17, 01-GW17DW, and 01-GW18. One shallow monitoring well, 01-GW18, was found to be damaged and could not be sampled. Samples were collected on a semi-annual basis and were analyzed for TCL Volatiles.

First Half 1997

No changes occurred during this quarter.

Second Half 1997

No changes occurred during this quarter

First Half 1998

The last submitted monitoring report for Site 1 included sample analytical data from this quarter. This current data reaffirms that a clear decrease in vinyl chloride and TCE concentrations has occurred since 1994, with vinyl chloride having not been detected at all during the past five sampling events. Concentrations of TCE in samples obtained from 01-GW10 have decreased from 4.0 μg/L to 1.6 μg/L in the last three years. Since 1994, concentrations of TCE in samples obtained from 01-GW17 have decreased from 27 μg/L to 3.6 μg/L. In addition, Site 1 is not located within 1,000 feet of any potable water supply wells. Based upon this information, a recommendation was made that monitoring activities be discontinued at Site 1.

Third Quarter 1998

Site 1 was granted approval to discontinue LTM activities. However, confirmatory groundwater sampling will continue at selected monitoring wells 01-GW10 and 01-GW17. This sampling is to verify that TCE concentrations have remained at low concentrations.

Fourth Quarter 1998

Confirmatory sampling continues and no changes have been made this quarter.

First Quarter 1999

Confirmatory sampling continues and no changes have been made this quarter.

Second Quarter 1999

Confirmatory sampling continues and no changes have been made this quarter.

2.3.2 Site 28

Second Half 1996 – Start of LTM Program

Long term monitoring began at site 28 with the sampling of five shallow monitoring wells (28-GW01, 28-GW02, 28-GW04, 28-GW07, and 28-GW08), two deep monitoring wells (28-GW01DW and 28-GW07DW), and three surface water\sediment samples (28-SW\SD01, 28-SW\SD02, and 28-SW\SD03). Sample collection occurred on a semi-annual basis with all three media tested for TAL metals only.

First Half 1997

No changes occurred during this quarter.

Second Half 1997

No changes occurred during this quarter.

First Half 1998

During this quarter of groundwater sampling, 28-GW08 could not be accessed. The immediate area around monitoring well 28-GW08 is being used to stage soil from base construction activities. During this staging, soil has been piled to such a great extent that 28-GW08 has been covered over. The monitoring well's location, physical condition, and its ability to provide reliable sample quality is in serious question. The future status of 28-GW08 has not been determined.

The last submitted monitoring report for Site 28 included sample analytical data from this quarter. The data indicates that iron and manganese have remained the most prevalent metals among all environmental samples obtained form Site 28. Iron and manganese concentrations have consistently exceeded both the screening standards and criteria among groundwater and surface water samples, respectfully. To a much lesser extent, aluminum, antimony, cadmium, copper, and lead have occasionally been detected at concentrations in excess of applicable screening criteria. However, the observed concentrations are not indicative of metal disposal activities but are indicative of the coastal plain environment which is naturally rich in metals. These detected concentrations do not pose a imminent threat to human health and the environment. Based upon the accumulated information presented in the monitoring reports, a recommendation was made that monitoring activities be discontinued at Site 28.

Third Quarter 1998

Site 28 was granted approval to discontinue LTM activities. However, confirmatory groundwater sampling will continue at selected monitoring wells 28-GW01, 28-GW02, 28-GW07, and 28-GW08, along with three surface water locations 28-SW01, 28-SW02, and 28-SW03. This data will continue to re-affirm that fluctuating levels of naturally occurring metals is a true representation of site conditions. Monitoring well 28-GW08 remains in-accessible and a decision about its status has not been determined.

Fourth Quarter 1998

Confirmatory sampling continues and no changes have been made this quarter.

First Quarter 1999

Confirmatory sampling continues and no changes have been made this quarter.

Second Quarter 1999

Confirmatory sampling continues and no changes have been made this quarter.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 7, Sites 1 and 28, as of July 1999. In addition, sampling locations, sample analyses, and sample designations are included within this section. The sampling locations included in the monitoring program at Sites 1 and 28 are based upon laboratory results and observational data obtained during past monitoring events. The evaluation of these results and observations concluded that the requirements of the ROD for Sites 1 and 28 had been fulfilled. Confirmatory sampling of selected locations will continue to verify these achieved ROD requirements.

3.1 Sampling

The following provides the number and location of confirmatory samples to be obtained quarterly as part of the monitoring program at Sites 1 and 28.

3.1.1 Site 1

Two shallow monitoring wells will be sampled and analyzed for VOCs as part of the confirmatory sampling at Site 1. Shallow monitoring wells 01-GW10 and 01-GW17 are located within the northern portion of the study area, and are employed to monitor conditions within the uppermost portion of the surficial aquifer. Table 1 provides construction details for both wells included in the monitoring program. The locations of monitoring wells throughout Site 1 are depicted in Figure 1.

3.1.2 Site 28

Three shallow monitoring wells and three surface water locations will be sampled and analyzed for metals as part of the confirmatory sampling at Site 28. Shallow monitoring wells 28-GW01, 28-GW02, and 28-GW07 are located within the western portion of the study area, west of Cogdels Creek. These shallow monitoring wells will be employed to monitor conditions within the uppermost portion of the surficial aquifer. Samples obtained from the New River, adjacent to Site 28, will be used to track potential migration of contaminants. Table 2 provides construction details for each of the monitoring wells included in the monitoring program. The locations of monitoring wells and surface water sampling locations at Site 28 are depicted in Figure 2.

3.2 Sample Designations

In order to identify and accurately track the various samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e. Installation Restoration Program)
Site Number	Monitoring activities will be conducted at Sites 1 and 28.
Media	GW = Groundwater SW = Surface Water
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a zero (e.g., 01-GW01).
QA/QC	TB = Trip Blank
Year	The number will reference the calendar year the sample was obtained (e.g., 99 would represent 1999).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR01-GW01DW-99A refers to:

IR01-GW01DW-99A	Installation Restoration
IR01-GW01DW-99A	Site 1
IR01-GW01DW-99A	Groundwater sample
IR01-GW01DW-99A	Monitoring well number 01
IR01-GW01DW-99A	Deep monitoring well
IR01-GW01DW-99A	Year 1999
IR01-GW01DW-99A	First quarter

Under this sample designation format the sample number IR28-SW01-99A refers to:

IR28-SW01DW-00A	Installation Restoration
IR28-SW01-99A	Site 28
IR28-SW01-99A	Surface water sample
IR28-SW01-99A	Sampling station number 1
IR28-SW01-99A	Year 1999
IR28-SW01-99A	First quarter

Under this sample designation format the sample number IR01-TB01-00A refers to:

IR01-TB01-00A	Installation Restoration
IR01-TB01-00A	Site 1
IR01-TB01-00A	Trip Blank
IR01-TB01-00A	Sequential number, in order of collection. The total number will depend upon how many trip blanks are required.
01-TB01-00A	Year 2000
01-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviation from this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

The following describes sample collection procedures and analytical requirements of the monitoring program. Periodic redevelopment of monitoring wells may be required prior to groundwater sample collection.

Groundwater samples will be collected from the identified monitoring wells at Sites 1 and 28. The following is the low-flow purge and sampling procedure used to obtain groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Sites 1 and 28.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples from Site 1 will be collected for VOC analysis. Samples collected at Site 28 will be analyzed for TAL metals. Because no samples will be retained for VOC analysis at Site 28; trip blanks will not be required. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 3 and 4 provides the sampling and analysis program for groundwater samples obtained at Sites 1 and 28 respectfully.

Surface water samples will be collected from three separate locations at Site 28. The following presents the sampling method to obtain the surface water samples:

1. Surface water samples must be collected from downstream locations first, to prevent potential migration of contaminants from upstream locations.

2. Collect samples by dipping transfer container directly into water. The unpreserved, laboratory-decontaminated transfer container will be used to fill preserved bottles. Rinse transfer container with surface water prior to use. Sample containers are to be labeled prior to collection.

3. Record temperature, pH, specific conductance, and dissolved oxygen in the field at each sampling station immediately following sample collection. These measurements will be recorded in a field notebook.

4. Store sample containers in a cooler with fresh ice until they are shipped to the laboratory.

The SOPs for surface water sampling are located in the SOP section of this document. Table 4 presents the sampling and analysis program for surface water at Site 28. Surface water sampling locations at Site 28 are depicted in Figure 2 All sample locations will be marked by placing a pin flag at the nearest bank. The sample number will be marked on the pin flag with indelible ink.

3.4 Quality Assurance / Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC analyses.

Equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Long-term Monitoring Work Plan and Baseline Study, Operable Unit No. 7 (Sites 1 and 28) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. 1996.

Baker Environmental, Inc. Monitoring Report Operable Unit No. 7 (Sites 1, 28, and 30) MCB, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Ongoing submittals starting in 1996.

Baker Environmental, Inc. Record of Decision, Operable Unit No. 7 (Sites 1, 28, and 30 for MCB, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. May 1996.

Water and Air Research, Inc. Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for Naval Energy and Environmental Support Activity. 1983.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 7 - SITES 1 AND 28
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Bentonite (feet, bgs)	Depth to Sand Pack (feet, bgs)	Stick-Up (feet, ags)
SITE 1									
1-GW10	1994	18.07	15.3	24	24	9.1 - 23.4	5.0	7.0	2.8
1-GW17	1994	23.00	20.1	25	25	10 - 24.3	6.0	8.0	3.0
SITE 28									
28-GW01	1994	7.34	4.8	17	17	2.5 - 16.2	0.0	1.5	2.5
28-GW02	1984	5.96	4.8	NA	16.5	2.5 - 16.5	NA	NA	1.6
28-GW07	1994	6.62	3.8	18	18	2.5 - 17.5	0.0	0.5	2.8
28-GW08	1994	14.16	11.6	24	24	7.9 - 22.7	4.0.0	6.0	2.6

Notes:

ags = above ground surface
msl = mean sea level
bgs = below ground surface
NA = Information not available

TABLE 2

SAMPLE SUMMARY MATRIX
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 7 - SITES 1 AND 28
MCB, CAMP LEJEUNE, NORTH CAROLINA

Location	Media	TCL Volatiles[(1)]	TAL Metals[(2)]	Sample Designation
SITE 1				
1-GW10	GW	X		IR01-GW10-**
1-GW17	GW	X		IR01-GW17-**
SITE 28				
28-GW01	GW		X	IR28-GW01-**
28-GW02	GW		X	IR28-GW02-**
28-GW07	GW		X	IR28-GW07-**
28-GW08	GW		X	IR28-GW08-**
28-SW01	SW		X	IR28-SW01-**
28-SW02	SW		X	IR28-SW02-**
28-SW03	SW		X	IR28-SW03-**

Notes:

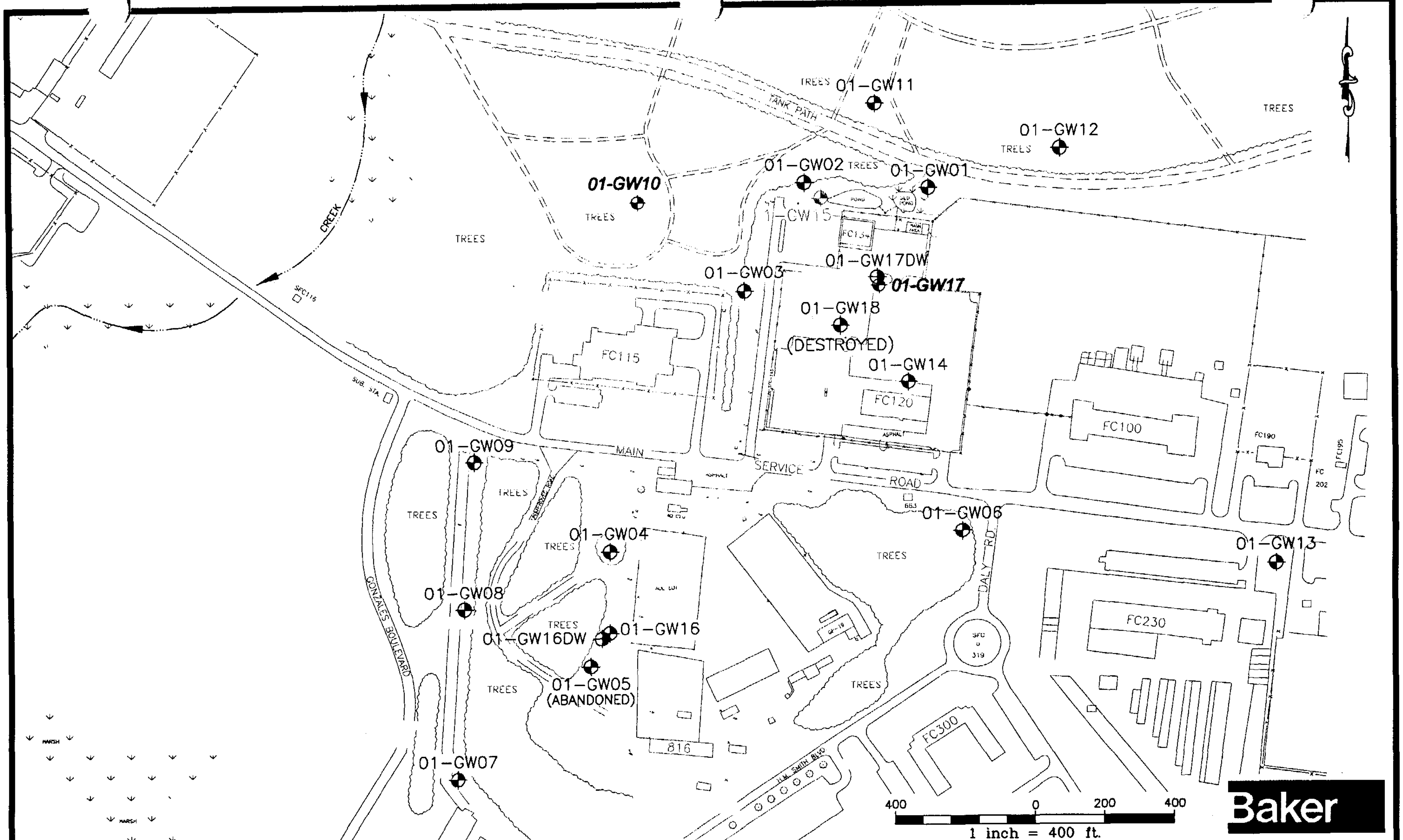
(1) Target Compound List Volatile Organic Compounds

(2) Target Analyte List Metals

X = Requested analysis
GW = Groundwater
SW = Surface Water

** = Year (e.g., 98 for 1998) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



Baker Environmental, Inc.

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

387404WP

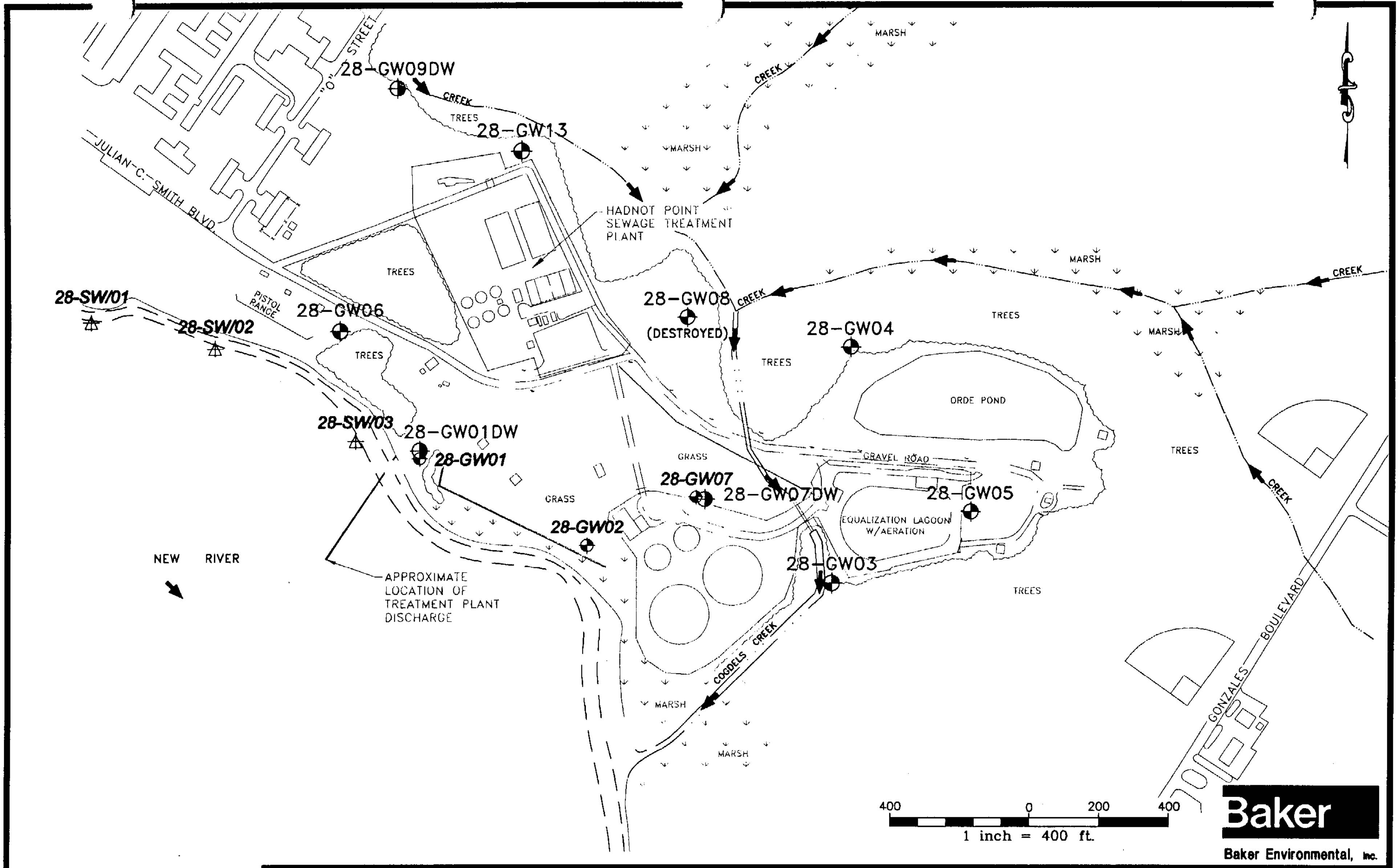
LEGEND

01-GW07 ⊕	SHALLOW MONITORING WELL
01-GW16DW ⊕	DEEP MONITORING WELL
◄——	APPROXIMATE SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON & ASSOC., JUNE 1994.

FIGURE 1
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 7 – SITE 1

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker Environmental, Inc.

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

367405WP

LEGEND

28-GW01 ⊕ SHALLOW MONITORING WELL
28-GW01DW ⊕ DEEP MONITORING WELL
28-SW/SD01 △ SURFACE WATER AND SEDIMENT SAMPLE LOCATION
← APPROXIMATE SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, FEBRUARY 1992 AND W.K. DICKSON, JUNE 1994

FIGURE 2
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 7 – SITE 28

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

LONG TERM MONITORING WORK PLAN

OPERABLE UNIT NO. 12 (SITE 3)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

The Record of Decision (ROD) for Operable Unit (OU) No. 12 (Site 3), Marine Corps Base (MCB), Camp Lejeune, North Carolina, was formulated in response to findings of previous investigations, and was signed on April 3, 1997. The ROD outlines remedial actions to be implemented at OU 12. Long Term Monitoring (LTM) was stipulated in the ROD to provide site-specific monitoring activities, which are currently being implemented. The objective of this work plan is to address the continuation of those monitoring activities at OU 12, which are scheduled to resume in July 1999.

This work plan entails four areas of discussion. The first provides a general description of the investigative area including its location and history of operation. The second is a brief review of the original ROD, discussing the areas of concern and the selected remedial alternatives. Next is a chronology of approved changes that have occurred since the ROD's acceptance. Finally, activities that are currently being implemented and are planned to continued under the monitoring program are outlined in detail.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 12

The study area, OU 12, is one of 18 operable units within MCB, Camp Lejeune. OU 12 encompasses approximately five acres within the mainside supply and storage areas on the base, and is generally flat and unpaved. The site is intersected by two roadways: a dirt path that runs north-south and forms a loop in the southern portion of the site, and a gravel road that runs east-west and leads directly to Holcomb Boulevard. The Camp Lejeune Railroad line runs parallel to the site's western edge and intersects an old railroad spur line at the site's southern extreme. Wooded areas lie north and east of the site (Figure P-1). Recently, OU 12 was formerly used as a staging area for hurricane debris.

OU 12 is comprised solely of Site 3, known as the Old Creosote Plant. The Old Creosote Plant operated from 1951 to 1952 to supply treated lumber during construction of the base railroad. Logs were cut into railroad ties at an on-site sawmill, then pressure treated with hot creosote stored in a railroad tank car. There is no indication of creosote disposal on site, and records show that creosote remaining in the pressure chamber at the end of the treatment cycle was stored for future use. Historical information indicates that the on-site sawmill was located to the north of the current gravel access road.

2.2 Record of Decision for Operable Unit No. 12

This section indicates previous investigations at OU 12 upon which the ROD is based, and describes the actions recommended to remediate areas of concern. Remedial actions for Site 3 were approved by representatives of the following:

- Naval Facilities Engineering Command, Atlantic Division
- Marine Corps Base Camp Lejeune
- U.S. Environmental Protection Agency - Region IV
- North Carolina Department of Environment, Health, and Natural Resources

In addition to agency approval, a public meeting was held to solicit concerns from the community regarding the selected remedial alternative. A 30-day comment period followed the public meeting. The ROD was signed after a responsiveness summary and final version of the decision document had been prepared.

2.2.1 Previous Investigations

Investigative activities for OU 12 began in 1983 with an Initial Assessment Study. Additional documents that are relevant to the accepted remedial alternatives for Site 3 include the following:

- Site Summary Report - 1990
- Site Inspection - 1991
- Final Remedial Investigation Report - July, 1996
- Final Feasibility Study - August, 1996
- Final Proposed Remedial Action Plan - October, 1996
- Final Record of Decision - January, 1997

Pertinent findings are summarized in the Final ROD for OU 12. As a result of these findings, areas of concern (AOCs) were located within the subsurface soil in the vicinity of monitoring well 03-MW02, and within groundwater areas centered around monitoring wells 03-MW02 and 03-MW06 (Figure 1). The subsurface soil AOC is considered to be a source of groundwater contamination. The areas of concern contain Semivolatile Organic Compounds (SVOCs) and Polyaromatic Hydrocarbons (PAHs) at concentrations that exceed federal and/or state standards, or risk-based criteria.

2.2.2 Selected Remedial Action

This section describes the Selected Remedial Actions as they were originally outlined in the accepted ROD.

The primary objective of the remedial action for Site 3 is to address SVOC and PAH contamination in the subsurface soil and the shallow groundwater aquifer. The Selected Remedial Actions for OU 12, as provided in the ROD, include source removal and biological treatment of contaminated subsurface soil, aquifer use restriction, and monitoring of groundwater.

Confirmatory soil sampling in the excavation area will be conducted subsequent to soil removal to ensure that contaminated soil has been removed to acceptable levels. Excavated soil will be treated with aerobic, solid-phase biological treatment in a biocell and the excavation area will be backfilled with "clean" soil.

The groundwater monitoring program will include quarterly sampling of groundwater from monitoring wells 03-MW02, 03-MW02IW, 03-MW06, 03-MW07, 03-MW08, and 03-MW11IW. Samples will be analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs) and SVOCs. If groundwater quality improves, the sampling frequency may be reduced from quarterly to semi-annual. Additionally, aquifer use restrictions prohibiting future potable use of the shallow and Castle Hayne (deeper) aquifers within a 100 foot radius of Site 3 will be implemented via the Base Master Plan. The remediation levels for groundwater contaminants of concern identified in the ROD are listed in Table 1.

The remedy provided within the ROD for Site 3 is a permanent, long term solution because contaminant levels in groundwater are minimal. Removal of the soil and periodic sampling is a reliable means of eliminating the source and monitoring contaminant persistence and migration.

2.3 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Site 3 that have been implemented since the signing of the ROD. These modifications are presented in detail in the Monitoring Reports for OU 12. All future recommendations to modify the monitoring program for OU 12 will also be presented in the monitoring reports.

2.3.1 First Half 1998 – Start of LTM Program

The initial monitoring at Site 3 consisted of five shallow monitoring wells: 03-MW02, 03-W06, 03-MW07, 03-MW11 and 03-MW13; two intermediate monitoring wells, 03-MW02IW and 03-MW11IW; as well as one deep monitoring well 03-MW02DW. Shallow monitoring well 03-MW08, formerly located in the northern portion of Site 3, was also initially scheduled to be sampled, but it was destroyed as a result of hurricane cleanup efforts prior to the start of the LTM program. Groundwater samples were collected on a semi-annual basis and analyzed for TCL VOCs and TCL SVOCs.

2.3.2 Second Half 1998

No changes occurred during this quarter.

2.3.3 First Half 1999

No changes occurred during this quarter.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for implementing the monitoring program at OU 12, Site 3 as of July 1999. In addition, sampling locations, sample analyses, and sample designations are included within this section.

3.1 Sampling

Groundwater samples will be collected semi-annually from four shallow monitoring wells, two intermediate monitoring wells, and one deep monitoring well. Samples obtained from shallow and intermediate monitoring wells will be used to assess potential contaminant concentrations in both the upper and lower portions of the surficial aquifer. The groundwater sample obtained from the deep monitoring well will be used to confirm whether known contaminants are migrating from the surficial aquifer to the Castle Hayne Aquifer. The following monitoring wells will be included in the sampling program at Site 3: 03-MW02, 03-MW02IW, 03-MW02DW, 03-MW06, 03-MW11, 03-MW11IW, and 03-MW13.

Table 2 provides construction details for each of the wells included in the monitoring program. The locations of monitoring wells throughout Site 3 are depicted in Figure 1. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 3.

Soil sampling has not been conducted subsequent to investigative activities associated with the RI, but may be incorporated in the work plan pending the source removal stipulated in the ROD.

3.2 Sample Designations

In order to identify and accurately track the various samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	Department of Defense's program to address CERCLA Requirements (i.e. Installation Restoration Program)
Site Number	Monitoring activities will be conducted at Site 3.
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a zero (e.g., 03-GW02).
QA/QC	TB = Trip Blank

Year	The number will reference the calendar year in which the sample was obtained (e.g., 99 would represent 1999).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR03-GW02IW-99A refers to:

IR03-GW02IW-99A	Installation Restoration
IR03-GW02IW-99A	Site 3
IR03-GW02IW-99A	Groundwater sample
IR03-GW02IW-99A	Monitoring well number 02
IR03-GW02IW-99A	Intermediate monitoring well
IR03-GW02IW-99A	Year 1999
IR03-GW02IW-99A	First quarter

Under this sample designation format the sample number IR03-TB01-00A refers to:

IR03-TB01-00A	Installation Restoration
IR03-TB01-00A	A Site 3
IR03-TB01-00A	Trip Blank
IR03-TB01-00A	Sequential number, in order of collection. The total number will depend upon how many trip blanks are required.
IR03-TB01-00A	Year 2000
IR03-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 3. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Site 3.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for volatile organic analysis (VOCs) will be collected first, followed by metals. Sample containers will be labeled and referenced on a laboratory chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 3 defines the sampling and analysis program for the groundwater monitoring wells at Site 3.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for volatile organic compounds. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC analyses.

Equipment rinsates, field blanks, field duplicates, and matrix spike and matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Record of Decision, Operable Unit No. 12 (Site 3), Marine Corps Base, Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. April 1997.

Baker Environmental, Inc. Semi-annual Monitoring Reports, Operable Unit No.12 (Site 3) MCB Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Ongoing submittals starting in January 1998.

TABLES

TABLE 1

REMEDIATION LEVELS FOR CONTAMINANTS OF CONCERN IN GROUNDWATER
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 12 - SITE 3
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Remediation Goal[1] (μg/L)
Benzene	1
Phenol	300
2-Methylphenol	78
2,4-Dimethylphenol	31
Naphthalene	21
2-Methylnaphthalene	63
Dibenzofuran	6
Phenanthrene	210
Benzo(a)anthracene	0.05
Chrysene	5
Chloroform	0.19
Carbazole	4
Benzo(b)fluoranthene	0.12
Benzo(k)fluoranthene	1
Benzo(a)pyrene	2
Iron	300
Aluminum	50

Notes:

(1)Baker Environmental, Inc. (1997). Record of Decision, Operable Unit No. 12 (Site 3). Final.

(μg/L) = micrograms per liter

TABLE 2

SUMMARY OF WELL CONSTRUCTION DETAILS
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 12 - SITE 3
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date Installed	Top of Casing Elevation (feet, msl)	Ground Surface Elevation (feet, msl)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)	Stick-Up (feet, ags)
03-MW02	06/21/91	35.91	32.36	17.0	17.0	16.8-6.8	2.0	4.0	3.55
03-MW02IW	11/19/94	35.19	32.50	87.0	86.5	86.5-71.5	61.0	66.5	2.69
03-MW02DW	06/28/95	34.06	32.19	140.5	140.0	140.0-125.0	119.0	122.0	1.87
03-MW06	11/19/94	30.55	27.93	23.0	22.0	22.0-7.0	3.5	5.0	2.62
03-MW11	06/15/95	32.69	30.69	32.0	31.5	31.5-16.5	11.5	14.0	2.0
03-MW11IW	06/29/95	32.55	30.30	88.0	87.0	87.0-72.0	66.0	69.0	2.25
03-MW13	06/14/95	22.93	20.80	22.0	21.5	21.5-6.5	2.0	4.0	2.13

Notes:

ags = Above ground surface
bgs = Below ground surface
msl = Mean sea level
NA = Information not available

TABLE 3

SAMPLE SUMMARY
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT NO. 12 - SITE 3
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles[1]	TCL Semivolatiles [2]	Sample Designation
03-MW02	GW	X	X	IR03-GW02-**
03-MW02IW	GW	X	X	IR03-GW02IW-**
03-MW02DW	GW	X	X	IR03-GW02DW-**
03-MW06	GW	X	X	IR03-GW06-**
03-MW11	GW	X	X	IR03-GW11-**
03-MW11IW	GW	X	X	IR03-GW11IW-**
03-MW13	GW	X	X	IR03-GW13-**

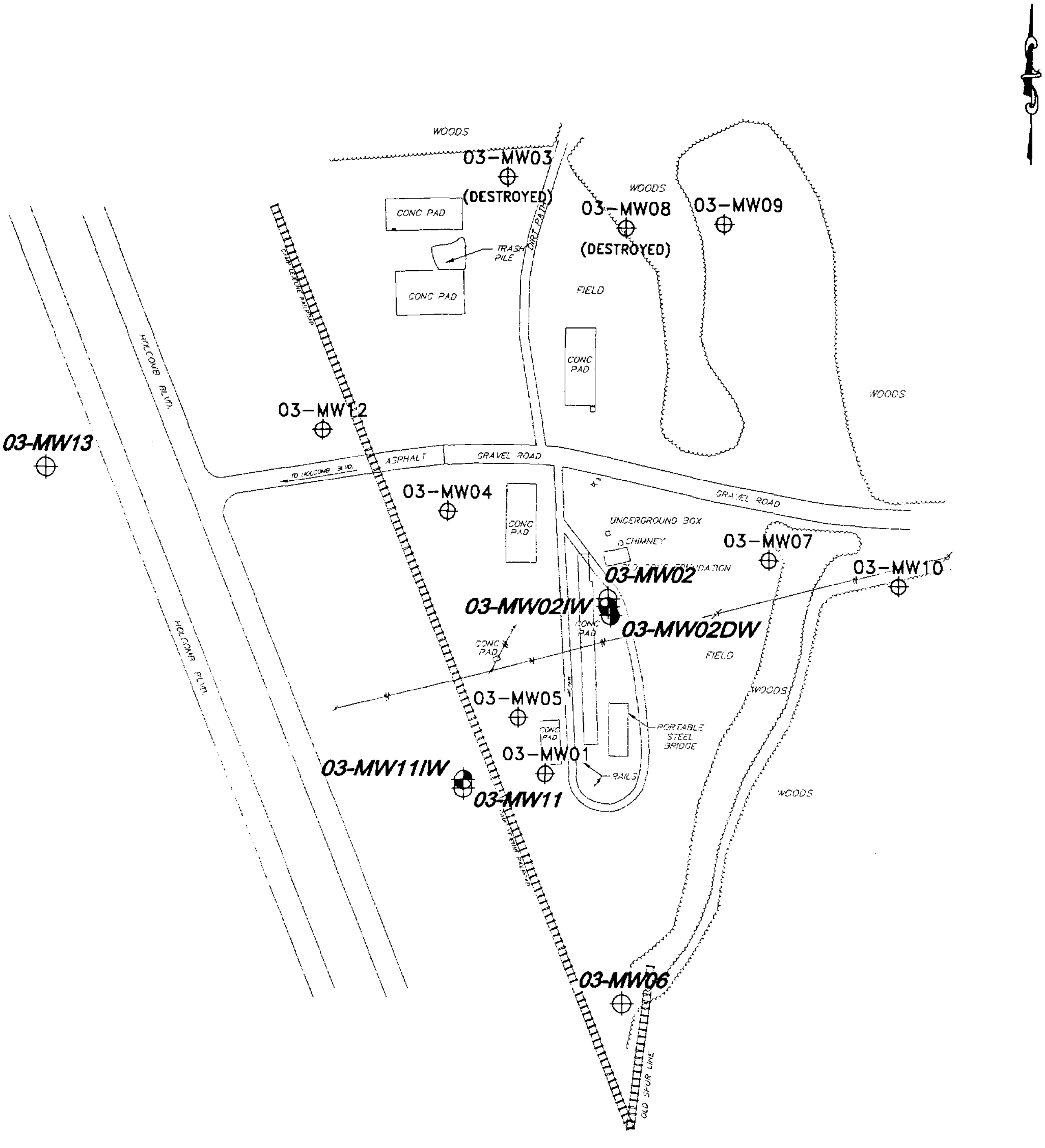
Notes:

(1) Target Compound List Volatile Organic Compounds
(2) Target Compound List Semivolatile Organics

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES

367406WP



NOTE:
-WELLS SHOWN IN BLACK
REGULAR FONT ARE NOT
INCLUDED IN THE
MONITORING PROGRAM.

200 0 100 200

1 inch = 200 ft.

Baker

Baker Environmental, Inc.

LEGEND

03-MW02
⊕ SHALLOW MONITORING WELL

3-MW02IW
◐ INTERMEDIATE MONITORING WELL

03-MW02DW
◑ DEEP MONITORING WELL

SOURCE: W.K. DICKSON & Co., INC., JANUARY 1995

FIGURE 1
SAMPLING LOCATION MAP
LONG TERM MONITORING WORK PLAN
OPERABLE UNIT No. 12 - SITE 3

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

NATURAL ATTENUATION MONITORING WORK PLAN

OPERABLE UNIT NO. 6 (SITES 36, 54, AND 86)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVE

In the recent past, field investigations have been performed by various consultants at Operable Unit (OU) No. 6 (Sites 36, 43, 44, 54, and 86), Marine Corps Base (MCB), Camp Lejeune, North Carolina. These investigations form the basis for the forthcoming Record of Decision (ROD), which defines site-specific remedial goals. Based on the nature of contamination revealed by data from the past investigations, Sites 36, 54, and 86 are candidates for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Baker-Environmental, Inc. (Baker) has been tasked to implement monitoring at Sites 36, 54, and 86 to provide additional data necessary to support NA as a remedial alternative.

The primary objective of this Work Plan (WP) is to outline upcoming activities to be implemented under the monitoring program at Sites 36, 54, and 86. Additionally, the WP provides a general description of OU 6 including site location and a history of operation, and describes the original monitoring program and any amendments implemented since its inception.

2.0 BACKGROUND

Marine Corps Base (MCB), Camp Lejeune is a training base for the United States Marine Corps, located in Onslow County, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 6

The study area, OU 6, is one of 18 operable units within MCB, Camp Lejeune. OU 6 is located within the northwest portion of the base and is comprised of five sites: 36, 43, 44, 54, and 86. Site 36 is located within the Camp Geiger operations area. The remaining four sites are located within the Marine Corps Air Station (MCAS), New River operations area.

2.1.1 Site 36

Site 36, the Camp Geiger Area Dump, is located approximately 1,000 feet east of Camp Geiger and 500 feet west of the New River, adjacent to the Camp Geiger Sewage Treatment Plant. Site 36 encompasses nearly 20 acres and is comprised primarily of open fields and wooded areas with dense understory. A gravel road bisects the site and provides access to Jack's Point Recreation Area, located approximately one-quarter mile to the east. In addition, the completion of the Route 17 Jacksonville Bypass project will divide Site 36. The site is bordered to the north and east by Brinson Creek and woods, to the east by woods, to the south by an unnamed tributary to the New River, and to the west by an improved (i.e., coarse gravel) road.

Site 36 is reported to have been used for the disposal of municipal wastes and mixed industrial wastes including trash, waste oils, solvents, and hydraulic fluids that were generated at MCAS, New

River. The dump was active from the late 1940s to the late 1950s. Most of the material was first burned and then buried; however, some unburned material was also buried.

2.1.2 Site 43

Site 43, the Agan Street Dump, is comprised of approximately 11 acres and is located within the operations area of MCAS, New River, two miles west of the New River. The site is bordered to the north by Edwards Creek, to the east and south by Strawhorn Creek, and to the west by Agan Street and the former sewage disposal facility. Much of the site is heavily vegetated with dense understory and trees greater than three inches in diameter. Marsh areas that are prone to flooding line both Strawhorn and Edwards Creeks. An improved gravel loop road provides access to the main portion of the study area; other improved paths extend outward from this road.

The Agan Street Dump reportedly received mainly inert material such as construction debris (i.e., fiberglass and lumber) and trash. Sludge from a former sewage disposal facility, located adjacent to the study area, was also dumped at Site 43. The years during which disposal operations took place are not known.

2.1.3 Site 44

Site 44, the Jones Street Dump, encompasses approximately 5 acres and is situated within the operations area of MCAS, New River. Vehicle access to the site is via Baxter Street, from Curtis Road. Site 44 is located at the northern terminus of Baxter Street, behind Base housing units situated along Jones Street. The site is partially surrounded by a six-foot cyclone fence, and a portion of the site lies to the east of the fenced area. The site is bordered to the north and west by Edwards Creek, to the south by Base housing units (along Jones Street), and to the east by woods and an unnamed tributary to Edwards Creek. A majority of the site is comprised of a gently dipping open field that slopes toward Edwards Creek. The field is covered with high grass, weeds, and small pine trees that are less than two inches in diameter. Surrounding the open field is a mature wooded area with dense understory.

Site 44 was reportedly in operation during the 1950s. Although the quantity of waste is not known, debris, cloth, lumber, and paint cans were reportedly disposed at the site. It was also reported that minor quantities of potentially hazardous waste may have been disposed at Site 44; however, the background information does not indicate the exact kind of hazardous waste disposed.

2.1.4 Site 54

Site 54, the Crash Crew Fire Training Burn Pit, is located near the southwest end of runway 5-23, within the operations area of MCAS, New River. The burn pit is approximately 90 feet in diameter and is situated at the center of this 1.5 acre site. An 8,000-gallon underground storage tank (UST) lies to the northwest of the burn pit. Fire training exercises are conducted within the burn pit using JP-type fuel, which is stored in the nearby UST. An oil and water separator, located approximately 100 feet southeast of the burn pit, is used for temporary storage and collection of the spent fuel. An improved gravel surface surrounds the burn pit, while the remaining portion of the site is comprised of a maintained lawn area. The ground surface slopes away from the central portion of the study area toward the south, southwest, and southeast. Two drainage ditches lead away from the burn pit area toward the south, on either side of the improved road. During periods of heavy precipitation, the ditches serve as channels for surface water runoff.

Site 54 has served as a fire training burn pit since the mid-1950s. Excess fuels, oils, and solvents were used to simulate fire conditions that would result from aircraft crashes. Fire training at Site 54 was originally conducted on the ground surface, within a bermed area. In 1975, a lined burn pit was constructed. The same burn pit remains in operation today; however, only JP-type fuels are used during training exercises.

2.1.5 Site 86

Site 86, Tank Area AS419-AS421 at MCAS, is located on the southwest corner of the Foster and Campbell Street intersection, within the operations area of MCAS, New River. The site is comprised of a lawn area surrounded by buildings, asphalt roads, and parking lots. Concrete pylons, upon which electric and steam overhead utilities are mounted, line the northern, western, and southern boundaries of the site. Campbell Street borders the site to the north and Foster Street lies adjacent to the east. Immediately to the south of the study area is Building As-502, the MCAS fire station. The entrance road to the fire station borders the study area to the west. The ground surface at Site 86 gently slopes to the south, toward a drainage ditch and culvert. Storm water drains that are located along Campbell Street receive runoff from the roadway and only the northernmost portion of the study area.

Site 86 served as a storage area for petroleum products from 1954 to 1988. In 1954, three 25,000-gallon above ground storage tanks were installed within an earthen berm. Additionally, a small pump house was constructed to transfer fuel oil to and from the ASTs. The three tanks were reportedly used for No.6 fuel oil storage until 1979. From 1979 to 1988 the tanks were used for temporary storage of waste oil. The three tanks were emptied in 1988 and are believed to have been removed in 1992. Today, the former location of the tanks is grass-covered and only a very slight depression remains.

2.2 Monitoring Timeline

The monitoring program at OU 6 began in July (third quarter) 1998 for Sites 54 and 86, and in October (fourth quarter) 1998 for Site 36. The following section briefly presents approved additions and modifications to the monitoring program at Sites 36, 54, and 86 that have been implemented since its inception. These modifications will be presented in detail in the monitoring reports for OU 6. All future recommendations to modify the monitoring program for OU 1 will also be presented in the monitoring reports. No monitoring reports have been submitted for this operable unit to date.

2.2.1 Third Quarter 1998 – Start of Monitoring Program at Sites 54 and 86

Site 54

The initial monitoring program at Site 54 consisted of the quarterly collection of groundwater samples from eight shallow monitoring wells: 54-MW06, 54-MW07, 54-MW08, 54-MW09, 54-MW10, 54-MW11, 54-MW12, and 54-MW13. Samples were to be analyzed for Volatile Organic Compounds (VOCs) and, as part of the natural attenuation study, nitrate and dissolved gases (i.e., ethene, ethane, and methane). Wells 54-MS07, 54-MW11, and 54-MW13 were designated as background wells for Site 54 and were also analyzed for Total Organic Carbon (TOC), Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 54, immediate field analyses for ferrous iron, alkalinity chloride, and sulfate were also conducted.

Site 86

The initial monitoring program at Site 86 consisted of the quarterly collection of groundwater samples from twelve intermediate and three deep monitoring wells. Intermediate wells included AS-428-GW06, 86-MW08IW, 86-MW10IW, 86-MW15IW, 86-MW16IW, 86-MW23IW, 86-MW25IW, 86-MW28IW, 86-MW29IW, 86-MW30IW, 86-MW31IW, and 86-MW32IW. Deep wells included 86-MW15DW, 86-MW19DW, and 86-MW31DW. Samples were analyzed for VOCs and, as part of the natural attenuation study, for dissolved gases and nitrate. Wells 86-MW28IW, 86-MW30IW, and 86-MW32IW were designated as background wells for Site 86 and were also analyzed for TOC, TON, nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 86, immediate field analyses for ferrous iron, alkalinity chloride, and sulfate were also conducted.

2.2.2 Fourth Quarter 1998 – Start of Monitoring Program at Site 36

Site 36

The initial monitoring program at Site 36 consisted of the quarterly collection of both groundwater and surface water samples. Four surface water samples were collected from distinct sampling points along the New River and were analyzed for volatile organic compounds. Groundwater samples were collected from six shallow, four intermediate, and one deep monitoring well to be analyzed for VOCs and, as part of the natural attenuation study, dissolved gases and nitrate. Shallow wells included 36-MW03, 36-MW09, 36-MW10, 36-MW12, 36-MW13, and 36-MW15. Intermediate wells included 36-MW01IW, 36-MW12IW, 36-MW13IW, and 36-MW16IW. The deep monitoring well was 36-MW10DW. Wells 36-MW03 and 36-MW09 were designated as background wells for Site 36 and were also analyzed for TOC, TON, nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 36, immediate field analyses for ferrous iron, alkalinity chloride, and sulfate were also conducted.

Site 54

No changes occurred during this quarter.

Site 86

No changes occurred during this quarter.

2.2.3 First Quarter 1999

Site 36

Monitoring wells 36-MW12 and 36-MW12IW were abandoned due to the construction of U.S. Route 17, Jacksonville Bypass. These wells were replaced by new monitoring wells 36-MW18 and 36-MW18IW.

Monitoring well 36-MW15 was also abandoned due to the highway construction. It was replaced by 36-MW19.

Henceforth, sulfate analyses at Site 36 were conducted by the laboratory rather than by field personnel.

Site 54

The analysis plan was adjusted to include Target Compound List Semivolatile analyses for all wells sampled. The primary pollutants at Site 54 are semivolatile organic compounds.

Henceforth, sulfate analyses at Site 54 were conducted by the laboratory rather than by field personnel.

Site 86

Henceforth, sulfate analyses at Site 86 were conducted by the laboratory rather than by field personnel.

2.2.4 Second Quarter 1999

Site 36

No changes occurred during this quarter.

Site 54

No changes occurred during this quarter.

Site 86

No changes occurred during this quarter.

Any recommendations regarding additions and modifications to the monitoring program at Sites 36, 54, and 86 will be presented in detail in monitoring reports for OU 6.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 6, Sites 36, 54, and 86 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

OU 6 has undergone four quarterly sampling events to date. A limited number of changes in the sampling program have been initiated and are reflected in the current sampling plan for OU 6, which follows.

3.1.1 Site 36

Both surface water and groundwater will be sampled at Site 36. Four surface water samples will be collected and analyzed for volatile organic compounds. Groundwater samples will be collected from six shallow, four intermediate, and one deep monitoring well, and will be analyzed for VOCs and, as part of the natural attenuation study, dissolved gases, sulfate, and nitrate. Wells 36-MW03 and 36-MW09 were designated as background wells for Site 36 and will additionally be analyzed for TOC, TON, nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 36, immediate field analysis for ferrous iron, alkalinity, and chloride are also conducted. Table 1 provides construction details for each of the monitoring wells included in the monitoring program and Table 2 provides the sampling and analysis program for groundwater and surface water samples obtained at Site 36. Intermediate monitoring wells are indicated by "IW" and the deep well is indicated by "DW". The shallow and intermediate monitoring wells will be employed to monitor conditions within the surficial aquifer. Samples obtained from the deep monitoring well will be representative of conditions within the deeper, Castle Hayne, aquifer. The location of monitoring wells throughout Site 36 are depicted in Figure 1. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 36.

1.1.2 Site 54

At Site 54, groundwater samples will be collected from eight shallow wells and will be analyzed for VOCs and, as part of the natural attenuation study, dissolved gases, sulfate, and nitrate Wells 54-MS07, 54-MW11, and 54-MW13 were designated as background wells for Site 54 and will additionally be analyzed for TOC, TON, nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 54, immediate field analysis for ferrous iron, alkalinity, and chloride are also conducted. Table 3 provides construction details for each of the monitoring wells included in the monitoring program and Table 4 provides the sampling and analysis program for groundwater samples obtained at Site 54. The location of monitoring wells throughout Site 54 are depicted in Figure 2. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 54.

1.1.3 Site 86

Groundwater samples will be collected from twelve intermediate and three deep monitoring wells and will be analyzed for VOCs and, as part of the natural attenuation study, dissolved gases and nitrate. Wells 86-MW28IW, 86-MW30IW, and 86-MW32IW were designated as background wells for Site 86 and will additionally be analyzed for TOC, TON, nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 86, immediate field analysis for ferrous iron, alkalinity, and chloride are also conducted. Table 5 provides construction details for each of the monitoring wells included in the monitoring program and Table 6 provides the sampling and analysis program for groundwater and surface water samples obtained at Site 86. In general, intermediate wells are indicated by "IW" and deep wells are indicated by "DW". Well AS-428-GW06 is an intermediate well. The intermediate wells will be employed to monitor conditions within the surficial aquifer. Samples obtained from the deeper monitoring wells will be representative of conditions within the deeper, Castle Hayne, aquifer. The location of monitoring wells throughout Site 86 are depicted in Figure 3. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 86.

3.2 Sample Designations

In order to identify and accurately track the various samples, all samples collected during the monitoring program, including quality assurance and quality control (QA/QC) samples, will be designated with a unique identification number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC samples, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site Number - Media and Station Number or QA/QC - Year and Quarter of Event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's Program to Address CERCLA Requirements (i.e., Installation Restoration Program)
Site Number	Monitoring activities will be conducted at Sites 36, 54, and 86.
Media	GW = Groundwater SW = Surface water
Station Number	Each sample location or monitoring well will be identified with a unique identification number.
QA/QC	TB = Trip Blank
Year	The number will reference the calendar year the sample was obtained (e.g., 00 would represent 2000).
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR36-GW10DW-00B refers to:

IR36-GW10DW-00B	Installation Restoration
IR36-GW10DW-00B	Site 36
IR36-GW10DW-00B	Groundwater sample
IR36-GW10DW-00B	Monitoring well number 10
IR36-GW10DW-00B	Deep monitoring well
IR36-GW10DW-00B	Year 2000
IR36-GW10DW-00B	Second quarter

Under this sample designation format the sample number IR36-SW02-00B refers to:

IR36-SW02-00B	Installation Restoration
IR36-SW02-00B	Site 36
IR36-SW02-00B	Surface water sample
IR36-SW02-00B	Monitoring location number 02
IR36-SW02-00B	Year 2000
IR36-SW02-00B	Second quarter

Under this sample designation format the sample number IR54-TB01-00B refers to:

IR54-TB01-00B	Installation Restoration
IR54-TB01-00B	Site 54
IR54-TB01-00B	Trip Blank
IR54-TB01-00B	Sequential number, in order of collection. The total number will depend upon how many trip blanks are required.
IR54-TB01-00B	Year 2000
IR54-TB01-00B	Second quarter

This sample designation format will be followed throughout the project. Required deviation from this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Sites 36, 54, and 86. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Sites 36, 54, and 86.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

Surface water samples will be collected from four discrete locations at Site 36. The following is the sampling method to be used to obtain the surface water samples:

1. Surface water samples will be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted, if required.

2. Samples will be collected by dipping the sample bottles directly into the water. An unpreserved, laboratory-decontaminated transfer bottle will be used to fill preserved bottles. Additionally, a transfer bottle will be used to fill all bottles if surface water is too shallow. Care will be taken when collecting samples for VOCs to avoid excessive agitation that could result in the loss of volatiles. Sample containers will be labeled prior to collection.

3. If sample containers do not contain preservative they will be rinsed at least once with the sample water prior to the final sample collection. In addition, the sampling container used to transfer the surface water into the sample bottles containing preservative will be rinsed once with the sample water.

4. Temperature, pH, specific conductance, and dissolved oxygen will be measured in the field at each sampling station immediately following sample collection.

5. The sample containers will be stored in a cooler with ice until laboratory shipment.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Tables 1, 3, and 5 define the sampling and analysis program for the groundwater monitoring wells at Sites 36, 54, and 86, respectively.

3.4 Quality Assurance / Quality Control

Quality assurance and quality control requirements for the monitoring program are limited to trip blanks and matrix spike/matrix spike duplicates (MS/MSD).

Trip blanks are defined as samples comprised of analyte-free water from the laboratory, which are shipped to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for volatile analyses.

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with selected target analytes and analyzed with the associated sample and MS sample. MS/MSD samples undergo the same extraction and analytical procedures as the unfortified field sample. The results of the MS and MSD are used together to determine the effect of the matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not on all samples in the QC batch. MS/MSD samples at Sited 54 and 86 will only be analyzed for VOCs. MS/MSD samples at Site 36 will be analyzed for VOCs and SVOCs.

Equipment rinsates, field blanks, and field duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, extraneous QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Remedial Investigation Report, Operable Unit No. 6 (Sites 36, 43, 44, 54, and 86) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 36
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
36-GW03	7/84	8.70	6.5	NA	20.0	NA	NA	NA	2.2
36-GW09	3/9/95	13.52	11.8	21.5	20.5	5.5-20.5	3.5-21	0-3.5	1.72
36-GW10	3/9/95	9.04	7.3	21.5	20.5	5.5-20.5	3-20.5	0-3	1.74
36-GW10IW	4/22/95	9.88	7.1	35.0	34.0	24-34	22-35	19-22	2.78
36-GW10DW	6/28/95	9.55	7.2	68.0	67.1	62-67	60-68	39-60	2.35
36-GW13	4/24/95	6.19	4.0	20.0	19.0	4-19	3-20	0.5-3	2.19
36-GW13IW	4/24/95	5.98	3.8	34.0	33.0	23-33	18-34	15-18	2.18
36-GW16IW	NA	NA	NA	NA	41.5	NA	NA	NA	NA
36-GW18	9/20/98	9.99	NA	19.0	19.0	4-19	2.5-19	0.5-2.5	NA
36-GW18IW	9/20/98	9.37	NA	36.0	36.0	31-36	29-36	27-29	NA
36-GW19	9/20/98	12.97	NA	19.0	18.0	3-18	2-18	0.5-2	NA

Notes:
msl - Mean sea level
bgs - Below ground surface
ft - Feet
NA - Data is not available.

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 36
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
36-GW03	7/84	8.70	6.5	NA	20.0	NA	NA	NA	2.2
36-GW09	3/9/95	13.52	11.8	21.5	20.5	5.5-20.5	3.5-21	0-3.5	1.72
36-GW10	3/9/95	9.04	7.3	21.5	20.5	5.5-20.5	3-20.5	0-3	1.74
36-GW10IW	4/22/95	9.88	7.1	35.0	34.0	24-34	22-35	19-22	2.78
36-GW10DW	6/28/95	9.55	7.2	68.0	67.1	62-67	60-68	39-60	2.35
36-GW13	4/24/95	6.19	4.0	20.0	19.0	4-19	3-20	0.5-3	2.19
36-GW13IW	4/24/95	5.98	3.8	34.0	33.0	23-33	18-34	15-18	2.18
36-GW16IW	NA	NA	NA	NA	41.5	NA	NA	NA	NA
36-GW18	9/20/98	9.99	NA	19.0	19.0	4-19	2.5-19	0.5-2.5	NA
36-GW18IW	9/20/98	9.37	NA	36.0	36.0	31-36	29-36	27-29	NA
36-GW19	9/20/98	12.97	NA	19.0	18.0	3-18	2-18	0.5-2	NA

Notes:

msl - Mean sea level
bgs - Below ground surface
ft - Feet
NA - Data is not available.

TABLE 2

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 36
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles(1)	Dissolved Gases(2)	Nitrate	Sulfate	TOC(3)	TON(4)	Nitrate/Nitrite	Ammonia	Orthophosphate	Sample Designation
36-MW03	GW	X	X	X	X	X	X	X	X	X	IR36-GW03-**
36-MW09	GW	X	X	X	X	X	X	X	X	X	IR36-GW09-**
36-MW10	GW	X	X	X	X						IR36-GW10-**
36-MW10IW	GW	X	X	X	X						IR36-GW10IW-**
36-MW10DW	GW	X	X	X	X						IR36-GW10DW-**
36-MW13	GW	X	X	X	X						IR36-GW13-**
36-MW13IW	GW	X	X	X	X						IR36-GW13IW-**
36-MW16IW	GW	X	X	X	X						IR36-GW16IW-**
36-MW18	GW	X	X	X	X						IR36-MW18-**
36-MW18IW	GW	X	X	X	X						IR36-MW18IW-**
36-MW19	GW	X	X	X	X						IR36-MW19-**
36-SW01	SW	X									IR36-SW01-**
36-SW02	SW	X									IR36-SW02-**
36-SW03	SW	X									IR36-SW03-**
36-SW04	SW	X									IR36-SW04-**

Notes:

(1) Target Compound List Volatile Organics Compounds

(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
SW = Surface Water
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

TABLE 3

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 54
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
54-GW06	3/25/95	20.77	21.22	18.0	16.0	11-16	7.5-18	4-7.5	-0.45
54-GW07	3/24/95	21.47	21.92	35.5	35.0	25-35	20-35.5	10-20	-0.45
54-GW08	4/8/95	20.99	21.12	29.5	29.5	24-29	22-29.5	18-22	-0.13
54-GW09	4/7/95	18.77	18.92	12.0	12.0	6.5-11.5	5-12	3-5	-0.15
54-GW10	4/7/95	19.43	19.52	13.0	13.0	7.5-12.5	6-13	4-6	-0.09
54-GW11	6/28/97	14.98	14.98	18.0	17.5	7.5-17.5	5.0-18	3.0-5	0.00
54-GW12	6/28/97	17.31	17.31	18.0	17.5	7.5-17.5	5.0-18	3.0-5	0.00
54-GW13	6/28/97	19.09	19.09	18.0	17.0	7.5-17.5	5.0-18	3.0-5	0.00

Notes:
msl - Mean sea level
bgs - Below ground surface
ft - Feet
Where stick up is negative, flush mount wells were installed.

TABLE 4

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 54
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles[1]	TCL Semivolatiles[2]	Dissolved Gases[3]	Nitrate	Sulfate	TOC[4]	TON[5]	Nitrate/Nitrite	Ammonia	Orthophosphate	Sample Designation
54-MW06	GW	X	X	X	X	X						IR54-GW06-**
54-MW07	GW	X	X	X	X	X	X	X	X	X	X	IR54-GW07-**
54-MW08	GW	X	X	X	X	X						IR54-GW08-**
54-MW09	GW	X	X	X	X	X						IR54-GW09-**
54-MW10	GW	X	X	X	X	X						IR54-GW10-**
54-MW11	GW	X	X	X	X	X	X	X	X	X	X	IR54-GW11-**
54-MW12	GW	X	X	X	X	X						IR54-GW12-**
54-MW13	GW	X	X	X	X	X	X	X	X	X	X	IR54-GW13-**

Notes:

(1) Target Compound List Volatile Organics Compounds

(2) Target Compound List Semivolatile Organics Compounds

(3) Methane, ethane, and ethene

(4) Total Organic Carbon

(5) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

TABLE 5

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 86
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
86-GW08IW	1/22/92	19.92	NA	30.0	30.0	20-30	18-30	16-18	NA
86-GW10IW	1/24/92	17.95	NA	30.0	30.0	20-30	18-30	16-18	NA
86-GW15DW	3/9/95	16.49	16.83	100.0	95.0	90-95	86-100	75-86	-0.34
86-GW15IW	3/9/95	16.56	16.94	57.0	55.0	45-55	41-57	33-41	-0.38
86-GW16IW	3/12/95	16.71	16.97	57.0	55.0	45-55	42-57	27-42	-0.26
86-GW19DW	3/20/95	18.67	15.77	100.0	95.0	90-95	85-100	81-85	2.9
86-GW23IW	4/26/95	17.36	17.59	65.0	64.0	64-64	49-65	46-49	-0.23
86-GW25IW	10/9/95	15.32	15.46	30.5	30.3	20-30	18-30.5	16-18	-0.14
86-GW28IW	6/25/97	15.80	NA	62.0	58.72	45-60	41-60.5	34-41	NA
86-GW29IW	6/26/97	16.97	NA	62.0	60.0	45-60	41-62	34.5-41	NA
86-GW30IW	6/28/97	17.57	NA	62.0	59.6	45-60	41-62	38.5-41	NA
86-GW31DW	7/30/98	NA	NA	90.0	90.0	80-90	78.5-90	68.5-78.5	NA
86-GW31IW	9/15/97	NA	NA	45.5	55.5	44-54	40-56	35-40	NA
86-GW32IW	7/30/98	NA	NA	60.0	60.0	50-60	45.5-60	39.5-47.5	NA
AS-428-GW06	6/2/95	21.47	NA	50.0	49.8	45-50	42-50	37-42	NA

Notes:
msl - Mean sea level
bgs - Below ground surface
ft - Feet
NA - Data is not available.
Where stick up is negative, flush mount wells were installed.

TABLE 6

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 6 - SITE 86
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles[(1)]	Dissolved Gases[(2)]	Nitrate	Sulfate	TOC[(3)]	TON[(4)]	Nitrate/Nitrite	Ammonia	Orthophosphate	Sample Designation
AS-428-GW06	GW	X	X	X	X	X	X	X	X	X	IR86-AS428-GW06-**
86-MW08IW	GW	X	X	X	X						IR86-GW08IW-**
86-MW10IW	GW	X	X	X	X						IR86-GW10IW-**
86-MW15IW	GW	X	X	X	X						IR86-GW15IW-**
86-MW15DW	GW	X	X	X	X						IR86-GW15DW-**
86-MW16IW	GW	X	X	X	X						IR86-GW16IW-**
86-MW19DW	GW	X	X	X	X						IR86-GW19DW-**
86-MW23IW	GW	X	X	X	X						IR86-GW23IW-**
86-MW25IW	GW	X	X	X	X						IR86-GW25IW-**
86-MW28IW	GW	X	X	X	X	X	X	X	X	X	IR86-GW28IW-**
86-MW29IW	GW	X	X	X	X						IR86-GW29IW-**
86-MW30IW	GW	X	X	X	X	X	X	X	X	X	IR86-GW30IW-**
86-MW31IW	GW	X	X	X	X						IR86-GW31IW-**
86-MW31DW	GW	X	X	X	X						IR86-GW31DW-**
86-MW32IW	GW	X	X	X	X	X	X	X	X	X	IR86-GW32IW-**

Notes:

(1) Target Compound List Volatile Organics Compounds

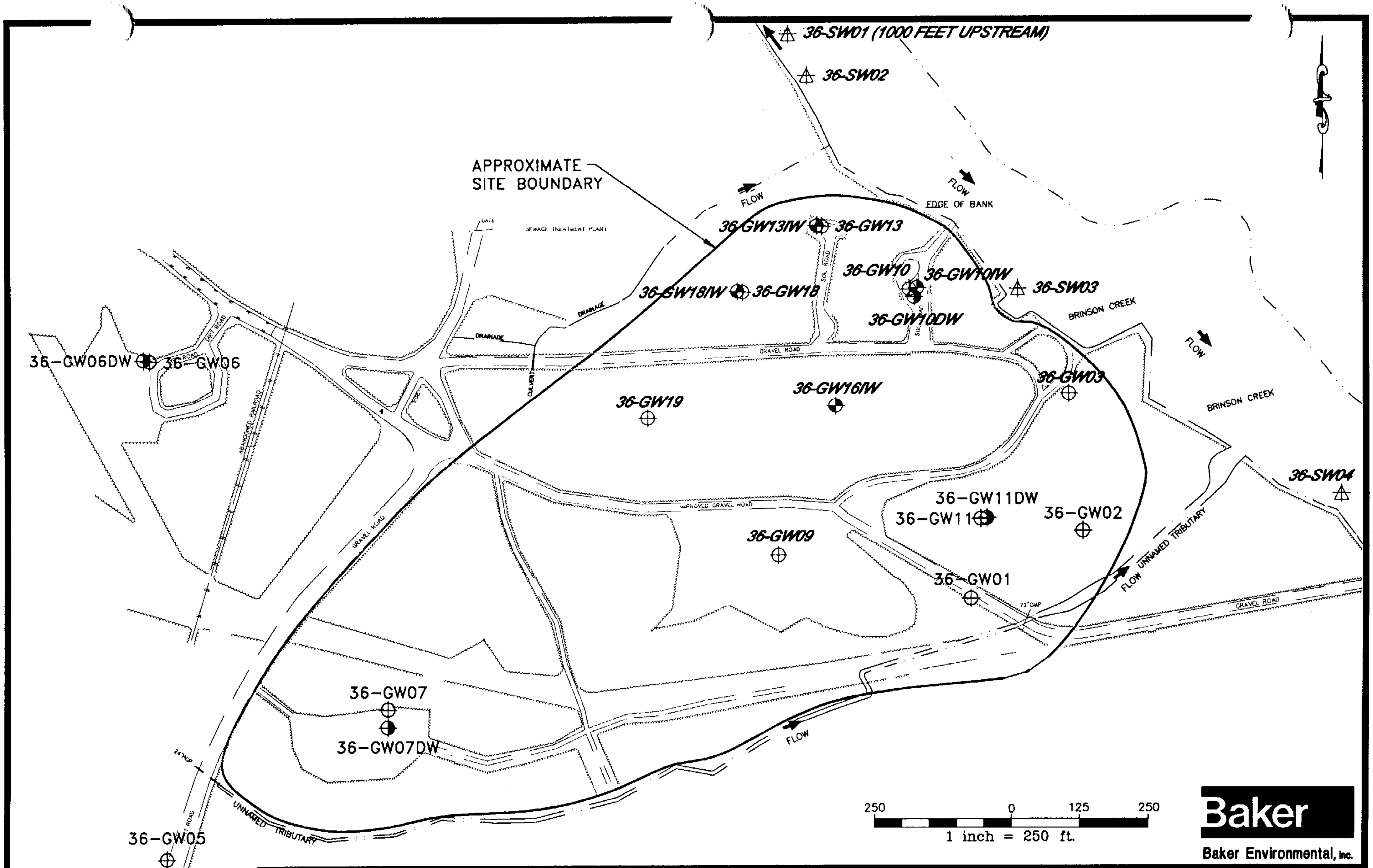
(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



Baker

Baker Environmental, Inc.

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

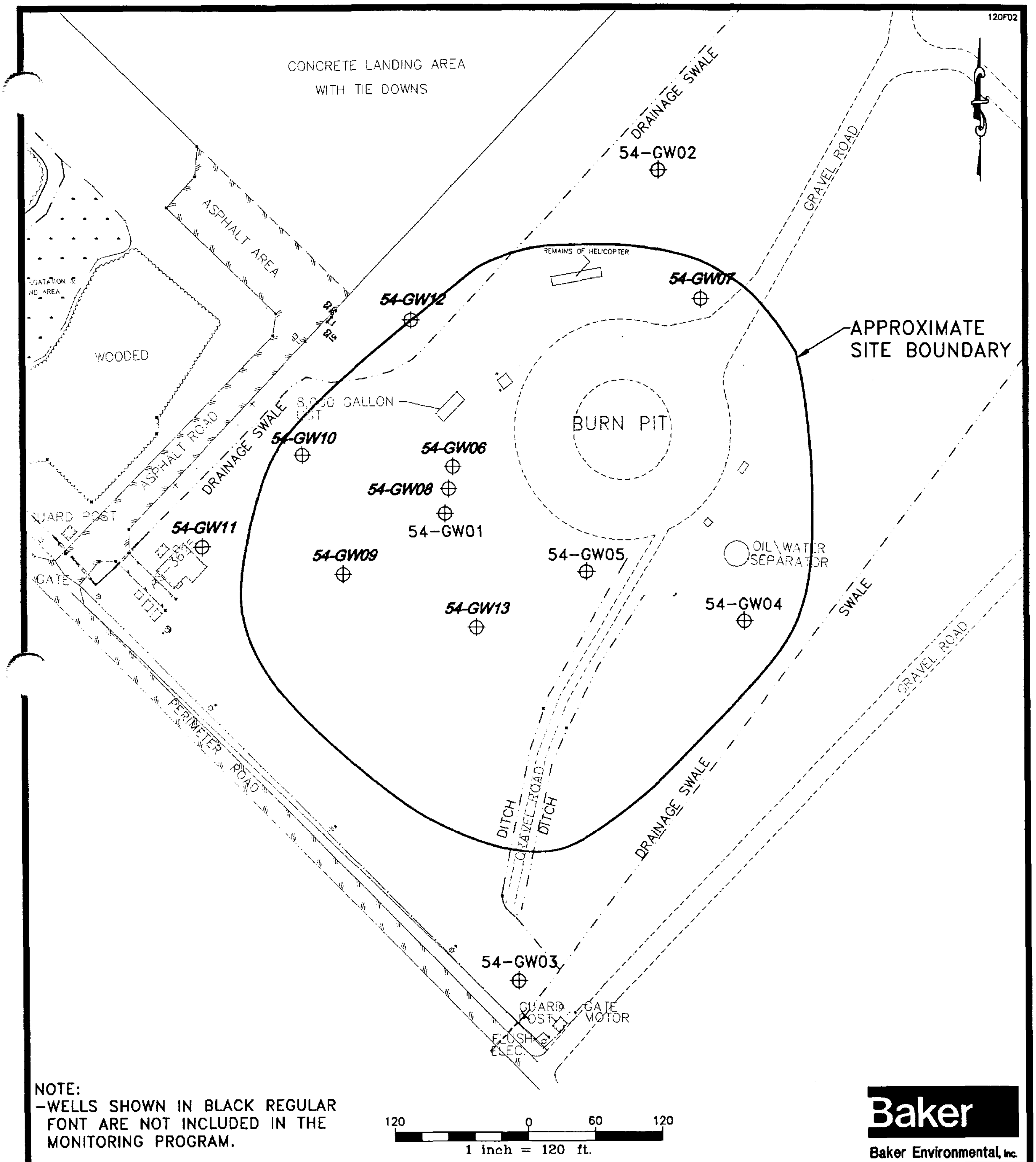
LEGEND

⊕	SHALLOW MONITORING WELL LOCATION
◐	INTERMEDIATE MONITORING WELL LOCATION
◑	DEEP MONITORING WELL LOCATION
△	SURFACE WATER SAMPLE LOCATION
→ FLOW	DIRECTION OF SURFACE WATER FLOW
— — —	EDGE OF CREEK, OR DRAINAGE DITCH

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 6 – SITE 36

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

120F01



NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

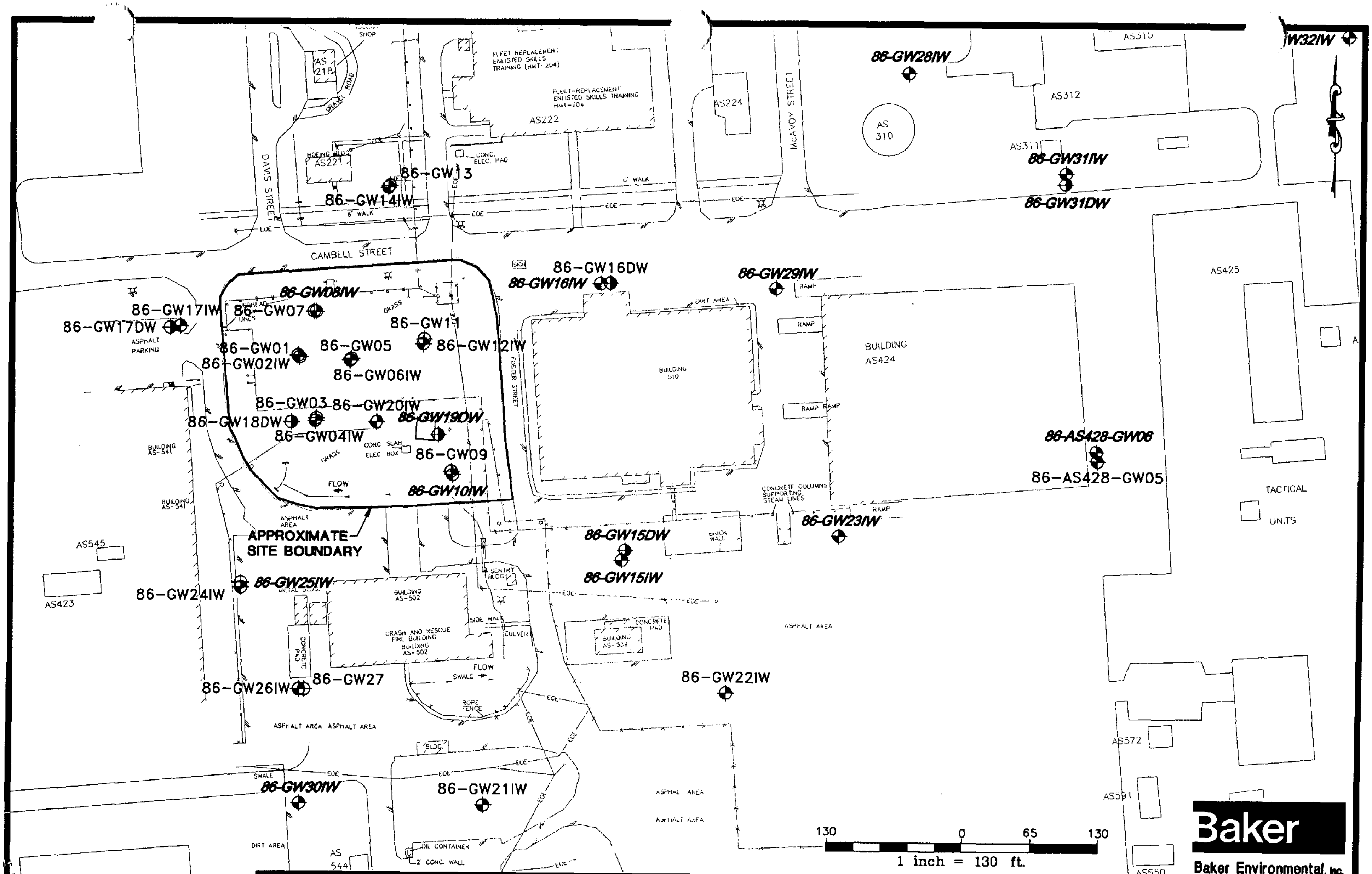
Baker
Baker Environmental, Inc.

LEGEND

54-GW07 ⊕ SHALLOW MONITORING WELL
—·—·— CENTERLINE OF DRAINAGE SWALE
⌒⌒⌒ TREE LINE

FIGURE 2
SAMPLING LOCATION MAP
NATURAL ATTENUATION
MONITORING WORK PLAN
OPERABLE UNIT No. 6 – SITE 54

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

120F04

LEGEND

⊕ - SHALLOW MONITORING WELL LOCATION
⊕ - INTERMEDIATE MONITORING WELL LOCATION
⊕ - DEEP MONITORING WELL LOCATION

Baker
Baker Environmental, Inc.

FIGURE 3
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 6 - SITE 86
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

NATURAL ATTENUATION MONITORING WORK PLAN

OPERABLE UNIT NO. 10 (SITE 35)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVES

In the recent past, field investigations have been performed by various consultants at Operable Unit (OU) No. 10 (Site 35), Marine Corps Base (MCB), Camp Lejeune, North Carolina. These investigations form the basis for the forthcoming Record of Decision (ROD), which defines site-specific remedial goals. Based on the nature of contamination revealed by data from the past investigations, Site 35 is a candidate for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Baker-Environmental, Inc. (Baker) has been tasked to implement monitoring at Site 35 to provide additional data necessary to support NA as a remedial alternative.

The primary objective of this Work Plan (WP) is to outline upcoming activities to be implemented under the monitoring program at Site 35. Additionally, the WP provides a general description of OU 10 including site location and a history of operation, and describes the original monitoring program and any amendments implemented since its inception.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow Country, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 10

The study area, OU 10, is one of 18 operable units within MCB, Camp Lejeune. OU 10 consists solely of Site 35, Camp Geiger Area Fuel Farm, a former fuel storage and dispensing facility located just north of the intersection of Fourth and "G" Streets (Figure P-1). The Fuel Farm consisted primarily of five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, a fuel loading/unloading pad, an oil/water separator, and a distribution island. The facility actively served Camp Geiger and the New River Air Station from 1945 to 1995, when it was demolished to make way for the proposed U.S. Route 17 Bypass, a six-lane divided highway, to be constructed by the North Carolina Department of Transportation (NCDOT). Results of various past environmental and groundwater investigations have expanded the study area beyond the confines of the former Fuel Farm to encompass approximately 150 adjacent acres.

Construction of Camp Geiger was completed in 1945, four years after construction of Camp Lejeune was initiated. Originally, the Fuel Farm ASTs were used for the storage of No. 6 fuel oil. An underground distribution line (now abandoned) extended from the ASTs to the former Mess Hall Heating Plant, located adjacent to "D" Street, between Third and Fourth Streets. The underground line dispensed No. 6 fuel oil to a UST that fueled the Mess Hall boiler. The Mess Hall, located across "D" Street to the west, is believed to have been demolished along with its Heating Plant in the 1960s. At some unrecorded date the facility was converted for storage of other petroleum products, including unleaded gasoline, diesel fuel, and kerosene.

From the date of this conversion until the facility was decommissioned in the spring of 1995, the ASTs at Site 35 were used to dispense gasoline, diesel, and kerosene to government vehicles and to supply underground storage tanks (USTs) in use at Camp Geiger and the nearby New River Marine Corps Air Station. The ASTs were supplied by commercial carrier trucks, which delivered product to fill ports located on the fuel loading/unloading pad located south of the ASTs. Six short-run (120 feet maximum) underground fuel lines were utilized to distribute the product from the unloading pad to the ASTs.

During the lifetime of the facility several releases of product occurred. Reports of a release from an underground distribution line near one of the ASTs date back to 1957-58 (ESE, 1990). Apparently, the leak occurred as the result of damage to a dispensing pump. At that time the Camp Lejeune Fire Department estimated that thousands of gallons of fuel were released, although records of the incident have since been destroyed. The fuel reportedly migrated to the east and northeast toward Brinson Creek. Interceptor trenches were excavated and the captured fuel was ignited and burned.

Routinely, the ASTs at Site 35 supplied fuel to an adjacent dispensing pump that was supplied by an underground line. A leak in an underground line at the station was reportedly responsible for the loss of roughly 30 gallons per day of gasoline over an unspecified period (Law, 1992). The leaking line was subsequently sealed and replaced.

In April 1990, an undetermined amount of fuel was discovered by Camp Geiger personnel along two unnamed drainage channels north of the Fuel Farm. Apparently, the source of the fuel, believed to be diesel or jet fuel, was an unauthorized discharge from a tanker truck that was never identified. The activity reportedly initiated an emergency clean-up that included the removal of approximately 20 cubic yards of soil.

The Fuel Farm was decommissioned and demolished during the spring of 1995. The ASTs were emptied, cleaned, dismantled, and removed along with all concrete foundations, slabs on grade, berms, and associated underground piping.

In addition to the Fuel Farm dismantling, soil remediation activities were executed between the spring of 1995 and the spring of 1996 along the proposed highway right-of-way as per an Interim Record of Decision executed on September 15, 1994.

2.2 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Site 35 that have been implemented since its inception. These modifications, and all future recommendations to modify the monitoring program, will be presented in detail in the Monitoring Reports for OU 10. No monitoring reports for OU 10 have been submitted to date.

2.2.1 First Quarter 1999 – Start of Monitoring Program

OU 10 is comprised solely of Site 35. Groundwater and surface water monitoring at Site 35 began in January 1999. Groundwater was sampled from seven shallow and nine deep monitoring wells. Shallow wells included 35-MW10S, 35-MW14S, 35-MW31A, 35-MW47A, 35-MW55A, 35-MW61A, and 35-MW62A. Deep monitoring wells included 35-MW10D, 35-MW14D, 35-MW31B, 35-MW40B, 35-MW47B, 35-MW55B, 35-MW63B, 35-MW64B, and 35-MW65B. Groundwater samples were analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs) and, as part of a natural attenuation study, dissolved gases (i.e., ethane, ethene, methane), and nitrate. Monitoring well 35-MW65B was designated as a background well for Site 35 and, as such, samples from this well were additionally analyzed for Total Organic Carbon (TOC), Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate.

Surface water was collected from three distinct locations along Brinson Creek (35-SW01, 35-SW02, and 35-SW03) and was analyzed for TCL VOCs. Sampling was to continue on a quarterly basis.

2.2.2 Second Quarter 1999

No changes occurred during this quarter.

Any recommendations regarding additions and modifications to the monitoring program at Site 35 will be presented in detail in monitoring reports for OU 10. No modifications have been made to date.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 10, Site 35. This work plan describes groundwater and surface water monitoring activities to be performed at Site 35 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Seven shallow and nine deep groundwater monitoring wells, and three surface water locations at Site 35 will be sampled quarterly as part of the monitoring program. The well locations and sample analyses have not changed from the original sampling plan initiated in January 1999 (described above). Figure 1 presents the locations of the monitoring wells and surface water locations to be included in the sampling program. Table 1 provides total depths of each of the monitoring wells included in the monitoring program. Table 2 summarizes VOC, natural attenuation, and background analyses to be performed. Following the completion of groundwater and surface water sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 35.

3.2 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including quality assurance and quality control (QA/QC) samples, will be designated with a unique number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, the depth (sediment) or round (groundwater) of the sample, QA/QC qualifiers, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site #-Media and Station # or QA/QC-Year and event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Site 35
Media	GW = Groundwater SW = Surface water
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a 0 (i.e., 35-GW10)
QA/QC	(TB) = Trip Blank
Year	The number will reference the calendar year the sample was obtained. For example: 99 = 1999 00 = 2000
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR35-GW10D-00A refers to:

IR35-GW10D-00A	Installation Restoration
IR35-GW10D-00A	Site 35
IR35-GW10D-00A	Groundwater sample
IR35-GW10D-00A	Monitoring well #10
IR35-GW10D-00A	Deep monitoring well
IR35-GW10D-00A	Year 2000
IR35-GW10D-00A	First quarter

Under this sample designation format the sample number IR35-GW31A-00A refers to:

IR35-GW31A-00A	Installation Restoration
IR35-GW31A-00A	Site 35
IR35-GW31A-00A	Groundwater sample
IR35-GW31A-00A	Monitoring well #31
IR35-GW31A-00A	Shallow monitoring well
IR35-GW31A-00A	Year 2000
IR35-GW31A-00A	First quarter

Under this sample designation format the sample number IR35-SW01-00A refers to:

IR35-SW01-00A	Installation Restoration
IR35-SW01-00A	Site 35
IR35-SW01-00A	Surface water sample
IR35-SW01-00A	Sampling location #1
IR35-SW01A-00A	Year 2000
IR35-SW01A-00A	First quarter

Under this sample designation format the sample number IR35-TB01-00A refers to:

IR35-TB01-00A	Installation Restoration
IR35-TB01-00A	Site 35
IR35-TB01-00A	Trip Blank
IR35-TB01-00A	Sequential number
IR35-TB01-00A	Year 2000
IR35-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 35. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged into the water treatment receptor trench at Site 35.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching ten Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

Surface water samples will be collected from three discrete locations at Site 35. The following is the sampling method to be used to obtain the surface water samples:

1. Surface water samples must be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted, if required.

2. Samples will be collected by dipping the sample bottles directly into the water. An unpreserved, laboratory-decontaminated transfer bottle will be used to fill preserved bottles. Additionally, a transfer bottle will be used to fill all bottles if surface water is too shallow. Care will be taken when collecting samples for VOCs to avoid excessive agitation that could result in the loss of volatiles. Sample containers will be labeled prior to collection.

3. If sample containers do not contain preservative they will be rinsed at least once with the sample water prior to the final sample collection. In addition, the sampling container used to transfer the surface water into the sample bottles containing preservative will be rinsed once with the sample water.

4. Temperature, pH, specific conductance, and dissolved oxygen must be measured in the field at each sampling station immediately following sample collection.

5. The sample containers will be stored in a cooler with ice until laboratory shipment.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 2 defines the sampling and analysis program for the groundwater and surface water monitoring program at Site 35.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) requirement for this monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC.

Equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates will not be collected during the monitoring program. The samples collected during the program will be considered confirmatory only; therefore, the above QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Feasibility Study, Operable Unit No. 10 (Site 35) for MCB Camp Lejeune, North Carolina. Draft. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. January 1997.

Environmental Science and Engineering, Inc. (ESE), 1990. Final Site Summary Report, MCB Camp Lejeune. ESE Project No. 49-02036, September 1990.

Law, 1992. Final Report, Underground Fuel Investigation and Comprehensive Site Assessment. Camp Geiger Fuel Farm. Marine Corps Base, Camp Lejeune, North Carolina.

TABLES

TABLE 1

SUMMARY OF WELL DEPTHS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 10 - SITE 35
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Well Depth (ft bgs)
IR35-MW10S	17.14
IR35-MW10D	31.86
IR35-MW14S	16.16
IR35-MW14D	35.62
IR35MW31A	14.93
IR35-MW31B	44.25
IR35-MW40B	43.91
IR35-MW47A	15.15
IR35-MW47B	34.40
IR35-MW55A	14.65
IR35-MW55B	27.36
IR35-MW61A	14.95
IR35-MW62A	16.50
IR35-MW63B	32.00
IR35-MW64B	32.80
IR35-MW65B	33.55

Notes:

bgs - Below ground surface

ft - Feet

TABLE 2

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 10 - SITE 35
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles(1)	Dissolved Gases(2)	Nitrate	Sulfate	TOC(3)	TON(4)	Nitrite	Ammonia	Orthophosphate	Sample Designation
IR35-MW10S	GW	X	X	X	X						IR35-GW10-**
IR35-MW10D	GW	X	X	X	X						IR35-GW10IW-**
IR35-MW14S	GW	X	X	X	X						IR35-GW14-**
IR35-MW14D	GW	X	X	X	X						IR35-GW14IW-**
IR35MW31A	GW	X	X	X	X						IR35-GW31-**
IR35-MW31B	GW	X	X	X	X						IR35-GW31IW-**
IR35-MW40B	GW	X	X	X	X						IR35-GW40IW-**
IR35-MW47A	GW	X	X	X	X						IR35-GW47-**
IR35-MW47B	GW	X	X	X	X						IR35-GW47IW-**
IR35-MW55A	GW	X	X	X	X						IR35-GW55-**
IR35-MW55B	GW	X	X	X	X						IR35-GW55IW-**
IR35-MW61A	GW	X	X	X	X						IR35-GW61-**
IR35-MW62A	GW	X	X	X	X						IR35-GW62-**
IR35-MW63B	GW	X	X	X	X						IR35-GW63IW-**
IR35-MW64B	GW	X	X	X	X						IR35-GW634IW-**
IR35-MW65B	GW	X	X	X	X	X	X	X	X	X	IR35-GW65IW-**
IR35-SW01	SW	X									IR35-SW01-**
IR35-SW02	SW	X									IR35-SW02-**
IR35-SW03	SW	X									IR35-SW03-**

Notes:

(1) Target Compound List Volatile Organic Compounds

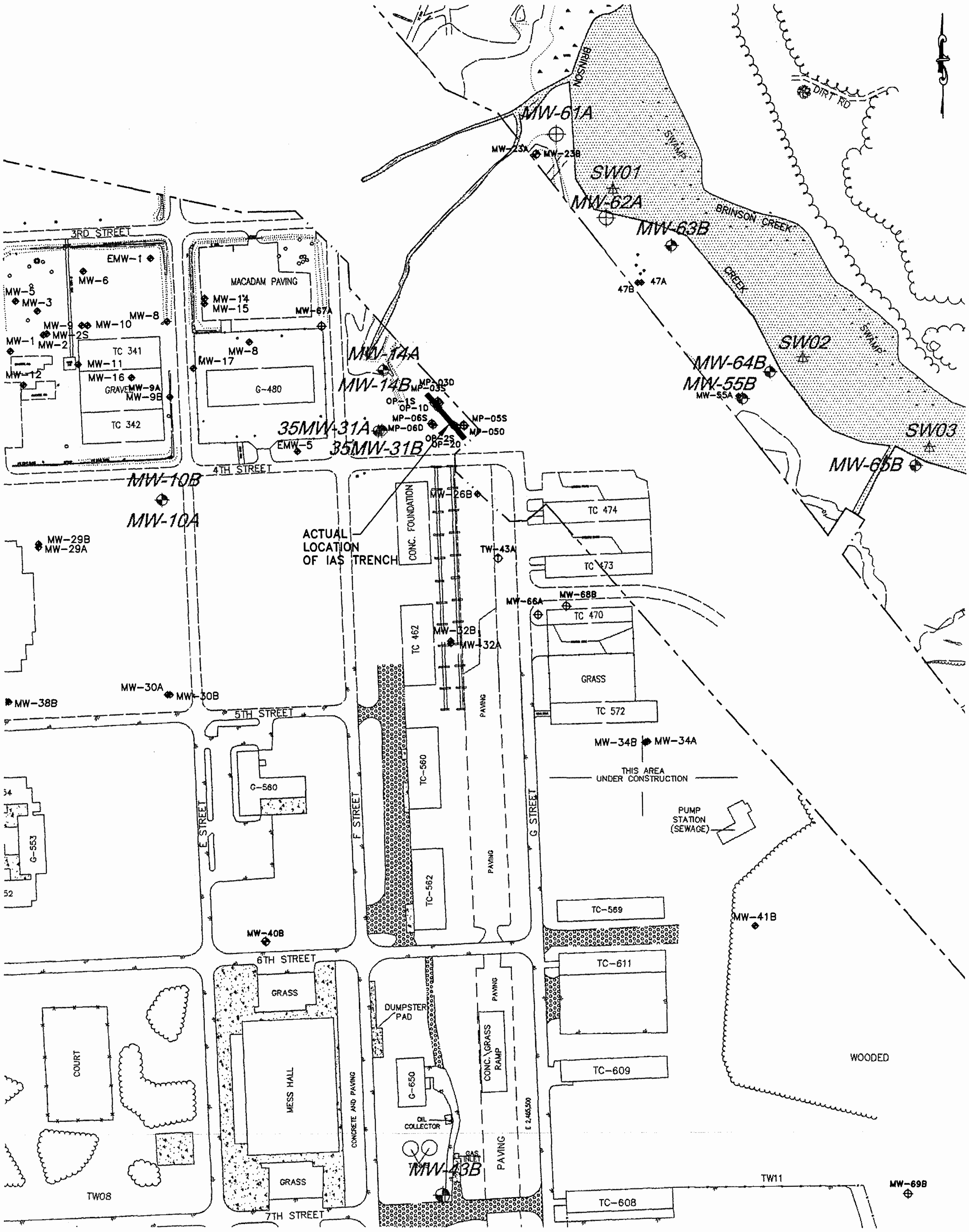
(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., B for April through June) in which the groundwater sample is obtained.

FIGURES



NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

180 0 90 180
1 inch = 180 ft.

367408WP

Baker
Baker Environmental, Inc.

LEGEND

⊕ – SHALLOW GROUNDWATER MONITORING WELL

◈ – INTERMEDIATE GROUNDWATER MONITORING WELL

△ – SURFACE WATER SAMPLE LOCATION

SOURCE: LANIER AND ASSOCIATES

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 10-SITE 35

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02335II042

NATURAL ATTENUATION MONITORING WORK PLAN

OPERABLE UNIT NO. 14 (SITE 69)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVES

In the recent past, field investigations have been performed by various consultants at Operable Unit (OU) No. 14 (Site 69), Marine Corps Base (MCB), Camp Lejeune, North Carolina. These investigations form the basis for the forthcoming Record of Decision (ROD), which defines site-specific remedial goals. Based on the nature of contamination revealed by data from the past investigations, Site 69 is a candidate for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Baker-Environmental, Inc. (Baker) has been tasked to implement monitoring at Site 69 to provide additional data necessary to support NA as a remedial alternative.

The primary objective of this Work Plan (WP) is to outline upcoming activities to be implemented under the monitoring program at Site 69. Additionally, the WP provides a general description of OU 14 including site location and a history of operation, and describes the original monitoring program and any amendments implemented since its inception.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow Country, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 14

The study area, OU 14, is one of 18 operable units within MCB, Camp Lejeune. OU 14 consists solely of Site 69. Site 69, the Rifle Range Chemical Dump, is located west of the New River in the area of MCB, Camp Lejeune know as the Rifle Range. Figure P-1 shows the location of OU 4 within the base. The site is approximately 14 acres in size and is situated in a topographic high area. The area is heavily wooded, and is overgrown to the point that the boundary of the former dump is not readily noticeable. Three surface water bodies are located within a quarter mile of the site: the New River to the east, an unnamed tributary of the New River to the North, and Everett Creek to the south. The site area is secluded; however, training exercises are conducted throughout the surrounding area. Currently, a fence surrounds the site to restrict access.

Site 69 has a reported history of chemical warfare materiel (CWM) disposal. During the period 1950 to 1976, the area was used to dispose chemical wastes including polychlorinated biphenyls (PCBs), solvents, pesticides, calcium hydrochlorite, high-test hypochlorite (HTH), and drums of "gas" which possibly contained CWM. The CMW suspected at MCB, Camp Lejeune are chemical agent identification sets (CAIS). There is a lack of information to properly identify the amount, types, or disposal methods associated with CAIS disposal at Site 69.

2.2 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Site 69 that have been implemented since its inception. These modifications, and all future recommendations to modify the monitoring program, will be presented in detail in the Monitoring Reports for OU 14. No monitoring reports for OU 14 have been submitted to date.

2.2.1 Second Half 1998 – Start of Monitoring Program

OU 14 is comprised solely of Site 69. Groundwater monitoring at Site 69 began in October of 1998 and consisted of the sampling of seven shallow, two intermediate, and five deep monitoring wells: 69-GW01, 69-GW02, 69-GW02DW, 69-GW03, 69-GW03DW, 69-GW10, 69-GW12, 69-GW12DW, 69-GW13DW, 69-GW14, 69-GW14IW, 69-GW15, 69-GW15IW, and 69-GW15DW. Groundwater samples were analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs). Wells 69-GW01, 69-GW02DW, 69-GW03, 9-GW10, 69-GW12, 69-GW14IW, 69-GW15, and 69-GW15IW were also analyzed for dissolved gases (i.e., ethene, ethane, and methane) and nitrate as part of a natural attenuation study. Wells 69-GW01, 69-GW10, 69-GW12, and 69-GW14IW were designated as background wells for Site 69 and were also analyzed for Total Organic Carbon (TOC), Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 69, immediate field analysis for ferrous iron, alkalinity, sulfate, and chloride were also conducted. Sampling was to continue on a semi-annual basis.

2.2.2 First Half 1999

Henceforth, sulfate analyses were conducted by the laboratory rather than by field personnel.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 14, Site 69. This work plan describes groundwater monitoring activities to be performed at Site 69 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Fourteen groundwater monitoring wells at Site 69 will be sampled semi-annually as part of the monitoring program. The well locations and sample analyses have not changed from the original sampling plan initiated in October of 1998 (described above). Figure 1 presents the locations of the monitoring wells to be included in the sampling program. Table 1 provides construction details for each of the monitoring wells included in the monitoring program. Intermediate wells are indicated by "IW" and the deep monitoring wells are indicated by "DW" Table 2 summarizes VOC, natural attenuation, and background analyses to be performed. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 69.

2.2 Monitoring Timeline

The following section briefly reviews additions and modifications to the monitoring program at Site 69 that have been implemented since its inception. These modifications, and all future recommendations to modify the monitoring program, will be presented in detail in the Monitoring Reports for OU 14. No monitoring reports for OU 14 have been submitted to date.

2.2.1 Second Half 1998 – Start of Monitoring Program

OU 14 is comprised solely of Site 69. Groundwater monitoring at Site 69 began in October of 1998 and consisted of the sampling of seven shallow, two intermediate, and five deep monitoring wells: 69-GW01, 69-GW02, 69-GW02DW, 69-GW03, 69-GW03DW, 69-GW10, 69-GW12, 69-GW12DW, 69-GW13DW, 69-GW14, 69-GW14IW, 69-GW15, 69-GW15IW, and 69-GW15DW. Groundwater samples were analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs). Wells 69-GW01, 69-GW02DW, 69-GW03, 9-GW10, 69-GW12, 69-GW14IW, 69-GW15, and 69-GW15IW were also analyzed for dissolved gases (i.e., ethene, ethane, and methane) and nitrate as part of a natural attenuation study. Wells 69-GW01, 69-GW10, 69-GW12, and 69-GW14IW were designated as background wells for Site 69 and were also analyzed for Total Organic Carbon (TOC), Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 69, immediate field analyses for ferrous iron, alkalinity, sulfate, and chloride were also conducted. Sampling was to continue on a semi-annual basis.

2.2.2 First Half 1999

Henceforth, sulfate analyses were conducted by the laboratory rather than by field personnel.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 14, Site 69. This work plan describes groundwater monitoring activities to be performed at Site 69 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Fourteen groundwater monitoring wells at Site 69 will be sampled semi-annually as part of the monitoring program. The well locations and sample analyses have not changed from the original sampling plan initiated in October of 1998 (described above). Figure 1 presents the locations of the monitoring wells to be included in the sampling program. Table 1 provides construction details for each of the monitoring wells included in the monitoring program. Intermediate wells are indicated by "IW" and the deep monitoring wells are indicated by "DW" Table 2 summarizes VOC, natural attenuation, and background analyses to be performed. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 69.

3.2 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including quality assurance and quality control (QA/QC) samples, will be designated with a unique number. The sample number will serve to identify the investigation, the site, the sample media, sampling location, QA/QC qualifiers, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site #-Media and Station # or QA/QC-Year and event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Site 69
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a 0 (i.e., 69-GW02)
QA/QC	(TB) = Trip Blank
Year	The number will reference the calendar year the sample was obtained. For example: 99 = 1999 00 = 2000
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR69-GW12DW-00A refers to:

IR69-GW12DW-00A	Installation Restoration
IR69-GW12DW-00A	Site 69
IR69-GW12DW-00A	Groundwater sample
IR69-GW12DW-00A	Monitoring well #12
IR69-GW12DW-00A	Deep monitoring well

IR69-GW12DW-00A	Year 2000
IR69-GW12DW-00A	First quarter

Under this sample designation format the sample number IR69-TB01-00A refers to:

IR69-TB01-00A	Installation Restoration
IR69-TB01-00A	Site 69
IR69-TB01-00A	Trip Blank
IR69-TB01-00A	Sequential number
IR69-TB01-00A	Year 2000
IR69-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 69. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Site 69.

7. The water quality parameters (WQPs), including temperature dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching ten Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 2 defines the sampling and analysis program for the groundwater monitoring wells at Site 69.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) requirement for this monitoring program are limited to trip blanks.

Trip blanks are defined as samples comprised of analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for volatile organics. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC.

Equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates will not be collected during the natural attenuation monitoring program. The samples collected during the program will be considered confirmatory only; therefore, the above QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Remedial Investigation Report, Operable Unit No. 14 (Site 69) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. December 1996.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 14 - SITE 69
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
69-GW02	7/18/84	36.89	34.70	20.42	20.42	5.94-20.42	4.77-20.42	3.67-4.77	2.19
69-GW02DW	1/21/94	36.94	34.1	50.0	50.0	40.0-50.0	37.5-50.0	35.0-37.5	2.84
69-GW03	7/18/84	36.66	34.70	20.35	20.35	5.87-20.35	4.71-20.35	3.71-4.71	1.96
69-GW03DW	NA	37.56	35.13	NA	NA	NA	NA	NA	2.43
69-GW04	7/18/84	41.45	38.60	20.25	20.25	5.77-20.25	4.54-20.25	3.50-4.54	2.85
69-GW08	7/17/84	37.28	34.7	20.4	20.4	5.92-20.4	4.63-20.4	3.35-4.63	2.58
69-GW10	1/9/94	41.89	39.00	17.0	16.0	6.0-16.0	4.0-17.0	0.0-4.0	2.89
69-GW11	1/7/94	28.82	25.90	19.0	19.0	9.0-19.0	6.0-19.0	2.0-6.0	2.92
69-GW12	1/6/94	11.15	8.40	13.5	12.5	2.0-12.5	1.5-13.5	0.0-1.5	2.75
69-GW12DW	1/22/94	9.38	7.50	60.0	58.0	48.0-58.0	45.0-60.0	43.0-45.0	1.88
69-GW13	5/24/94	38.12	35.80	13.5	13.0	3-13	2-13.5	0.25-2	2.32
69-GW14	12/17/94	35.22	33.07	14.0	13.0	3.0-13.0	1.5-14.0	0.5-1.5	2.15
69-GW14IW	12/17/94	35.21	32.77	62.0	60.0	45.0-60.0	40.0-62.0	34.0-40.0	2.44
69-GW15	3/23/95	37.41	35.70	13.0	13.0	3.0-13.0	2.0-13.0	1.0-2.0	1.71
69-GW15DW	NA	NA	NA	NA	NA	NA	NA	NA	NA
69-GW15IW	3/24/95	37.54	35.70	60.0	60.0	45.0-60.0	43.0-60.0	40.0-43.0	1.84
69-DW15UW	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

msl - Mean sea level
bgs - Below ground surface
ft - Feet
NA - Data is not available.

TABLE 2

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 14 - SITE 69
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles(1)	Dissolved Gases(2)	Nitrate	Sulfate	TOC(3)	TON(4)	Nitrite	Ammonia	Orthophosphate	Sample Designation
69-GW01	GW	X	X	X	X	X	X	X	X	X	IR69-GW01-**
69-GW02	GW	X									IR69-GW02-**
69-GW02DW	GW	X	X	X	X						IR69-GW02DW-**
69-GW03*	GW	X	X	X	X						IR69-GW03-**
69-GW03DW*	GW	X									IR69-GW03DW-**
69-GW10	GW	X	X	X	X	X	X	X	X	X	IR69-GW10-**
69-GW12	GW	X	X	X	X	X	X	X	X	X	IR69-GW12-**
69-GW12DW	GW	X									IR69-GW12DW-**
69-GW13DW	GW	X									IR69-GW13DW-**
69-GW14	GW	X									IR69-GW14-**
69-GW14IW	GW	X	X	X	X	X	X	X	X	X	IR69-GW14IW-**
69-GW15*	GW	X	X	X	X						IR69-GW15-**
69-GW15IW*	GW	X	X	X	X						IR69-GW15IW-**
69-GW15DW*	GW	X									IR69-GW15DW-**

Notes:

(1) Target Compound List Volatile Organics Compounds

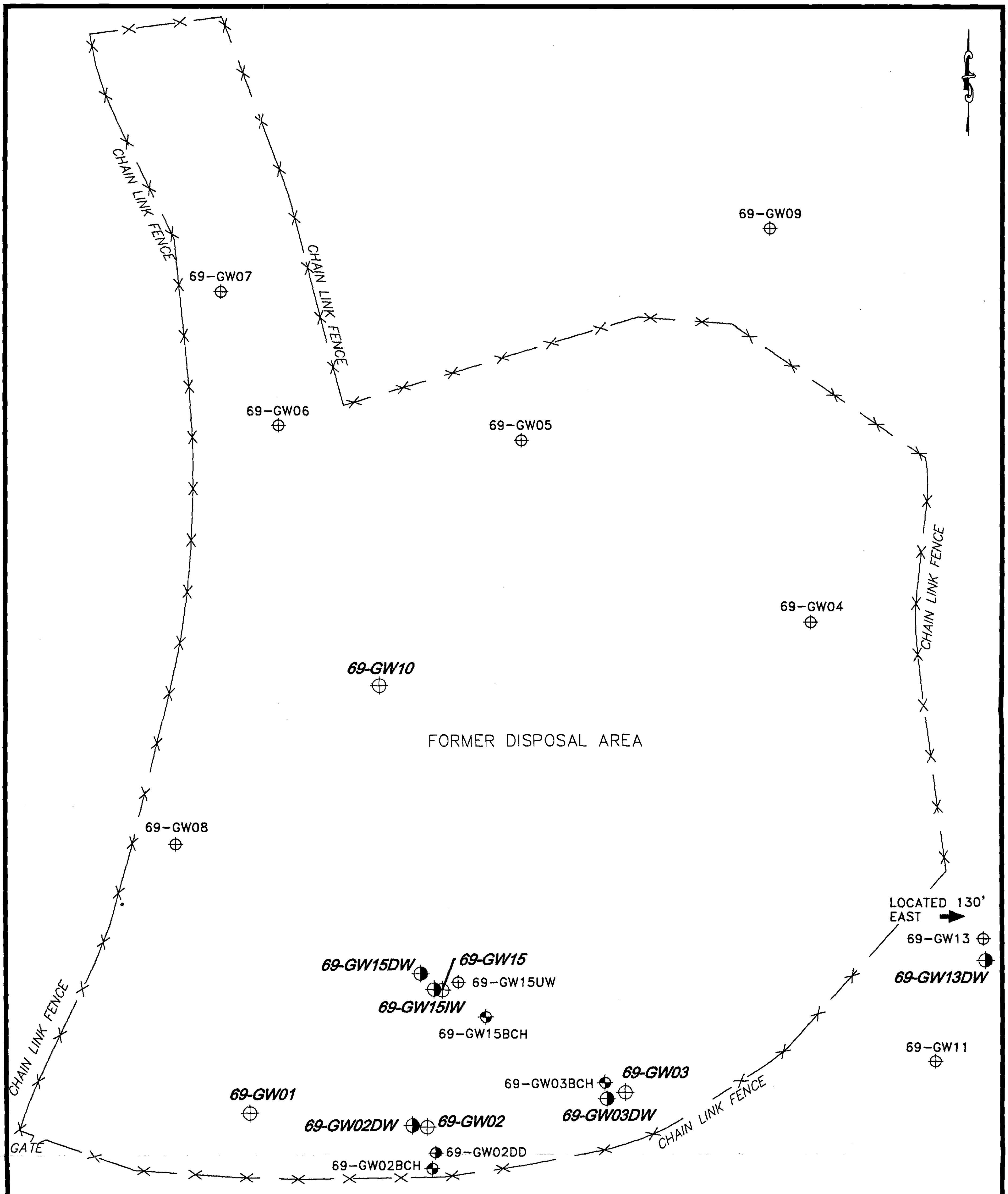
(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



NOTES:
- ENTIRE AREA IS HEAVILY WOODED.
- WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

LEGEND

69GW15BCH ⊕ DEEP ZONE CASTLE HAYNE WELLS
69GW09 ⊕ SHALLOW WELLS
69GW02DW ◐ UPPER ZONE CASTLE HAYNE WELLS
69-GW02DD ◑ INTERMEDIATE ZONE CASTLE HAYNE WELLS

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO.14 – SITE 69

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02335II052

NATURAL ATTENUATION MONITORING WORK PLAN

OPERABLE UNIT NO. 15 (SITE 88)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVES

In the recent past, field investigations have been performed by various consultants at Operable Unit (OU) No. 15 (Site 88), Marine Corps Base (MCB), Camp Lejeune, North Carolina. These investigations form the basis for the forthcoming Record of Decision (ROD), which defines site-specific remedial goals. Based on the nature of contamination revealed by data from the past investigations, Site 88 is a candidate for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Baker-Environmental, Inc. (Baker) has been tasked to implement monitoring at Site 88 to provide additional data necessary to support NA as a remedial alternative.

The primary objective of this Work Plan (WP) is to outline upcoming activities to be implemented under the monitoring program at Site 88. Additionally, the WP provides a general description of OU 15 including site location and a history of operation, and describes the original monitoring program and any amendments implemented since its inception.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow Country, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 15

The study area, OU 15, is one of 18 operable units within MCB, Camp Lejeune. OU 15 consists solely of Site 88. Site 88, Building 25, Morale, Welfare, and Recreation (MWR) Dry Cleaners, is located on Post Lane Road, approximately 500 feet east of the intersection between Post Lane Road and Main Service Road (Figure P-1). The study area of Site 88 encompasses approximately 12 areas mainly to the northwest of Building 25. The Dry Cleaning facility consists of one main building, a surrounding lawn area, and several small sheds housing ancillary equipment. Within a lawn area on the north side of the main building are several steam lines, below grade concrete vaults, and shallow drainage channels. The concrete vaults house a portion of the steam lines. Steam condensate from the steam lines is directed away from the main building by shallow drainage channels.

Building 25 has been operating as a dry cleaning facility since the 1940s. An underground storage tank (UST) area, consisting of five tanks, was formerly located on the north side of Building 25. These USTs are known to have been used to stored dry cleaning fluids. The USTs were reportedly installed in the 1940s, at the time the building was constructed. They were used in conjunction with the dry cleaning operations until the early 1970s. During this time, Varsol™ was stored in the USTs. (Varsol™ is a petroleum distillate dry cleaning fluid.) Because of Varsol™'s flammability, its use was discontinued in the 1970s and replaced with tetrachloroethene, or perchloroethene (PCE). PCE was stored in one 150 gallon aboveground storage tank (AST) outside Building 25 in the same vicinity as the USTs, from the 1970s to mid-1980s. It has been reported by dry cleaning personnel that spent PCE was disposed of in floor sewer drains. Currently, the dry cleaning machines are equipped with self-containment units, eliminating the need for the AST, which was subsequently removed. There are two dry cleaning units in operation. One unit was brought on-line in December, 1986, and the second in March, 1995.

2.2 Start of Monitoring Program – First Half 1999

OU 15 is comprised solely of Site 88. Groundwater monitoring at Site 88 began in January 1999 and consisted of the sampling of four shallow and four intermediate ("IW") monitoring wells: 88-MW01, 88-MW02, 88-MW02IW, 88-MW04, 88-MW05, 88-MW05IW, 88-MW07IW, and 88-MW09IW. Groundwater samples were analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs) and, as part of a natural attenuation study, dissolved gasses (i.e., ethene, ethane, and methane), sulfate, and nitrate. Wells 88-MW01 and 88-MW04 were designated as background wells for Site 88 and were additionally analyzed for Total Organic Carbon (TOC), Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 88, immediate field analyses for ferrous iron, alkalinity, and chloride were also conducted. Sampling was to continue on a semiannual basis.

Any recommendations regarding additions and modifications to the monitoring program at Site 88 will be presented in detail in the Monitoring Reports for OU 15. No modifications have been made and no monitoring reports for OU 15 have been submitted to date.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 15, Site 88. This work plan describes groundwater monitoring activities to be performed at Site 88 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

Eight groundwater monitoring wells at Site 88 will be sampled semi-annually as part of the monitoring program. Monitoring wells 88-MW01 and 88-MW04 were originally designated as background sampling locations. However, recent detections of tetrachloroethene (PCE) indicate that these wells are located within the contaminant plume. For this reason, laboratory analyses for background parameters including TOC, TON, nitrite, ammonia, and orthophosphate have been eliminated from the sampling program. Replacement background sampling locations are yet to be determined.

The remainder of the sampling program has not changed from the original plan initiated in 1999 (described above). Figure 1 presents the locations of the monitoring wells to be included in the sampling program. Table 1 provides construction details for each of the monitoring wells included in the monitoring program. Table 2 summarizes VOC, natural attenuation, and background analyses to be performed. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Site 88.

3.2 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including quality assurance and quality control (QA/QC) samples, will be designated with a unique number. The sample number will serve to identify the investigation, site, sample media, sampling location, QA/QC qualifiers, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site #-Media and Station # or QA/QC-Year and event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Site 88
Media	GW = Groundwater
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a 0 (i.e., 88-GW02)
QA/QC	(TB) = Trip Blank
Year	The number will reference the calendar year the sample was obtained. For example: 99 = 1999 00 = 2000
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR88-GW05IW-00A refers to:

IR88-GW05IW-00A	Installation Restoration
IR88-GW05IW-00A	Site 88
IR88-GW05IW-00A	Groundwater sample
IR88-GW05IW-00A	Monitoring well #05
IR88-GW05IW-00A	Intermediate monitoring well
IR88-GW05IW-00A	Year 2000
IR88-GW05IW-00A	First quarter

Under this sample designation format the sample number IR88-TB01-00A refers to:

IR88-TB01-00A	Installation Restoration
IR88-TB01-00A	Site 88
IR88-TB01-00A	Trip Blank
IR88-TB01-00A	Sequential number

IR88-TB01-00A	Year 2000
IR88-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Site 88. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Site 88.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching 10 Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 2 defines the sampling and analysis program for the groundwater monitoring wells at Site 88.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) requirement for this monitoring program are limited to trip blanks and matrix spike/matrix spike duplicates (MS/MSD).

Trip blanks are defined as samples comprised of analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC.

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with selected target analytes and analyzed with the associated sample and MS sample. MS/MSD samples undergo the same extraction and analytical procedures as the unfortified field sample. The results of the MS and MSD are used together to determine the effect of the matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not on all samples in the QC batch. MS/MSD samples at Site 88 will only be analyzed for VOCs.

Equipment rinsates, field blanks, field duplicates will not be collected during the long term monitoring program. The samples collected during the program will be considered confirmatory only; therefore, the above QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Focused Remedial Investigation Report, Operable Unit No. 15 (Site 88) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. May 1998.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 15 - SITE 88
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
88-MW01	5/1/97	26.07	26.50	22.0	22.0	7.0-22.0	5.0-22.0	2.0-5.0	-0.43
88-MW02	5/2/97	25.11	26.60	23.0	23.0	8.0-23.0	6.0-23.0	3.5-6.0	-1.49
88-MW02IW	5/3/97	25.10	26.58	50.0	50.0	45.0-50.0	40.0-50.0	34.5-40	-1.48
88-MW04	5/2/97	24.54	23.05	25.0	25.0	10.0-25.0	8.0-25.0	5.0-8.0	1.49
88-MW05	5/3/97	23.97	24.58	23.0	23.0	8.0-23.0	6.0-23.0	3.0-6.0	-0.61
88-MW05IW	5/3/97	24.30	24.74	50.0	50.0	45.0-50.0	40.0-50.0	35.0-40.0	-0.44
88-MW07IW	5/5/97	23.30	23.67	50.0	50.0	45.0-50.0	40.0-50.0	35.0-45.0	-0.37
88-MW09IW	5/5/97	21.83	22.00	50.0	50.0	45.0-50.0	40.0-50.0	34.0-40.0	-0.17

Notes:

msl - Mean sea level
bgs - Below ground surface
ft - Feet

Where stick up is negative, flush mount wells were installed.

TABLE 2

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 15 - SITE 88
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles[(1)]	Dissolved Gases[(2)]	Nitrate	Sulfate	Sample Designation
88-MW01	GW	X	X	X	X	IR88-GW01-**
88-MW02	GW	X	X	X	X	IR88-GW02-**
88-MW02IW	GW	X	X	X	X	IR88-GW02IW-**
88-MW04	GW	X	X	X	X	IR88-GW04-**
88-MW05	GW	X	X	X	X	IR88-GW05-**
88-MW05IW	GW	X	X	X	X	IR88-GW05IW-**
88-MW07IW	GW	X	X	X	X	IR88-GW07IW-**
88-MW09IW	GW	X	X	X	X	IR88-GW09IW-**

Notes:

(1) Target Compound List Volatile Organics Compounds

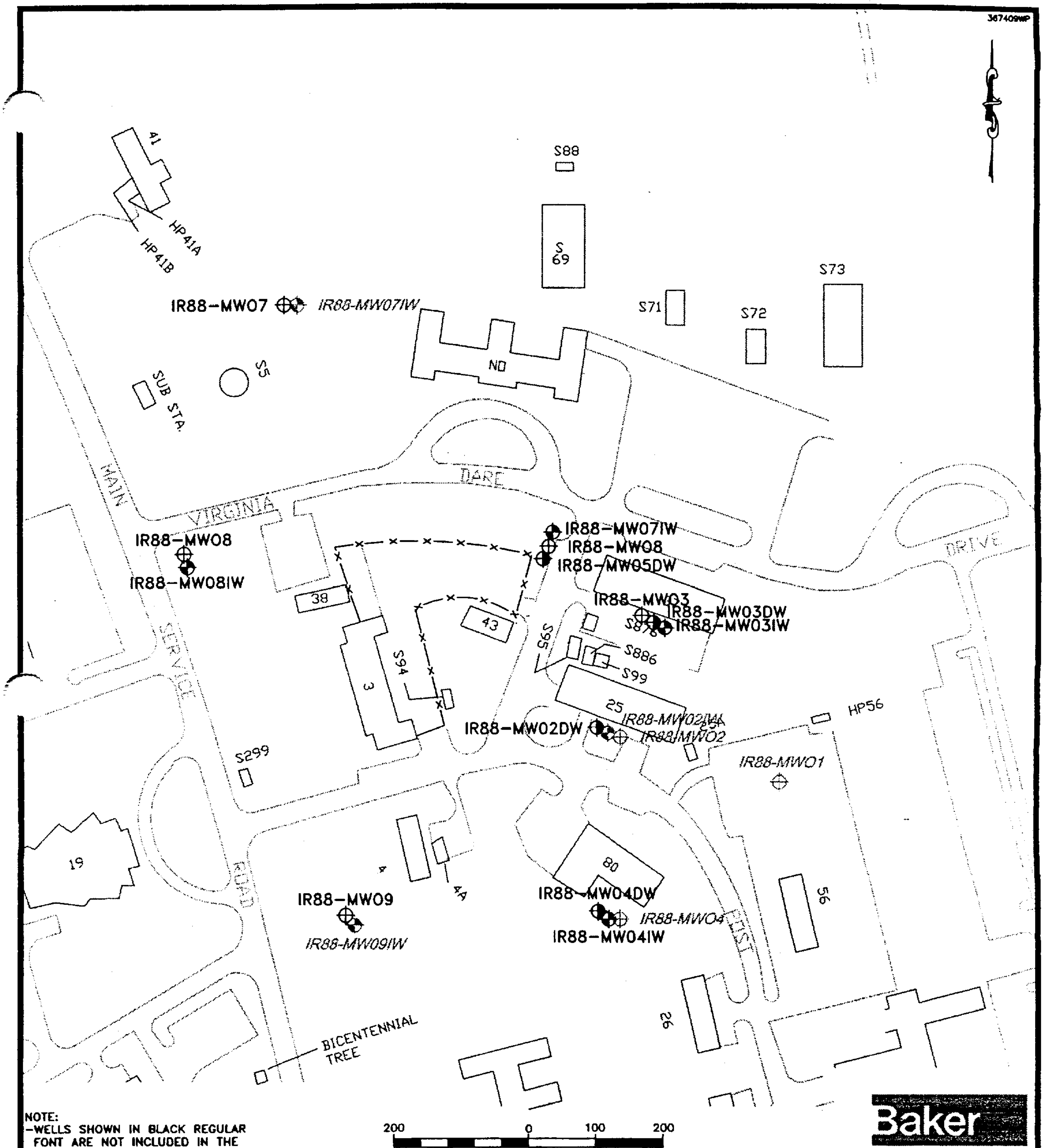
(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

Baker Environmental, Inc.

LEGEND

⊕ - SHALLOW MONITORING WELL LOCATION
◐ - INTERMEDIATE MONITORING WELL LOCATION
● - DEEP MONITORING WELL LOCATION

SOURCE: LANTDIV, 1992

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 15-SITE 88

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

NATURAL ATTENUATION MONITORING WORK PLAN

OPERABLE UNIT NO. 16 (SITES 89 AND 93)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER - 0120

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by:

CH2M HILL FEDERAL GROUP, LTD.
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 OBJECTIVES

In the recent past, field investigations have been performed by various consultants at Operable Unit (OU) No. 16 (Sites 89 and 93), Marine Corps Base (MCB), Camp Lejeune, North Carolina. These investigations form the basis for the forthcoming Record of Decision (ROD), which defines site-specific remedial goals. Based on the nature of contamination revealed by data from the past investigations, Sites 89 and 93 are candidates for remediation via monitored natural attenuation (NA). NA is a process by which natural subsurface mechanisms reduce contaminant toxicity, mobility, or volume. These mechanisms include biodegradation, dispersion, dilution, sorption, volatilization, and chemical/biochemical stabilization. Baker-Environmental, Inc. (Baker) has been tasked to implement monitoring at Sites 89 and 93 to provide additional data necessary to support NA as a remedial alternative.

The primary objective of this Work Plan (WP) is to outline upcoming activities to be implemented under the monitoring program at Sites 89 and 93. Additionally, the WP provides a general description of OU 6 including site location and a history of operation, and describes the original monitoring program and any amendments implemented since its inception.

2.0 BACKGROUND

Marine Corps Base, Camp Lejeune is a training base for the United States Marine Corps, located in Onslow Country, North Carolina. The base covers approximately 236 square miles and includes 14 miles of coastline. MCB, Camp Lejeune is bounded to the southeast by the Atlantic Ocean, to the northeast by State Route 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is located north of the base.

2.1 Description of Operable Unit No. 14

The study area, OU 16, is one of 18 operable units within MCB, Camp Lejeune. OU 16 consists of Sites 89 and 93.

2.1.1 Site 89

Site 89 is located near the intersection of "G" and Eighth Streets near the Defense Reauthorization and Marketing Office (DRMO) area of Camp Geiger (Figure P-1). Site 89 is the larger of the two sites within OU 16. It encompasses a significant portion of Camp Geiger, which includes all of the DRMO and additional areas to the south and east. Originally, the site was focused on a small area with in the DRMO that contained an underground storage tank (UST), identified as STC-868. The UST was a steel 550-gallon waste oil tank located between Building STC-867 (a soil storage facility) and an elevated wash rack. The tank was installed in 1983 and used for the storage of waste oil. This UST was reportedly closed by removal in 1993. The site has since been expanded to include the entire DRMO and additional areas outside the DRMO fence, including the heavily wooded areas to the south and the east. The majority of the western portion of Site 89 is covered by asphalt, roads, and gravel parking areas. Edwards Creek is the nearest surface water body, located along the western and southern portions of the site. The stream is located approximately 525 feet south of the former UST location. The land surface of Site 89 slopes in the direction of Edwards Creek, which begins as a series of drainage ditches within Camp Geiger.

The major finding of the initial UST investigation at Site 89 was the detection of chlorinated solvents in the groundwater. The presence of chlorinated compounds demonstrated that impact to the groundwater involved compounds not normally associated with a petroleum UST site. Historical records of the area show that a base motor pool was in operation until approximately 1988. The base motor poor was then relocated to an asphalt paved area immediately north of the DRMO facility where it is in current operation.

2.1.2 Site 93

Site 93 is located near Building TC-942 at the intersection of Ninth and "E" Streets within Camp Geiger. The buildings in this portion of Camp Geiger were constructed during the Korean War. Building TC-942 currently functions as a supply room for the Marine Infantry School. Items such as field jackets, ponchos, and canteens are stored in the building. Other buildings in the area serve as classrooms for the school and barracks. Associated with Building TC-942 was a 550-gallon oil storage UST located at the southwest corner of the building.

The UST at Site 93 was installed in 1983 and permanently closed as part of a tank removal in December 1993. Based on elevated concentrations of oil and grease discovered at the time of tank removal, a release is suspected to have occurred. Upon removal of the tank, an investigation was conducted that included the installation of five monitoring wells around the former UST and the collection of soil and groundwater samples. The site now includes the area to the north, south, east, and west of Buildings TC-940 and TC-942.

2.2 Start of Monitoring Program – First Half 1999

OU 16 is comprised of Sites 89 and 93. Groundwater monitoring at both sites and surface water sampling at Site 89 began in January 1999.

Both surface water and groundwater were sampled at Site 89. Groundwater monitoring consisted of the sampling of four shallow and five intermediate ("IW") monitoring wells: 89-MW02, 89-MW03, 89-MW03IW, 89-MW04, 89-MW04IW, 89-MW05, 89-MW05IW, 890-MW06IW, 89-MW08IW. Groundwater samples were analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs) and, as part of a natural attenuation study, dissolved gases (i.e., ethene, ethane, and methane), nitrate, sulfate, and Total Organic Carbon (TOC). Well 89-MW08IW was designated as a background well for Site 89 and samples from this well were additionally analyzed for Total Organic Nitrogen (TON), nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 89, immediate field analyses for ferrous iron, alkalinity, and chloride were also conducted. Surface water samples were collected from four distinct sampling locations along Edwards Creek: 89-SW04, 89-SW06, 89-SW07, and 89-SW11. Surface water samples were analyzed for VOCs. Sampling of both groundwater and surface water was to continue on a semiannual basis.

The monitoring program at Site 93 consisted of the sampling of groundwater from three shallow monitoring wells: 93-GW02, 93-GW04, and 93-GW05. Samples were analyzed for VOCs and, as part of a natural attenuation study, dissolved gases, nitrate, sulfate, and TOC. Wells 93-GW04 and 93-GW05 were also analyzed for TON. Well 93-GW04 was designated as the background well for Site 93 and, as such, samples from this well were additionally analyzed for nitrite, ammonia, and orthophosphate. To accurately evaluate the NA process at Site 93, immediate field analyses for ferrous iron, alkalinity, and chloride were also conducted. Sampling was to continue on a semiannual basis.

Any recommendations regarding additions and modifications to the monitoring program at Sites 89 and 93 will be presented in detail in monitoring reports for OU 16. No modifications have been made to date.

3.0 SCHEDULED MONITORING TASKS

The section that follows provides specific procedures for continuing the monitoring program at OU 16, Sites 89 and 93. This work plan describes groundwater and surface water monitoring activities to be performed at OU 16 as of July 1999. This section identifies sampling locations, sample analyses, and sample designations.

3.1 Sampling

At Site 89, thirteen groundwater monitoring wells and four surface water locations will be sampled semi-annually as part of the monitoring program. Three groundwater monitoring wells at Site 93 will also be included in the monitoring program. The monitoring well and surface water locations and sample analyses have not changed from the original sampling plan initiated in January of 1999 (described above). Figures 1 and 2 present the locations of the monitoring wells to be included in the sampling program at Sites 89 and 93, respectively. Tables 1 and 2 provide construction details for each of the monitoring wells included in the monitoring program at Sites 89 and 93, respectively. Tables 3 and 4 summarize VOC and natural attenuation analyses to be performed. Following the completion of groundwater sampling, a complete round of groundwater elevations will be collected from all existing monitoring wells at Sites 89 and 93.

3.2 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this investigation, including quality assurance and quality control (QA/QC) samples, will be designated with a unique number. The sample number will serve to identify the investigation, site, sample media, sampling location, QA/QC qualifiers, and the quarter and year in which the samples were collected.

The sample designation format is as follows:

IR - Site #-Media and Station # or QA/QC-Year and event

An explanation of each of these identifiers is given below.

IR	The Department of Defense's program to address CERCLA requirements (i.e., Installation Restoration Program)
Site Number	This investigation includes Sites 89 and 93
Media	GW = Groundwater SW = Surface water
Station Number	Each sample location or monitoring well will be identified with a unique identification number. Single digit location numbers must be proceeded by a 0 (i.e., 89-GW02)
QA/QC	(TB) = Trip Blank
Year	The number will reference the calendar year the sample was obtained. For example: 99 = 1999 00 = 2000
Quarter	The last letter of the sample designation corresponds to the quarter of the calendar year in which the sample was collected. A = First quarter (January - March) B = Second quarter (April - June) C = Third quarter (July - September) D = Fourth quarter (October - November)

Under this sample designation format the sample number IR89-GW03IW-00A refers to:

IR89-GW03JW-00A	Installation Restoration
IR89-GW03IW-00A	Site 89
IR89-GW03IW-00A	Groundwater sample
IR89-GW03IW-00A	Monitoring well #03
IR89-GW03IW-00A	Intermediate monitoring well
IR89-GW03IW-00A	Year 2000
IR89-GW03IW-00A	First quarter

Under this sample designation format the sample number IR89-SW06-00A refers to:

IR89-SW06-00A	Installation Restoration
IR89-SW06-00A	Site 89
IR89-SW06-00A	Surface water sample
IR89-SW06-00A	Sampling location # 06
IR89-SW06-00A	Year 2000
IR89-SW06-00A	First quarter

Under this sample designation format the sample number IR93-TB01-00A refers to:

IR93-TB01-00A	Installation Restoration
IR93-TB01-00A	Site 93
IR93-TB01-00A	Trip Blank
IR93-TB01-00A	Sequential number
IR93-TB01-00A	Year 2000
IR93-TB01-00A	First quarter

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

3.3 Sample Collection and Analyses

Groundwater samples will be collected from the identified monitoring wells at Sites 89 and 93. The following is the low-flow purge and sampling procedure to be used for obtaining the groundwater samples:

1. The well cap will be removed, and escaping gases will be measured at the well head using a Photoionization Detector (PID) or Flame Ionization Detector (FID). This will assist in determining the need for respiratory protection.

2. The well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.

3. The static water level will be measured. The total depth of the well will not be measured as to not stir up the sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.

4. The sampling device intake (virgin, 1/4 inch inside diameter [ID] polypropylene or polyethylene tubing) will slowly be lowered until the bottom end is 2 to 3 feet below the top of the water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well). Flow rates of less than 1 liter per minute (L/min) are expected.

6. Investigative Derived Waste (IDW) (i.e., purge water) will be discharged onto the ground surface at Sites 89 or 93.

7. The water quality parameters (WQPs), including temperature, dissolved oxygen, turbidity, pH, and specific conductance will be measured frequently. These measurements will be recorded in a field log notebook.

8. Purging will be completed when a minimum of three well volumes has been removed and three successive WQP readings have stabilized within 10%, or there is no further discernable upward or downward trend. At low values, certain WQPs (such as dissolved oxygen) may vary more than 10%, but have reached a stable plateau. Turbidity levels will be acceptable upon reaching ten Nephelometric Turbidity Units (NTU) or less.

9. Upon WQP stabilization, groundwater samples will be collected. Samples for VOCs will be collected first, followed by samples for the remaining required analyses. Sample containers will be labeled and referenced on a laboratory Chain of Custody form.

10. The sample jars will be stored in a cooler on ice until they are shipped to the laboratory.

Surface water samples will be collected from four discrete locations at Site 89. The following is the sampling method to be used to obtain the surface water samples:

1. Surface water samples must be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted, if required.

2. Samples will be collected by dipping the sample bottles directly into the water. An unpreserved, laboratory-decontaminated transfer bottle will be used to fill preserved bottles. Additionally, a transfer bottle will be used to fill all bottles if surface water is too shallow. Care will be taken when collecting samples for VOCs to avoid excessive agitation that could result in the loss of volatiles. Sample containers will be labeled prior to collection.

3. If sample containers do not contain preservative they will be rinsed at least once with the sample water prior to the final sample collection. In addition, the sampling container used to transfer the surface water into the sample bottles containing preservative will be rinsed once with the sample water.

4. Temperature, pH, specific conductance, and dissolved oxygen will be measured in the field at each sampling station immediately following sample collection.

5. The sample containers will be stored in a cooler with ice until laboratory shipment.

The standard operation procedure (SOP) for collection and sampling is located in the SOP section of this document. Table 2 defines the sampling and analysis program for the monitoring program at Sites 89 and 93.

3.4 Quality Assurance and Quality Control

Quality assurance and quality control requirement for this monitoring program are limited to trip blanks and matrix spike/matrix spike duplicates (MS/MSDs).

Trip blanks are defined as samples comprised of analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOC.

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with selected target analytes and analyzed with the associated sample and MS sample. MS/MSD samples undergo the same extraction and analytical procedures as the unfortified field sample. The results of the MS and MSD are used together to determine the effect of the matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not on all samples in the QC batch. MS/MSD samples at Sites 89 and 93 will only be analyzed for VOCs.

Equipment rinsates, field blanks, and field duplicates will not be collected during the natural attenuation monitoring program. The samples collected during the program will be considered confirmatory only; therefore, the above QA/QC samples have been eliminated from the program.

4.0 REFERENCES

Baker Environmental, Inc. Remedial Investigation Report, Operable Unit No. 16 (Sites 89 and 93) for MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. June 1998.

TABLES

TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 16 - SITE 89
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
IR89-MW03IW	5/15/97	13.48	13.89	42.0	41.5	36.5-41.5	34.0-42.0	32.0-34.0	-0.41
IR89-MW04	4/16/97	11.91	9.43	14.0	14.0	4.0-14.0	2.0-14.0	1.0-2.0	2.48
IR89-MW04IW	4/16/97	11.16	9.69	37.5	37.5	32.5-37.5	30.0-37.5	28.0-30.0	1.47
IR89-MW05	4/20/97	12.37	12.92	14.0	14.0	4.0-14.0	2.0-14.0	1.0-2.0	-0.55
IR89-MW05IW	4/18/97	12.41	13.07	46.0	40.0	35.0-40.0	33.0-40.0	28.0-33.0	-0.66
IR89-MW06IW	5/2/97	11.71	9.88	40.0	37.0	32.0-37.0	30.0-37.0	28.0-30.0	1.83
IR89-MW08IW	5/13/97	13.26	11.31	40.0	37.0	32.0-37.0	30.0-37.0	28.0-33.0	1.95
IR89-MW02	6/22/94	14.81	13.7	NA	NA	NA	NA	NA	1.11
IR89-MW03	6/22/94	15.38	14.2	NA	NA	NA	NA	NA	1.18

Notes:
msl - Mean sea level
bgs - Below ground surface
ft - Feet
NA - Data is not available.
Where stick up is negative, flush mount wells were installed.

TABLE 2

SUMMARY OF WELL CONSTRUCTION DETAILS
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 16 - SITE 93
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of PVC Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
93-MW02	4/22/97	12.76	13.31	14.0	14.0	4.0-14.0	2.0-14.0	1.0-2.0	-0.55
93-MW04	5/6/97	15.42	15.72	15.0	14.0	4.0-14.0	2.0-15.0	1.0-2.0	-0.30
93-MW05	4/20/97	13.64	11.02	14.0	14.0	4.0-14.0	2.0-14.0	1.0-2.0	2.62

Notes:

msl - Mean sea level
bgs - Below ground surface
ft - Feet
Where stick up is negative, flush mount wells were installed.

TABLE 3

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 16 - SITE 89
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles(1)	Dissolved Gases(2)	Nitrate	Sulfate	TOC(3)	TON(4)	Nitrite	Ammonia	Orthophosphate	Sample Designation
89-MW02	GW	X	X	X	X	X					IR89-GW02-**
89-MW03	GW	X	X	X	X	X					IR89-GW03-**
89-MW03IW	GW	X	X	X	X	X					IR89-GW03IW-**
89-MW04	GW	X	X	X	X	X					IR89-GW04-**
89-MW04IW	GW	X	X	X	X	X					IR89-GW04IW-**
89-MW05	GW	X	X	X	X	X					IR89-GW05-**
89-MW05IW	GW	X	X	X	X	X					IR89-GW05IW-**
89-MW06IW	GW	X	X	X	X	X					IR89-GW06IW-**
89-MW08IW	GW	X	X	X	X	X	X	X	X	X	IR89-GW08IW-**
89-SW06	SW	X									IR89-SW06-**
89-SW07	SW	X									IR89-SW07-**
89-SW04	SW	X									IR89-SW04-**
89-SW11	SW	X									IR89-SW11-**

Notes:

(1) Target Compound List Volatile Organics Compounds

(2) Methane, ethane, and ethene

(3) Total Organic Carbon

(4) Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

TABLE 4

SAMPLE SUMMARY
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT NO. 16 - SITE 93
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Media	TCL Volatiles[1]	Dissolved Gases[2]	Nitrate	Sulfate	TOC[3]	TON[4]	Nitrite	Ammonia	Orthophosphate	Sample Designation
93-GW02	GW	X	X	X	X	X					IR93-GW02-**
93-GW04	GW	X	X	X	X	X	X	X	X	X	IR93-GW04-**
93-GW05	GW	X	X	X	X	X	X				IR93-GW05-**

Notes:

[1] Target Compound List Volatile Organics Compounds

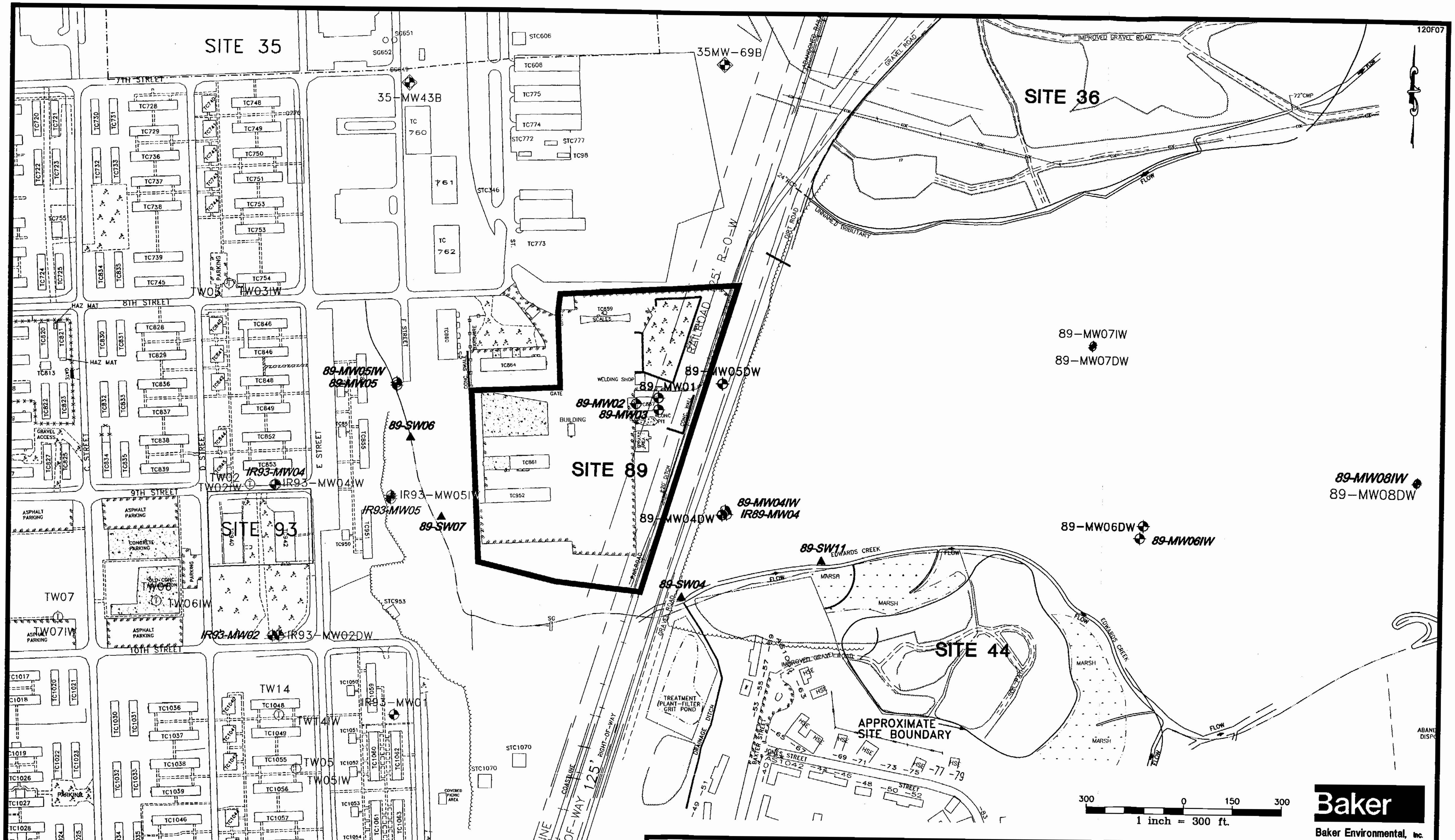
[2] Methane, ethane, and ethene

[3] Total Organic Carbon

[4] Total Organic Nitrogen

GW = Groundwater
X = Requested Analysis
** = Year (e.g., 99 for 1999) and Quarter (e.g., A for January through March) in which the groundwater sample is obtained.

FIGURES



SOURCE: LANTDIV, FEBRUARY 1992
SURVEY: BRENT A. LANIER AND ASSOCIATES, 1995
SOURCE: BARDEN LANIER AND ASSOCIATES, SEPT. 1996.OCT. 1991

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

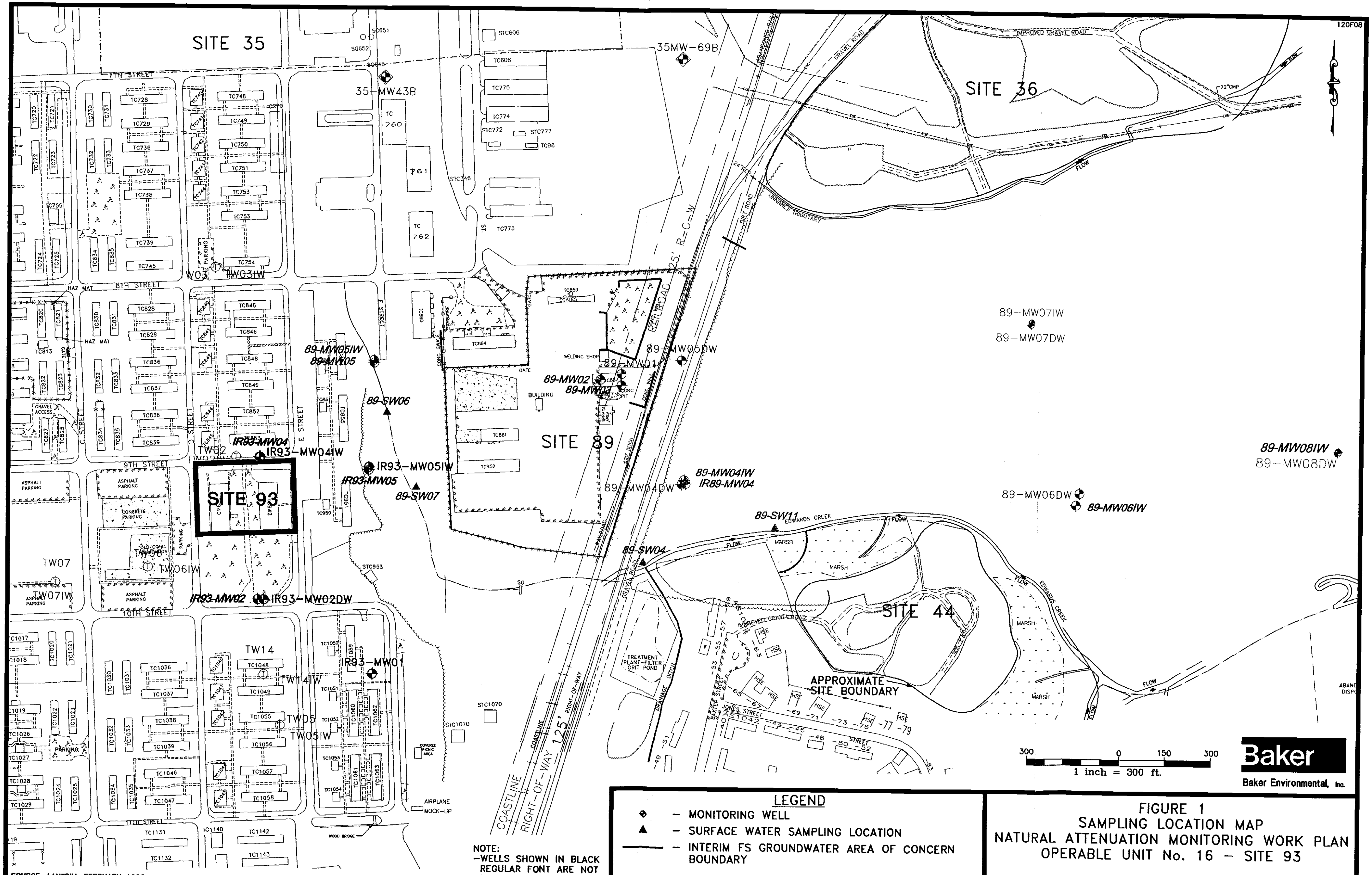
LEGEND

- ⊕ – MONITORING WELL
- ▲ – SURFACE WATER SAMPLING LOCATION
- —— – INTERIM FS GROUNDWATER AREA OF CONCERN BOUNDARY

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 16 – SITE 89

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02335 II B 12



SOURCE: LANTDIV, FEBRUARY 1992
SURVEY: BRENT A. LANIER AND ASSOCIATES, 1995
SOURCE: BARDEN LANIER AND ASSOCIATES, SEPT. 1996.OCT. 1991

NOTE:
-WELLS SHOWN IN BLACK REGULAR FONT ARE NOT INCLUDED IN THE MONITORING PROGRAM.

LEGEND

⊕ - MONITORING WELL
▲ - SURFACE WATER SAMPLING LOCATION
— - INTERIM FS GROUNDWATER AREA OF CONCERN BOUNDARY

FIGURE 1
SAMPLING LOCATION MAP
NATURAL ATTENUATION MONITORING WORK PLAN
OPERABLE UNIT No. 16 – SITE 93

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Baker
Baker Environmental, Inc.

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURES (SOPS)

Groundwater Sample Acquisition

Surface Water and Sediment Sample Acquisition

Electronic Data Deliverable Standards and Procedures

GROUNDWATER SAMPLE ACQUISITION

GROUNDWATER SAMPLE ACQUISITION
TABLE OF CONTENTS

GROUNDWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this guideline is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This guideline provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

3.0 DEFINITIONS

None.

4.0 PROCEDURES

To be useful and accurate, a groundwater sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to minimize any changes in water quality parameters.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells (Attachment A). This reference is not intended as a monitoring plan or procedure for a specific application, but rather is a review of methods.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be pumped prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.

2. Wells that can be pumped to dryness with the sampling equipment being used, shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from separation of flow streams by physical division (for example, around clay lenses) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Purging rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, thus result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site-specific and must be addressed in the Sampling and Analysis Plan.

4.1 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

The following list is an example of the type of equipment that generally must be on hand when sampling groundwater wells:

1. Sample packaging and shipping equipment: Coolers for sample shipping and cooling, chemical preservatives, and appropriate packing cartons and filler, labels and chain-of-custody documents.

2. Field tools and instrumentation: PID; Thermometer; pH meter; specific conductivity meter; appropriate keys (for locked wells) or bolt-cutter; tape measure; plastic sheeting; water-level indicator; calibrated buckets and, where applicable, flow meter.

3. Pumps

    a. Shallow-well pumps: Centrifugal, Packer Pumps, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.

    b. Deep-well pumps: Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.

4. Tubing: Sample tubing such as teflon, polyethylene, polypropylene, or PVC. Tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.

5. Other Sampling Equipment: Bailers, Packer Pumps, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

6. Pails: Plastic, graduated.

Ideally, sample withdrawal equipment should be completely inert, economical, easily cleaned, sterilized, and reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

4.2 Calculations of Well Volume for Purging

The volume of the cylinder of water in a well is given by:

$$V_w = \pi r^2 h$$

Where:
V_w = volume of standing water in well (in cubic feet)
π = pi, 3.14
r = well radius (in feet)
h = standing water in well (in feet)

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).

2. Determine well or casing diameter (D).

3. Measure and record static water level (DW-depth to water below ground level or top of casing reference point).

4. Determine the depth of the well (TD) to the nearest 0.01-foot by sounding using a clean, decontaminated weighted tape measure, referenced to the top of PVC casing or ground surface.

5. Calculate number of linear feet of static water (total well depth minus the depth to static water level).

6. Calculate the volume of water in the casing:

$$V_{gal} = V_W \text{ x } 7.48 \text{ gallons/ft}^3$$

$$V_{purge} = Vgal \text{ (\# Well Vol)}$$

Where:

V_W = Volume of water standing in well in cubic feet (i.e., one well volume)
V_{gal} = Volume of water in well in gallons
V_{purge} = Volume of water to be purged from well in gallons
Well Vol. =Number of well volumes of water to be purged from the well (typically three to five)

7. Determine the minimum number of gallons to be evacuated before sampling. (Note: V_{purge} should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

Table 4-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

TABLE 4-1
WELL VOLUMES

Diameter of Casing or Hole (in.)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth
1	0.041	0.0055
2	0.163	0.0218
4	0.653	0.0873
6	1.469	0.1963
8	2.611	0.3491
10	4.080	0.5454

4.3 Evacuation of Static Water (Purging)

The amount of purging a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Region IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize. The well is considered properly purged when the values have stabilized.

If a well is dewatered before the required volume is purged, the sample should be collected from the well once as a sufficient volume of water has entered the well. In order to avoid stagnation, the well should not be allowed to fully recharge before the sample is collected. The field parameters (pH, conductance, and temperature) should be recorded when the well was dewatered.

4.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate and use.

Limitations on the use of bailers include the following:

- Limited volume of sample.
- Time consuming to remove stagnant water using a bailer.
- Collection and transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.
- Unable to collect depth-discrete sample.

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (generally not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 10 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps will cause significant loss of dissolved gases, including volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samples - This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift pumps are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics. An inert gas such as nitrogen is generally used as a gas source.

Submersible Pumps - Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed air or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

4.4 Sampling

The sampling approach consisting of the following, should be developed as part of the Sampling and Analysis Plan prior to the field work:

1. Background and objectives of sampling.

2. Brief description of area and waste characterization.

3. Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

4. Sampling equipment to be used.

5. Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

6. Sample preservation requirements.

7. Schedule.

8. List of team members.

9. Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

4.4.1 Sampling Methods

The collection of a groundwater sample includes the following steps:

1. First open the well cap and use volatile organic detection equipment (HNu or OVA) on the escaping gases at the well head to determine the need for respiratory protection. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.

2. When proper respiratory protection has been donned, measure the total depth and water level (with decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well .

3. Lower purging equipment or intake into the well to a distance just below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).

4. Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters. Record the method of discharge measurement.

5. Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

6. Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.

7. Record measurements of specific conductance, temperature, and pH during purging to ensure that the groundwater level has stabilized. Generally, these measurements are made after the removal of three, four, and five well volumes.

8. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.

9. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

10. In the event that groundwater recovery time is very slow (e.g., 24 hours), sample collection can be delayed until the following day. However, it is preferred that such a well be bailed early in the morning so that sufficient volume of water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

11. Add preservative if required. Label, tag, and number the sample bottle(s).

12. Volatile organics septum vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure. If the second attempt still produces air bubbles, note on Chain-of-Custody form and in field notebook and submit sample to the laboratory.

    Fill the remaining sample containers in order of decreasing volatilability (semivolatiles next, then pesticides, PCBs, inorganics, etc.).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see SOP F302).

15. Decontaminate all equipment.

4.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. Container requirements shall follow those given in NEESA 20.2 047B.

4.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Sample volume and preservation requirements shall follow those given in NEESA 20.2-047B.

4.4.4 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it should be double-bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged, and thus possibly become cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage.

4.4.5 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in NEESA 20.2-047B.

5.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).

- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

6.0 REFERENCES

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U. S. EPA, 1996. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Region IV Environmental Services Division, Athens, Georgia.

ATTACHMENT A

ASTM D4448-85A
STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS

Designation: D 4448 – 85a

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103
Reprinted from the Annual Book of ASTM Standards, Copyright ASTM
If not listed in the current combined index, will appear in the next edition.

Standard Guide for Sampling Groundwater Monitoring Wells[1]

This standard is issued under the fixed designation D 4448; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers procedures for obtaining valid, representative samples from groundwater monitoring wells. The scope is limited to sampling and "in the field" preservation and does not include well location, depth, well development, design and construction, screening, or analytical procedures.

1.2 This guide is only intended to provide a review of many of the most commonly used methods for sampling groundwater quality monitoring wells and is not intended to serve as a groundwater monitoring plan for any specific application. Because of the large and ever increasing number of options available, no single guide can be viewed as comprehensive. The practitioner must make every effort to ensure that the methods used, whether or not they are addressed in this guide, are adequate to satisfy the monitoring objectives at each site.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Guide

2.1 The equipment and procedures used for sampling a monitoring well depend on many factors. These include, but are not limited to, the design and construction of the well, rate of groundwater flow, and the chemical species of interest. Sampling procedures will be different if analyzing for trace organics, volatiles, oxidizable species, or trace metals is needed. This guide considers all of these factors by discussing equipment and procedure options at each stage of the sampling sequence. For ease of organization, the sampling process can be divided into three steps: well flushing, sample withdrawal, and field preparation of samples.

2.2 Monitoring wells must be flushed prior to sampling so that the groundwater is sampled, not the stagnant water in the well casing. If the well casing can be emptied, this may be done although it may be necessary to avoid oxygen contact with the groundwater. If the well cannot be emptied, procedures must be established to demonstrate that the sample represents groundwater. Monitoring an indicative parameter such as pH during flushing is desirable if such a parameter can be identified.

2.3 The types of species that are to be monitored as well as the concentration levels are prime factors for selecting sampling devices **(1, 2)**.[2] The sampling device and all materials and devices the water contacts must be constructed of materials that will not introduce contaminants or alter the analyte chemically in any way.

2.4 The method of sample withdrawal can vary with the parameters of interest. The ideal sampling scheme would employ a completely inert material, would not subject the sample to negative pressure and only moderate positive pressure, would not expose the sample to the atmosphere, or preferably, any other gaseous atmosphere before conveying it to the sample container or flow cell for on-site analysis.

2.5 The degree and type of effort and care that goes into a sampling program is always dependent on the chemical species of interest and the concentration levels of interest. As the concentration level of the chemical species of analytical interest decreases, the work and precautions necessary for sampling are increased. Therefore, the sampling objective must clearly be defined ahead of time. For example, to prepare equipment for sampling for mg/L (ppm) levels of Total Organic Carbon (TOC) in water is about an order of magnitude easier than preparing to sample for μg/L (ppb) levels of a trace organic like benzene. The specific precautions to be taken in preparing to sample for trace organics are different from those to be taken in sampling for trace metals. No final Environmental Protection Agency (EPA) protocol is available for sampling of trace organics. A short guidance manual, **(3)** and an EPA document **(4)** concerning monitoring well sampling, including considerations for trace organics are available.

2.6 Care must be taken not to cross contaminate samples or monitoring wells with sampling or pumping devices or materials. All samples, sampling devices, and containers must be protected from the environment when not in use. Water level measurements should be made before the well is flushed. Oxidation-reduction potential, pH, dissolved oxygen, and temperature measurements and filtration should all be performed on the sample in the field, if possible. All but temperature measurement must be done prior to any significant atmospheric exposure, if possible.

2.7 The sampling procedures must be well planned and all sample containers must be prepared and labeled prior to going to the field.

3. Significance and Use

3.1 The quality of groundwater has become an issue of national concern. Groundwater monitoring wells are one of

---

[1] This guide is under the jurisdiction of ASTM Committee D-34 on Waste Disposal and is the direct responsibility of Subcommittee D34.01 on Sampling and Monitoring.

Current edition approved Aug. 23 and Oct. 25, 1985. Published May 1986.

[2] The boldface numbers in parentheses refer to a list of references at the end of this guide.

TABLE 1 Typical Container and Preservation Requirements for a Ground-Water Monitoring Program

Sample and Measurement	Volume Required (mL)	Container P—Polyethylene G—Glass	Preservative	Maximum Holding Time
Metals As/Ba/Cd/Cr/Fe Pb/Se/ Ag/Mn/Na	1000–2000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Mercury	200–300	P/G (special acid cleaning)	high purity nitric acid to pH <2 +0.05 % $K_2Cr_2O_7$	28 days
Radioactivity alpha/beta/radium	4000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Phenolics	500–1000	G	cool, 4°C H_2SO_4 to pH <2	28 days
Miscellaneous	1000–2000	P	cool, 4°C	28 days
Fluoride	300–500	P		28 days
Chloride	50–200	P/G		28 days
Sulfate	100–500	P/G		48 hours
Nitrate	100–250	P/G		6 h
Coliform	100	P/G		on site/24 h
Conductivity	100	P/G		on site/6 h
pH	100	P/G		48 h
Turbidity	100	P/G		
Total organic carbon (TOC)	25–100	P/G	cool, 4°C or cool, 4°C HCl or H_2SO_4 to pH <2	24 h 28 days
Pesticides, herbicides and total organic halogen (TOX)	1000–4000	G/TFE-fluorocarbon lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Extractable organics	1000–2000	G/TFE-fluorocarbon-lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Organic purgeables acrolein/acrylonitrile	25–120	G/vial TFE-fluorocarbon-lined septum	cool, 4°C	14 days 3 days

the more important tools for evaluating the quality of groundwater, delineating contamination plumes, and establishing the integrity of hazardous material management facilities.

3.2 The goal in sampling groundwater monitoring wells is to obtain samples that are truly representative of the aquifer or groundwater in question. This guide discusses the advantages and disadvantages of various well flushing, sample withdrawal, and sample preservation techniques. It reviews the parameters that need to be considered in developing a valid sampling plan.

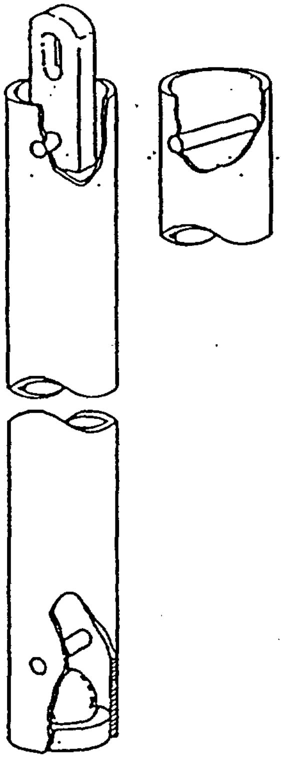
4. Well Flushing (Purging)

4.1 Water that stands within a monitoring well for a long period of time may become unrepresentative of formation water because chemical or biochemical change may cause water quality alterations and even if it is unchanged from the time it entered the well, the stored water may not be representative of formation water at the time of sampling, or both. Because the representativeness of stored water is questionable, it should be excluded from samples collected from a monitoring well.

4.2 The surest way of accomplishing this objective is to remove all stored water from the casing prior to sampling. Research with a tracer in a full scale model 2 in. PVC well (5) indicates that pumping 5 to 10 times the volume of the well via an inlet near the free water surface is sufficient to remove all the stored water in the casing. The volume of the well may be calculated to include the well screen and any gravel pack if natural flow through these is deemed insufficient to keep them flushed out.

4.3 In deep or large diameter wells having a volume of water so large as to make removal of all the water impractical, it may be feasible to lower a pump or pump inlet to some point well below the water surface, purge only the volume below that point then withdraw the sample from a deeper level. Research indicates this approach should avoid most contamination associated with stored water (5, 6, 7). Sealing the casing above the purge point with a packer may make this approach more dependable by preventing migration of stored water from above. But the packer must be above the top of the screened zone, or stagnant water from above the packer will flow into the purged zone through the well's gravel/sand pack.

4.4 In low yielding wells, the only practical way to remove all standing water may be to empty the casing. Since it is not always possible to remove all water, it may be advisable to let the well recover (refill) and empty it again at least once. If introduction of oxygen into the aquifer may be of concern, it would be best not to uncover the screen when performing the above procedures. The main disadvantage of methods designed to remove all the stored water is that large volumes may need to be pumped in certain instances. The main advantage is that the potential for contamination of samp with stored water is minimized.



NOTE—Taken from Ref (15).

FIG. 1 Single Check Valve Bailer

4.5 Another approach to well flushing is to monitor one or more indicator parameters such as pH, temperature, or conductivity and consider the well to be flushed when the indicator(s) no longer change. The advantage of this method is that pumping can be done from any location within the casing and the volume of stored water present has no direct bearing on the volume of water that must be pumped. Obviously, in a low yielding well, the well may be emptied before the parameters stabilize. A disadvantage of this approach is that there is no assurance in all situations that the stabilized parameters represent formation water. If significant drawdown has occurred, water from some distance away may be pulled into the screen causing a steady parameter reading but not a representative reading. Also, a suitable indicator parameter and means of continuously measuring it in the field must be available.

4.6 Gibb (4, 8) has described a time-drawdown approach using a knowledge of the well hydraulics to predict the percentage of stored water entering a pump inlet near the top of the screen at any time after flushing begins. Samples are taken when the percentage is acceptably low. As before, the advantage is that well volume has no direct effect in the duration of pumping. A current knowledge of the well's hydraulic characteristics is necessary to employ this approach. Downward migration of stored water due to effects other than drawdown (for example density differences) is not accounted for in this approach.

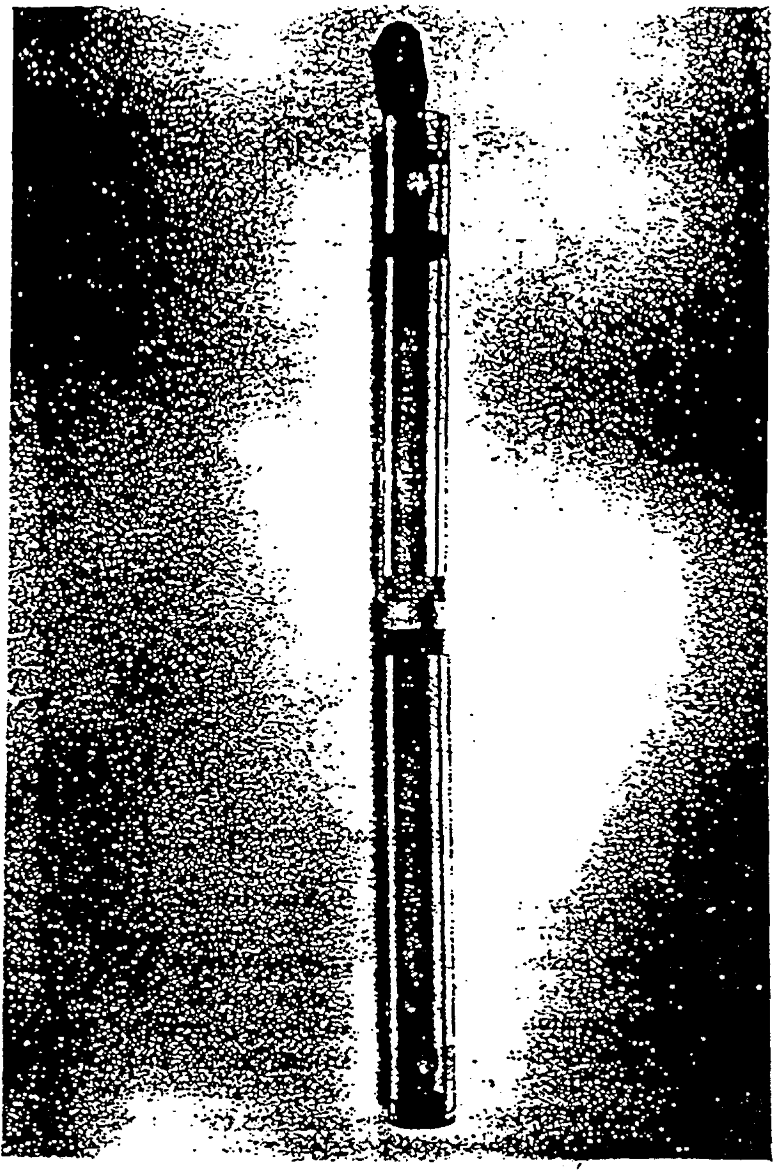
4.7 In any flushing approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around a well and can cause contaminants that were not present originally to be drawn into the well.

5. Materials and Manufacture

5.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what compounds may be present in the sampling environment and how the sample materials may interact via leaching, adsorption, or catalysis. In some situations, PVC or some other plastic may be sufficient. In others, an all glass apparatus may be necessary.

5.2 Most analytical protocols suggest that the devices used in sampling and storing samples for trace organics analysis (μg/L levels) must be constructed of glass or TFE-fluorocarbon resin, or both. One suggestion advanced by the EPA is that the monitoring well be constructed so that only TFE-fluorocarbon tubing be used in that portion of the sampling well that extends from a few feet above the water table to the bottom of the borehole. (3, 5) Although this type of well casing is now commercially available, PVC well casings are currently the most popular. If adhesives are avoided, PVC well casings are acceptable in many cases although their use may still lead to some problems if trace organics are of concern. At present, the type of background presented by PVC and interactions occurring between PVC and groundwater are not well understood. Tin, in the form of an organotin stabilizer added to PVC, may enter samples taken from PVC casing. (9)

5.3 Since the most significant problem encountered in trace organics sampling, results from the use of PVC adhesives in monitoring well construction, threaded joints might avoid the problem (3, 5). Milligram per litre (parts per million) levels of compounds such as tetrahydrofuran, methyl-ethyl-ketone, and toluene are found to leach into



NOTE—Taken from Ref (17).

FIG. 2 Acrylic Point Source Bailer

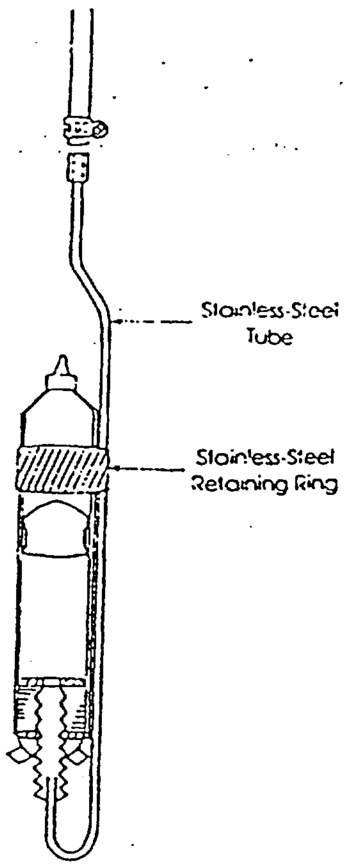
groundwater samples from monitoring well casings sealed with PVC solvent cement. Pollutant phthalate esters (**8, 10**) are often found in water samples at ppb levels; the EPA has found them on occasion at ppm levels in their samples. The ubiquitous presence of these phthalate esters is unexplained, except to say that they may be leached from plastic pipes, sampling devices, and containers.

5.4 TFE-fluorocarbon resins are highly inert and have sufficient mechanical strength to permit fabrication of sampling devices and well casings. Molded parts are exposed to high temperature during fabrication which destroys any organic contaminants. The evolution of fluorinated compounds can occur during fabrication, will cease rapidly, and does not occur afterwards unless the resin is heated to its melting point.

5.5 Extruded tubing of TFE-fluorocarbon for sampling may contain surface traces of an organic solvent extrusion aid. This can be removed easily by the fabricator and, once removed by flushing, should not affect the sample. TFE-fluorocarbon FEP and TFE-fluorocarbon PFA resins do not require this extrusion aid and may be suitable for sample tubing as well. Unsintered thread-sealant tape of TFE-fluorocarbon is available in an "oxygen service" grade and contains no extrusion aid and lubricant.

5.6 Louneman, et al. (**11**) alludes to problems caused by a lubricating oil used during TFE-fluorocarbon tubing extrusion. This reference also presents evidence that a fluorinated ethylene-propylene copolymer adsorbed acetone to a degree that later caused contamination of a gas sample.

5.7 Glass and stainless steel are two other materials generally considered inert in aqueous environments. Glass is probably among the best choices though it is not inconceivable it could adsorb some constituents as well as release other contaminants (for example, Na, silicate, and Fe). Of cou glass sampling equipment must be handled carefully field. Stainless steel is strongly and easily machin



NOTE—Taken from Ref (21).

FIG. 3 Schematic of the Inverted Syringe Sampler

fabricate equipment. Unfortunately, it is not totally immune to corrosion that could release metallic contaminants. Stainless steel contains various alloying metals, some of these (for example Ni) are commonly used as catalysts for various reactions. The alloyed constituents of some stainless steels can be solubilized by the pitting action of nonoxidizing anions such as chloride, fluoride, and in some instances sulfate, over a range of pH conditions. Aluminum, titanium, polyethylene, and other corrosion resistant materials have been proposed by some as acceptable materials, depending on groundwater quality and the constituents of interest.

5.8 Where temporarily installed sampling equipment is used, the sampling device that is chosen should be non-plastic (unless TFE-fluorocarbon), cleanable of trace organics, and must be cleaned between each monitoring well use in order to avoid cross-contamination of wells and samples. The only way to ensure that the device is indeed "clean" and acceptable is to analyze laboratory water blanks and field water blanks that have been soaked in and passed through the sampling device to check for the background levels that may result from the sampling materials or from field conditions. Thus, all samplings for trace materials should be accompanied by samples which represent the field background (if possible), the sampling equipment background, and the laboratory background.

5.9 Additional samples are often taken in the field and spiked (spiked-field samples) in order to verify that the sample handling procedures are valid. The American Chemical Society's committee on environmental improvement
published guidelines for data acquisition and data evaluati
which should be useful in such environmental evaluatic
(10, 12).

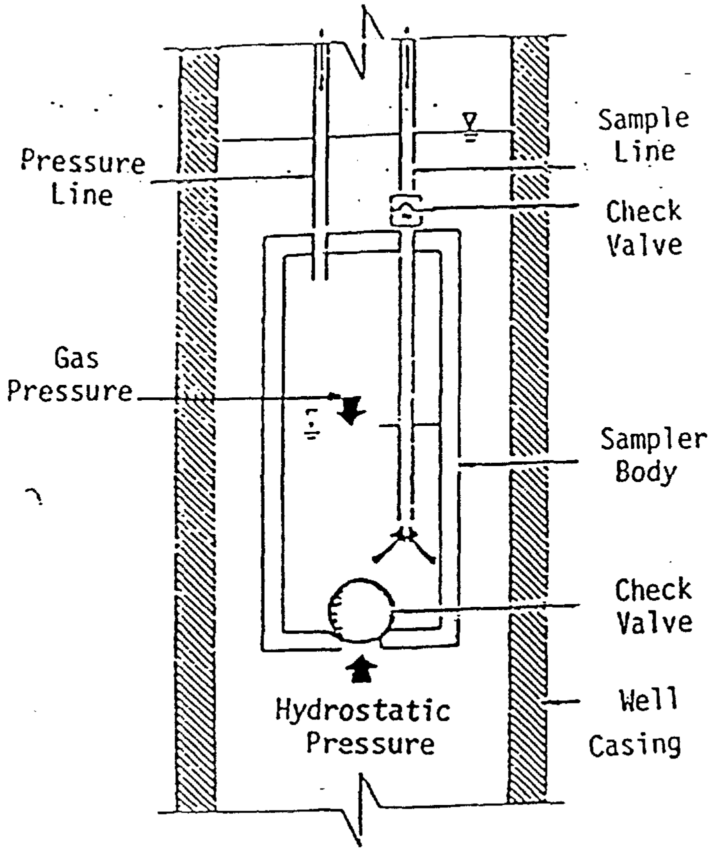
6. Sampling Equipment

6.1 There is a fairly large choice of equipment presen
available for groundwater sampling from single screen
wells and well clusters. The sampling devices can be cate
rized into the following eight basic types.

6.1.1 *Down-Hole Collection Devices:*

6.1.1.1 Bailers, messenger bailers, or thief samplers
14) are examples of down-hole devices that probably pro
valid samples once the well has been flushed. They are
practical for removal of large volumes of water. Th
devices can be constructed in various shapes and sizes fro
variety of materials. They do not subject the sample
pressure extremes.

6.1.1.2 Bailers do expose part of the sample to
atmosphere during withdrawal. Bailers used for sampling
volatile organic compounds should have a sample cock
draft valve in or near the bottom of the sampler allow
withdrawal of a sample from the well below the expos
surface of the water or the first few inches of the sam
should be discarded. Suspension lines for bailers and oth
samplers should be kept off the ground and free of oth
contaminating materials that could be carried into the w
Down-hole devices are not very practical for use in d



NOTE—Taken from Ref (5).

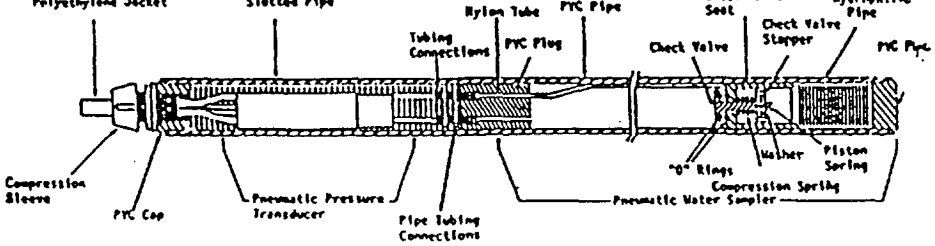
FIG. 4 The Principal of Gas Displacement Pumping

wells. However, potential sample oxidation during transfer of the sample into a collection vessel and time constraints for lowering and retrieval for deep sampling are the primary disadvantages.

6.1.1.3 Three down-hole devices are the single and double check valve bailers and thief samplers. A schematic of a single check valve unit is illustrated in Fig. 1. The bailer may be threaded in the middle so that additional lengths of blank casing may be added to increase the sampling volume. TFE-fluorocarbon or PVC are the most common materials used for construction (15).

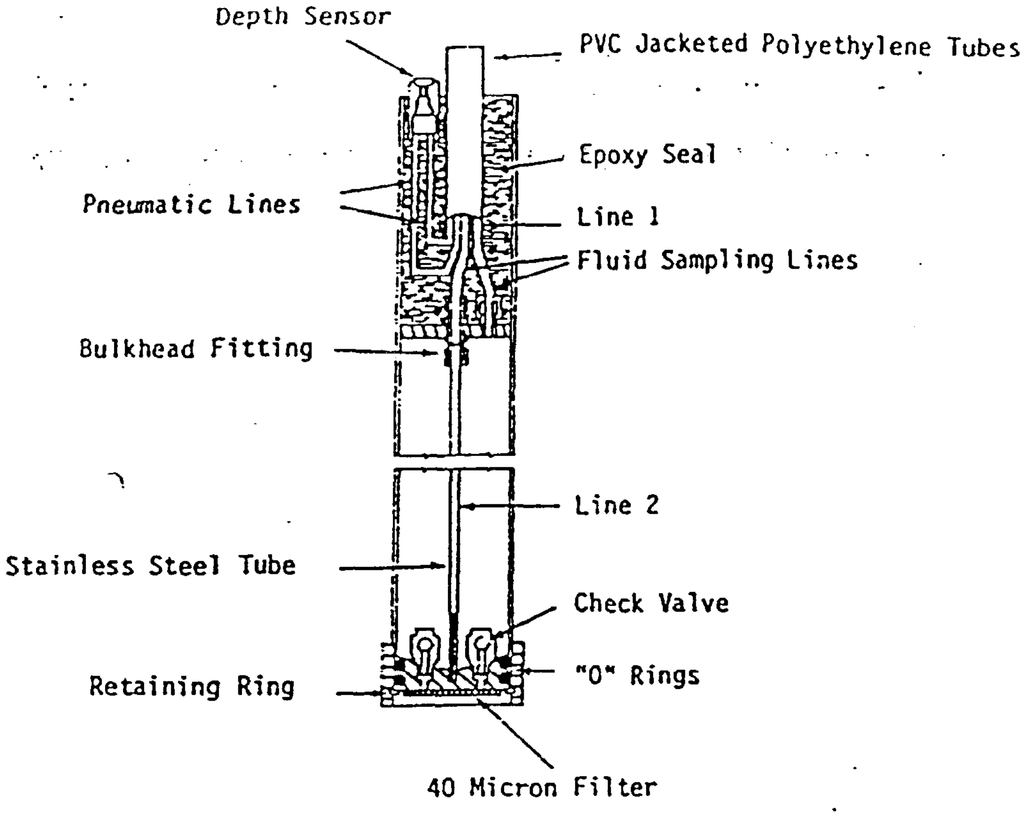
6.1.1.4 In operation, the single check valve bailer is lowered into the well, water enters the chamber through the bottom, and the weight of the water column closes the check valve upon bailer retrieval. The specific gravity of the ball should be about 1.4 to 2.0 so that the ball almost sits on the check valve seat during chamber filling. Upon bailer withdrawal, the ball will immediately seat without any samples loss through the check valve. A similar technique involves lowering a sealed sample container within a weighted bottle into the well. The stopper is then pulled from the bottle via a line and the entire assembly is retrieved upon filling of the container (14, 16).

6.1.1.5 A double check valve bailer allows point source sampling at a specific depth (15, 17). An example is shown in Fig. 2. In this double check valve design, water flows through the sample chamber as the unit is lowered. A venturi tapered inlet and outlet ensures that water passes freely through the



NOTE—Taken from Ref (41).

FIG. 5 Pneumatic Water Sampler With Internal Transducer



NOTE—Taken from Ref (42).

FIG. 6 Pneumatic Sampler With Externally Mounted Transducer

unit. When a depth where the sample is to be collected is reached, the unit is retrieved. Because the difference between each ball and check valve seat is maintained by a pin that blocks vertical movement of the check ball, both check valves close simultaneously upon retrieval. A drainage pin is placed into the bottom of the bailer to drain the sample directly into a collection vessel to reduce the possibility of air oxidation. The acrylic model in Fig. 2 is threaded at the midsection allowing the addition of threaded casing to increase the sampling volume.

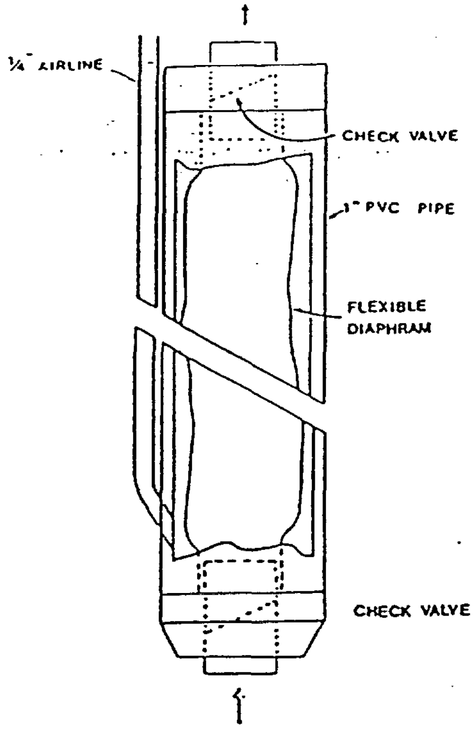
6.1.1.6 Another approach for obtaining point source samples employs a weighted messenger or pneumatic change to "trip" plugs at either end of an open tube (for example, tube water sampler or thief sampler) to close the chamber (18). Foerst, Kemmerer, and Bacon samplers are of this variety (14, 17, 19). A simple and inexpensive pneumatic sampler was recently described by Gillham (20). The device (Fig. 3) consists of a disposable 50 mL plastic syringe modified by sawing off the plunger and the finger grips. The syringe is then attached to a gas-line by means of a rubber stopper assembly. The gas-line extends to the surface, and is used to drive the stem-less plunger, and to raise and lower the syringe into the hole. When the gas-line is pressurized, the rubber plunger is held at the tip of the syringe. The sampler is then lowered into the installation, and when the desired depth is reached, the pressure in the gas-line is reduced to atmospheric (or slightly less) and water enters the syringe. The sampler is then retrieved from the installation and the syringe detached from the gas-line. After the tip is sealed, the syringe is used as a short-term storage container. A number
of thief or messenger devices are available in vario
materials and shapes.

6.1.2 *Suction Lift Pumps:*

6.1.2.1 Three types of suction lift pumps are the dire
line, centrifugal, and peristaltic. A major disadvantage of a
suction pump is that it is limited in its ability to raise wat
by the head available from atmospheric pressure. Thus, if t
surface of the water is more than about 25 ft below t
pump, water may not be withdrawn. The theoretical suctio
limit is about 34 ft, but most suction pumps are capable
maintaining a water lift of only 25 ft or less.

6.1.2.2 Many suction pumps draw the water throu
some sort of volute in which impellers, pistons, or oth
devices operate to induce a vacuum. Such pumps a
probably unacceptable for most sampling purposes beca
they are usually constructed of common materials such
brass or mild steel and may expose samples to lubrican
They often induce very low pressures around rotating var
or other such parts such that degassing or even cavitati
may occur. They can mix air with the sample via small lea
in the casing, and they are difficult to adequately cle
between uses. Such pumps are acceptable for purging
wells, but should not generally be used for sampling.

6.1.2.3 One exception to the above statements is a pe
staltic pump. A peristaltic pump is a self-priming, lo
volume suction pump which consists of a rotor with b
bearing rollers (21). Flexible tubing is inserted around t
pump rotor and squeezed by heads as they revolve in
circular pattern around the rotor. One end of the tubing
placed into the well while the other end can be connec



NOTE—Taken from Ref (4).

FIG. 7 Bladder Pump

directly to a receiving vessel. As the rotor moves, a reduced pressure is created in the well tubing and an increased pressure (<40 psi) on the tube leaving the rotor head. A drive shaft connected to the rotor head can be extended so that multiple rotor heads can be attached to a single drive shaft.

6.1.2.4 The peristaltic pump moves the liquid totally within the sample tube. No part of the pump contacts the liquid. The sample may still be degassed (cavitation is unlikely) but the problems due to contact with the pump mechanism are eliminated. Peristaltic pumps do require a fairly flexible section of tubing within the pumphead itself. A section of silicone tubing is commonly used within the peristaltic pumphead, but other types of tubing can be used particularly for the sections extending into the well or from the pump to the receiving container. The National Council of the Paper Industry for Air and Stream Improvement (22) recommends using medical grade silicone tubing for organic sampling purposes as the standard grade uses an organic vulcanizing agent which has been shown to leach into samples. Medical grade silicone tube is, however, limited to use over a restricted range of ambient temperatures. Various manufacturers offer tubing lined with TFE-fluorocarbon or Viton[3] for use with their pumps. Gibb (1, 8) found little difference between samples withdrawn by a peristaltic pump and those taken by a bailer.

6.1.2.5 A direct method of collecting a sample by suction consists of lowering one end of a length of plastic tubing into the well or piezometer. The opposite end of the tubing is connected to a two way stopper bottle and a hand held or mechanical vacuum pump is attached to a second tubing leaving the bottle. A check valve is attached between the two lines to maintain a constant vacuum control. A sample c then be drawn directly into the collection vessel with[illegible] contacting the pump mechanism (5, 23, 24).

6.1.2.6 A centrifugal pump can be attached to a length of plastic tubing that is lowered into the well. A foot valve is usually attached to the end of the well tubing to assist in priming the tube. The maximum lift is about 4.6 m (15 ft) for such an arrangement (23, 25, 26).

6.1.2.7 Suction pump approaches offer a simple sample retrieval method for shallow monitoring. The direct line method is extremely portable though considerable oxidation and mixing may occur during collection. A centrifugal pump will agitate the sample to an even greater degree although pumping rates of 19 to 151 Lpm (5 to 40 gpm) can be attained. A peristaltic pump provides a lower sampling rate with less agitation than the other two pumps. The withdrawal rate of peristaltic pumps can be carefully regulated by adjustment of the rotor head revolution.

6.1.2.8 All three systems can be specially designed so that the water sample contacts only the TFE flourocarbon or silicone tubing prior to sample bottle entry. Separate tubing is recommended for each well or piezometer sampled.

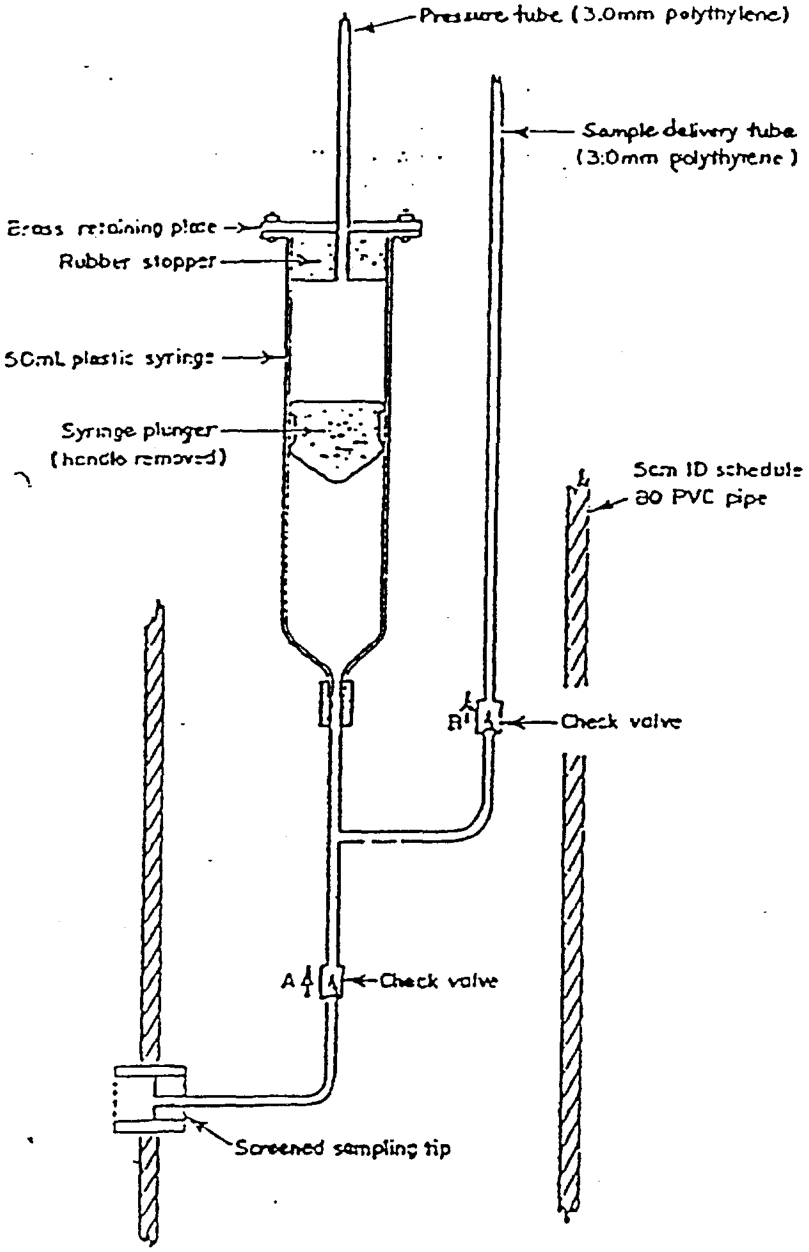
6.1.3 *Electric Submersible Pumps:*

6.1.3.1 A submersible pump consists of a sealed electric motor that powers a piston or helical single thread worm at a high rpm. Water is brought to the surface through an access tube. Such pumps have been used in the water well industry for years and many designs exist (5, 26).

6.1.3.2 Submersible pumps provide relatively high charge rates for water withdrawal at depths beyond suc[illegible]

---

[3] Viton is a trademark of E. I. du Pont de Nemours & Co., Wilmington, DE 19898 and has been found suitable for this purpose.



NOTE—Taken from Ref (48).

FIG. 8 Positive Displacement Syringe Pump

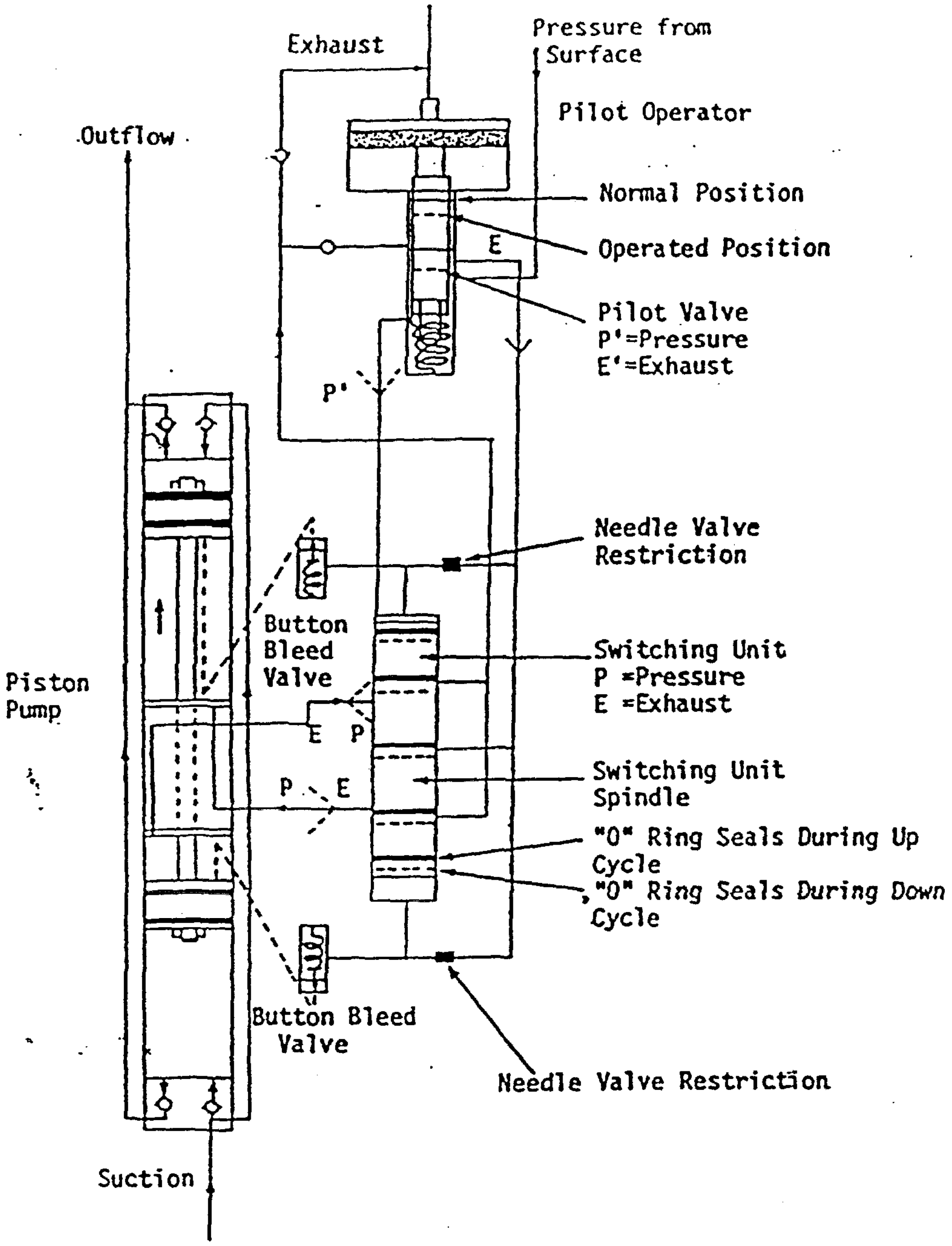
lift capabilities. A battery operated unit 3.6 cm (1.4 in.) in diameter and with a 4.5 Lpm (1.2 gpm) flow rate at 33.5 m (110 ft) has been developed (27). Another submersible pump has an outer diameter of 11.4 cm (4.5 in.) and can pump water from 91 m (300 ft). Pumping rates vary up to 53.0 Lpm (14 gpm) depending upon the depth of the pump (28).

6.1.3.3 A submersible pump provides higher extraction rates than many other methods. Considerable sample agitation results, however, in the well and in the collection tube during transport. The possibility of introducing trace metals into the sample from pump materials also exists. Steam cleaning of the unit followed by rinsing with unchlorinated, deionized water is suggested between sampling when analysis for organics in the parts per million (ppm) or parts per billion (ppb) range is required (29).

6.1.4 *Gas-Lift Pumps:*

6.1.4.1 Gas-lift pumps use compressed air to bring a wate sample to the surface. Water is forced up an eductor pip that may be the outer casing or a smaller diameter pip inserted into the well annulus below the water level **(30, 31)**

6.1.4.2 A similar principle is used for a unit that consist of a small diameter plastic tube perforated in the lower end This tube is placed within another tube of slightly large diameter. Compressed air is injected into the inner tube; th air bubbles through the perforations, thereby lifting the wate sample via the annulus between the outer and inner tubin **(32)**. In practice, the eductor line should be submerged to depth equal to 60 % of the total submerged eductor lengt during pumping (26). A 60 % ratio is considered optim although a 30 % submergence ratio is adequate.



NOTE—Taken from Ref (49).

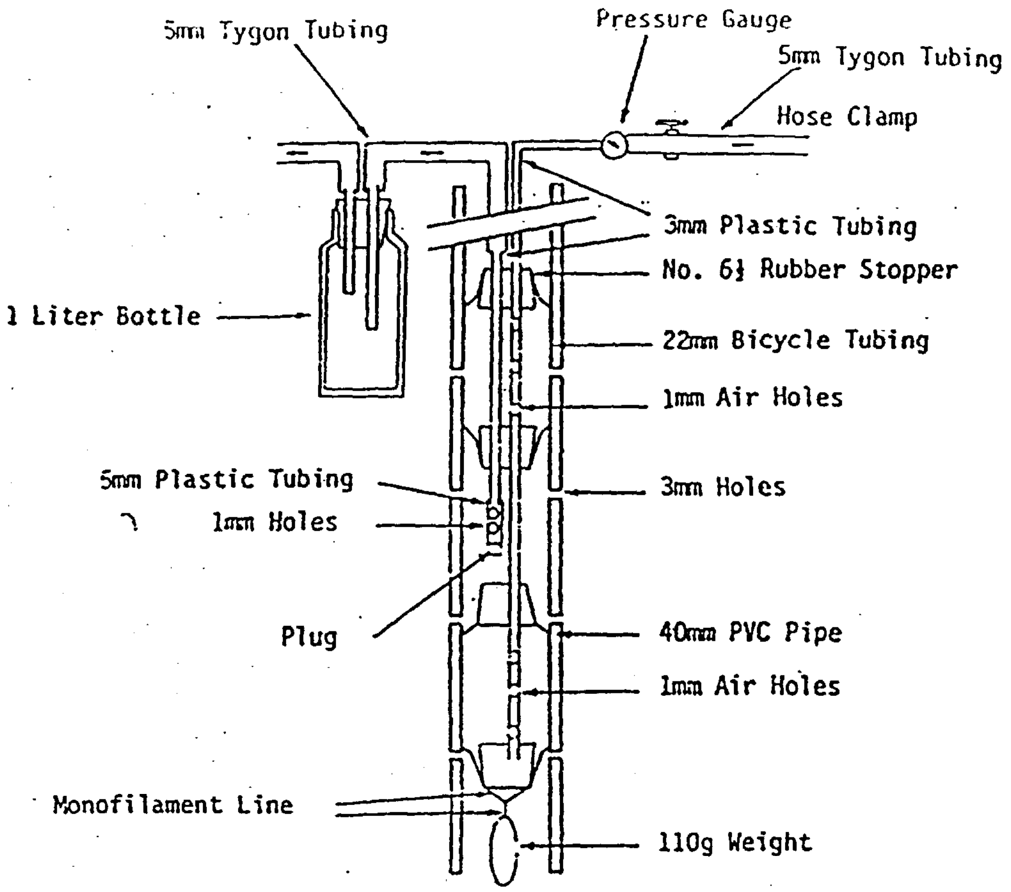
FIG. 9 Gas Driven Piston Pump

6.1.4.3 The source of compressed gas may be a hand pump for depths generally less than 7.6 m (25 ft). For greater depths, air compressors, pressurized air bottles, and air compressed from an automobile engine have been used.

6.1.4.4 As already mentioned, gas-lift methods result in considerable sample agitation and mixing within the well, and cannot be used for samples which will be tested for volatile organics. The eductor pipe or weighted plastic tubing is a potential source of sample contamination. In addition, Gibb (8) uncovered difficulties in sampling for inorganics. These difficulties were attributed to changes in redox, pH, and species transformation due to solubility constant changes resulting from stripping, oxidation, and pressure changes.

6.1.5 *Gas Displacement Pumps:*

6.1.5.1 Gas displacement or gas drive pumps are distinguished from gas-lift pumps by the method of sample transport. Gas displacement pumps force a discrete column of water to the surface via mechanical lift without extensive mixing of the pressurized gas and water as occurs with air-lift equipment. The principle is shown schematically in Fig Water fills the chamber. A positive pressure is applied



NOTE—Taken from Ref (53).

FIG. 10 Packer Pump Arrangement

gas line closing the sampler check valve and forcing water up the sample line. By removing the pressure the cycle can be repeated. Vacuum can also be used in conjunction with the gas (30). The device can be permanently installed in the well (33, 34, 35) or lowered into the well (36, 37).

6.1.5.2 A more complicated two stage design constructed of glass with check valves made of TFE-fluorocarbon has been constructed (38, 39). The unit was designed specifically for sample testing for trace level organics. Continuous flow rates up to 2.3 Lpm (0.6 gpm) are possible with a 5.1 cm (2 in.) diameter unit.

6.1.5.3 Gas displacement pumps have also been developed with multiple functions. The water sample in Fig. 5 provides piezometric data measurements with an internally mounted transducer (40). A sample with its transducer exposed externally for piezometric measurements is illustrated in Fig. 6 (41). The sensor can activate the gas source at the surface to cause sample chamber pressurization at the predetermined depth. Another design can be used as a water sampler or as a tool for injecting brine or other tracers into a well (42).

6.1.5.4 Gas displacement pumps offer reasonable potential for preserving sample integrity because little of the driving gas comes in contact with the sample as the sample is conveyed to the surface by a positive pressure. There is, however, a potential loss of dissolved gasses or contamination from the driving gas and the housing materials.

6.1.6 *Bladder Pumps:*

6.1.6.1 Bladder pumps, also referred to as gas-operated squeeze pumps, consist of a flexible membrane enclosed by a rigid housing. Water enters the membrane through a check valve in the vessel bottom; compressed gas injected into the cavity between the housing and bladder forces the sample through a check valve at the top of the membrane and into a discharge line (Fig. 7). Water is prevented from re-enterin the bladder by the top check valve. The process is repeated t cycle the water to the surface. Samples taken from depths o 30.5 m (100 ft) have been reported.

6.1.6.2 A variety of design modifications and material are available (43, 44). Bladder materials include neopren rubber, ethylene propylene terpolymer (E.P.T.), nitrile, an the fluorocarbon Viton.[3] A bladder made of TFE-fluor carbon is also under development (45). Automated sampli systems have been developed to control the time betwee pressurization cycles (46).

6.1.6.3 Bladder pumps provide an adaptable sampli tool due primarily to the number of bladder shapes that a feasible. These devices have a distinct advantage over g displacement pumps in that there is no contact with t driving gas. Disadvantages include the large gas volum required, low pumping rates, and potential contaminati from many of the bladder materials, the rigid housing, both.

6.1.7 *Gas Driven Piston Pumps:*

6.1.7.1 A simple and inexpensive example of a gas driven piston pump is a syringe pump (47). The pump (Fig. 8) is constructed from a 50 mL plastic syringe with plunger stem removed. The device is connected to a gas line to the surface and the sample passes through a check valve arrangement to a sampling container at the surface. By successively applying positive and negative pressure to the gas-line, the plunger is activated driving water to the surface.

6.1.7.2 A double piston pump powered by compressed air is illustrated in Fig. 9. Pressurized gas enters the chamber between the pistons; the alternating chamber pressurization activates the piston which allows water entry during the suction stroke of the piston and forces the sample to the surface during the pressure stroke (48). Pumping rates between 9.5 and 30.3 L/hr (2.5 to 8 gal/hr) have been reported from 30.5 m (100 ft). Depths in excess of 457 m (1500 ft) are possible.

6.1.7.3 The gas piston pump provides continuous sample withdrawal at depths greater than is possible with most other approaches. Nevertheless, contribution of trace elements from the stainless steel and brass is a potential problem and the quantity of gas used is significant.

6.1.8 *Packer Pump Arrangement:*

6.1.8.1 A packer pump arrangement provides a means by which two expandable "packers" isolate a sampling unit between two packers within a well. Since the hydraulic or pneumatic activated packers are wedged against the casing wall or screen, the sampling unit will obtain water samples only from the isolated well portion. The packers are deflated for vertical movement within the well and inflated when the desired depth is attained. Submersible, gas lift, and suction pumps can be used for sampling. The packers are usually constructed from some type of rubber or rubber compound (48, 49, 50, 51). A packer pump unit consisting of a vacuum sampler positioned between two packers is illustrated in Fig. 10 (52).

6.1.8.2 A packer assembly allows the isolation of discrete sampling points within a well. A number of different samplers can be situated between the packers depending upon the analytical specifications for sample testing. Vertical movement of water outside the well casing during sampling is possible with packer pumps but depends upon the pumping rate and subsequent disturbance. Deterioration of the expandable materials will occur with time with the increased possibility of undesirable organic contaminants contributing to the water sample.

7. Sample Containers and Preservation

7.1 Complete and unequivocal preservation of samples, whether domestic wastewater, industrial wastes, or natural waters, is practically impossible. At best, preservation techniques only retard the chemical and biological changes that inevitably continue after the sample is removed from the source. Therefore, insuring the timely analysis of a sample should be one of the formost considerations in the sampling plan schedule. Methods of preservation are somewhat limited and are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Preservation methods are generally limited to pH control, chemical addition, refrigeration and freezing. For water samples, immediate refrigeration just above freezing (4°C in wet ice) is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. There may be spe cases where it might be prudent to include a reco thermometer in the sample shipment to verify the max and minimum temperature to which the samples were exposed. Inexpensive devices for this purpose are available.

7.2 All bottles and containers must be specially precleaned, pre-labelled, and organized in ice-chests (isolating samples and sampling equipment from the environment) before one goes into the field. Otherwise, in any comprehensive program utter chaos usually develops in the field or laboratory. The time in the field is very valuable and should be spent on taking field notes, measurements, and in documenting samples, not on labelling and organizing samples. Therefore, the sampling plan should include clear instructions to the sampling personnel concerning the information required in the field data record logbook (notebook), the information needed on container labels for identification, the chain-of-custody protocols, and the methods for preparing field blanks and spiked samples. Example of detailed plans and documentation procedures have been published (14, 53).

7.3 The exact requirements for the volumes of sample needed and the number of containers to use may vary from laboratory to laboratory. This will depend on the specific analyses to be performed, the concentration levels of interest, and the individual laboratory protocols. The manager of the sampling program should make no assumptions about the laboratory analyses. He should discuss the analytical requirements of the sampling program in detail with the labora coordinator beforehand. This is especially the case some analyses and preservation measures must be perf at the laboratory as soon as possible after the samples arrive. Thus, appropriate arrangements must be made.

7.4 There are a number of excellent references available which list the containers and preservation techniques appropriate for water and soils (13, 14, 50, 54, 55, 56). The "Handbook for Sampling and Sample Preservation of Water and Wastewater" is an excellent reference and perhaps the most comprehensive one (14). Some of this information is summarized in Table 1.

7.5 Sample containers for trace organic samples require special cleaning and handling considerations (57). The sample container for purgeable organics consist of a screwcap vial (25 to 125 mL) fitted with a TFE-flourocarbon faced silicone septum. The vial is sealed in the laboratory immediately after cleaning and is only opened in the field just prior to pouring sample into it. The water sample then must be sealed into the vial headspace free (no air bubbles) and immediately cooled (4°C) for shipment. Multiple samples (usually about four taken from one large sample container) are taken because leakage of containers may cause losses, may allow air to enter the containers, and may cause erroneous analysis of some constituents. Also, some analyses are best conducted on independent protected samples.

7.6 The purgeable samples must be analyzed by the laboratory within 14 days after collection, unless they are be analyzed for acrolein or acrylonitrile (in which case are to be analyzed within 3 days). For samples for extractions (extractable organics-base neutrals, aci[illegible]nd pesticides), the sample bottles are narrow mouth, screw cap quart bottles or half-gallon bottles that have been precleaned, rinsed with the extracting organic solvent and oven dried at 105°C for at least 1 h. These bottles must be sealed with TFE-fluorocarbon lined caps (Note). Samples for organic extraction must be extracted within 7 days and analyzed within 30 days after extraction. Special pre-cleaned, solvent rinsed and oven-dried stainless steel beakers (one for each monitoring well) may be used for transferring samples from the sampling device to the sample containers.

NOTE—When collecting samples, the bottles should not be overfilled or prerinsed with sample before filling because oil and other materials may remain in the bottle. This can cause erroneously high results.

7.7 For a number of groundwater parameters, the most meaningful measurements are those made in the field at the time of sample collection or at least at an on-site laboratory. These include the water level in the well and parameters that sometimes can change rapidly with storage. A discussion of the various techniques for measuring the water level in the well is contained in a NCASI publication (5) and detailed procedures are outlined in a U.S. Geological Survey publication (58). Although a discussion of these techniques is beyond the scope of this guide, it is important to point out that accurate measurements must be made before a well is flushed or only after it has had sufficient time to recover. Parameters that can change rapidly with storage include specific conductance, pH, turbidity, redox potential, dissolved oxygen, and temperature. For some of the other parameters, the emphasis in groundwater monitoring is o the concentration of each specific dissolved component, no the total concentration of each. Samples for these types o measurements should be filtered through 0.45 μm membrane filters ideally in the field or possibly at an on-sit laboratory as soon as possible. Analyses often requirin filtered samples include all metals, radioactivity parameter total organic carbon, dissolved orthophosphate (if needed and total dissolved phosphorous (if needed) (13, 14). I metals are to be analyzed, filter the sample prior to aci preservation. For TOC organics, the filter material should b tested to assure that it does not contribute to the TOC. Th type or size of the filter to be used is not well understood However, if results of metal, TOC or other parameters tha could be effected by solids are to be compared, the sam filtering procedure must be used in each case. Repeate analytical results should state whether the samples wer filtered and how they were filtered.

7.8 Shipment and receipt of samples must be coordinate with the laboratory to minimize time in transit. All sample for organic analysis (and many other parameters), shoul arrive at the laboratory within one day after it is shipped an be maintained at about 4°C with wet ice. The best way to ge them to the laboratory in good condition is to send them i sturdy insulated ice chests (coolers) equipped with bottl dividers. 24-h courier service is recommended, if persona delivery service is not practical.

REFERENCES

(1) Gibb, J. P., Schuller, R. M., Griffin, R. A., *Monitoring Well Sampling and Preservation Techniques*, EPA-600/9-80-101, 1980.

(2) Pettyjohn, W. A., Dunlap, W. J., Cosby, R. L., Keeley, J. W., "Sampling Ground Water for Organic Contaminants," *Ground Water*, Vol 19, (2), March/April 1981, pp. 180–189.

(3) Dunlap, W. J., McNabb, J. F., Scalf, M. R., Cosby, R. L., *Sampling for Organic Chemicals and Microorganisms in the Subsurface*, EPA-600/2-77-176, NTIS PB 276 679, August 1977, 35 pp.

(4) Scalf, M. R., McNabb, J. F., Dunlap, W. J., and Cosby, R. L., *Manual of Ground Water Quality Sampling Procedures*, National Water Well Association, NTIS PB-82 103 045, 1981.

(5) "A Guide to Groundwater Sampling," *NCASI Technical Bulletin*, No. 362, January 1982.

(6) Humenick, M. J., Turk, L. J., Coldrin, M., "Methodology for Monitoring Ground Water at Uranium Solution Mines," *Ground Water*, Vol 18 (3), May–June 1980, p. 262.

(7) Marsh, J. M., and Lloyd, J. W., "Details of Hydrochemical Variations in Flowing Wells," *Ground Water*, Volume 18 (4), July–August 1980, p. 366.

(8) Gibb, J. P., Schuller, R. M., Griffin, R. A., "Collection of Representative Water Quality Data from Monitoring Wells," *Proceeding of the Municipal Solid Waste Resource Recovery Symposium*, EPA-600/9-81-002A, March 1981.

(9) Boettner, E. A., Gwendolyn, L. B., Zand, H., Aquino, R., *Organic and Organotin Compounds Leached from PVC and CPVC Pipe*, NTIS P8 82-108 333, 1982.

(10) Junk, G. A., Svec, H. J., Vick, R. D., Avery, M. J., "Contamination of Water by Synthetic Polymer Tubes," *Environmental Science and Technology*, Vol 8 (13) 1100, December 1974.

(11) Louneman, W. A., Bufalini, J. J., Kuntz, R. L., and Meeks, S. A., "Contamination from Fluorocarbon Films," *Environmental Science and Technology*, Vol 15 (1), January 1981.

(12) ASC Committee on Environmental Improvement, "Guidelines fo Data Acquisition and Data Quality Evaluation in Environmenta Chemistry," *Analytical Chemistry*, Vol 52, 1980, pp. 2242–2249.

(13) *Procedures Manual for Ground Water Monitoring at Solid Wast Disposal Facilities*, EPA/530/SW-611, August 1977.

(14) *Handbook for Sampling and Sample Preservation of Water an Wastewater*, U.S. Dept. of Commerce NTIS PB-259 946, September 1976.

(15) Timco Manufacturing Co., Inc., "Variable Capacity Bailer," *Timc Geotechnical Catalogue*, Prairie du Sac, WI, 1982.

(16) deVera, E., Simmons, B., Stephens, R., Storm, D., *Samplers an Sampling Procedures for Hazardous Waste Streams*, Environmental Protection Agency, EPA-600/2-80-018, 1980, p. 51.

(17) Morrison, R., *Ground Water Monitoring Technology*, Timc Manufacturing Co., 1982, p. 276.

(18) Eijelkamp, "Equipment for Soil Research," *General Catalogu* Geisbeek, The Netherlands, 1979, pp. 82–83.

(19) Wood, W., "Guidelines for Collection and Field Analysis o Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United State Geological Survey*, Chapter D2, 1976, p. 24.

(20) Gilham, R. W., "Syringe Devices for Groundwater Monitoring, *Ground Water Monitoring Review*, Vol 2 (2), Spring 1982, p. 36.

(21) Masterflex, *Masterflex Pump Catalogue*, Barnant Corp. Barrington, IL, 1981.

(22) "Guidelines for Contracting Sampling and Analyses for Priorit Pollutants in Pulp and Paper Industry Effluents," *NCASI Strea Improvement Technical Bulletin*, No. 335, August 1980.

(23) Allison, L., "A Simple Device for Sampling Ground Water i Auger Holes." *Soil Science Society of America Proceedings* 35 844–45, 1971.

(24) Willardson, L., Meek, B., Huber, M., "A Flow Path Ground Wate

Sampler," *Soil Science Society of America Proceedings* 36: 965–66, 1972.

(25) Wilson, L., *Monitoring in the Vadose Zone: A Review of Technical Elements and Methods*, U.S. Environmental Protection Agency, EPA-60017-80-134, 1980, p. 180.

(26) *Ground Water and Wells*, Johnson, E. E., Inc., St. Paul, MN, 1980, p. 440.

(27) Keck, W. G. and Associates, *New "Keck" Submersible Water Sampling Pump for Groundwater Monitoring*, Keck, W. G. and Associates, East Lansing, MI, 1981.

(28) McMillion, L., and Keeley, J. W., "Sampling Equipment for Ground-Water Investigation," *Ground Water*, Vol 6, 1968, pp. 9–11.

(29) Industrial and Environmental Analysts, Inc., *Procedures and Equipment for Groundwater Monitoring*, Industrial and Environmental Analysts, Inc., Essex Junction, VT, 1981.

(30) Trescott, P., and Pinder, G., "Air Pump for Small-Diameter Piezometers," *Ground Water*, Vol 8, 1970, pp. 10–15.

(31) Sommerfeldt, T., and Campbell, D., "A Pneumatic System to Pump Water From Piezometers," *Ground Water*, Vol 13, p. 293.

(32) Smith, A., "Water Sampling Made Easier with New Device," *The Johnson Drillers Journal*, July–August 1976, pp. 1–2.

(33) Morrison, R., and Ross, D., "Monitoring for Groundwater Contamination at Hazardous Waste Disposal Sites," *Proceedings of 1978 National Conference on Control of Hazardous Material Spills*, April 13, Miami Beach, FL, 1968, pp. 281–286.

(34) Morrison, R., and Brewer, P. "Air-Lift Samplers for Zone-of-Saturation Monitoring," *Ground Water Monitoring Review*, Spring 1981, pp. 52–54.

(35) Morrison, R., and Timmons, R., "Groundwater Monitoring II," *Groundwater Digest*, Vol 4, 1981, pp. 21–24.

(36) Bianchi, W. C., Johnson, C., Haskell, E., "A Positive Action Pump for Sampling Small Bore Holes," *Soil Science Society of America Proceedings*, Vol 26, 1961, pp. 86–87.

(37) Timmons, R., Discussion of "An All-Teflon Bailer and An Air-Driven Pump for Evacuating Small-Diameter Ground-Water Wells" by D. Buss and K. Bandt, *Ground Water*, Vol 19, 1981, pp. 666–667.

(38) Timco Manufacturing Co., Inc., "Gas Lift Teflon Pump," *Timco Geotechnical Catalogue*, Prairie du Sac, WI, 1982.

(39) Tomson, M., King, K., Ward, C., "A Nitrogen Powered Continuous Delivery, All Glass Teflon Pumping System for Groundwater Sampling from Below 10 Meters," *Ground Water*, Vol 18, 1980, pp. 444–446.

(40) *Pneumatic Water Sampler*, Slope Indicator Co., Seattle, WA, 1982.

(41) Petur Instrument Co., Inc., *Petur Liquid Sampler*, Petur Instrument Co., Inc., Seattle, WA, 1982.

(42) Idler, G., "Modification of an Electronic Downhole Water Sampler," *Ground Water*, Vol 18, 1980, pp. 532–535.

(43) *Remote Sampler Model 200*, Markland Specialty Engineerin Ltd., Etobicoke, Ontario, Bulletin 200/78, 1978.

(44) Middleburg, R., "Methods for Sampling Small Diameter Wells [illegible] Chemical Quality Analysis," *Presented at the National Conference on Quality Assurance of Environmental Measurements*, Nov. 27–29, Denver, CO, 1978.

(45) *Air Squeeze Pump*, Leonard Mold and Die Works, Denver, CO, 1982.

(46) *Automatic Sampler Controller: Markland Model 105 and 2105*, Markland Specialty Engineering, Ltd., Etobicoke, Ontario, Bulletin 105/78, 1981.

(47) Gillham, R. W., and Johnson, P. E., "A Positive Displacement Ground-Water Sampling Device," *Ground Water Monitoring Review*, Vol 1 (2), Summer 1981, p. 33.

(48) Signor, D., "Gas-Driven Pump for Ground-Water Samples," *U.S. Geological Survey, Water Resources Investigation 78–72*, Open File Report, 1978.

(49) *Tigre Tierra HX Pneumatic Packer*, Tigre Tierra, Inc., Puyallup, WA, 1981.

(50) Cherry, R., "A Portable Sampler for Collecting Water Samples from Specific Zones in Uncased or Screened Wells," *U.S. Geological Survey*, Prof. Paper 25-C, 1965, pp. 214–216.

(51) Grisak, G., Merritt, W., Williams, D., "Fluoride Borehole Dilution Apparatus for Groundwater Velocity Measurements," *Canadian Geotechnical Journal*, Vol 14, 1977, pp. 554–561.

(52) Galgowski, C., Wright, W., "A Variable-Depth Ground-Water Sampler," *Soil Science Society of America Proceedings*, Vol 44, 1980, pp. 1120–1121.

(53) *Samplers and Sampling Procedures for Hazardous Waste Streams*, USEPA MERL Laboratory, Cincinnati, OH, EPA-600/2-80-018, January 1980.

(54) *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, USEPA EMSL Laboratory, Cincinnati, OH, March 1979

(55) *Federal Register*, Vol 44, No. 244, Dec. 18, 1979, 75050–75052.

(56) *Standard Methods for the Examination of Water and Wastewater*, APAA, 14th ed., Washington, DC, 1976, pp. 38–45.

(57) *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, EPA-600/4-79-019, USEPA EMSL Laboratory, Cincinnati, OH, March 1979.

(58) U.S. Department of Interior, "Groundwater," Chapter II, *National Handbook of Recommended Methods for Water Data Acquisition*, 1980.

SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION

SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION
TABLE OF CONTENTS

SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION

1.0 PURPOSE

This procedure describes methods and equipment commonly used for collecting environmental samples of surface water and aquatic sediment either for on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this SOP is generally applicable to all environmental sampling of surface waters (Section 5.2) and aquatic sediments (Section 5.3), except where the analyte(s) may interact with the sampling equipment.

Specific sampling problems may require the adaptation of existing equipment or design of new equipment.

3.0 DEFINITIONS

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes.

Composite Sample - A sample collected over time that typically consists of a series of discrete samples which are combined or composited.

4.0 PROCEDURES

Collecting a representative sample from surface water or sediments is difficult due to water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location, selection, and collection methods are important to ensure that a truly representative sample has been collected. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are only as good as the confidence that can be placed on the representativeness of the samples.

4.1 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which effect adsorption/desorption). The sampling plan must therefore reflect not only the mixing characteristics of streams and lakes, but also the role of fluvial-sediment transport, deposition, and chemical sorption.

4.1.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and (d) groundwater flow influx to the water body. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (when constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly nondetectable concentrations. Such dispersion does not, however, always readily occur throughout the entire body of water; the mixing may be limited to specific flow streams within the water body. For example, obtaining a representative sample of contamination from the center of a channel immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants which may accumulate in low-energy environments while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb on particulate matter. Nitrogen, phosphorus, and the heavy metals also may be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

The first step in selecting sampling locations; therefore, is to review site history, define hydrologic boundaries and features of the site, and identify the sources, pathways and potential distribution of contamination based on these considerations. The numbers, types and general locations of required samples upgradient, on site and downgradient can then be identified.

4.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Wading or sampling from a stream bank often is sufficient for springs, seeps, and small streams. Bridges or piers are the first choice for locating a sampling station on a larger stream or small river; they provide ready access and also permit the sampling technician to sample any point across the stream or river. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment.

If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample. Use of boats or wading to collect samples requires the use of U. S. Coast Guard approved personal flotation devices (PFDs).

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant load carried by the stream. If a gaging station is not conveniently located on a selected stream, obtaining stream flow data by direct or indirect methods shall be explored.

4.1.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined. For single-event, site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this often is not recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at established and consistent intervals, as specified in the Sampling and Analysis Plan (often monthly or quarterly), and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

4.2 Surface Water Sample Collection

This section presents methods for collection of samples from various surface water bodies, as well as a description of types of surface water sampling equipment. The guidance in this section should be used to develop specific sampling procedures based on site conditions and investigation goals. A summary of sampling techniques and procedures is given in Section 5.2.5.

4.2.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) method.

Samples from different depths or cross-sectional locations, collected during the same sampling episode, shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be collected depend on the river's width, depth, discharge, and amount of suspended sediment. With a greater number of individual points sampled, it is more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling location can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section.

For larger streams greater than three feet in depth, two samples at each station shall be taken from just below the surface, and just above the bottom.

4.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify according to physical or chemical differences than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling locations on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is conducted on each aliquot of the vertical composite. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical grab samples shall be composited to form a single sample. These vertical samples often are collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite sample consists of several vertical samples collected at various depths.

As it is likely that poor mixing may occur in lakes with irregular shape (with bays and coves that are protected from the wind), separate composite samples may be needed to adequately represent water quality. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements now are made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

4.2.3 Estuaries

Estuarine areas are by definition among those zones where inland freshwaters (both surface and ground) mix with marine waters. Estuaries generally are categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas normally is based upon the tidal phases, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements coupled with vertical dissolved oxygen and temperature profiles.

4.2.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Dip sampler
- Weighted bottle
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for: specific conductance; temperature; pH; and dissolved oxygen (optional) as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

4.2.4.1 Dip Sampling

Water often is sampled by filling a container, either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents, and both vertical and horizontal distributions. Dip sampling often is the most appropriate sampling method for springs, seeps, ditches, and small streams.

4.2.4.2 Weighted Bottle Sampling

A grab sample also can be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is as follows:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

4.2.4.3 Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. A "messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

4.2.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container directly in the body of water. The following suggestions are applicable to sampling springs, seeps, ditches, culverts, small streams and other relatively small bodies of water, and are presented to help ensure that the samples obtained are representative of site conditions:

- The most representative samples will likely be collected from near mid-stream, the center of flow in a culvert, etc.
- Downstream samples shall be collected first, with subsequent samples taken while moving upstream. Care shall be taken to minimize sediment disturbance while collecting surface water samples. If necessary, sediment samples shall be collected after the corresponding surface water sample.
- Samples may be collected either by immersing the approved sample container or a glass or nalgene beaker into the water. Sample bottles (or beakers) which do not contain preservatives shall be rinsed at least once with the water to be sampled prior to sample collection.
- Care shall be taken to avoid excessive agitation of the water which may result in the loss of volatile constituents. Additionally, samples for volatile organic analyses shall be collected first, followed by the samples for other constituents.
- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate, shall be collected immediately following sample collection for laboratory analyses.

- The sampling location shall be marked via wooden stake placed at the nearest bank or shore. The sampling location number shall be marked with indelible ink on the stake.

- The following information shall be recorded in the field logbook:
    - Project location, date and time.
    - Weather.
    - Sample location number and sample identification number.
    - Flow conditions (i.e., high, low, in flood, etc.) and estimate of flow rate.
    - Visual description of water (i.e., clear, cloudy, muddy, etc.).
    - On-site water quality measurements.
    - Sketch of sampling location including boundaries of water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake.
    - Names of sampling personnel.
    - Sampling technique, procedure, and equipment used.

General guidelines for collection of samples from larger streams, ponds or other water bodies are as follows:

- The most <u>representative</u> samples are obtained from mid-channel at mid- stream depth in a well-mixed stream.

- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work may also proceed from zones suspected of low contamination to zones of high contamination.

- It is suggested that sample containers which do not contain preservative be rinsed at least once with the water to be sampled before the sample is taken.

- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one composite sample, or several grids are selected at random.

- Care should be taken to avoid excessive agitation of the water that would result in the loss of volatile constituents.

- When obtaining samples in 40 ml septum vials for volatile organics analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces inward. The bottle can be turned upside down to check for air bubbles after the bottle is filled and capped.

- Do not sample at the surface unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing upstream.

- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate shall be collected immediately following sample collection for laboratory analysis.
- Items to be recorded in the field logbook are the same as those described above for small streams.

4.3 Sediment Sampling

Sediment samples usually are collected at the same locations as surface water samples. If only one sediment sample is to be collected, the sample location shall be approximately at the center of the water body. If, however, multiple samples are required, sediment samples should be collected along a cross-section to characterize the bed material. A common procedure for obtaining multiple samples is to sample at quarter points along the cross-section of flow. As with surface water samples, sediment samples should be collected from downstream to upstream.

4.3.1 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

When boats are used for sampling, U. S. Coast Guard approved personal flotation devices must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers
- Bucket/hand auger
- Stainless steel spoon or trowel

4.3.1.1 Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

4.3.1.2 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permits direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the chance of metal contamination from the frame of the device.

4.3.1.3 Bucket (Hand) Auger

Bucket (hand) augering is a viable method for collecting sediment samples in narrow, intermittent streams or tidal flats. Typically, a 4-inch auger bucket with a cutting head is pushed and twisted into the ground and removed as the bucket is filled. The auger hole is advanced one bucket at a time, to a depth specified in the project plans.

When a specific vertical sampling interval is required, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of sediment should be removed from the bucket to minimize the changes of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples.

4.3.1.4 Stainless Steel Spoon or Trowel

For loosely packed sediments, a stainless steel scoop or trowel can be used to collect a representative sample, in narrow intermittent streams or tidal flats.

Use the scoop or trowel to collect the sample from a desired depth. Remove heavy debris, rocks, and twigs before collecting the sample. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.

4.3.2 Sediment Sampling Procedure

The following general procedure should be used, where applicable, for sampling sediment from springs, seeps, small streams, ditches, or other similar small bodies of water. Procedures sampling larger bodies of water (i.e., rivers, lakes, estuaries, etc.) should be developed on a project-specific basis, as needed.

- Sediment samples shall be collected only after the corresponding surface water sample has been collected, if one is to be collected.
- Sediment samples shall be collected from downstream locations to upstream locations.
- Samples shall be collected by excavating a sufficient amount of bottom material using a scoop, beaker, spoon, trowel, or auger. Samples should be collected with the sampling device facing upstream and the sample collected from downstream to upstream. Care should be taken to minimize the loss of fine-grained materials from the sample.
- The sample shall be transferred to the appropriate sample containers. Sampling personnel shall use judgment in removing large plant fragments to limit bias caused by bio-organic accumulation.
- The sampling location shall be marked via a wooden stake placed at the nearest bank or shore. The sample location number shall be marked on the stake with indelible ink.
- The following information shall be recorded in the field logbook:
    - Project location, date and time.
    - Weather.
    - Sample location number and sample identification number.
    - Flow conditions.
    - Sketch of sampling location including boundaries of water body, sample location, water depth, sample collection depth, relative position with respect to the site, location of wooden identifier stake.
    - Chemical analyses to be performed.

5.0 QUALITY ASSURANCE RECORDS

The description of the sampling event in the field logbook shall serve as a quality assurance record. Other records include chain-of-custody and sample analysis request forms.

6.0 REFERENCES

1. Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

2. Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

3. U.S. EPA, 1996. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, USEPA Region IV, Environmental Services Division, Athens, Georgia.

4. U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

ELECTRONIC DATA DELIVERABLE STANDARDS AND PROCEDURES

FINAL

CONTRACTOR ELECTRONIC DATA DELIVERABLE STANDARDS AND PROCEDURES

ENVIRONMENTAL MANAGEMENT DEPARTMENT
MARINE CORPS BASE CAMP LEJEUNE

SEPTEMBER 15, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF ATTACHMENTS

1.0 PURPOSE AND SCOPE

The purpose of this document is to establish standards and procedures for the creation of electronic data deliverables (EDDs) by contractors working for the Environmental Management Department (EMD) of Marine Corps Base (MCB) Camp Lejeune (the Activity). The scope of this document covers data generated as part of environmental investigations and groundwater monitoring under the Activity's installation restoration (IR) and underground storage tank (UST) programs. This data includes sample location information for new sample locations (groundwater, soil, sediment, and surface water), well construction and geologic data for newly installed wells, hydrogeologic data, and laboratory analytical data for the environmental samples. These standards also apply to analytical data generated during routine sampling of the potable supply wells on board the Activity and future efforts associated with Solid Waste Management Unit (SWMU) sites.

It is anticipated that other departments at Camp Lejeune (e.g., public works) will have environmental data associated with other types of projects outside the EMD. It shall be the responsibility of the EMD to provide these standards and coordinate the data delivery with other departments. Furthermore, as new sample types and types of locations are added to future Camp Lejeune environmental programs, or new sampling technologies are developed, it shall be the responsibility of the EMD to update this document for future implementation.

2.0 CONTENTS OF DOCUMENT

The contents of this document include the following topics:

Standard Naming Conventions - Standard nomenclature for sample locations (groundwater monitoring wells, soil borings, sediment and surface water sample locations) and sample identifications (unique names for each analytical sample collected).

Guidance for Laboratory Deliverables - Guidance for contractors on the content and format of EDDs and/or paper analytical data reports which are requested and received by the contractor from analytical laboratory subcontractors.

New Sample Location and Well/Boring Deliverables - Requirements for the content and format of all contractor EDDs to Camp Lejeune containing data for new sample locations and newly installed groundwater monitoring wells and soil borings.

Sampling and Analysis Deliverables - Requirements for the content and format of all contractor EDDs to Camp Lejeune containing sampling and analysis data for the environmental samples collected.

Arc/Info Coverages - Requirements for the content and format for the generation of tabular data for Arc/Info coverages.

3.0 STANDARD NAMING CONVENTIONS

The naming of sample locations and analytical samples taken at those locations must comply with the following naming convention standards to insure uniformity across the Activity, the uniqueness of sample location and analytical sample names, and database integrity. For existing monitoring wells or previously established sediment or surface water sample stations where new samples are to be collected, the EMD will be responsible for providing contractors with the standard names already assigned to these locations. In the case of new sample locations, the EMD will provide contractors with the next available names for each type of sample location being established on the site.

Please note that not all historic naming conventions on board the Activity comply with the naming convention detailed below. All new sample locations and analytical samples must comply with this standard.

3.1 Location Names

Location names are assigned based on the following combination of location identifiers. The '&' indicates that the two indicators joined are concatenated to create the location name. See the example below.

(Site Type) & (Site #)-(Type of Location) & (Location) & (Well Depth *[Optional]***)**

Definition of identifiers:

Site Type:

UST = Underground storage tank associated site
AST = Aboveground storage tank associated site
IR = Location associated with an IR site
PSW = Potable supply well
SWMU = Solid waste management unit site

Site #:

The site # is the number assigned to the site in the Initial Assessment Study (WAR, 1983); or the number, (i.e. building or tank system) of the associated UST or AST (if applicable).

Please note that PSW locations do not have site # or type of location indicators. Potable supply wells are named with only site type and location #.

Type of Location:

BG = Background location of any media
IS = In-situ location (i.e., hydropunch/geoprobe/soil gas)
MW = Monitoring well
PZ = Piezometer
RW = Recovery well (extraction well)

SB = Soil boring (depth > 1' below ground surface)
SD = Sediment location
SS = Surface soil location (depth < or = 1' below ground surface)
SW = Surface water location
TP = Test pit location
TW = Temporary well

Location #:

Each location of a given location type will be assigned a unique identification number for each site. If there are existing locations, a new location will be given the next available number for that location type on the site.

Depth [Optional]:

In cases where multiple screened wells (i.e., well cluster or nested wells) are installed by depth, the contractor has the option to use a two letter designation to distinguish between well depths:

IW = Intermediate well
DW = Deep well

Please note that the letter designations assigned to a depth refer to "relative" depths that are specific to a site (i.e., an intermediate well at one site can be a deep well at another).

Example 1: The location name **IR06-MW01IW** refers to:

IR06-MW01IW => IR site
IR**06**-MW01IW => Site 6
IR06-**MW**01IW => Location is a monitoring well
IR06-MW**01**IW => Monitoring well number 1
IR06-MW01**IW** => Intermediate well

Example 2: The potable supply well name **PSW-HP617** refers to:

PSW-HP617 => Potable supply well
PSW-**HP617** => Well number HP617

EDD Note: Sample location names are stored in the WELL_ID field for all EDDs regardless of the type of location. **The maximum character length for well_id is 30 characters.** See Section 5 for details.

3.2 Sample Identification Names

Sample identification names, or sample IDs, are assigned based on the following combination of sample identifiers. The '&' indicates that the two indicators joined are concatenated to create the sample identification name. The 'or' indicates that only one of the two indicators are used depending on the type of sample. See examples below.

(Site Type) & (Site #)-(Type of Sample) & (Location #) & (Dissolved Flag *[Optional]*)-(Depth) or (Sample Round #)

Definition of identifiers:

Site Type: Site type is defined the same as in sample location names. See Section 3.1.

Site #: Site # is defined the same as in sample location names. See Section 3.1.

Type of Sample:

BG = Sample collected from a background sample location (any media)
IS = Groundwater or soil sample collected from an in-situ sample location
GW = Groundwater sample collected from a monitoring well
MW = Soil sample collected from a soil boring which will be converted into a monitoring well
PZ = Groundwater sample collected from a piezometer
RW = Groundwater sample collected from a recovery well
SB = Soil sample collected from any depth of a soil boring that was not converted into a well
SD = Sediment sample
SS = Surface soil sample collected from a surface soil sample location other than a boring completed by a drill rig (e.g., spoon or hand auger)
SW = Surface water sample
TP = Soil sample collected from a test pit
TW = Groundwater sample collected from a temporary well
TW-S = Soil sample collected from a soil boring converted into a temporary well

Location #:

Location # is defined the same as in sample location names. See Section 3.1.

Dissolved Flag [Optional]:

The optional dissolved flag, the letter 'D', is used to flag those groundwater samples that are **field** filtered for dissolved metals analysis.

Depth:

The use of either depth or the sample round # is dependent upon the sample type. Soil samples are the only sample types where depth is used in the sample ID designation. Soil samples are identified by sample types BG, IS, MW, SB, SD, SS, TP, and TW-S. A number will reference the depth interval of the sample as follows (with the exception of SD samples, see below):

00 = ground surface to 1 foot below ground surface (bgs)
01 = 1 to 3 feet bgs
02 = 3 to 5 feet bgs
03 = 5 to 7 feet bgs
04 = 7 to 9 feet bgs
05 = 9 to 11 feet bgs, etc.

Sediment samples are collected at depth intervals that are not consistent with soil sampling; therefore, a separate sample depth code will be used for sediment samples:

A = 0 to 6 inches
B = 6 to 12 inches, etc.

Sample Round #:

The sample round # is used for water sample types BG, IS, GW, PZ, SW, and TW. Sample round numbers are also used for potable supply wells, site type PSW, and sediment samples, sample type SD. (Sediment samples are the only sample types that are identified by both sample depth and sample round number.) A combination of the last 2 digits of the year in which the sample was collected and a letter corresponding to the quarter of the year during which the sample was collected will be used as the sample round #.

96B = 1996, second quarter (April through June)

In the event that multiple samples are collected from the same water or SD location during a quarter, single-digits 1 - 9 may follow the quarter identifier:

98A2 = 1998, first quarter (January through March), second sample from this particular location during this quarter.

The quarter designations are as follows:

A = 1st Quarter, January through March
B = 2nd Quarter, April through June
C = 3rd Quarter, July through September
D = 4th Quarter, October through December

Example 3: The soil sample ID **IR02-MW05DW-01** indicates the following information:

IR02-MW05DW-01 => IR site
IR02-MW05DW-01 => Site 2
IR02-MW05DW-01 => Soil sample from a monitoring well boring
IR02-MW05DW-01 => Monitoring well location 5
IR02-MW05DW-01 => Deep monitoring well boring
IR02-MW05-DW01 => Soil sample collected from the 1 to 3 foot depth

Example 4: The groundwater sample ID **IR02-GW05DWD-97D** is for a groundwater sample taken from the same well.

IR02-GW05DWD-97D => IR site
IR**02**-GW05DWD-97D => Site 2
IR02-**GW**05DWD-97D => Groundwater sample
IR02-GW**05**DWD-97D => Monitoring well location 5
IR02-GW05**DW**D-97D => Deep monitoring well
IR02-GW05DW**D**-97D => Dissolved (field) analysis
IR02-GW05DWD-**97D** => Sample collected in the 4th quarter of 1997

Example 5: The groundwater sample ID **PSW-HP617-98A** is for a groundwater sample taken from the same well.

PSW-HP617-98A => Potable supply well
PSW-**HP617**-98A => Well number HP617
PSW-HP617-**98A** => Sample collected in the 1st quarter of 1998

Example 6: The surface water sample ID **IR28-SW02-97D** indicates the following information:

IR28-SW02-97D => IR Site
IR**28**-SW02-97D => Site 28
IR28-**SW**02-97D => Surface Water Sample
IR28-SW**02**-97D => Surface Water Station 2
IR28-SW02-**97D** => Sample collected in the 4th quarter of 1997

Example 7: The sediment sample ID **IR28-SD02A-97D** indicates the following information:

IR28-SD02A-97D => IR Site
IR**28**-SD02A-97D => Site 28
IR28-**SD**02A-97D => Sediment Sample
IR28-SD**02**A-97D => Sediment Sample Station 2
IR28-SD02**A**-97D => Sample depth of 0 to 6 inches
IR28-SD02A-**97D** => Sample collected in the 4th quarter of 1997

EDD Note: Sample IDs will be stored in the field named SAMPLE_ID for the required EDDs. **The maximum character length for sample_id is 30 characters.** See Section 5 for details.

4.0 GUIDANCE FOR LABORATORY DELIVERABLES

Contractors who perform sampling and analysis of environmental media as part of the IR, UST, SWMU, or potable water supply well monitoring programs at the Activity establish content and format requirements for the electronic deliverables generated by their subcontracted laboratories. In order to guarantee that contractors request all of the required analytical data from their laboratories, a sample laboratory deliverable format for Camp Lejeune EMD contractors is provided in Table 4-1. This example contains the minimum set of laboratory analytical fields that must be received by the contractor from the laboratory. Using this simple deliverable format may facilitate the contractor's generation of the sampling and analysis EDD (See Section 6).

The example laboratory EDD structure is provided to EMD contractors as guidance not as a standard for their laboratory deliverables. Most environmental contractors have established data management systems that require different laboratory deliverable structures. Contractors who currently do no have their own internal standards or established requirements for laboratory EDDs can use the example laboratory deliverable structure. It is recommended that the laboratory EDD be provided as a .dbf file (dBase) although different deliverable file types can be requested at the contractor's discretion.

TABLE 4-1: EXAMPLE LABORATORY EDD

Field Name	Field Type	Length	Dec.	Description
SAMPLE_ID	Character	30	0	Sample ID given by contractor[1]
LAB_ID	Character	20	0	Sample ID given by laboratory
MATRIX	Character	2	0	Sample matrix/media[2]
DATE_SAMP	Date	8	0	Date sample was collected (MM/DD/YY)
SAMP_TIME	Character	4	0	24-hour time (i.e., 1:10pm = 1310)
LAB	Character	20	0	Laboratory name[2]
METHOD	Character	12	0	Analysis method (i.e. EPA method)[2]
CAS	Character	11	0	CAS Number of analyte[2]
PARAMETER	Character	40	0	Name for analyzed chemical
RESULT	Number	16	7	Concentration result
DET_LIMI	Number	16	7	Reported detection limit
UNITS	Character	6	0	Units of measure for result[2]
DATA_QUAL	Character	5	0	Data qualifiers[2]
CONC_FAC	Number	4	2	Dilution of sample (if none = 1.0)
TOT_DIS	Character	2	0	Total or dissolved result (T or D)

Notes:

[1] Name must comply with naming convention in Section 3.

[2] Domain values for these fields are defined in Section 6.

It is recommended that all EMD contractors who receive analytical results from laboratories do so both in paper and electronic formats. Upon receipt of the data, a contractor is responsible for a complete Quality Assurance/Quality Control (QA/QC) of the electronic files against the official paper report submitted by the laboratory. If a contractor receives only paper-based laboratory deliverables, manual data entry must be performed to create the required electronic sampling and analysis data deliverables detailed in Section 6. Whenever data entry tasks are performed, a complete QA/QC of the entered data must be done against the original paper report. It is recommended that the QA/QC performed be documented.

5.0 NEW SAMPLE LOCATION AND WELL/SOIL BORING DELIVERABLES

Contractors collecting samples from newly established sample locations or installing new groundwater monitoring wells or soil borings must provide EDDs to Camp Lejeune which contain specified sample location data. The data required about the sample location depends upon the location type. All location types require survey data (northing, easting, and elevation) and a limited number of location-specific data, which is detailed below. Both newly installed monitoring wells, soil borings, and test pits require that geologic information be provided regarding the lithologic units encountered during installation. Monitoring wells also require well construction data in the EDD.

5.1 Required EDD For All New Sample Locations

For every new sample location, regardless of location type, a separate record in a database table called WELL.dbf must be provided to the EMD. (Please discuss with the EMD the file naming convention and file delivery mechanism for all EDDs.) The structure of this database table is provided in Table 5-1 with the list of acceptable entries for restricted fields in Table 5-2. As detailed in Section 3.0, all newly established sample location names must comply with the sample location naming convention. The next available location numbers will be provided by the EMD.

TABLE 5-1: WELL.dbf

Field Name	Field Type	Length	Dec.	Description	Location Type
WELL_ID	Character	30	0	Sample location name	*
AREA	Character	20	0	Name of area within Camp Lejeune[1]	*
DATE_INST	Date	8	0	Date sample location established[2]	*
GRND_ELEV	Number	10	2	Ground surface elevation (ft msl)	*[3]
ELEV_UNIT	Character	6	0	Always 'FT'	*
XCOORD	Character	14	0	X UTM coordinate (meters)	*
YCOORD	Character	14	0	Y UTM coordinate (meters)	*
COORD_SYS	Character	15	0	Always 'UTM'	*
COORD_UNI	Character	6	0	Always 'M' for meters	*
FIELD1	Character	30	0	Well/boring total depth (ft bgs)	MW,SB
FIELD2	Character	30	0	Well/boring diameter (ft)	MW
FIELD3	Character	30	0	Depth to top of well screen (ft bgs)	MW
FIELD4	Character	30	0	Depth to bottom of well screen (ft bgs)	MW
FIELD5	Character	30	0	Measuring point elevation (ft msl)[4]	MW
WELL_TYPE	Character	12	0	Sample location type[1]	*
VALID	Logical	1	0	Always .F.	*
AQUIFER	Character	30	0	Aquifer in which well is screened[1]	MW
COMMENTS	Memo	10	0	Comments	*
WELL_PURP	Character	30	0	Sample location purpose	*

Notes:

* = All sample location types require this field.

[1] These fields require an entry from the list of acceptable entries listed in Table 5-2.

[2] Date in MM/DD/YY format

[3] For some sample location types, surveyed ground surface elevations will not be possible (i.e. sediment stations). Provide estimated elevation in these cases.

[4] Typically the elevation of the top of inner well casing.

bgs = Below ground surface; msl = Mean sea level; UTM = Universal Transverse Mercator

TABLE 5-2: ACCEPTABLE FIELD ENTRIES FOR WELL.dbf

Field Name	Acceptable Entry	Description
AREA	A	Amphibious Area
	AS	Air Station
	BA	Beach Area
	BB	Courthouse Bay
	BM	Berkeley Manor
	CG	Camp Geiger
	FC	French Creek
	HP	Hadnot Point
	LCH	Midway Park
	MG	Maganize Area
	MP	Montford Point
	NH	Naval Hospital
	PP	Paradise Point
	RR	Rifle Range
	TT	Terrawa Terrace
	VL	Verona Loop
WELL_TYPE	ABN	Abandoned Well
	BG	Background Sample Location
	RW	Recovery Well
	IS	Insitu Sample Location
	MW	Monitoring Well
	PSW	Potable Supply Well (Public)
	PZ	Piezometer
	SB	Soil Boring
	SD	Sediment Sample Location
	SS	Surface Soil Sample Location
	SW	Surface Water Sample Location
	TP	Test Pit
	TW	Test/Temporary Well
AQUIFER	CASTLE HAYNE	Castle Hayne Aquifer
	SURFICIAL	Surficial Aquifer

5.2 Geologic Deliverable for New Wells and Soil Borings

The geologic data deliverables provided by contractors to Camp Lejeune will include lithologic descriptions of all soils encountered and documented when installing a well, boring, or test pit. Table 5-3 documents the table structure for the EDD database table LITHLOG.dbf.

TABLE 5-3: LITHLOG.dbf

Field Name	Field Type	Length	Decimals	Description
WELL_ID	Character	30	0	Well, soil boring, or test pit location name[1]
AREA	Character	20	0	Name of area within Camp Lejeune[1]
BEGDEPTH	Number	10	2	Beginning depth of lithologic sample
ENDDEPTH	Number	10	2	Ending depth of lithologic sample
USCS	Character	2	0	Universal Soil Classification Code[2,3]

Notes:

[1] Entries MUST match the corresponding records in WELL.dbf exactly.

[2] The USCS codes are typically assigned based on a grain size analysis, but USCS codes can be visually assigned based on ASTM guidance.

[3] USCS codes are listed in Table 5-4. These are the only valid entries for this field.

TABLE 5-4: ACCEPTABLE FIELD ENTRIES FOR LITHLOG.dbf

Field Name	Code	Description
USCS	CH	Inorganic Clays of High Plasticity, Fat Clays.
	CL	Inorganic Clays of Low to Medium Plasticity; Gravelly Clays, Sandy, Silty, Lean Clays.
	GC	Clayey Gravels, Poorly Graded Sand-Clay Mixtures.
	GM	Silty Gravels, Poorly Graded Sand-Silt Mixture.
	GP	Poorly Graded Gravels, Gravel-Sand Mixtures; Little or No Fines.
	GW	Well Graded Gravels, Gravel-sand Mixtures; Little or No Fines.
	LS	Limestone
	MH	Inorganic Silts, Micaceous or Diamaceous Fine Sandy or Silty Soils, Elastic Silts.
	ML	Inorg. Silts & Very Fine Sands; Rock Flour, Silty or Clayey Find Sands w/Slight Plasticity
	OH	Organic Clays of Medium to High Plasticity.
	OL	Organic Silts and Organic Silt-Clays of Low Plasticity.
	PT	Peat, Highly Organic Soils
	SC	Clayey Sands, Poorly Graded Sand-Clay Mixtures.
	SM	Silty Sands, Poorly Graded Sand-Clay Mixtures.
	SP	Poorly Graded Sands, Gravelly Sands; Little or No Fines.
	SW	Well Graded Sands, Gravelly Sands; Little or No Fines.

5.3 Data Entry Program

Contractors will have the choice to create the required new sample location EDDs, up to two .dbf tables per deliverable, in one of two ways. With the documented table structures and valid entries or domains provided above, contractors can create the tables themselves. This is favorable if the contractor already manages these types of data electronically and has sufficient database experience. In order to facilitate the generation of the required tables, a data entry program has been created which will also be made available to contractors which will allow for this data to be easily entered electronically through user-friendly data entry screens. If a portion of the new sample location data is maintained electronically, a combination approach will also likely be possible for contractors to generate the required database files.

6.0 SAMPLING AND ANALYSIS DELIVERABLES

Contractors will supply the EMD with a sampling and analysis EDD whenever laboratory analytical sampling is performed, field measurements are taken (when directed specifically by the EMD), or depth to groundwater is measured. In order to simplify the process of generating the required EDD files for loading into the Camp Lejeune environmental data management system, a process has been developed which allows for a single flat file .dbf table, LABDATA.dbf, to be created and delivered to the EMD by its contractors. The table structure, which must be generated by EMD contractors, is presented in Table 6.1.

TABLE 6-1: FLAT FILE SAMPLING AND ANALYSIS EDD (LABDATA.dbf)

Field Name	Field Type	Length	Dec.	Description
WELL_ID	Character	30	0	Sample location name
SAMPLE_ID	Character	30	0	Sample ID given by contractor
LAB_ID	Character	20	0	Sample ID given by laboratory
LAB	Character	20	0	Laboratory name[1,2]
MATRIX	Character	2	0	Sample matrix/media[3]
SAMP_TYPE	Character	10	0	Sample type[2]
SAMP_TIME	Character	4	0	24-hour time (i.e., 1:10pm = 1310)
DATE_SAMP	Date	8	0	Date sample was collected
SAMPLE_BY	Character	30	0	Contractor performing sampling
BEGDEPTH	Number	16	6	Beginning depth for soil samples
ENDDEPTH	Number	16	6	Ending depth for soil samples
METHOD	Character	12	0	Analysis method (i.e. EPA method)[3]
PARAMETER	Character	40	0	Name for chemical or measurement
CAS	Character	11	0	CAS number (include hyphens)[4]
RESULT	Number	16	7	Concentration or measurement result
DET_LIMI	Number	16	7	Reported detection limit
UNITS	Character	6	0	Units of measure for result[3]
DATA_QUAL	Character	5	0	Data qualifiers[2]
TOT_DIS	Character	2	0	Total or dissolved results (T or D)
CONC_FAC	Number	4	2	Dilution of sample (if none = 1.0)
COMMENT	Memo	10	0	Specific comments on result

Notes:

[1] Each laboratory will have one valid, unique LAB entry. If the laboratory name is not in Table 6.2, choose a name and document the need for the addition to the EMD.

[2] Valid entries for this field are listed in Table 6-2. If additional entries are necessary, please inform the EMD.

[3] Valid entries for this field are included in the tables in Attachment A.

[4] The EMD has a database of CAS numbers (CHEMICAL.dbf) which is used in its data management system. All CAS numbers delivered must match those in CHEMICAL.dbf. This file is available to contractors from the EMD. If a parameter is analyzed which has a CAS

number, but is not in CHEMICAL.dbf, please document the need for this addition to the EMD. If a CAS number does not exist for the parameter measured or analyzed, leave this field blank.

TABLE 6-2: ACCEPTABLE FIELD ENTRIES FOR SAMPLING AND ANALYSIS EDD

Field Name	Acceptable Entry	Description
DATA-QUAL	B	Analyte detected in associated method blank
	D	Sample diluted and reanalyzed
	J	Estimated value
	N	Presumptive evidence of compound
	R	Rejected value
	U	Non-detection
	BJ	Definition of B and J combined
	NJ	Definition of N and J combined
	UJ	Definition of U and J combined
	UN	Definition of U and N combined
	UR	Definition of U and R combined
SAMP_TYPE	BG	Background sample
	GW	Monitoring well groundwater sample
	IS	In-situ Sample Location
	MW	Soil sample from monitoring well boring
	PZ	Piezometer groundwater sample
	RW	Recovery well groundwater sample
	SB	Soil boring sample
	SD	Sediment sample location
	SS	Surface soil sample location
	SW	Surface water sample location
	TP	Test pit sample
	TW	Temporary well groundwater sample
	TW-S	Soil sample from temporary well boring
LAB	TRIANGLE	Triangle Labs
	PRECISION	Precision Labs
	RAS	Radian Analytical Services

7.0 TABULAR DATA FOR ARC/INFO COVERAGES

In addition to providing an EDD for chemistry, geologic, and hydrogeologic data, the contractor is also responsible for preparing tabular data sets for importing into the Activities Arc/Info GIS. Attachment A includes examples of the tabular data requirements under the user defined attributes. Note that the requirements for IR, UST, and SWMU attributes are identical. Tabular data can be provided as either a .dfb or dBase file.

ATTACHMENT A
ACCEPTABLE ENTRIES FOR MATRIX, METHOD, AND UNITS

ATTACHMENT A
ACCEPTABLE ENTRIES FOR MATRIX

MATRIX CODE	MATRIX DECRIPTION
AG	SOIL GAS
SE	SEDIMENT (ASSOCIATED WITH SURFACE WATER)
SL	SLUDGE
SO	SOIL
SW	SWAB OR WIPE
WD	WELL DEVELOPMENT WATER
WG	GROUND WATER
WL	LEACHATE
WP	DRINKING WATER
WS	SURFACE WATER
WV	WATER FROM VADOSE ZONE

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
A303A	METALS (BY DIRECT ASPIRATION INTO AN AIR-ACETYLENE FLAME)
A303C	DTRMNTN OF AL,*BA,BE,*MO,OS,RE,SI,TH,TI AND V BY DIRECT ASPRTN INTO NITRS OX-ACETYLN FLME
A312B	CHROMIUM, HEXAVALENT (COLORIMETRIC METHOD)
A403	ALKALINITY
A405	BROMIDE
A406B	TITRIMETRIC METHOD FOR FREE CARBON DIOXIDE
A407A	CHLORIDE (ARGENTOMETRIC)
A407B	CHLORIDE (MERCURIC NITRATE METHOD)
A412D	COLORIMETRIC METHOD
A412E	CYANIDE, BY ION SELECTION ELECTRODE
A412F	CYANIDE, AMENABLE TO CHLORINATION
A413C	FLUORIDE (SPADNS)
A418B	NITRATE ELECTRODE SCREENING METHOD
A418F	NITROGEN (NITRATE, AUTOMATED CADMIUM REDUCTION METHOD)
A419	NITROGEN (NITRITE)
A424G	PHOSPHATE (ASCORBIC ACID REDUCTION)
A426D	SULFATE (AUTOMATED METHYLTHYMOL BLUE METHOD)
A429	ANIONS BY ION CHROMATOGRAPHY
A506	TOTAL ORGANIC HALIDES (TOX)
A508A	CHEMICAL OXYGEN DEMAND (COD)
A508B	CHEMICAL OXYGEN DEMAND (CLOSED REFLUX, TITRIMETRIC)
A509A	ORGANOCHLORINE PESTICIDES
A509B	CHLORINATED PHENOXY HERBICIDES
A510B	PHENOLS, CHLOROFORM EXTRACTION METHOD
A701C	GAMMA SPECTRALANALYSIS
A703	GROSS ALPHA-GROSS BETA
A704	TOTAL RADIOACTIVE STRONTIUM AND STRONTIUM 90 WATER
A705	TOTAL RADIUM
A706	RADIUM 226 BY RADON IN WATER (SOLUBLE, SUSPENDED AND TOTAL)
A707	RADIUM 228 (SOLUBLE, TENTATIVE)
A708	TRITIUM
A709	RADIOACTIVE CESIUM
A710A	RADIOACTIVE IODINE, PRECIPITATION METHOD
A711	URANIUM
A711A	URANIUM RADIOCHEMICAL (TENTATIVE)
A907A	TOTAL BACTERIA (POUR PLATE METHOD)
A907B	TOTAL BACTERIA (SPREAD PLATE METHOD)
A907C	TOTAL BACTERIA (MEMBRANE FILTER METHOD)
D1140	AMOUNT OF MATERIAL IN SOILS FINER THAN THE # 200 (75 UM) SIEVE
D1385	HYDRAZINE (SPECTROPHOTOMETRIC)
D1556	DENSITY OF SOIL IN PLACE BY THE SAND-CONE METHOD
D1890	BETA PARTICLE RADIOACTIVITY OF WATER
D1943	ALPHA PARTICLE RADIOACTIVITY OF WATER
D2166	UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOIL
D2167	DENSITY AND UNIT WEIGHT OF SOIL IN PLACE BY THE RUBBER BALLOON METHOD
D2216	PERCENT SOLID
D2325	CAPILLARY-MOISTURE RELATIONSHIPS FOR CRSE- AND MDM-TXTRD SOILS BY POROUS-PLATE APPARATUS
D2434	PERMEABILITY
D2460	RADIONUCLIDES OF RADIUM IN WATER
D2487	CLASSIFICATION OF SOILS, FOR ENGINEERING PURPOSES
D2937	DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD
D2974	TOTAL ORGANIC CONTENT
D3152	CAPILLARY-MOISTURE RELATIONSHIPS FOR FINE-TEXTURED SOILS BY PRESSURE-MEMBRANE APPARATUS
D3155	LIME CONTENT OF UNCURED SOIL-LIME MIXTURES
D3385	INFILTRATION RATE OF SOILS IN FIELD USING DOUBLE-RING INFILTROMETERS
D3695	VOLATILE ALCOHOLS IN WATER BY DIRECT AQUEOUS INJECTION GC
D421	DRY PREPARATION OF SOIL SAMPLES FOR PARTICLE-SIZE ANALYSIS AND DTRMNTN OF SOIL CONTENTS
D4219	UNCONFINED COMPRESSIVE STRENGTH INDEX OF CHEMICAL-GROUTED SOILS
D422	GRAIN SIZE
D4221	DISPERSIVE CHARACTERISTICS OF CLAY SOIL BY DOUBLE HYDROMETER

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
D427	SHRINKAGE FACTORS OF SOILS
D4318	LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS
D4373	CALCIUM CARBONATE CONTENT OF SOILS
D4380	DENSITY OF BENTONITIC SLURRIES
D4381	SAND CONTENT BY VOLUME OF BENTONITIC SLURRIES
D4452	X-RAY RADIOGRAPHY OF SOIL-SAMPLES
D4525	PERMEABILITY OF ROCKS BY FLOWING AIR
D4542	PORE WATER EXTRACTION AND DETERMINATION OF THE SOLUBLE SALT
D4564	DENSITY OF SOIL IN PLACE BY THE SLEEVE METHOD
D4643	DETERMINATION OF WATER (MOISTURE) CONTENT OF SOIL BY THE MICROWAVE
D854	SPECIFIC GRAVITY OF SOILS
E110.2	COLOR (COLORIMETRIC-PLATINUM-COBALT)
E110.3	COLOR (SPECTROPHOTOMETRIC)
E120.1	SPECIFIC CONDUCTANCE
E130.1	HARDNESS, TOTAL (COLORIMETRIC, AUTOMATED EDTA)
E130.2	HARDNESS, TOTAL (TITRIMETRIC)
E140.1	ODOR (THRESHOLD ODOR, CONSISTENT SERIES)
E150.1	PH, ELECTROMETRIC
E160.1	RESIDUE, FILTERABLE (TDS)
E160.2	RESIDUE, NON-FILTERABLE
E160.3	RESIDUE, TOTAL GRAVIMETRIC, DRIED AT 103-105 DEGREES CELSIUS
E160.4	RESIDUE, VOLATILE (GRAVIMETRIC, IGNITION AT 550 DEGREES CELSIUS)
E160.5	SETTLEABLE MATTER (VOLUMETRIC, IMHOFF CONE)
E162.4	VOLATILE ORGANIC COMPOUNDS BY ISOTOPE DILUTION GC/MS
E162.5	SEMIVOLATILE ORGANIC COMPOUNDS BY ISOTOPE DILUTION GC/MS
E170.1	TEMPERATURE
E180.1	TURBIDITY (NEPHELOMETRIC)
E200.7	INDUCTIVELY COUPLED PLASMA (ICP) METAL SCREEN
E202.1	ALUMINUM
E202.2	ALUMINUM (AA, FURNACE TECHNIQUE)
E204.1	ANTIMONY (AA, DIRECT ASPIRATION)
E204.2	ANTIMONY (AA, FURNACE TECHNIQUE)
E206.2	ARSENIC (AA, FURNACE)
E206.3	ARSENIC (AA, HYDRIDE)
E208.1	BARIUM (AA, DIRECT ASPIRATION)
E208.2	BARIUM (AA, FURNACE)
E210.1	BERYLLIUM
E210.2	BERYLLIUM (AA, FURNACE TECHNIQUE)
E212.3	BORON (COLORIMETRIC, CURCUMIN)
E213.1	CADMIUM (AA, DIRECT ASPIRATION)
E213.2	CADMIUM (AA, FURNACE)
E215.1	CALCIUM (AA, DIRECT ASPIRATION)
E218.1	CHROMIUM (AA, DIRECT ASPIRATION)
E218.2	CHROMIUM (AA, FURNACE)
E218.4	CHROMIUM HEXAVALENT (AA, CHELATION-EXTRACTION)
E218.5	SOLUBLE CHROMIUM (AA,FURNACE)
E219.1	COBALT (AA, DIRECT ASPIRATION)
E219.2	COBALT (ATOMIC ABSORPTION, FURNACE TECHNIQUE)
E220.1	COPPER (AA, DIRECT ASPIRATION)
E220.2	COPPER (AA, FURNACE)
E236.1	IRON (AA, DIRECT ASPIRATION)
E236.2	IRON (AA FURNACE TECHNIQUE)
E239.1	LEAD (AA, DIRECT ASPIRATION)
E239.2	LEAD (AA, FURNACE)
E242.1	MAGNESIUM (AA, DIRECT ASPIRATION)
E243.1	MANGANESE (AA, DIRECT ASPIRATION)
E243.2	MANGANESE (AA, FURNACE TECHNIQUE)
E245.1	MERCURY (COLD VAPOR, MANUAL)
E245.2	MERCURY (COLD VAPOR, AUTOMATED)
E245.5	MERCURY (COLD VAPOR, SEDIMENTS)
E246.1	MOLYBDENUM (AA, DIRECT ASPIRATION)
E246.2	MOLYBDENUM (AA, FURNACE TECHNIQUE)
E249.1	NICKEL (AA, DIRECT ASPIRATION)
E249.2	NICKEL (AA, FURNACE)

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
E258.1	POTASSIUM BY AA, DIRECT ASPIRATION
E270.1	SELENIUM (AA, DIRECT ASPIRATION)
E270.2	SELENIUM (AA, FURNACE)
E270.3	SELENIUM (AA, HYDRIDE)
E272.1	SILVER (AA, DIRECT ASPIRATION)
E272.2	SILVER (AA, FURNACE)
E273.1	SODIUM (AA, DIRECT ASPIRATION)
E273.2	SODIUM (AA, FURNACE TECHNIQUE)
E279.1	THALLIUM (AA, DIRECT ASPIRATION)
E279.2	THALLIUM (AA, FURNACE)
E283.1	TITANIUM (AA, DIRECT ASPIRATION)
E283.2	TITANIUM (AA, FURNACE TECHNIQUE)
E286.1	VANADIUM (AA, DIRECT ASPIRATION)
E286.2	VANADIUM (AA, FURNACE TECHNIQUE)
E289.1	ZINC (AA, DIRECT ASPIRATION)
E289.2	ZINC (AA, FURNACE)
E300	DETERMINATION OF INORGANIC ANIONS IN WATER BY ION CHROMATOGRAPHY
E305.1	ACIDITY (TITRIMETRIC)
E310.1	ALKALINITY (TITRIMETRIC)
E310.2	ALKALINITY COLORIMETRIC, METHYL
E325.1	CHLORIDE (COLORIMETRIC, AUTOMATED FERRICYANIDE AAI)
E325.2	CHLORIDE, AS CL (COLORIMETRIC, AUTOMATED FERRICYANIDE AAII)
E325.3	CHLORIDE (TITRIMETRIC, MERCURIC NITRATE)
E330.2	CHLORINE, TOTAL RESIDUAL (TITRIMETRIC, BACK, IODOMETRIC)
E335.1	CYANIDES, AMENABLE TO CHLORINATION (TITRIMETRIC; SPECTROPHOTOMETRIC)
E335.2	TOTAL CYANIDE
E335.3	TOTAL CYANIDE (COLORIMETRIC, AUTOMATED UV)
E340.1	FLUORIDE (COLORIMETRIC)
E340.2	FLUORIDE (POTENTIOMETRIC, ION SELECTIVE ELECTRODE)
E340.3	FLUORIDE (COLORIMETRIC, AUTOMATED COMPLEXONE)
E345.1	IODIDE (TITRIMETRIC)
E350.1	NITROGEN (AMMONIA-COLORIMETRIC, AUTOMATED PHENATE)
E350.3	NITROGEN, AMMONIA (POTENTIOMETRIC, ION SELECTIVE ELECTRODE)
E351.2	NITROGEN, KJELDAHL, TOTAL (COLORIMETRIC SEMI-AUTOMATED BLOCK DIGESTER, AAII)
E351.3	NITROGEN, KJELDAHL, TOTAL (COLORIMETRIC; TITRIMETRIC; POTENTIOMETRIC)
E351.4	NITROGEN, KJELDAHL, TOTAL (POTENTIOMETRIC, ION SELECTIVE ELECTRODE)
E352.1	NITROGEN (NITRATE - COLORIMETRIC BRUCINE)
E353.1	NITROGEN, NITRATE-NITRITE (COLORIMETRIC AUTOMATED, HYDRAZINE
E353.2	NITROGEN, NITRATE-NITRITE (COLORIMETRIC AUTOMATED, CADMIUM REDUCTION)
E353.3	NITROGEN, NITRATE-NITRITE
E354.1	NITROGEN, NITRITE (SPECTROPHOTOMETRIC)
E360.1	OXYGEN DISSOLVED (MEMBRANE ELECTRODE)
E365.1	PHOSPHORUS, ALL FORMS (COLORIMETRIC, AUTOMATED, ASCORBIC ACID)
E365.2	PHOSPHORUS, ALL FORMS (AS P)
E365.3	PHOSPHORUS, ALL FORMS (COLORIMETRIC, ASCORBIC ACID, TWO REAGENT)
E365.4	PHOSPHORUS, TOTAL (COLORIMETRIC, AUTOMATED BLOCK DIGESTOR AAII)
E370.1	SILICA, DISSOLVED (COLORIMETRIC)
E375.1	SULFATE, COLORIMETRIC, AUTOMATED CHLORANILATE
E375.2	SULFATE, COLORIMETRIC, AUTOMATED METHYLTHYMOL BLUE, AAII
E375.3	SULFATE (AS SO4), GRAVIMETRIC
E375.4	SULFATE (AS SO4), TURBIDIMETRIC
E376.2	SULFIDE (COLORIMETRIC, METHYLENE BLUE)
E377.1	SULFITE (TITRIMETRIC)
E405.1	BIOCHEMICAL OXGEN DEMAND
E410.1	CHEMICAL OXYGEN DEMAND
E410.2	CHEMICAL OXYGEN DEMAND
E410.3	COD (TITRIMETRIC, HIGH LEVEL FOR SALINE WATERS)
E410.4	CHEMICAL OXYGEN DEMAND (COLORIMETRIC, AUTOMATED MANUAL)
E413.1	OIL AND GREASE, TOTAL RECOVERABLE (GRAVIMETRIC)
E413.2	OIL AND GREASE, TOTAL RECOVERABLE (SPECTROPHOTOMETRIC IR)
E415.1	TOTAL ORGANIC CARBON (COMBUSTION OR OXIDATION)
E415.2	TOTAL ORGANIC CARBON (UV PROMOTED, PERSULFATE OXIDATION)
E418.1	PETROLEUM HYDROCARBONS, TOTAL RECOVERABLE (SPECTROPHOTO IR)

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
E420.1	PHENOLICS, TOTAL RECOVERABLE (SPECTROPHOTOMETRIC, MAN. 4-AAP)
E425.1	METHYLENE BLUE ACTIVE SUBSTANCES (MBAS)
E430.2	NTA (COLORIMETRIC, AUTOMATED, ZINC-ZINCON)
E450.1	TOTAL ORGANIC HALIDES (TOX)
E501.1	TRIHALOMETHANES
E502.1	VOLATILE HALOGENATED ORGANIC COMPOUNDS
E502.2	VOC IN WATER,PRGE/TRAP CAPLARY COLMN GC (PHOTOIONIZATN/ELECTROLYTC COND. DETECTORS SERIES)
E503.1	VOLATILE AROMATIC AND UNSATURATED ORGANIC COMPOUNDS
E504	1,2-DIBROMOETHANE AND 1,2-DIBROMO-3-CHLOROPROPANE
E505	ORGANOHALIDE PESTICIDES AND AROCLORS (MICROEXTRACTION)
E507	DETERMINATION OF NITROGEN AND PHOSPHORUS CONTAINING PESTICIDES IN
E508	DETERMINATION OF CHLORINATED PESTICIDES IN GROUND WATER
E510.1	DETERMINATION OF THE MAXIMUM TOTAL TRIHALOMETHANE POTENTIAL
E515	DETERMINATION OF CHLORINATED HERBICIDES IN DRINKING WATER
E524	MEASUREMENT OF PURGEABLE ORGANIC COMPOUNDS IN DRINKING WATER
E524.1	VOLATILE ORGANIC COMPOUNDS IN WATER BY PURGE AND TRAP GC/MS
E524.2	VOLATILE ORGANIC COMPOUNDS IN PURGE AND TRAP CAPILLARY COLUMN GC/MS
E601	PURGEABLE HALOCARBONS
E602	PURGEABLE AROMATICS
E603	ACROLEIN AND ACRYLONITRILE
E604	PHENOLS
E605	BENZIDINES
E606	PHTHALATE ESTERS
E607	NITROSAMINES
E608	ORGANOCHLORINE PESTICIDES AND PCBS
E609	NITROAROMATICS AND ISOPHORONE
E610	POLYNUCLEAR AROMATIC HYDROCARBONS
E611	HALOETHERS
E612	CHLORINATED HYDROCARBONS
E613	2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN
E614	DETERMINATION OF ORGANOPHOSPHORUS PESTICIDES IN WASTEWATER
E615	CHLORINATED HERBICIDES IN INDUSTRIAL AND MUNICIPAL WASTEWATER
E617	DETERMINATION OF CARBOPHENOTHION IN WASTEWATER
E619	DETERMINATION OF TRIAZINE PESTICIDES IN WASTEWATER
E624	VOLATILE ORGANICS GC/MS
E625	EXTRACTABLE PRIORITY POLLUTANTS (BASE/NEUTRAL AND ACID)
E632	DETERMINATION OF CARBAMATE AND UREA PESTICIDES IN WASTEWATER
G51	PH OF SOIL FOR USE IN CORROSION TESTING
N0500	TOTAL DUST
N0600	NUISANCE DUST, RESPIRABLE
N1000	ALLYL CHLORIDE
N1002	CHLOROPRENE
N1003	HALOGENATED HYDROCARBONS
N1004	SYM-DICHLOROETHYL ETHER
N1005	METHYLENE CHLORIDE
N1007	VINYL CHLORIDE
N1008	ETHYLENE DIBROMIDE
N1009	VINYL BROMIDE
N1010	EPICHLOROHYDRIN
N1011	ETHYL BROMIDE
N1012	DIBROMODIFLUOROMETHANE
N1013	1,2-DICHLOROPROPANE
N1014	METHYL IODIDE
N1300	KETONES I
N1301	KETONES II
N1400	ALCOHOLS I
N1401	ALCOHOLS II
N1402	ALCOHOLS III
N1403	ALCOHOLS IV
N1450	ESTERS I
N1500	HYDROCARBONS, BP 36-126 C
N1501	AROMATIC HYDROCARBONS IN AIR
N1550	NAPHTHAS

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
N1551	TURPENTINE
N1600	CARBON DISULFIDE
N1601	1,1-DICHLORO-1-NITROETHANE
N1602	DIOXANE
N1603	ACETIC ACID
N1604	ACRYLONITRILE
N1606	ACETONITRILE
N1607	ETHYLENE OXIDE
N1608	GLYCIDOL
N1609	TETRAHYDROFURAN
N1610	ETHYL ETHER
N1611	METHYLAL
N1612	PROPYLENE OXIDE
N173	METAL BY ATOMIC ABSORTION
N189	ANTIMONY
N2000	METHANOL
N2001	CRESOL, ALL ISOMERS
N2002	AMINES, AROMATIC
N2003	1,1,2,2-TETRABROMOETHANE (ACETYLENETETRA BROMIDE)
N2004	DIMETHYLACETAMIDE AND DIMETHYLFORMAMIDE
N2005	NITROBENZENES
N2007	AMINOETHANOL COMPOUNDS
N209	CHLORINE
N217	BENZENE SOLUBLES
N219	PHOSGENE
N221	ALIPHATIC AMINES
N236	4,4'-METHYLENE-BIS-(2-CHLOROANILINE)
N2500	2-BUTANONE
N2501	ACROLEIN
N2502	FORMALDEHYDE
N2503	MEVINPHOS
N2504	TETRAETHYL PYROPHOSPHATE
N2506	ACETONE CYANOHYDRIN
N2507	NITROGLYCERIN AND ETHYLENE GLYCOL DINITRATE
N2508	ISOPHORONE
N2510	1-OCTANETHIOL
N2513	ETHYLENE CHLOROHYDRIN
N2514	ANISIDINE
N2515	DIAZOMETHANE
N2516	DICHLOROFLUOROMETHANE
N2517	PENTACHLOROETHANE
N2518	HEXACHLORO-1,3-CYCLOPENTADIENE
N2519	ETHYL CHLORIDE
N2520	METHYL BROMIDE
N2521	METHYLCYCLOHEXANONE
N2523	1,3-CYCLOPENTADIENE
N2524	DIMETHYL SULFATE
N269	4-AMINOBIPHENYL
N272	2-NITROPROPANE
N273	4-NITROBIPHENYL
N276	ETHYLENE DIAMINE
N278	VINYL ACETATE
N331	METHYL ETHYL KETONE PEROXIDE
N3500	FORMALDEHYDE
N3501	FORMALDEHYDE
N3502	PHENOL
N3503	HYDRAZINE
N3505	TETRAMETHYL THIOUREA
N3506	ACETIC ANHYDRIDE
N5000	CARBON BLACK
N5001	2,4-D AND 2,4,5-T
N5002	WARFARIN
N5003	PARAQUAT
N5004	HYDROQUINONE

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCRIPTION
N5005	THIRAM
N5006	CARBARYL
N5007	ROTENONE
N5008	PYRETHRUM
N5009	BENZOYL PEROXIDE
N5010	BROMOXYNIL AND BROMOXYNIL OCTANOATE
N5011	ETHYLENE THIOUREA
N5012	EPN, MALATHION, AND PARATHION
N5013	DYES, BENZIDINE-, O-TOLIDINE, O-DIANISIDINE
N5014	CHLORINATED TERPHENYL (60% CHLORINE)
N5016	STRYCHNINE
N5017	DIBUTYL PHOSPHATE
N5018	2,4,7-TRINITROFLUOREN-9-ONE
N5019	AZELAIC ACID
N5020	DIBUTYL PHTHALATE AND DI (2-ETHYLHEXYL) PHTHALATE
N5021	O-TERPHENYL
N5022	ARSENIC, ORGANO
N5023	COAL TAR PITCH VOLATILES
N5500	ETHYLENE GLYCOL
N5502	ALDRIN AND LINDANE
N5503	POLYCHLOROBIPHENYLS (PCB'S)
N5505	ISOCYANATE GROUP
N5506	POLYNUCLEAR AROMATIC HYDROCARBONS (HPLC)
N5508	KEPONE
N5509	BENZIDINE AND 3,3'-DICHLOROBENZIDINE
N5514	DEMETON
N5515	POLYNUCLEAR AROMATIC HYDROCARBONS (GC)
N6000	MERCURY
N6001	ARSINE
N6402	PHOSPHORUS TRICHLORIDE
N6600	NITROUS OXIDE
N6601	OXYGEN
N6700	NITROGEN DIOXIDE
N6701	AMMONIA
N7013	ALUMINUM AND COMPOUNDS, AS AL
N7020	CALCIUM AND COMPOUNDS, AS CA
N7024	CHROMIUM AND COMPOUNDS, AS CR
N7027	COBALT AND COMPOUNDS, AS CO
N7029	COPPER (DUST AND FUME)
N7030	ZINC AND COMPOUNDS, AS ZN
N7048	CADMIUM AND COMPOUNDS, AS CD
N7074	TUNGSTEN (SOLUBLE AND INSOLUBLE)
N7082	LEAD
N7102	BERYLLIUM AND COMPOUNDS, AS BE
N7200	WELDING AND BRAZING FUME
N7300	ELEMENTS (INDUCTIVELY COUPLED PLASMA)
N7400	FIBERS, ASBESTOS IN AIR
N7500	SILICA, CRYSTALLINE, RESPIRABLE
N7501	SILICA, AMORPHOUS
N7502	ZINC OXIDE
N7505	LEAD SULFIDE
N7506	BORON CARBIDE
N7600	CHROMIUM, HEXAVALENT
N7601	SILICA, CRYSTALLINE
N7602	SILICA, CRYSTALLINE (IR)
N7900	ARSENIC AND COMPOUNDS, AS AS
N7901	ARSENIC TRIOXIDE, AS AS
N7902	FLUORIDES (AEROSOL AND GAS)
N7903	ACIDS, INORGANIC
N7904	CYANIDES, AEROSOL AND GAS
S100	HEXACHLORONAPHTHALENE
S102	FLUOROTRICHLOROMETHANE
S108	DICHLOROTETRAFLUOROETHANE
S111	DICHLORODIFLUOROMETHANE

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
S124	1,1,2,2-TETRACHLOROETHANE
S125	TRIFLUOROBROMOMETHANE
S126	1,2,3-TRICHLOROPROPANE
S128	TRICHLORONAPHTHALENE
S129	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE
S130	TETRACHLORONAPHTHALENE
S131	1,1,1,2-TETRACHLORODIFLUOROETHANE
S132	1,1,2,2-TETRACHLORODIFLUOROETHANE
S134	1,1,2-TRICHLOROETHANE
S149	METHYL HYDRAZINE
S150	MORPHOLINE
S153	MONOMETHYLANILINE
S155	TETRAMETHYL SUCCINONITRILE
S158	2-AMINOPYRIDINE
S160	PHENYL HYDRAZINE
S161	PYRIDINE
S179	PHTHALIC ANHYDRIDE
S181	QUINONE
S187	TELLURIUM HEXAFLUORIDE
S188	RHODIUM (FUME AND DUST)
S189	RHODIUM (SOLUBLE)
S208	TRIBUTYL PHOSPHATE
S209	TRIORTHOCRESYL PHOSPHATE
S210	TRIPHENYL PHOSPHATE
S214	DINITROBENZENE
S215	DINITROTOLUENE
S219	NITROETHANE
S224	TETRANITROMETHANE
S225	TETRYL
S227	N-PROPYL NITRATE
S228	PICRIC ACID
S24	DIPHENYL
S244	SULFUR HEXAFLUORIDE
S249	CARBON DIOXIDE
S272	OIL MIST
S274	DDT ISOMERS
S278	CHLORDANE
S293	NICOTINE
S297	PENTACHLOROPHENOL
S308	SULFUR DIOXIDE
S335	TETRACHLOROETHYLENE
S336	TRICHLOROETHYLENE (TCE)
S340	CARBON MONOXIDE
S346	ALLYL GLYCIDYL ETHER
S350	N-BUTYL MERCAPTAN
S36	ETHYL FORMATE
S365	FURFURYL ALCOHOL
S368	ISOPROPYL ETHER
S374	METHYLCYCLOHEXANOL
S38	METHYL ACRYLATE
S383	TETRAETHYL LEAD
S385	TITANIUM DIOXIDE
S39	METHYL CELLUSOLVE ACETATE
S4	HYDROGEN SULFIDE
S42	METHYL ACETATE
S49	ETHYL ACETATE
S50	ISOPROPYL ACETATE
S67	CHLORINATED CAMPHENE (TOXAPHENE)
S69	DIPROPYLENE GLYCOL METHYL ETHER
S72	PHENYL ETHER
S73	PHENYL ETHER-BIPHENYL MIXTURE
S74	PHENYL GLYCIDYL ETHER
S77	ISOPROPYL GLYCIDYL ETHER
S8	OZONE

ATTACHMENT A
ACCEPTABLE ENTRIES FOR METHOD

METHOD	METHOD DESCIPTION
S81	N-BUTYL GLYCIDYL ETHER
S87	PROPANE
S91	BUTADIENE
S93	LIQUID PETROLEUM GAS
S96	PENTACHLORONAPHTHALENE
S97	OCTACHLORONAPHTHALENE
S99	METHYL CHLORIDE
SW1010	FLASH POINT (CLOSED CUP TESTER)
SW1020	SETAFLASH CLOSED-CUP METHOD FOR DETERMINING IGNITABILITY
SW1110	CORROSIVITY TOWARD STEEL
SW3810	HEADSPACE
SW3820	HEXADECANE EXTRACTION AND SCREENING OF PURGEABLE ORGANICS
SW6010	INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROSCOPY
SW7020	ALUMINUM (AA, DIRECT ASPIRATION)
SW7040	ANTIMONY (AA, DIRECT ASPIRATION)
SW7041	ANTIMONY (AA, FURNACE TECHNIQUE)
SW7060	ARSENIC (AA, FURNACE TECHNIQUE)
SW7061	ARSENIC (AA, GASEOUS HYDRIDE)
SW7080	BARIUM (AA, DIRECT ASPIRATION)
SW7090	BERYLLIUM (AA, DIRECT ASPIRATION)
SW7091	BERYLLIUM (AA, FURNACE TECHNIQUE)
SW7130	CADMIUM (AA, DIRECT ASPIRATION)
SW7131	CADMIUM (AA, FURNACE TECHNIQUE)
SW7140	CALCIUM (AA, DIRECT ASPIRATION)
SW7190	CHROMIUM (AA, DIRECT ASPIRATION)
SW7191	CHROMIUM (AA, FURNACE TECHNIQUE)
SW7195	CHROMIUM, HEXAVALENT (COPRECIPITATION)
SW7196	CHROMIUM, HEXAVALENT (COLORIMETRIC)
SW7197	CHROMIUM, HEXAVALENT (CHELATION/EXTRACTION)
SW7198	CHROMIUM, HEXAVALENT (DIFFERENTIAL PULSE POLAROGRAPHY)
SW7200	COBALT (AA, DIRECT ASPIRATION)
SW7201	COBALT (AA, FURNACE TECHNIQUE)
SW7210	COPPER (AA, DIRECT ASPIRATION)
SW7211	COPPER (FURNACE)
SW7380	IRON (AA, DIRECT ASPIRATION)
SW7420	LEAD (AA, DIRECT ASPIRATION)
SW7421	LEAD (AA, FURNACE TECHNIQUE)
SW7450	MAGNESIUM (AA, DIRECT ASPIRATION)
SW7460	MANGANESE (AA, DIRECT ASPIRATION)
SW7470	MERCURY IN LIQUID WASTE (MANUAL COLD-VAPOR TECHNIQUE)
SW7471	MERCURY IN SOLID OR SEMISOLID WASTE (MANUAL COLD-VAPOR TECH)
SW7480	MOLYBDENUM (AA, DIRECT ASPIRATION)
SW7481	MOLYBDENUM (AA, FURNACE TECHNIQUE)
SW7520	NICKEL (AA, DIRECT ASPIRATION)
SW7550	OSMIUM (AA, DIRECT ASPIRATION)
SW7610	POTASSIUM (AA, DIRECT ASPIRATION)
SW7740	SELENIUM (AA, FURNACE TECHNIQUE)
SW7741	SELENIUM (AA, GASEOUS HYDRIDE)
SW7760	SILVER (AA, DIRECT ASPIRATION)
SW7770	SODIUM (AA, DIRECT ASPIRATION)
SW7840	THALLIUM (AA, DIRECT ASPIRATION)
SW7841	THALLIUM (AA, FURNACE TECHNIQUE)
SW7870	TIN (AA, DIRECT ASPIRATION)
SW7910	VANADIUM (AA, DIRECT ASPIRATION)
SW7911	VANADIUM (AA, FURNACE TECHNIQUE)
SW7950	ZINC (AA, DIRECT ASPIRATION)
SW8010	HALOGENATED VOLATILE ORGANICS
SW8015	NONHALOGENATED VOLATILE ORGANICS
SW8020	AROMATIC VOLATILE ORGANICS
SW8030	ACROLEIN, ACRYLONITRILE, ACETONITRILE
SW8040	PHENOLS
SW8060	PHTHALATE ESTERS
SW8080	ORGANOCHLORINE PESTICIDES AND PCBS
SW8090	NITROAROMATICS AND CYCLIC KETONES

ATTACHMENT A
ACCEPTABLE ENTRIES FOR UNIT

UNIT	UNIT DESCIPTION
%	PERCENT
%MASS	PERCENT MASS
%RECOV	PERCENT RECOVERED
%VOL	PERCENT VOL
BBL	BARRELS
CONC	CONCENTRATION
CUYD	CUBIC YARDS
DAY	DAYS
DEG C	DEGREES CENTIGRADE
DEG F	DEGREES FAHRENHEIT
FT	FEET
G	GRAMS
G/CM3	GRAMS PER CUBIC CENTIMETER
G/L	GRAMS PER LITER
G/ML	GRAMS PER MILLILITER
G/SEC	GRAMS PER SECOND
GAL	GALLONS
GAL/M	GALLONS PER MINUTE
GL	GALLONS
GPM	GALLONS PER MINUTE
L/HR	LITERS PER HR
L/M	LITERS PER MINUTE
LB	POUNDS
LB/CF	POUNDS PER CUBIC FT
LB/DAY	POUNDS PER DAY
LB/GAL	POUNDS PER GALLON
LB/HR	POUNDS PER HOUR
LB/YR	POUNDS PER YEAR
LT	LITERS
MG	MILLIGRAMS
MG/KG	MILLIGRAMS PER KILOGRAM
MG/L	MILLIGRAMS PER LITER
MGAL	1000 GALLONS
MGD	MILLION GALLONS PER DAY
ML	MILLILITERS
ML/SEC	MILLILITERS PER SECOND
MMGD	MILLION GALLONS PER DAY
MPCT	MASS PERCENT
NA	NOT APPLICABLE
NA(PH)	N/A STANDARD UNITS FOR PH
PPB	PARTS PER BILLION
PPBV	PARTS PER BILLION BY VOLUME
PPM	PARTS PER MILLION
PPMM	PARTS PER MILLION BY MASS
PPMV	PARTS PER MILLION BY VOLUME
SG H20	SPECIFIC GRAVITY OF WATER
TGAL	1000 GALLONS

ATTACHMENT A
ACCEPTABLE ENTRIES FOR UNIT

UNIT	UNIT DESCIPTION
UG	MICROGRAMS
UG/KG	MICROGRAMS PER KILOGRAM
UG/L	MICROGRAMS PER LITER
UL	MICROLITERS
VCONC	CONCENTRATION BY VOLUME

ATTACHMENT B
ARC/INFO DATA REQUIREMENTS

ENVIRONMENTAL

DoD Underground Storage Tank (UST) Groundwater Monitoring Well Locations

Description	**UST Groundwater Monitoring Well Locations**	
Coverage Type	**Point**	
Creation Date	**May 22, 1997**	
File Name	**ehustloc**	
Attribute Information	**Points attributed by well ID, coordinates, site, purpose, status, source, and coordinate system**	
Time Period of Content	**September 1996 through May 1997**	
Status	Progress:	**Complete - Last Update: June 23, 1997**
Source Information	Scale:	
	Media:	
	Process Description:	**Conventional surveying or survey grade GPS unit used to collect coordinate data. Tabular data used to generate the coverage in ARC/INFO.**
Spatial Reference System	Coordinate System:	**UTM GRS 1980 Spheriod**
	Horizontal Datum:	**NAD 1983**
Point of Contact	**Mr. Rich Bonelli**	**(412) 269-2033**
	Mr. Mike Kuhn	**(412) 269-6149**

USER-DEFINED ATTRIBUTES

1	2	3	4	5	6	7	8
WELL_ID	**XCOORD**	**YCOORD**	**SITE**	**WELL_PURP**	**STATUS**	**SOURCE**	**COORD_SYS**
X(30)	**X(14)**	**X(14)**	**X(10)**	**X(30)**	**X(10)**	**X(10)**	**X(15)**

1.	WELL_ID	Well Identification
2.	XCOORD	UTM Easting Coordinate
3.	YCOORD	UTM Northing Coordinate
4.	SITE	Site Designation
5.	*WELL_PURP	Well Purpose Description
6.	**STATUS	Well Activity
7.	***SOURCE	Coordinate Source
8.	COORD_SYS	Coordinate System

* **MONITORING WELL**
RECOVERY WELL

** **ACTIVE** = Well currently at site
ABANDONED = Well removed or destroyed

*** **SURVEYED** = Surveyed coordinates (GPS or conventional)
MAPPING = Estimated coordinates using hardcopy mapping provided by contractor

ENVIRONMENTAL

DoD Potable Water Supply Well Locations

Description	**Potable Supply Well Locations**	
Coverage Type	**Point**	
Creation Date	**May 22, 1997**	
File Name	**ehsuploc**	
Attribute Information	**Points attributed by well ID, coordinates, region, status, source, and coordinate system**	
Time Period of Content	**September 1996 through May 1997**	
Status	Progress:	**Complete - Last Update: June 23, 1997**
Source Information	Scale:	
	Media:	
	Process Description:	**Survey grade GPS unit used to collect coordinate data. Tabular data used to generate the coverage in ARC/INFO.**
Spatial Reference System	Coordinate System:	UTM GRS 1980 Spheriod
	Horizontal Datum:	NAD 1983
Point of Contact	**Mr. Rich Bonelli**	(412) 269-2033
	Mr. Mike Kuhn	(412) 269-6149

USER-DEFINED ATTRIBUTES

1	2	3	4	5	6	7
WELL_ID	XCOORD	YCOORD	REGION	STATUS	SOURCE	COORD_SYS
X(30)	X(14)	X(14)	X(30)	X(10)	X(10)	X(15)

1.	WELL_ID	Well Identification
2.	XCOORD	UTM Easting Coordinate
3.	YCOORD	UTM Northing Coordinate
4.	REGION	Area Designation
5.	*STATUS	Well Activity
6.	**SOURCE	Coordinate Source
7.	COORD_SYS	Coordinate System

* **ACTIVE** = Well in production
INACTIVE = Well not in use
ABANDONED = Well removed or destroyed

** **SURVEYED** = Survey grade GPS coordinates

ENVIRONMENTAL

DoD Installation Restoration Program (IRP) Groundwater Monitoring Well Locations

Description	**IRP Groundwater Monitoring Well Locations**	
Coverage Type	**Point**	
Creation Date	**May 22, 1997**	
File Name	**ehirloc**	
Attribute Information	**Points attributed by well ID, coordinates, site, purpose, status, source, and coordinate system**	
Time Period of Content	**September 1996 through May 1997**	
Status	Progress:	**Complete - Last Update: June 23, 1997**
Source Information	Scale: Media:	
	Process Description:	**Conventional surveying or survey grade GPS unit used to collect coordinate data. Tabular data used to generate the coverage in ARC/INFO.**
Spatial Reference System	Coordinate System: Horizontal Datum:	**UTM GRS 1980 Spheriod** **NAD 1983**
Point of Contact	**Mr. Rich Bonelli** **Mr. Mike Kuhn**	**(412) 269-2033** **(412) 269-6149**

USER-DEFINED ATTRIBUTES

1	2	3	4	5	6	7	8
WELL_ID	**XCOORD**	**YCOORD**	**SITE**	**WELL_PURP**	**STATUS**	**SOURCE**	**COORD_SYS**
X(30)	X(14)	X(14)	X(10)	X(30)	X(10)	X(10)	X(15)

1.	WELL_ID	Well Identification
2.	XCOORD	UTM Easting Coordinate
3.	YCOORD	UTM Northing Coordinate
4.	SITE	Site Designation
5.	*WELL_PURP	Well Purpose Description
6.	**STATUS	Well Activity
7.	***SOURCE	Coordinate Source
8.	COORD_SYS	Coordinate System

* **MONITORING WELL**
RECOVERY WELL

** **ACTIVE** = Well currently at site
ABANDONED = Well removed or destroyed

*** **SURVEYED** = Surveyed coordinates (GPS or conventional)
MAPPING = Estimated coordinates using hardcopy mapping provided by contractor