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FINAL

SUPPLEMENTAL FIELD INVESTIGATION

WORK PLAN

SITE 89, OPERABLE UNIT 16

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0181

APRIL 2001

Prepared for:

DEPARTMENT OF THE NAVY
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Final

Supplemental Field Investigation

Project Plans

Site 89, Operable Unit 16

Marine Corps Base

Camp Lejeune, North Carolina

Navy CLEAN II Program

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LIST OF ACRONYMS AND ABBREVIATIONS

Baker	Baker Environmental, Inc.
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
DCE	Dichloroethene
DEHNR	(North Carolina) Department of Health and Natural Resources
DoN	Department of the Navy
DNAPL	Dense, Non-Aqueous Phase Liquid
DQO	Data Quality Objective
DRMO	Defense Reutilization Marketing Office
ECBSOPQAM	Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual
FFA	Federal Facilities Agreement
FSAP	Field Sampling and Analysis Plan
HASP	Health and Safety Plan
IAS	Initial Assessment Study
IDW	Investigation Derived Waste
LANTDIV	Atlantic Division Naval Facilities Engineering Command
LTM	Long-Term Monitoring
MCB	Marine Corps Base
MIP	Membrane Interface Probe
NPL	National Priorities List
OU	operable unit
PCA	1,1,2,2-Tetrachloroethane
PCE	Tetrachloroethene
ppb	parts per billion
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SI	Supplemental Investigation
SPLP	Synthetic Precipitation Leaching Procedure

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TAL	Target Analyte List
1,1,2-TCA	1,1,2-Tetrachloroethane
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TCRA	Time-Critical Removal Action
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VC	Vinyl Chloride
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This Supplemental Investigation Work Plan addresses a contaminant source area that has been identified in the southern portion of Site 89 of Operable Unit No. 16, Marine Corp Base (MCB) Camp Lejeune, North Carolina. Site 89 is located near the intersection at "G" and Eighth Streets in the Camp Geiger Area of MCB Camp Lejeune (see Figure 1-1).

Historically, the southern area of Site 89 has been used for heavy vehicle storage and maintenance operations. The Defense Reutilization and Marketing Office (DRMO) operations were located at Site 89 up until the year 2000. Base personnel have reported the extensive use of solvents at the site.

Previous investigations of Site 89 have identified excessively high concentrations of 1,1,2,2-tetrachloroethane (PCA), trichloroethene (TCE), and other volatile organic compounds (VOCs) in soil and groundwater.

A significant source area found within the vadose zone in the southern area of the site in early 2000 warranted an immediate removal action. A Time Critical Removal Action (TCRA) to address removal of highly-contaminated vadose zone soils in the southern portion of Site 89 was implemented by the Remedial Action Contractor (RAC) beginning in the summer of 2000 and is anticipated to be completed in the spring of 2001.

The scope of this Supplemental Investigation is limited to the southern portion of the site where the highest concentrations and most significant mass of chlorinated solvent contamination is found and where the TCRA is being implemented, which is referred to herein as the "source area". The saturated zone within this source area is the focus of the investigation.

This investigation will include installation of monitoring wells, advancement of soil borings, and sample analysis. A detailed investigation plan is presented in Section 3.0 of this Work Plan.

1.1 Objectives of Supplemental Investigation

The objectives of the Supplemental Investigation are threefold:

1. Define the vertical and horizontal extent of the source area (including DNAPL) contamination below the water table in the southern portion of the site;

2. Characterize stratigraphy and hydrogeology in the southern portion of the site; and

3. Provide data needed to support selection, design, and implementation of remedial technologies to address source zone contamination (including DNAPL) within the saturated zone in the southern portion of the site.

1.2 Work Plan Format

The following elements are presented in this Work Plan.

Section 2.0 - Site Background and Current Site Conceptual Model
Section 3.0 – Supplemental Investigation Tasks
Section 4.0 – Project Management and Staffing
Section 5.0 - Project Schedule
Section 6.0 - References

Section 2.0 provides site background and history, as well as a current site conceptual model. This model is a concise description of known hydrogeological and contaminant conditions. Section 3.0 provides a general discussion of the proposed Supplemental Investigation field program and reporting tasks, but more importantly, provides the rationale for the number, type, and location of samples. More detailed descriptions of the field investigation activities are documented in the Field Sampling and Analysis Plan (FSAP). Section 4.0 discusses project staffing for implementing the investigation. The project schedule is provided in Section 5.0. References used in developing the Work Plan are provided in Section 6.0.

SECTION 1.0 FIGURE

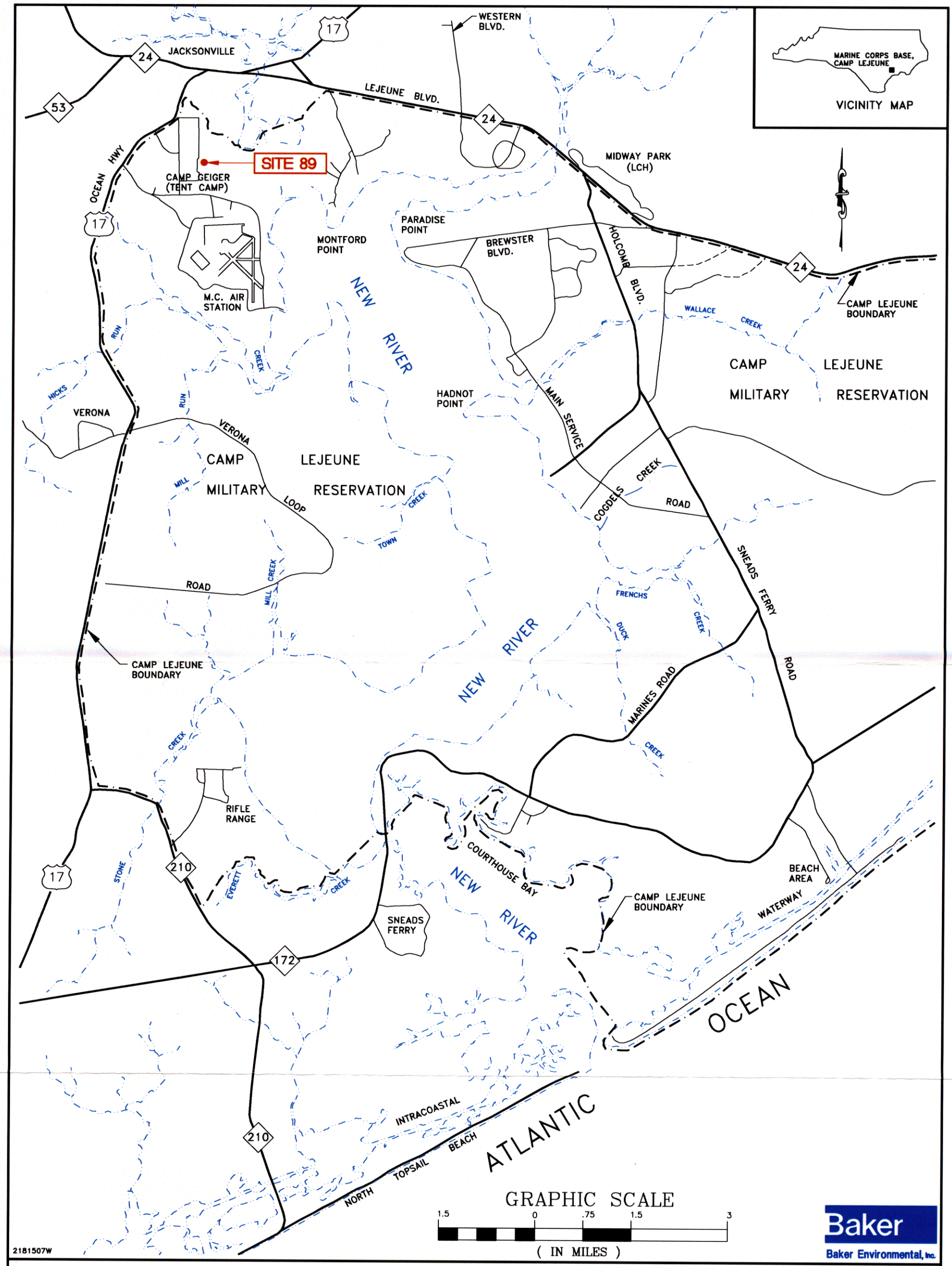


FIGURE 1-1
LOCATION MAP - SITE 89
SITE SUMMARY CTO - 0181

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 SITE BACKGROUND AND CURRENT SITE CONCEPTUAL MODEL

This section presents a brief summary of the site background and history. Detailed descriptions of the site background, history, and conditions are presented in previous documents referenced herein. The conceptual model presented in Section 2.2 is a synthesis of the available information that includes stratigraphy, hydrogeology, and the nature and extent of contamination.

2.1 Site Background

Site 89 is located near the intersection of "G" and Eighth Street in the Camp Geiger area of MCB Camp Lejeune. Between 1987 and the summer of 2000, the DRMO operations were located at Site 89. The DRMO was essentially a used military equipment salvage yard and metals recycling center. Prior to 1987, Site 89 was used for heavy vehicle maintenance and storage. Base personnel also report that the DRMO was used as a storage/staging area for fuel bladders. A former underground storage tank (UST) was located just south of Building TC-867 (Figure 2-1). The detection of chlorinated solvents in the groundwater around the UST initially led to the RI/FS at Site 89. Significantly increasing concentrations of PCA at well MW02 (located adjacent to the former UST) led to additional investigations that focused on the former fuel bladder storage area and heavy vehicle maintenance and storage area. These additional investigations found significant chlorinated solvent contamination in the southern portion of the DRMO, which is the focus of the current TCRA and this Supplemental Investigation. A detailed site description and history can be found in the Final Remedial Investigation Report, Operable Unit No. 16 (Sites 89 and 93) (Baker, 1998) and the Final Action Memorandum for Time-Critical Removal Action Site 89, Operable Unit 16 (Baker, 2000a).

The site is bordered by a former railroad and wooded areas to the east, Edwards Creek to the south and west, and the Camp Geiger motor pool to the north (Figure 2-1).

Previous investigations and actions at Site 89 include:

- An Initial Assessment Study (IAS), conducted by Water and Air Research, Inc., in 1983
- A Well Site Check conducted by R.E. Wright Environmental, Inc. in 1994
- An RI/FS conducted by Baker in 1996 and 1997
- Continuing Long-Term Monitoring (LTM) conducted by Baker since April 1999
- Immediate Response field efforts conducted by Baker in June/July1999
- Soil contamination delineation conducted by Baker in October 1999 and December 1999
- Additional delineation of soil and groundwater contamination conducted by Baker in March 2000
- Pre-TCRA soil delineation conducted by Baker in April 2000
- Time-Critical Removal Action of contaminated vadose zone soils conducted by OHM Remediation Services during 2000 and 2001

The immediate response field investigation efforts focused primarily on defining soil contamination in the vadose zone and associated groundwater contamination. The findings from these and previous investigations indicated that contaminants including PCA, tetrachloroethene (PCE), TCE, and vinyl chloride (VC) exceeded screening criteria in soil, groundwater, surface water, and sediment. The findings also indicated that a significant contaminant source zone was present below the water table in the southern portion of Site 89, and was (in part) in the form of a DNAPL.

2.2 Current Site Conceptual Model

The current site conceptual model was developed based on data collected from previous investigations, including the RI, immediate response investigation activities, and the soil delineation investigations. The model describes current conditions relative to stratigraphy, hydrogeology, and the nature and extent of contamination. This model is dynamic in that it is updated and refined as new data are acquired. The purpose of this model is to provide a basis from which contaminant fate and transport and risks can be assessed, and appropriate remedial action alternatives and data gaps can be identified. Data gaps are discussed in Section 3.4 of this Work Plan.

In general, the site stratigraphy can be categorized into the following units (Baker, 1998):

- The uppermost sediments beneath Site 89 consist of fine sand, trace to some silt, and trace to little clay, with a thickness of approximately 7 feet. Occasional, small clay lenses are apparent within, and at the base of this upper sand. These lenses exhibit a typical thickness of 2 to 4 feet.

- Below the upper sand is another fine sand, with trace to and silt, and trace to some clay. Its thickness is approximately 13 feet.

- A relatively fine-grained layer is present at some locations at Site 89, beginning at a depth of 14-feet below ground surface (bgs) in the former vehicle maintenance and storage source area. This layer is a very fine sand with some silt, trace to some clay, and is approximately 4-feet thick. The water content was observed to be less than the sand layers above and shell layer below, which may be important to the fate and transport of DNAPL. The extent and thickness of this layer has not been fully defined within the former DRMO area.

- Below the lower sand is a marine layer, consisting of interbedded shell and calcareous sand layers, with a trace to and silt, trace to little clay. The thickness of this layer is variable, ranging from 25- to 60-feet. This layer has been identified as the River Bend Formation, and is the upper portion of the Castle Hayne aquifer system.

- Below the marine layer is a locally semi-confining layer. This layer consists of fine sand, little to and silt, trace to some clay. This layer is generally encountered from 40- to 45-feet bgs in the southern portion of Camp Geiger, including Site 89, and is approximately 15-feet thick.

It should be noted that, during the TCRA, the RAC contractor encountered debris in the uppermost sediments within the excavation.

Groundwater is shallow at Site 89, generally within 5 feet of the ground surface, and occurs in the upper and lower sands and the marine layer. Shallow groundwater flow within the surficial aquifer is strongly controlled by Edwards Creek. Within the former DRMO area, groundwater flow is somewhat radial, defined by the curve of the Creek. Shallow/intermediate well pairs on both sides of Edwards Creek show groundwater flow potential in an upward direction, which suggests that groundwater discharges to Edwards Creek. East of the railroad right-of-way, shallow groundwater flow is to the east, toward the New River. Groundwater flow within the upper portion of the Castle Hayne aquifer is controlled more by the New River, as flow is easterly (Baker 2000d).

The horizontal hydraulic conductivity in the upper and lower fine sand units averages 8.4 feet/day across Site 89. The horizontal hydraulic conductivity in the shell and sand unit averages 170.2 feet/day across Site 89. This information is based on slug tests conducted in wells mostly outside the DRMO fence, to the east (Baker, 1998).

Chlorinated solvent and fuel compounds have been detected in soil, groundwater, surface water, and sediment at Site 89 (Baker 2000a and 2000c). Contaminants include PCA, 1,1,2-tetrachloroethane (1,1,2-TCA), 1,1-dichloroethene, 1,2-dichloroethane, PCE, TCE, 1,2-dichloroethene (1,2-DCE), vinyl chloride, chlorobenzene, acetone, methylene chloride, 2-butanone, 4-methyl-2-pentanone, benzene, toluene, ethylbenzene, and xylenes (BTEX). The most significant compound in terms of concentration and extent are PCA and TCE, and to a lesser extent PCE and vinyl chloride. Figure 2-2 summarizes the extent of PCA and TCE contamination in soil and groundwater.

The data collected to date suggest that there are multiple soil contaminant plumes. In the former vehicle maintenance and storage area (southern portion of Site 89), a substantial PCA soil plume appears to be relatively young and has been superimposed on an older TCE/petroleum soil plume. Evidence to support this interpretation include:

- PCA has been found at concentrations much higher than TCE.
- PCA does not degrade to TCE.
- TCE is a common degreaser used in vehicle maintenance.
- Petroleum-related constituents (including BTEX) have also been observed in soils.

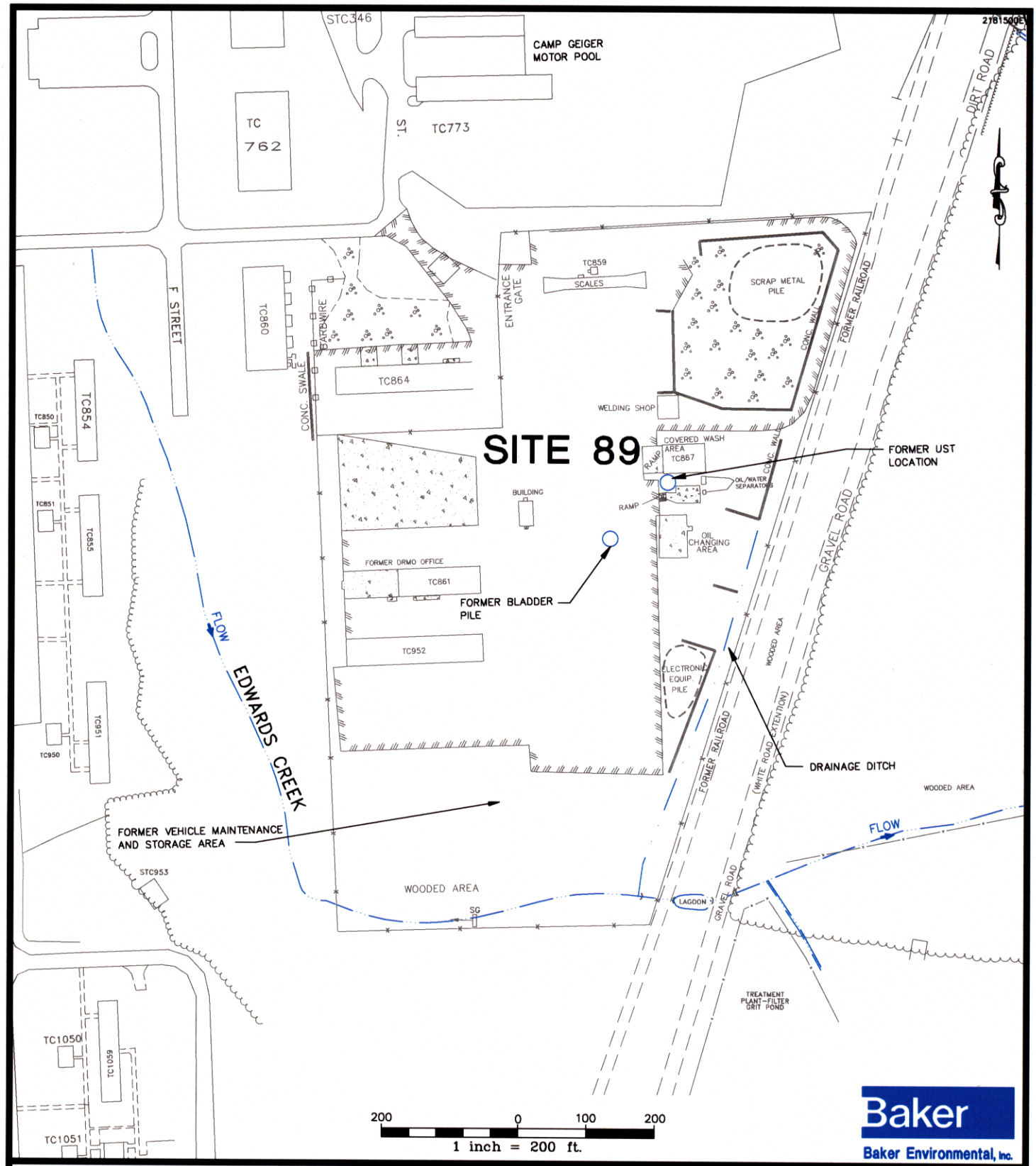
A second source area is located between the former UST area and the scrap metal pile in the northern portion of the site. In the second source area, PCA has been detected in soils, but at relatively low concentrations.

Significant contamination has been found in soil both above and below the water table. Vadose zone soil contamination has been well defined in the former vehicle maintenance and storage area (Baker, 2000c and Figure 2-2). Significant concentrations of chlorinated solvents, most notably PCA and TCE, were detected below the water table at concentrations of 87,000,000 parts per billion (ppb) and 3,000,000 ppb, respectively. Relatively low concentrations of petroleum contamination (as BTEX) were also observed above the water table in the extreme southern portion of the former maintenance area at a maximum concentration of 11,200 ppb (total BTEX). Data from soil samples and groundwater samples from the maintenance area source zone indicate the presence of residual DNAPL above and below the water table (Figure 2-2 and Baker, 2000b). The extent of DNAPL has not been defined. PCA and TCE contamination in vadose soils was also observed in the vicinity of the former UST, but at much lower concentrations compared to the southern area (13 ppb and 1,100 ppb respectively).

Shallow groundwater contamination is also significant (Baker, 2000b/2000c and Figure 2-2). The highest concentrations of PCA (1,800,000 ppb) and TCE (360,000 ppb) appear to be within, and downgradient of, the former vehicle maintenance and storage area source zone. The nature and extent of groundwater contamination within, and downgradient of, the continuing source zone has not been fully characterized. PCA and TCE were also observed in wells in the vicinity of the former UST, but at significantly lower concentrations than in the former maintenance area (26,000 ppb and 6,600 ppb respectively). A large TCE plume is evident east of the site, which appears to have emanated from Site 89.

Surface water and sediment samples from Edwards Creek and a drainage ditch located on the eastern side of the former DRMO also contained PCA and TCE (Baker, 2000c). Surface water contamination is highest at the southern end of the drainage ditch just as it discharges into Edwards Creek (PCA at 2,500 ppb and TCE at 730 ppb). Sediment contamination is also highest in the southern end of the drainage ditch just as it discharges into Edwards Creek (PCA at 2,500 ppb and TCE at 730 ppb).

SECTION 2.0 FIGURES



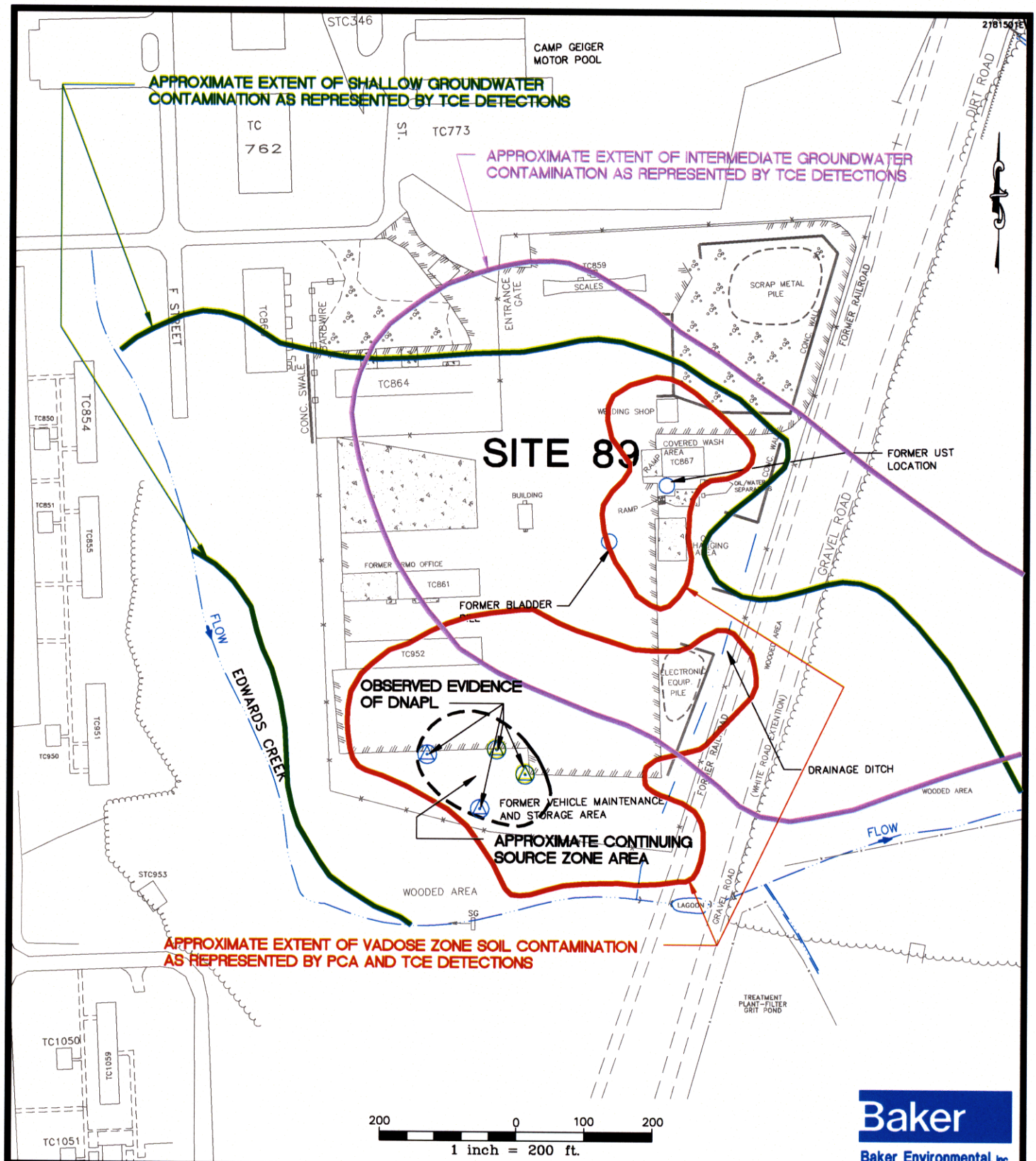
LEGEND

—x—x— FENCE LINE

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

FIGURE 2-1
CURRENT SITE CONDITIONS
SITE 89 – CTO 0181

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- FENCE LINE
- EVIDENCE OF DNAPL BASED ON SOIL CONTAMINANT CONCENTRATIONS ABOVE SOLUBILITY LIMITS OF PCA AND TCE
- EVIDENCE OF DNAPL BASED ON CONTAMINANT CONCENTRATIONS IN GROUNDWATER ABOVE 10% SOLUBILITY LIMITS FOR PCA AND TCE

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

FIGURE 2-2
SUMMARY OF CONTAMINATION
SITE 89 – CTO 0181

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 SUPPLEMENTAL INVESTIGATION TASKS

This section identifies the tasks and field investigations required to complete the proposed field activities for the Supplemental Investigation at Site 89. In addition, data quality and sampling objectives are presented (Section 3.3).

3.1 Project Management

Project Management involves activities such as technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, preparation of monthly progress reports, and communication with LANTDIV and the Activity.

3.2 Subcontract Procurement

This task involves the procurement of services such as drilling, surveying, laboratory analysis, and data validation. Procurement of these services will be performed in accordance with the Navy Clean Contract Procurement Manual.

3.3 Data Quality and Sampling Objectives

The purpose of this section is to define the site-specific data quality and sampling objectives in order to fulfill the overall goals of characterizing the source area in the southern portion of Site 89, so that a remedial action may be implemented. The site-specific objectives presented in this section have been identified based on the USEPA seven-step data quality objectives (DQO) process, as presented in USEPA Guidance for the Data Quality Objectives Process (USEPA, 2000a) and USEPA Data Quality Objectives Process for Hazardous Waste Site Investigations (USEPA, 2000b).

3.3.1 Data Quality Objectives Process

DQOs are qualitative and quantitative statements, developed using the USEPA DQO Process, that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as a basis for establishing the quality and quantity of data needed to support decisions. DQOs define the performance criteria that limit the probabilities of making decision errors by considering the purpose of collecting data; defining the appropriate type of data needed; and specifying tolerable probabilities of making decision errors. The seven-step DQO process is as follows:

- Step 1 – State the Problem
- Step 2 – Identify the Decision
- Step 3 – Identify the Inputs to the Decision
- Step 4 – Define the Boundaries of the Study
- Step 5 – Develop a Decision Rule
- Step 6 – Specify Tolerable Limits on Decision Errors
- Step 7 – Optimize the Design for Obtaining Data

In Step 1 of the DQO Process, the planning team is established, the problem is described, a conceptual model of the environmental hazard to be investigated is developed, and available resources, constraints and deadlines are identified.

Step 2 of the DQO Process should identify the principal study question, define alternative actions, develop a decision statement and state each decision in terms of whether to take action, and organize multiple decisions into an order of priority.

Step 3 of the DQO Process should identify the kinds of information needed, identify the sources of information, determine the basis for setting the action level, and confirm the appropriateness of proposed sampling and analyses methods.

Step 4 of the DQO Process should define the target population (i.e., what is to be sampled), determine the spatial and temporal boundaries, identify practical restraints, and define the scale of decision making.

Step 5 of the DQO Process should define the population parameter, determine what action is needed, and confirm that the action level exceeds minimum detection limits.

Step 6 of the DQO Process should specify tolerable limits on decision errors.

Step 7 of the DQO Process is the review of existing environmental data, evaluation of the operational decision rules, development of general data collection design alternatives, calculation of the number of samples to be taken, and selection of the most resource-effective data collection system.

The seven-step DQO process for Site 89 is documented in the sections that follow.

3.3.1.1 Step 1 - State the Problem

The first activity associated with this step is to establish the planning team. For Site 89, the planning team includes the USEPA, North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR) (Superfund and Groundwater Divisions), LANTDIV, the Activity, CH2M Hill, and Baker Environmental. These team members are decision-makers for the DQO Process.

The problem is that the planning team's objective is to implement remediation of the source area in the southern portion of the DRMO; however, the source area has not been adequately characterized and the limits of the source area are not defined. A current conceptual site model is provided in the Site Summary Report (Baker, 2000d) and is summarized in Section 2.2 of this Work Plan. Data gaps are presented in Section 3.4 of this Work Plan.

The Project Schedule is presented in Section 5.0 of this Work Plan. This schedule presents the anticipated completion and/or submittal dates for specific tasks or documents.

3.3.1.2 Step 2 – Identify the Decision

The principal study question identified is:

- What is the extent of the contaminant source zone below the water table in the southern portion of Site 89?

Before a decision statement can be formulated, a definition of the contaminant source zone must be clarified. Contaminants in an aquifer matrix can dissolve into groundwater under two conditions:

1. Free-phase and/or residual non-aqueous phase liquid (NAPL) (in the case of Site 89; dense NAPL, or DNAPL)

2. Contaminant concentrations in the aquifer matrix at less than NAPL solubilities that are still providing a source of dissolved groundwater contamination.

For this Supplemental Investigation, the contaminant source zone will be defined by the presence of NAPL, and by the presence of contaminants at concentrations greater than 10% of their NAPL (pure-phase) solubility.

Considering the principal study question and definition of the contaminant source zone, the decision statement is as follows:

- Define the contaminant source zone by determining whether or not the concentration of a given VOC at any given sampling point below the water table exceeds NAPL saturation or exceeds 10% of NAPL saturation.

3.3.1.3 Step 3 - Identify the Inputs to the Decision

Existing information regarding the extent of the source zone below is limited. Partial source zone delineation (shown on Figure 3-1) can be performed using the data collected during the March 2000 event. It is evident that additional data are required to completely delineate the DNAPL and the source zone and characterize the aquifer. The kinds of data and sources used to resolve the decision statement include:

Kinds of Information	Sources of Information
Location of DNAPL	Existing and new field/laboratory analytical data, in situ VOC measurements, dye shake tests, and NAPL ribbon samplers
Location of Capillary Barriers	Existing boring logs and new soil borings and in situ electrical conductivity measurements
Nature and Extent of Dissolved-Phase Groundwater Plume	Existing analytical data from existing wells, and new data from new and existing wells
Chemical Solubilities	Published chemical reference books

The criterion for determining the presence of DNAPL will be based on analytical results (using the solubility criteria presented in Section 3.3.1.5) and results of NAPL indicator tests (dye shake test and NAPL ribbon samplers). Data collected to date indicate that PCA concentrations represent approximately 95% of the total VOC concentration. The remainder is primarily TCE. The solubility limit of PCA in water is 2,900 mg/L at 20°C. The solubility limit of TCE in water is 1,100 mg/L at 20°C (Montgomery, 1990). Contaminants at concentrations in excess of either their pure-phase solubility or 10% of that solubility will be used to determine the presence of source area contamination in the groundwater.

As described in Section 3.4, total VOCs will be measured in closely spaced in-situ samples by a Membrane Interface Probe (MIP). This data will be verified by the selection of certain samples for GC/MS analytical methods (by either mobile laboratory of fixed-base laboratory). Both the MIP and GC/MS detection limits will be well below the action levels. Additionally, ribbon NAPL samplers (RNS) and dye shake tests will be deployed at select locations to verify the presence of DNAPL and will provide qualitative information regarding the presence or absence of DNAPL.

3.3.1.4 Step 4 - Define the Boundaries of the Study

The subsurface soil below the water table is what will be sampled (the target population in DQO parlance) Figure 3-1 shows proposed boring locations within the target population. The estimated dimension of the subsurface soil sampling unit is approximately 150,000 sq. ft. (3.4 acres). Based on existing analytical data, the source zone (including DNAPL) is expected to be much smaller, but the actual extent is not currently known. The depth of the subsurface soil sampling is estimated to be a maximum of 20 feet, but the actual depth is not currently known.

Temporal changes in the extent of NAPL are expected to be limited. NAPL mass loss does occur through dissolution of the NAPL into the groundwater; however, typical NAPL dissolution rates are extremely slow. Thus, NAPL mass loss with respect to duration of investigation and remediation will be negligible. Thus data collection is not time dependent and the decision regarding the source zone will be based on existing conditions at the time of investigation.

Practical constraints to sample collection are insignificant. There are no physical barriers or access issues at this site. Weather conditions (such as heavy rain) can delay sampling, but is not a serious constraint.

3.3.1.5 Step 5 - Develop a Decision Rule

The decision rule constructed for this investigation contains two components:

1) If a given concentration at a given sampling point exceeds the solubility limit for that contaminant (action level), then that sampling point will be considered to be DNAPL in the source zone. For the purpose of this investigation, the following solubilities will be used as action levels:

   - 2,900 mg/L for PCA
   - 1,100 mg/L for TCE

2) If a given concentration at a given sampling point exceeds 10% of the solubility limit for that contaminant (action level), then that sampling point will be considered to be in the source zone. For the purpose of this investigation, the following concentrations will be used as action levels:

   - 290 mg/L for PCA
   - 110 mg/L for TCE

3.3.1.6 Step 6 - Specify Tolerable Limits on Decision Errors

Specification of tolerable limits on the decision errors will not be performed at this time. The sampling grid is flexible and will include points inside and outside the suspected source zone, so that the limits of the source zone will be completely established. Specification of tolerable limits on the decision errors may be performed at a later date as determined by the planning team.

3.3.1.7 Step 7 - Optimize the Design for Obtaining Data

There are two fundamental goals for Step 7, and both rely on the review of existing data and information:

- To evaluate the decision rule
- To design and optimize the sampling and analysis program

The decision rule developed in Step 5 has been shown to be valid following review of existing data. In this case, a simple statistical hypothesis test will be used, broadly classified as a one-sample test. The test will involve a comparison of individual analytical data to a known value (solubilities of PCA and/or TCE).

Existing information/data has been reviewed to evaluate and develop the data collection strategy for the field program. Investigations for locating and determining the nature and extent of a source zone differ from a typical Remedial Investigation in several ways:

- Horizontal sample spacings are small (in some locations borings are spaced 25 feet apart)
- Vertical sample spacings are on the order of inches
- In-situ data collection is important in field interpretation and planning
- The work plan needs to be dynamic, allowing flexibility for field decisions (i.e., relocating sampling points)

The development of alternate sampling plans is not practical given the dynamic nature of this investigation. Additionally, the flexibility of the work plan optimizes resources, in that the number and location of sampling points is determined by field conditions.

The proposed sampling and analysis program is detailed in the next section.

3.4 Supplemental Investigation Field Program

An overview of the investigation activities to be conducted at the site is presented in this section. Specific details with respect to the sampling procedures, locations and number of samples, and analytical methods are provided in the FSAP and QAPP. The field program described below will provide data to meet the overall investigation objectives presented in Section 1.1 of this Work Plan.

Soil borings will be advanced in the former vehicle maintenance and storage area via direct-push rig and truck-mounted drill rig (Figure 3-1). The purpose of the borings is to characterize stratigraphy and delineate DNAPL/source zone below the groundwater table. Permanent monitoring wells will be installed within and downgradient of the former vehicle maintenance

and storage area source zone to further define the extent of groundwater contamination. All soil boring locations and permanent monitoring wells will be surveyed.

The site conceptual model identified three primary data gaps:

- An undelineated continuing source zone (including DNAPL) in the former vehicle maintenance and storage area below the water table.
- Insufficient stratigraphy characterization in and around the source zone, particularly potential DNAPL vertical flow barriers.
- Insufficient data regarding dissolved-phase groundwater contamination within the source zone and immediately downgradient of the source area.

The soil and groundwater investigation presented below has been designed to fill these data gaps. This will be accomplished through the use of soil borings and permanent monitoring wells as discussed in the following paragraphs.

Soil Investigation

Approximately 56 direct-push borings will be advanced at locations shown on Figure 3-1. The sampling program will consist of borings spaced at 25 to 100-foot intervals on a grid covering the entire southern portion of the DRMO. Borings will be spaced at 25-foot intervals in the area where soil contaminant concentrations are highest (where free-phase DNAPL is suspected). Borings will be spaced at 50-foot intervals in the area where groundwater contaminant concentrations are highest. Borings will be spaced at staggered 100-foot intervals in other areas.

The purpose of these borings is to address the stratigraphy and source zone delineation data gaps. The borings will be advanced to depths required to vertically delineate the source area. Based on information obtained from some of the previous investigations, the borings are expected to be a maximum of 20 feet deep, but could be deeper depending on the concentration of contamination. One or two borings may be advanced deeper outside the suspected source zone to characterize the stratigraphy below 20 feet. The borings located on the east-west centerline (Line 1) and on two north-south centerlines (Line 2 and 3) will be advanced first (a total of 23 borings). These three lines of borings should indicate a gross extent of DNAPL and source zone contamination. Boring distances may be adjusted, or additional borings added to the initial lines to determine a gross extent. The grid size and boring spacing may then be adjusted accordingly so that the remaining borings can adequately and accurately define the source zone extent.

Two rigs will be mobilized to the site, either Geoprobe or Stratoprobe rigs. The first rig will be equipped with a Membrane Interface Probe (MIP) and a soil electrical conductivity probe. The probe pair, run in tandem, will produce real-time vertical profiles of stratigraphy and total VOC concentration distribution on closely spaced intervals (typically a few centimeters).

The second rig will be equipped with standard soil coring tools and will immediately follow the MIP rig. This second rig will be used to collect soil core samples at about 40 of the 56 MIP boring locations. (These borings will be offset slightly from the MIP borings.) The purpose of this rig is to collect soil samples for confirmation of the MIP results and determination of individual VOC concentrations via on-site GC/MS. It is anticipated that five samples will be collected from each of the 40 borings (for a total of 200 samples).

Ten percent of the samples subject to field GC/MS will be split and be shipped to a fixed-base lab to confirm the findings of the field GS/MS and to assess whether or not DNAPL is present. It is anticipated that 20 samples will be split for fixed-base laboratory analysis. The fixed-base analytical data will be input into a computer program called, "NAPLANAL." NAPLANAL partitions contaminant concentrations into water, soil, and NAPL based on certain aquifer matrix and contaminant characteristics.

All of the subsurface soil samples collected from the borings for analysis will be analyzed for target compound list (TCL) volatile organic compounds (VOCs). To support the remedial technology evaluation, selected samples will be analyzed for total organic carbon (TOC), grain size, synthetic precipitation leaching procedure (SPLP), and laboratory permeability. These samples will be sent to fixed-base laboratories.

Dye-shake tests will also be performed at selected borings where the presence of DNAPL is suspected (as determined by the MIP and previous investigation data). This simple and quick test will be performed by the field geologist supervising the operation of the second rig. In this test, a small amount of Red Sudan dye is placed in a jar with a soil sample and is shaken. If DNAPL is present, the sample turns red. The dye shake test results will confirm the presence of absence of DNAPL in individual samples.

Based on the results of the MIP and dye shake tests ribbon NAPL samplers (RNS) will be deployed. It is anticipated that approximately four ribbon NAPL samplers (RNSs) will be deployed at selected borings where the presence of DNAPL is confirmed or suspected. The RNS is an inflatable cloth tube that is saturated with a dye that becomes red in the presence of NAPLs. The RNS will exhibit a positive response to the presence of NAPL and will provide a continuous vertical profile of DNAPL distribution in the subsurface. The dye shake tests and RNSs also will assist in qualitatively calibrating MIP responses.

There are several advantages to using on-site data collection tools such as the MIP/conductivity probe technology:

- It is recognized by the Technology Innovation Office of the USEPA that many lower-quality data points (e.g., MIP/field GC/MS) is more likely to yield a defensible site decision than fewer high quality data points (e.g., CLP fixed-based analysis) (CLU-IN, 2000). Additionally, many lower-quality data points generate a more complete site characterization.

- Savings in fixed-base analytical laboratory costs offset the increased field costs.

- Delineation can be completed in one mobilization based on real time data collection.

- The number of samples can be optimized based on field data.

- The project duration can be shortened and overall costs reduced.

Groundwater Investigation

Two permanent monitoring well clusters will be installed to address the groundwater data gap. Permanent monitoring wells will be used rather than temporary wells, so that they can be used for slug testing, remedial performance assessment, and possible long-term monitoring. The wells

will be constructed of stainless steel because of the possible presence of DNAPL and its resistance to extreme heat should a thermal remedial technology be implemented in the future.

Each cluster will contain one Type II shallow monitoring well (approximately 15-ft deep) and one intermediate Type II monitoring well (approximately 40-ft deep) for a total of four new wells. One cluster will be placed in the approximate center of the source zone, the other directly downgradient of the source area (Figure 3-1) between existing clusters MW11 and MW09. The shallow monitoring well will be installed in the surficial aquifer and will intersect the water table. The intermediate monitoring well will be installed in the upper portion of the Castle Hayne aquifer, immediately above a semi-confining layer observed at approximately 40-feet bgs.

Groundwater samples will be collected from existing monitoring well clusters MW09, MW11, the two new monitoring well clusters, as well as shallow monitoring wells MW08, MW10, and MW12. This sampling scheme will provide data for groundwater surrounding the former vehicle maintenance and storage area. Samples will be analyzed at a fixed-base laboratory for TCL VOCs using CLP protocols.

If the analytical results indicate the presence of significant contamination in either of the proposed intermediate wells, deeper wells may be required to fully delineate the vertical extent of dissolved-phase contamination. This work will be scoped and preformed during a later phase and will not be detailed in this Work Plan.

Slug tests will be conducted as necessary to estimate horizontal hydraulic conductivity of the aquifer in the source zone area to support remedial action selection. To date, no horizontal hydraulic conductivity estimates have been performed in this area. At a minimum, three slug tests will be performed to estimate the hydraulic conductivity of the shallow aquifer, as hydraulic conductivity is essential in evaluating remedial technologies.

Surface Water/Sediment Investigation

Surface water and sediment samples will be collected to assess current conditions in Edwards Creek and evaluate historical trends in contaminant concentrations. Five surface water samples and five sediment samples will be collected from Edwards Creek, one each from five stations as shown on Figure 3-1.

Investigation Derived Waste (IDW) Handling

Soil cuttings from drilling and groundwater from well development and sampling will be generated. Details regarding IDW handling and disposal are provided in Section 6.10 of the FSAP.

3.5 Sample Analysis and Validation

This task involves efforts relating to the following post-field sampling activities:

- Sample Management
- Laboratory Analysis
- Data Validation

Sample management activities involve: coordination with laboratories; tracking of samples submitted for analysis; tracking of analyses received, and; tracking of information related to samples submitted and received from a third party validator. Sample management also involves resolving technical or administrative problems (e.g., reanalysis, resubmission of information) as necessary.

Laboratory analysis begins when the samples are shipped from the field and received by the laboratory. Validation begins when the validator receives the "raw" laboratory data. Baker will also receive the data from the laboratory, and enter it into a database for tracking purposes. A validation report will be expected within three weeks following receipt of laboratory data packages by the validator. CLP data will be validated per the CLP criteria as outlined in the following documents:

- USEPA, National Functional Guidelines for Organic Data Review (EPA 540/R-99-008) (B99-963506)

- USEPA, Hazardous Site Evaluation Division, Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, 1994.

All other data will be validated in accordance with the method of analysis using the National Functional Guidelines as a reference.

3.6 Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. It also involves the evaluation of any field-generated data, including water level measurements, test boring logs, and other field notes. Efforts under this task will include the tabulation of validated data and field data, generation of test boring logs and monitoring well construction logs, generation of geologic cross-section diagrams, and the generation of other diagrams associated with field notes or data received from the laboratory (e.g., sampling location maps).

3.7 Supplemental Investigation Report

A report will be prepared that will:

- Discuss investigation procedures that deviated from the FSAP
- Provide complete analytical results package
- Discuss major findings

Reporting of the Supplemental Investigation results will be including as part of the Technology Evaluation Report, which will present an evaluation of technologies that may be used to remediate the contaminant source zone.

SECTION 3.0 FIGURE

2181504E

SITE 89

TC855
TC951
TC950
STC953
FLOW
EDWARDS CREEK
FORMER DRMO OFFICE
TC861
TC952
BUILDING
RAMP
AREA
TC867
OIL/WATER SEPARATORS
CONC.
OIL CHANGING AREA
GRAVEL ROAD
WOODED AREA
ELECTRONIC EQUIP. PILE
±20' DITCH
FORMER RAILROAD
(WHITE ROAD EXTENTION)
LAGOON
SG
FORMER VEHICLE STORAGE AND MAINTENANCE AREA
LINE 1
LINE 2
LINE 3
89-MW12
89-MW10
89-MW08
SB66
TW101
DNAPL
TW102
DNAPL
SB67
SB69 DNAPL
MW17
MW17IW
89-MW11IW
89-MW11
TW103 DNAPL
MW16
MW16IW
89-SW07
89-MW09IW
89-MW09
89-SW03
89-SW02
89-SW04
89-SW09

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

100 0 50 100
1 inch = 100 ft.

Baker
Baker Environmental, Inc.

LEGEND

- PROPOSED MONITORING WELL LOCATION
- PROPOSED BORING LOCATION
- PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION
- DNAPL – EVIDENCE OF DNAPL BASED ON SOIL CONTAMINANT CONCENTRATIONS ABOVE SOLUBILITY LIMITS OF PCA AND TCE
- DNAPL – EVIDENCE OF DNAPL BASED ON CONTAMINANT CONCENTRATIONS IN GROUNDWATER ABOVE 10% SOLUBILITY LIMITS FOR PCA AND TCE
- GROUNDWATER MONITORING WELL (OCT. 1999)
- SOIL BORING LOCATION (MARCH 2000)
- TEMPORARY WELL LOCATION (MARCH 2000)
- FENCE LINE
- ESTIMATED EXTENT OF THE SUSPECTED SOURCE ZONE
- PROJECTED EXTENT OF THE SUSPECTED SOURCE ZONE

FIGURE 3-1
PROPOSED BORING AND MONITORING WELL LOCATIONS
SITE 89 – CTO 0181
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

4.0 PROJECT MANAGEMENT AND STAFFING

Mr. Michael Slade, CH2M Hill Project Manager, will provide overall coordination, project administration, and senior QA/QC functions. In addition, Mr. Slade will keep abreast of all project activities and will maintain close communication with the Navy Technical Representative and the Base.

Ms. Tracey L. O'Keefe, P.E. will manage the Baker Project Team. Her primary responsibilities will include guiding, monitoring and coordination of the technical aspects of the project. Ms. O'Keefe also will be responsible for Baker project administration and the overall quality assurance and quality control (QA/QC) of project deliverables.

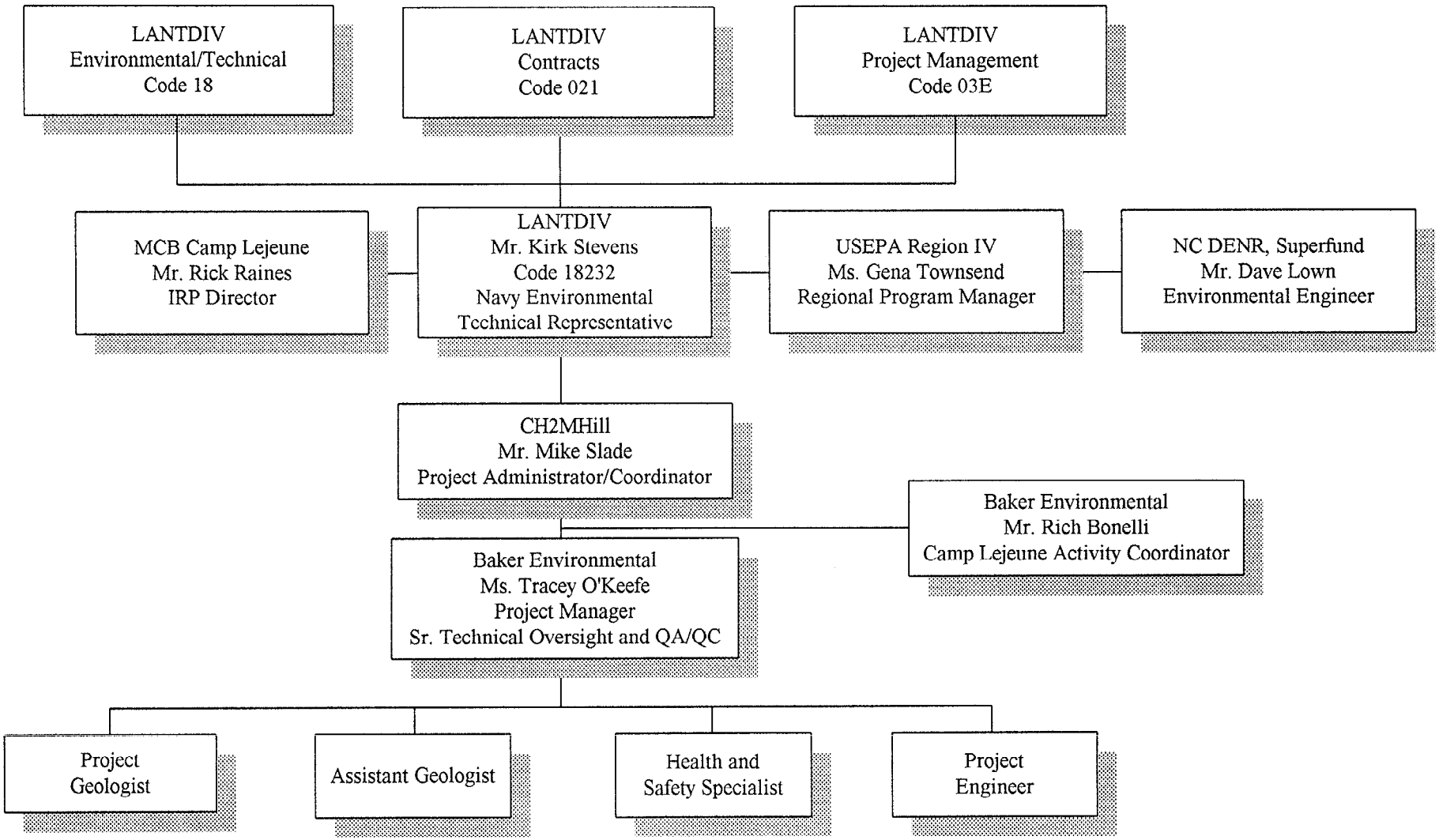
Mr. Richard Bonelli, P.G., the Baker Activity coordinator, will serve as essential member of the management team, maintaining communication with CH2M Hill, LANTDIV, and the Base.

The Baker Project Team will include a Project Geologist, an Assistant Geologist, and technical support staff as shown in Figure 4-1.

SECTION 4.0 FIGURE

FIGURE 4-1

PROJECT ORGANIZATION
SITE 89 SUPPLEMENTAL INVESTIGATION - CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA



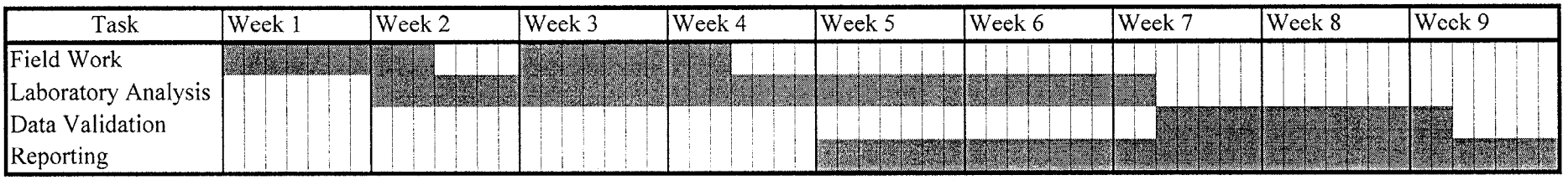
5.0 SCHEDULE

The proposed schedule as defined by Project Milestones is presented in Figure 5-1. The field investigation will commence following completion of the on-going TCRA.

SECTION 5.0 FIGURE

FIGURE 5-1

PROPOSED PROJECT SCHEDULE
SITE 89 SUMMPLEMENTAL INVESTIGATION - CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA



Notes: 1) Initiation of the field work will be contingent upon completion date of the TCRA.
2) Reporting for the Supplemental Investigation will be submitted in conjunction with the technology evaluation report, which may be on a different timeline.

6.0 REFERENCES

Baker, 1998	Final Remedial Investigation Report, Operable Unit No. 16 (Sites 89 and 93). June 1998.
Baker, 2000a	Final Action Memorandum for Time-Critical Removal Action Site 89, Operable Unit 16. June 15, 2000.
Baker, 2000b	Letter report to LANTDIV. May 3, 2000.
Baker, 2000c	Letter report to LANTDIV. February 1, 2000.
Baker, 2000d	Summary Report for Site 89, October 26, 2000.
CLU-IN, 2000	Dynamic Data Collection Strategy Using systematic Planning and Innovative Field-Based Measurement Technologies. Internet seminar sponsored by USEPA, Technology Innovation Office, November 2000. http://www.clu-in.org/conf/tio/sysplan
FFA, 1989	Camp Lejeune Federal Facility Agreement (FFA). December 6, 1989.
Montgomery, 1990	Montgomery, J.H., Welkom, LM. Groundwater Chemicals Desk Reference. 1990.
USEPA, 1987	Draft Engineering Evaluation/Cost Analysis Guidance for Non-Time-Critical Removal Actions. USEPA, June 2, 1987
USEPA, 1993	Guidance on Conducting for Non-Time-Critical Removal Actions Under CERCLA (EPA/540-R-93-057). USEPA, August 1993.
USEPA, 2000a	USEPA Guidance for the Data Quality Objectives Process, USEPA, August, 2000.
USEPA, 2000b	USEPA Data Quality Objectives for Hazardous Waste Site Investigations, USEPA, January 2000.

FINAL

SUPPLEMENTAL FIELD INVESTIGATION

FIELD SAMPLING AND ANALYSIS PLAN

SITE 89, OPERABLE UNIT 16

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0181

APRIL 2001

Prepared for:

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

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ACRONYMS AND ABBREVIATIONS

AQTESOLV	Aquifer Test Solver
ASTM	American Society for Testing and Materials
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
CFR	Code of Federal Register
CLP	Contract Laboratory Program
COC	Chain of Custody
CPVC	Chlorinated Polyvinyl Chloride
CTO	Contract Task Order
DEHNR	Department of Environment, Health, and Natural Resources
DNAPL	Dense, Non-Aqueous Phase Liquid
DQO	Data Quality Objective
DRMO	Defense Reutilization Management Office
DRO	Diesel Range Organics
ECBSOPQAM	Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual
Eh	Oxidation-Reduction Potential
EMD	Environmental Management Division
ESD	Environmental Services Division
FSAP	Field Sampling and Analysis Plan
GC/MS	Gas Chromatograph/Mass Spectoroscopy
GRO	Gasoline Range Organics
HASP	Health and Safety Plan
HSA	Hollow-Stem Augers
ID	Inside Diameter
IDW	Investigation Derived Waste
L/min	Liter per Minute
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MIP	Membrane Interface Probe
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NFESC	Naval Facilities Engineering Service Center
NTU	Nephelometric Turbidity Unit
O_2/LEL	Oxygen/Combustible Gas Meter
OD	Outside Diameter
OU	Operable Unit

ACRONYMS AND ABBREVIATIONS
(Continued)

PCB	Polychlorinated Biphenyl
PID	Photo Ionization Detector
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RQD	Rock Quality Designation
SI	Supplemental Investigation
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
TDS/TSS	Total Dissolved Solids/Total Suspended Solids
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WQP	Water Quality Parameter

1.0 INTRODUCTION

This Field Sampling and Analysis Plan (FSAP) presents the proposed Supplemental Investigation field activities that are to be conducted at Operable Unit (OU) No. 16, Site 89 – the former Defense Reutilization Marketing Office [DRMO] at Marine Corps Base (MCB), Camp Lejeune, North Carolina. The field activities will include the advancement of direct-push and auger borings and the installation of additional permanent shallow and intermediate monitoring wells. The FSAP is part of the Project Plans, which also include the Work Plan, Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HASP).

The primary purpose of the FSAP is to provide guidance for all project field activities by describing in detail the sampling and data collection methods to be used in implementing the various field tasks identified in the Supplemental Investigation Work Plan for Site 89. This document also helps to ensure that project activities are carried out in accordance with the United States Environmental Protection Agency (USEPA) Region IV and Naval Facilities Engineering Service Center (NFESC) standard operating procedures (SOPs), so that data obtained during the field investigation are of sufficient quantity and quality to evaluate the nature and extent of source zone contamination and to evaluate potential technologies for remediation at the source area.

2.0 SITE BACKGROUND

A description of the history and setting of Site 89 is contained in Section 2.0 of the Supplemental Investigation Work Plan.

3.0 SAMPLING OBJECTIVES

The sampling and data quality objectives are to provide data to delineate the extent of the contaminant source zone and to support the design and implementation of a remedial action. Detailed sampling and data quality objectives are presented in Section 3.0 of the Work Plan.

4.0 SAMPLING LOCATIONS AND FREQUENCY

This section of the FSAP describes the location and frequency of environmental samples to be collected during the sampling program. Support activities, sampling locations, sample matrix, constituents to be analyzed for and Quality Assurance/Quality Control (QA/QC) requirements are discussed within this section. Detailed investigation procedures, sampling, handling, and analytical requirements are provided in Sections 6.0 and 7.0, respectively.

The following investigation and support activities will be conducted at Site 89:

- Surveying
- Groundwater Investigation
- Soil Investigation
- Quality Assurance/Quality Control Samples
- Investigation Derived Waste Handling

Each activity is described in the subsections that follow.

4.1 Surveying

This task will involve the surveying of the borings and permanent monitoring wells. The location of each boring and the corresponding elevation will be surveyed. The location and elevation of a reference point on top of the well riser and the elevation of the ground surface will be surveyed for each newly installed monitoring well. Survey points will include latitude and longitude coordinates, and an elevation expressed in feet above mean sea level. The vertical accuracy of the survey will be within 0.01 feet and the horizontal accuracy will be within 0.1 feet. All survey points will be correlated to the North Carolina State Plane Coordinate System.

4.2 Soil Investigation

A soil investigation will be conducted in the vicinity of the contaminant source zone in the former vehicle maintenance and storage area (in the southern portion of the former DRMO). A utility clearance will be conducted prior to monitoring well boring installation. The subsections that follow provide a description of the proposed investigation.

4.2.1 Sampling Locations

Approximately fifty-six direct push borings will be advanced in locations shown on Figure 4-1. In situ VOC concentration and soil electrical conductivity measurements will be made throughout the depth of each boring. Each boring is expected to be approximately 20 feet deep with one or two borings advanced deeper for stratigraphy characterization. A Geoprobe or Stratoprobe rig will be fitted with a Membrane Interface Probe (MIP) and a soil conductivity probe. The probe pair, run in tandem, will produce a real-time vertical profile of stratigraphy and contaminant distribution on closely spaced intervals (typically a few centimeters).

A second rig will be equipped with standard soil sampling tools and will follow the MIP rig. The purpose of this rig is to collect soil samples for confirmation of the MIP results and determination of individual VOC concentrations via on-site GC/MS analysis. Continuous soil core samples will be collected at about 40 of the 56 MIP borings. (These borings will be slightly offset from the MIP borings.) It is anticipated that five samples will be collected from each of the 40 borings (for a total of 200 samples). Samples will be submitted for on-site analysis on the basis of the MIP

results. Samples will be collected from no/low total VOC concentrations, moderate total VOC concentrations, and high total VOC concentrations. It should also be noted that soil samples will not be collected from TCRA-treated soil and backfilled areas or from depths of less than 5-feet of the ground surface, where previous characterization has been performed.

Ten percent of the samples subject to field GC/MS will be split and shipped to a fixed-base lab to confirm the findings of the field GS/MS. Samples for laboratory analysis will be collected below the water table by SW-846 Method 5035 (using Encore™ Samplers).

4.2.2 Analytical Requirements

Four types of data will be generated during this investigation:

- Qualitative field data
- Semi-quantitative field data
- Quantitative field and mobile laboratory data
- Quantitative fixed-base laboratory data

It is recognized that this investigation will be driven by, and interpretations made from, data from field-based analytical methods. Some of the investigation technologies proposed are considered innovative, but have proven results and demonstrated reliability. SOPs regarding the use of equipment such as the MIP, the electronic capture detector (ECD), the gas chromatograph/mass spectroscopy (GC/MS), and RNS will not be included in this document due to the large amount of information the SOPs would contain. However, contractors specialized in the use of these methods will be used and their SOPs will be available upon request. A brief discussion of the analytical requirements follows:

The qualitative field data will include the Ribbon NAPL Sampler (RNS) and dye shake test. Four RNSs will be deployed at selected borings where DNAPL is suspected. The project geologist also will perform the dye shake test on selected samples where DNAPL is suspected. Both these tests will indicate whether or not DNAPL is present.

Semi-quantitative field data will include PID and O_2/LEL measurements. PID and O_2/LEL measurements will be taken periodically to monitor the working environment. The PID will also be used to screen all soil samples collected.

Quantitative field and mobile laboratory data will include the following:

- Total VOC concentration profiles in 56 borings

- Individual VOC concentrations from five select samples in 40 borings

- Soil conductivity measurement profiles in 56 borings

Total VOCs will be measured during MIP pushes using an electron capture detector (ECD). Selected samples from confirmatory borings will be analyzed for individual VOCs via field GC/MS. The number of samples selected will be based on observed conditions, but is expected that no more than 5 samples will be selected from each boring.

Quantitative fixed-base laboratory data will include various soil analyses. All samples will be analyzed on a routine, 21-day turnaround time. Fixed-base laboratory analytical requirements will be as follows:

- 15 subsurface soil samples analyzed for Target Compound List (TCL) volatile organic compounds (VOCs).
- 10 subsurface soil samples will be collected for synthetic precipitation leaching procedure (SPLP)
- 3 subsurface soil samples will be collected for laboratory analysis of permeability
- 3 subsurface soil samples will be collected for grain size distribution analysis and soil classification
- 5 subsurface soil samples will be analyzed for total organic carbon (TOC)

The requirements are also summarized on Table 4-1. Section 7.0 of the FSAP and Section 8.0 of the QAPP discuss the analytical methods to be used.

4.3 Groundwater Investigation

A groundwater investigation will be conducted in the vicinity of the former vehicle maintenance and storage area source zone. The purpose of the groundwater investigation is to further delineate the extent of contamination within, and downgradient of the source zone. This task will be accomplished through the installation and sampling of additional monitoring wells. The subsections that follow provide a description of the proposed groundwater investigation.

4.3.1 Well Construction and Locations

Two permanent well clusters will be installed (Figure 4-1) in the surficial and upper Castle Hayne aquifers to verify the extent of groundwater contamination. Each of the clusters will include one shallow and one intermediate monitoring well (both Type II wells).

The shallow permanent monitoring wells will be installed to a depth of approximately 15 feet. These wells will be constructed of 2-inch inside diameter (ID) stainless steel pipe, with 10 feet of 0.01-inch slot well screen. The permanent intermediate monitoring wells will be installed to a depth of approximately 40 feet. These wells will be constructed of 2-inch inside diameter (ID) stainless steel pipe, with 5 feet of 0.01-inch slot well screen. Section 6.2 presents specific details on procedures for permanent monitoring well installation.

4.3.2 Sampling and Analytical Requirements

One groundwater sample will be collected from each of the new monitoring wells (89-MW16, 89-MW16IW, 89-MW17, 89-MW17IW), as well as from existing wells 89-MW08, 89-MW09, 89-MW09IW, 89-MW10, 89-MW11, 89-MW11IW, and MW12 (Table 4-1). Upon completion of the permanent monitoring well installation, one round of groundwater sampling will be conducted. Samples will be collected using low flow purging and sampling methodology. Section 6.4 presents specific details on procedures for groundwater sampling. Groundwater measurements will be taken to confirm groundwater flow direction and tidal influence.

All groundwater samples from the monitoring wells will be analyzed by a fixed-base laboratory for TCL VOCs. Two samples (from wells 89-MW16 and 89-MW17) will be analyzed for diesel range (DRO) and gasoline range (GRO) total petroleum hydrocarbons (TPH). Routine, 21-day analytical turnaround time will be requested for all groundwater samples. Groundwater field measurements, including pH, conductivity, dissolved oxygen, reduction/oxidation potential, turbidity, and temperature (Level I quality), also will be collected. Depth-to-groundwater measurements will be taken from the wells and Edwards Creek to confirm groundwater flow direction and tidal influence.

4.3.3 Aquifer Properties Testing

In situ slug tests will be performed on select monitoring wells. Slug tests will be performed after groundwater sampling has been conducted. The procedure for slug test performance is found in Section 6.7.

4.4 Surface Water/Sediment Investigation

Surface water samples will be collected to assess current conditions in Edwards Creek and evaluate historical trends in contaminant concentrations. The subsections that follow provide a description of the proposed investigation.

4.4.1 Sampling Locations

One surface water sample and one sediment sample will be collected from Edwards Creek at five station locations as shown on Figure 4-1. These station locations are consistent with previous sampling locations, and will keep the same sample location identification. Sections 6.5 and 6.6 present specific details on procedures for surface water and sediment sampling, respectively.

4.4.2 Analytical Requirements

Five surface water and five sediment samples (Table 4-1) will be analyzed by a fixed-base laboratory for TCL VOCs. Samples will be analyzed on a routine, 21-day turnaround time.

4.5 Quality Assurance/Quality Control Samples

QA/QC requirements for this investigation are presented in the QAPP. The following QA/QC samples will be collected during field sampling activities:

Trip Blanks

Trip blanks are defined as samples which originate from the 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 volatile organic analysis (VOA) samples. The blanks will only be analyzed for TCL 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 VOA.

Equipment Rinsates

Equipment rinsates are defined as samples that are obtained by running organic-free water over/through decontaminated sample collection equipment. One equipment rinsate sample will be collected for each media. Virgin equipment will be used for collection of soil samples (Encore™ Samplers) and groundwater samples (polyethylene tubing). One rinsate sample for each sampling device is sufficiently representative of the entire lot. The results from the rinsates will be used to evaluate the decontamination methods. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples.

Field Blanks

Field blanks consist of the source water used in decontamination. Field blanks will be collected by pouring organic-free water from the container directly into sample bottles. Field blanks will not be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled. One field blank will be prepared at the commencement of the project.

Field Duplicates

Field duplicates for soil samples will be collected by selecting segments of soil from the length of the core and placed in the Encore™ Samplers. Groundwater duplicate samples will be collected simultaneously. The water samples will not be composited. Field duplicates will be collected at a frequency of 10 percent.

Matrix Spike/Matrix Spike Duplicates

Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples will be collected to evaluate the matrix effect of the sample upon the analytical methodology. A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix. MS/MSD samples will be collected at a frequency of 5 percent.

4.6 Investigation Derived Waste (IDW) Handling

Soil cuttings will be collected and contained in a roll-off box. One rigid storage tank with a capacity of 1,000 gallons will be stationed on site for containing groundwater development and purge water. A composite soil sample from the roll-off box will be collected and analyzed for full Toxicity Characteristic Leaching Procedure (TCLP) organic and inorganic compounds and Resource Conservation and Recovery Act (RCRA) hazardous waste characterization (corrosivity, reactivity, and ignitability). One sample will be collected from the tank and analyzed for full TCL organics, Target Analyte List (TAL) metals, as well as total dissolved solids (TDS) and total suspended solids (TSS). Although significant concentrations of inorganic compounds are not expected, analysis for inorganic compounds is typically requested by waste disposal facilities, including on-base groundwater treatment plants. Additional details regarding IDW handling and disposal are provided in Section 6.10.

Based on previous investigation information, it is expected that IDW will not exhibit hazardous characteristics associated with metals, corrosivity, reactivity, or ignitability.

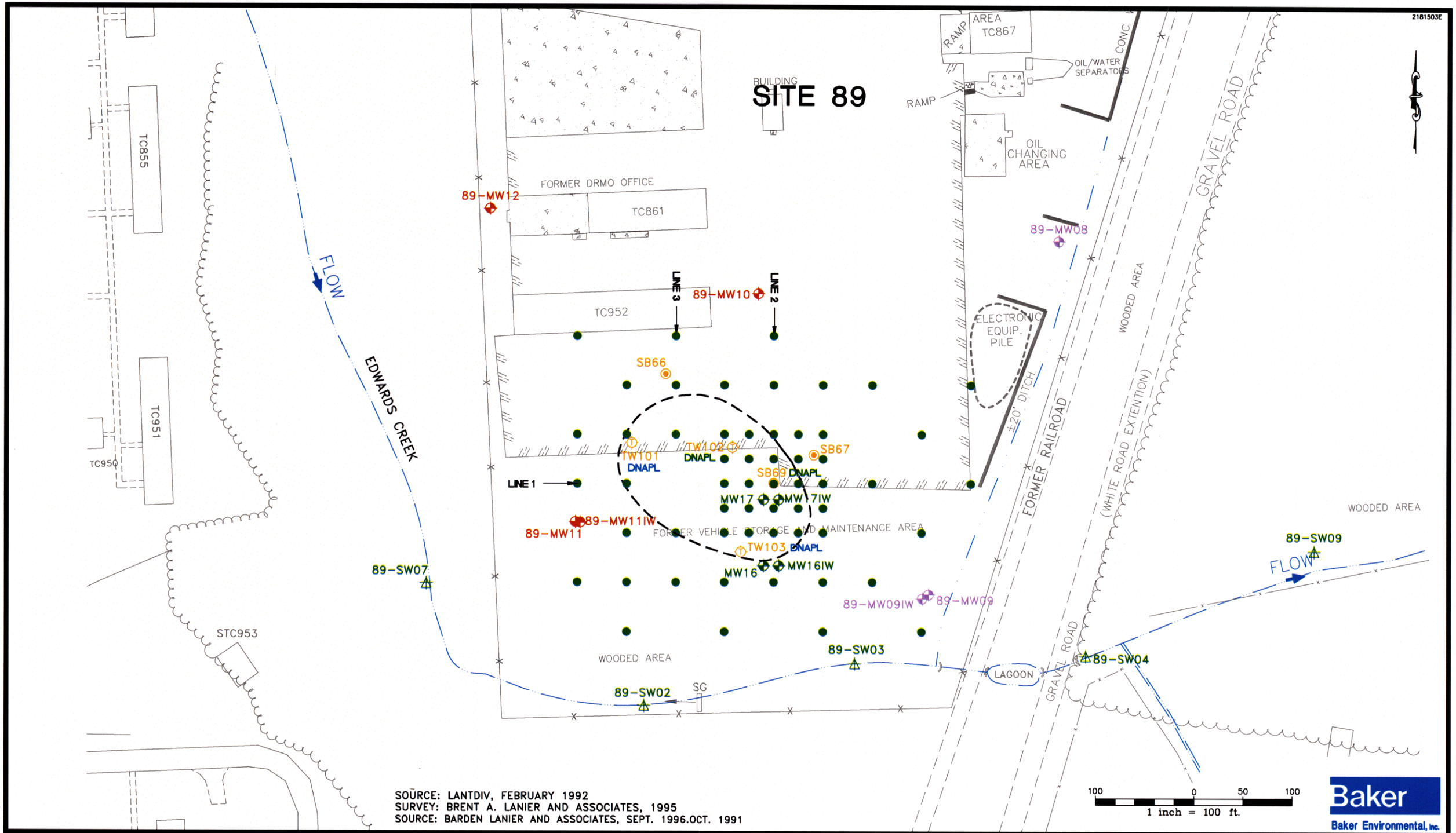
SECTION 4.0 TABLE

TABLE 4-1

SAMPLING PROGRAM SUMMARY
SITE 89 EE/CA INVESTIGATION - CTO-0181
MCB, CAMP LEJEUNE, NORTH CAROLINA

			Water Quality Parameters						Fixed-Base Laboratory Analysis																		
Site	Media	Sample ID	pH	Temperature	Specific Conductivity	Turbidity	Dissolved Oxygen	Oxidation Reduction Potential	CLP SOW VOA (Aqueous)	CLP SOW VOA (Solid)	CLP SOW Metals (Aqueous)	CLP SOW SVOAs (Aqueous)	TPH-GRO	TPH-DRO	TOC	SPLP	Grain Size	Permeability	TSS/TDS	TCLP-VOA	TCLP-SVOA	TCLP-Metals	Ignitability	Reactivity	Corrosivity	Paint Filter Test	Comments
DRMO (Site 89)	Soils	IR89-IS- -								1					1	1	1	1									
		IR89-IS- -								1						1											
		IR89-IS- -								1																	
		IR89-IS- -								1					1	1											
		IR89-IS- -								1						1											
		IR89-IS- -								1																	
		IR89-IS- -								1					1	1	1	1									
		IR89-IS- -								1						1											
		IR89-IS- -								1																	
		IR89-IS- -								1					1	1											
		IR89-IS- -								1						1											
		IR89-IS- -								1																	
		IR89-IS- -								1					1	1	1	1									
		IR89-IS- -								1						1											
		IR89-IS- -								1																	
		IR89-IS- -								1																	
		IR89-IS- -								1																	
		IR89-IS- -								1																	
		IR89-IS- -								1																	
		IR89-IS- -								1																	
	Groundwater	IR89-GW08-01B	1	1	1	1	1	1	1																		
		IR89-GW09-01B	1	1	1	1	1	1	1																		
		IR89-GW09IW-01B	1	1	1	1	1	1	1																		
		IR89-GW10-01B	1	1	1	1	1	1	1																		
		IR89-GW11-01B	1	1	1	1	1	1	1																		
		IR89-GW11IW-01B	1	1	1	1	1	1	1																		
		IR89-GW12-01B	1	1	1	1	1	1	1																		
		IR89-GW16-01B	1	1	1	1	1	1	1				1	1													
		IR89-GW16IW-01B	1	1	1	1	1	1	1																		
		IR89-GW17-01B	1	1	1	1	1	1	1				1	1													
		IR89-GW17IW-01B	1	1	1	1	1	1	1																		
	Suface Water	IR89-SW02							1																		
		IR89-SW03							1																		
		IR89-SW04							1																		
		IR89-SW07							1																		
		IR89-SW09							1																		
	Sediment	IR89-SD02								1																	
		IR89-SD03								1																	
		IR89-SD04								1																	
		IR89-SD07								1																	
		IR89-SD09								1																	
	IDW Samples	IR89-IDW01-01B																		1	1	1	1	1	1	1	Roll-off Box
		IR89-IDW02-01B							1		1	1							1				1	1	1		Storage Tank
	Duplicates	IR89-IS - D								1																	Soil
		IR89-IS - D								1																	Soil
		IR89-GW16-01BD							1				1	1													Groundwater
		IR89-SW03D							1																		Surface Water
		IR89-SD03D								1																	Sediment
	MS/MSDs	IR89-IS - MS/MSD								1																	Soil
		IR89-GW16-01B MS/MSD							1				1	1													Groundwater
		IR89-SW03 MS/MSD							1																		Surface Water
		IR89-SD03 MS/MSD								1																	Sediment
	Blanks/Rinsates	IR89-ERSB01-01B							1																		Equipment Risnate
		IR89-ERGW01-01B							1																		Equipment Risnate
		IR89-FB01-01B							1																		Field Blank
		IR89-TB01-01B							1																		Trip Blank
		IR89-TB02-01B							1																		Trip Blank
		IR89-TB03-01B							1																		Trip Blank
		IR89-TB04-01B							1																		Trip Blank
		IR89-TB05-01B							1																		Trip Blank
		IR89-TB06-01B							1																		Trip Blank
		IR89-TB07-01B							1																		Trip Blank
		IR89-TB08-01B							1																		Trip Blank
		IR89-TB09-01B							1																		Trip Blank
		IR89-TB10-01B							1																		Trip Blank
		Environmental Samples	11	11	11	11	11	11	16	25	0	0	2	2	5	10	3	3	0	0	0	0	0	0	0	0	
		Duplicates	--	--	--	--	--	--	2	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
		MS/MSDs	--	--	--	--	--	--	2	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
		Blanks/Rinsates	--	--	--	--	--	--	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		IDW Samples	--	--	--	--	--	--	1	0	1	1	0	0	0	0	0	0	1	1	1	1	2	2	2	1	
		Total Samples	11	11	11	11	11	11	34	30	1	1	4	4	5	10	3	3	1	1	1	1	2	2	2	1	

SECTION 4.0 FIGURE



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

LEGEND

- PROPOSED MONITORING WELL LOCATION
- PROPOSED BORING LOCATION
- PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION
- DNAPL – EVIDENCE OF DNAPL BASED ON SOIL CONTAMINANT CONCENTRATIONS ABOVE SOLUBILITY LIMITS OF PCA AND TCE
- DNAPL – EVIDENCE OF DNAPL BASED ON CONTAMINANT CONCENTRATIONS IN GROUNDWATER ABOVE 10% SOLUBILITY LIMITS FOR PCA AND TCE
- GROUNDWATER MONITORING WELL (OCT. 1999)
- SOIL BORING LOCATION (MARCH 2000)
- TEMPORARY WELL LOCATION (MARCH 2000)
- FENCE LINE
- ESTIMATED EXTENT OF THE SUSPECTED SOURCE ZONE
- PROJECTED EXTENT OF THE SUSPECTED SOURCE ZONE

FIGURE 4-1
PROPOSED BORING AND MONITORING WELL LOCATIONS
SITE 89 – CTO 0181
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

5.0 SAMPLE DESIGNATION

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

The sample designation format is as follows:

Site#-Media/Station# or QA/QC-Depth/Round

An explanation of each of these identifiers is given below.

Site#	This investigation includes Site 89. This will include either the prefix "IR" meaning Installation Restoration Program, or "UST" meaning Underground Storage Tank Program.
Media	MW = Monitoring Well Boring GW = Groundwater IS = In-Situ Sampled Soil Boring
Station#	Each soil test boring or monitoring well will be identified with a unique identification number.
QA/QC	FB = Field Blank D = Duplicate Sample (following depth/round) TB = Trip Blank ER = Equipment Rinsate MS/MSD = Matrix Spike/Matrix Spike Duplicate
Depth/Round	Depth indicators will be used for soil samples.

The number will reference the depth interval of the sample. For example:

03 = 5 to 7 feet below ground surface
04 = 7 to 9 feet below ground surface
05 = 9 to 11 feet below ground surface, etc.

Round indicator will be used for groundwater samples. For example:

00A = sampling conducted in the first quarter of 2000
00B = sampling conducted in the second quarter of 2000
00C = sampling conducted in the third quarter of 2000
00D = sampling conducted in the forth quarter of 2000

Under this sample designation format, the sample number IR89-GW05IWD-01 refers to:

IR89-GW05IWD-99C	Site 89
IR89-GW05IWD-99C	Groundwater sample
IR89-GW05IWD-99C	Monitoring well #5
IR89-GW05IWD-99C	Intermediate monitoring well
IR89-GW05IWD-99C	Sample Collected in the third quarter of 1999
IR89-GW05IWD-99C	Duplicate (QA/QC) sample

The sample designation IR89IS01-08D refers to:

IR89-IS01-08D Site 89
IR89-IS01-08D In-Situ Sampled Soil Boring
IR89-IS01-08D Boring #1
IR89-IS01-08D Sample depth interval 15 to 17 feet bgs
IR89-IS01-08D Duplicate (QA/QC) sample

The sample designation IR89-ERSB-01 refers to:

IR89-ERSB-01	Site 89
IR89-ERSB-01	Equipment Rinsate
IR89-ERSB-01	Rinate taken from soil sampling equipment
IR89-ERSB-01	Equipment Rinsate Sample #1

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

6.0 INVESTIGATIVE PROCEDURES

The investigative procedures to be used for Site 89 are discussed in the subsections that follow. These procedures include soil sample collection, permanent monitoring well installation, well development, groundwater sample collection, in-situ slug tests, decontamination procedures, and handling of site investigation derived wastes. All of these procedures will comply with the field methods described in the USEPA, Region IV, Environmental Services Division (ESD), Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (ECBSOPQAM), May 1996 (updated in 1997). Additional guidance from other sources such as American Society for Testing and Materials (ASTM) may be used, but if the ASTM and ESD methods conflict, the ESD procedure will be used. Additionally, in instances where the ESD has no SOP, other guidance sources will be used, such as manufacturer's SOP manuals. Field deviations will be recorded in the field logbook and discussed with the project manager.

6.1 Soil Sample Collection

Subsurface soil samples from MIP confirmatory borings will be collected by a Geoprobe or Stratoprobe rig. Subsurface soil samples from well borings and other stratigraphy confirmation borings will be advanced by a truck-mounted drill. All boring locations will be screened for the presence of utilities. Appendix A contains Baker Environmental, Inc. (Baker's) SOP for soil sample acquisition.

Soil samples will be collected using either a Geoprobe Macro Core Sampler (MIP confirmation) or a split-spoon sampler (well installation). A Geoprobe Macro Core Sampler is a steel tube, with a drive shoe on one end. This device can be driven into unconsolidated material using a percussion hammer. The Sampler is 1-1/2 inches in outside diameter (OD) and is available in three common lengths (2-feet, 3-feet, and 4-feet). The Sampler contains an acetate liner in which soil samples are collected. A split-spoon sampler is a steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. This device can be driven into unconsolidated material using a drive weight connected to the drilling rig. A split-spoon sampler (used for performing Standard Penetration Tests) is 2 inches in OD and 1-3/8 inches in inside diameter (ID). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. Split-spoons capable of obtaining 24-inch long samples will be utilized during this investigation.

Samples will generally be collected continuously. The exceptions include:

- In TCRA-treated, backfilled soils
- In soils less than 5-feet deep where previous investigations generated sufficient information
- Shallow permanent well borings. Since intermediate well boring will be sampled, it will not be necessary to sample the adjacent shallow well boring.

The site geologist will describe the physical characteristics of the samples. The soil will be classified according to the Modified Bermeister Classification System. Soil sample descriptions will be recorded in the field geologist's logbook.

Selected samples from the confirmatory borings will be collected for on-site analysis. Five soil samples will be collected from each boring by methods described in Sections 6.1.1 and 6.1.2.

6.1.1 Split-Spoon Sample Collection and Field Screening Procedures

The following procedure will be used for collecting split-spoon soil samples:

1. The borehole will be advanced to the desired depth using hollow-stem auger drilling techniques. The split-spoon will be lowered into the borehole inside the boring or hollow-stem auger.

2. The subsurface soil samples will be collected by driving the split-spoon with blows from a 140-pound hammer falling 30-inches in accordance with SOP F102 Soil and Rock Sample Acquisition (Appendix A). The sampler will be driven 24-inches. Once at the desired depth, the split-spoon will be pulled from the borehole.

3. The number of blows required to effect each six inches of penetration or fraction thereof will be recorded in the field logbook. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, "N". If the sampler is driven less than 18-inches, the penetration resistance is the number for the last one-foot of penetration. (If less than one foot is penetrated, the logs will state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24-inches, the sum of second and third 6-inch increments will be used to calculate the penetration resistance. (Refusal of the split-spoon will be noted at 50 blows over an interval equal to or less than 6-inches; the interval driven will be noted with the blow count.)

4. The sampler will be brought to the surface and both ends and one half of the split-spoon removed such that the soil recovered rests in the remaining half of the barrel. Organic vapors emanating from the soil sample will be immediately screened using a photo ionization detector (PID). The maximum PID measurement for each sample will be recorded. The recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil will be described; then put into sample jars (see Section 6.1.3 for procedures concerning submitting soil samples to the laboratory).

5. Split-spoon samplers will be decontaminated after each use and prior to the initial use at a site according to the procedures outlined in Section 6.6.

6. This operation will be repeated until the borehole has been advanced to the selected depth. Split-spoon samples will be collected continuously until groundwater is encountered.

7. After samples for laboratory analysis have been collected according to Section 6.1.2, a portion of remaining soil will be collected to screen for the presence of DNAPL. Soil will be exposed to Sudan IV dye according to procedures detailed in Appendix A.

6.1.2 Macro Core Sample Collection and Field Screening Procedures

The following procedure will be used for collecting Macro Core soil samples:

1. The borehole will be advanced to the desired depth by driving the Macro Core Sampler. The Macro Core Sampler contains a piston with a drive tip that is initially held in place inside the Sampler. This piston prevents soil from entering the Sampler.

2. Once at the desired depth, the piston is released from the Sampler by inserting a release key (attached to small-diameter rods) into the hollow drive rods. The Sampler is then driven further to collect a soil sample. As the Sampler is driven, the piston is pushed up into the Sampler by the entering soil.

3. The sampler will be brought to the surface, the drive shoe removed, and the acetate liner pulled from the Sampler. The liner will then be split open by using a decontaminated knife. Organic vapors emanating from the soil sample will be immediately screened using a PID. The maximum PID measurement for each sample will be recorded. The recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil will be described; then put into sample jars (see Section 6.1.3 for procedures concerning submitting soil samples for analysis).

4. The sampler barrel and drive shoe will be decontaminated after each use and prior to the initial use at a site according to the procedures outlined in Section 6.6.

6. This operation will be repeated until the borehole has been advanced to the selected depth. Samples will be collected continuously, with the exceptions noted in Section 6.1.

7. After samples for laboratory analysis have been collected according to Section 6.1.3, a portion of remaining soil will be collected to screen for the presence of DNAPL. Soil will be exposed to Sudan IV dye according to procedures detailed in Appendix A.

6.1.3 Soil Sample Laboratory Submission Procedures

The following procedure will be used for submitting soil samples to the laboratory:

1. Soil for volatile organic analysis will be collected after PID screening, as necessary. Discrete samples will be collected from soil exhibiting the highest PID reading in that sample. For on-site analysis, soil will be collected using a decontaminated stainless steel spoon and placed directly into jars provided by the mobile laboratory. Samples split for fixed-base laboratory analysis will be collected using the Encore™ Sampler. Three samplers will be required for each sample; one for high-range analysis, one for low-range analysis, and one spare. The Encore™ Sampler is a small corer, approximately 1-inch long by ½-inch in diameter. Each individual Sampler is removed from a sealed foil bag and connected to a T-handle. The T-handle is then used to push the Sampler into the soil by hand. For loose sands, several pushes may be needed to completely fill the 5-gram Sampler. A cap is then placed over the open end of the Sampler and locked into position. The label is then affixed to the Sampler and placed into a labeled foil bag. All three Samplers for each sample will be placed into one foil bag to save cooler space and minimize sample labeling and handling.

2. Soil will next be collected from the sampler for SPLP analysis, as necessary. Soil will be taken from the sampler using a decontaminated stainless steel spoon and placed directly into the appropriate sample container.

3. The remaining soil sample will be placed in a virgin aluminum pie pan, homogenized, and placed in a sample container for TOC analysis, as necessary.

4. All pertinent sampling information will be recorded; such as soil description, sample depth, sample number and location, and the time of sample collection in addition to the above mentioned items. Additionally, the Encore™ Samplers will be labeled as outlined in Section 7.0.

5. The Encore™ Samplers will be stored in a cooler with ice until laboratory shipment.

6. The samples will be packed for shipping. COC seals will be attached to the shipping package. COC/Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).

7. The split-spoon sampler will be decontaminated as described in Section 6.6. Disposable latex gloves will be replaced between sample stations to prevent cross-contamination of the samples.

Soil samples for grain size and permeability analysis will be collected by Shelby tube Methods as detailed in Appendix A, Attachment B.

6.2 Permanent Monitoring Well Installation

During this field investigation, shallow and intermediate monitoring wells will be installed. The subsections that follow contain monitoring well installation procedures.

6.2.1 Shallow Monitoring Well

Shallow monitoring wells will be installed to monitor the shallow water-bearing zone (water table). It is estimated that these monitoring wells will be installed to a depth of approximately 15 feet bgs. The procedure for the installation and construction of shallow monitoring wells is presented below (also see Figure 6-1):

- Activity personnel will approve all shallow monitoring well locations. The presence of underground utilities in and around these locations will be determined.

- A borehole will be advanced by a drill rig using 6-1/4-inch inside diameter (ID) hollow-stem augers (HSAs) to depth.

- Upon completion of the borehole to the desired depth, shallow monitoring well construction materials will be installed (inside the hollow-stem augers).

- Stainless steel screen and casing will be used for shallow monitoring well construction. This is due to expected exposure to high concentrations of dissolved contaminants, potential exposure to DNAPL, and the potential use of heat-based remediation technologies.

- 10 feet of 2-inch ID, Schedule 40, #10 slot (0.010 inch) stainless steel screen with a bottom cap will be installed. The screen will be connected to threaded, flush-joint, stainless steel riser. The casing will be installed to be slightly below the ground surface. A stainless steel riser slip-cap, vented to the atmosphere, will be placed at the top of the casing. The top of the well screen will be placed such that two feet of the screen (as subsurface conditions permit) extends above the water table to allow for seasonal groundwater fluctuations.

- The annular space around the screen will be backfilled with a well-graded medium to course sand (No. 1 or No. 2 Silica Sand) as the hollow-stem augers are being withdrawn from the borehole. Sand will be placed from the bottom of the boring to approximately two feet above the top of the screened interval. A lesser distance above the top of the screened interval may be packed with sand if the monitoring well is very shallow to allow for placement of sealing material.

- A sodium bentonite seal at least 24-inches thick will be placed above the sand pack, unless shallow groundwater conditions are encountered. The bentonite will be hydrated with potable water, as necessary, before further completion of the shallow monitoring well.

- The annular space above the bentonite seal will be backfilled with a cement-bentonite grout consisting of three to four percent bentonite powder (by dry weight) and seven gallons of potable water per 94-pound bag of Portland cement.

- The depth intervals of all backfilled materials will be measured with a weighted measuring tape to the nearest 0.1 foot and recorded in the field logbook.

- The shallow monitoring wells will be completed at the ground surface or "flush-mounted". The shallow monitoring well will be completed at the surface using a "flush" access vault. If the monitoring well is installed through a paved surface, concrete surface, or high traffic area, the annular space will be grouted to a depth of at least 2.5-feet and the monitoring well will be finished with a concrete collar. The concrete will be crowned to meet the finished grade of the surrounding pavement, as required. If appropriate, the vault around the buried wellhead will have a water drain to the surrounding soil and a watertight cover.

- All monitoring wells will have a locking cap connected to the protective casing. Each monitoring well will be tagged which will contain general monitoring well construction information and marked as "Test Well - Not For Consumptive Use".

- Figure 6-1 depicts a typical Type II flush mounted monitoring well construction diagram.

6.2.2 Intermediate Monitoring Well

Procedures for the installation and construction of Type II intermediate monitoring wells are presented below:

- Activity personnel will approve all intermediate monitoring well locations. The presence of underground utilities in and around these locations will be determined.

- A borehole will be advanced by a drilling rig using 3-1/4 inch ID hollow-stem augers. 2-foot split-spoon samples will be collected while the borehole is advanced. Samples will be collected according to the procedures outlined in Section 6.1. The boring will be completed when the semi-confining unit has been encountered (typically 40 feet bgs in the former DRMO area).

- Upon completion of the borehole to the desired depth, 6-1/4 inch ID HSAs will be used to ream the borehole to a sufficient diameter to accommodate a 2" well and annulus materials. The intermediate monitoring well construction materials will be installed inside the hollow-stem augers.

- Stainless steel screen and casing will be used for intermediate monitoring well construction. This is due to the potential use of heat-based remediation technologies.

- 5 feet of 2-inch ID, Schedule 40, #10 slot (0.010 inch) stainless steel screen with a bottom cap will be installed. The screen will be connected to threaded, flush-joint, stainless steel riser. The riser will be installed slightly below the ground surface. A stainless steel slip-cap, vented to the atmosphere, will be placed at the top of the riser.

- The annular space around the screen will be backfilled with a well-graded medium to course sand (No. 1 or No. 2 Silica Sand) as the hollow-stem augers are being withdrawn from the borehole. Sand will be placed from the bottom of the boring to approximately two feet above the top of the screened interval.

- A sodium bentonite seal at least 24-inches thick will be placed above the sand pack. The bentonite will be allowed to hydrate before further completion of the intermediate monitoring well.

- The annular space above the bentonite seal will be backfilled with a cement-bentonite grout consisting of three to four percent bentonite powder (by dry weight) and seven gallons of potable water per 94-pound bag of Portland cement. The bentonite seal will be installed using a tremie pipe.

- The depth intervals of all backfilled materials will be measured with a weighted measuring tape to the nearest 0.1 foot and recorded in the field logbook.

- The intermediate monitoring wells will be completed at the ground surface or "flush-mounted". The intermediate monitoring well will be completed at the surface using a "flush" access vault. If the monitoring well is installed through a paved surface, concrete surface, or high traffic area, the annular space will be grouted to a depth of at least 2.5-feet and the monitoring well will be finished with a concrete collar. The concrete will be crowned to meet the finished grade of the surrounding pavement, as required. If appropriate, the vault around the buried wellhead will have a water drain to the surrounding soil and a watertight cover.

- All monitoring wells will have a locking cap connected to the protective casing. Each monitoring well will be tagged which will contain general monitoring well construction information and marked as "Test Well - Not For Consumptive Use."

Figure 6-1 depicts a typical Type II intermediate flush mount monitoring well construction diagram.

6.3 Well Development

All permanent monitoring wells which are to be sampled will be developed as specified in the ECBSOPQAM. The purpose of monitoring well development is:

- To stabilize and increase the permeability of the filter pack around the well screen

- To restore the permeability of the formation which may have been reduced by the drilling operations

- To remove fine-grained materials that may have entered the monitoring well or filter pack during installation.

The selection of the monitoring well development method typically is based on drilling methods, monitoring well construction and installation details, and the characteristics of the formation. Well development will not be initiated until a minimum of 48 hours has elapsed subsequent to monitoring well completion. This time period will allow the cement grout to set. The monitoring wells will be developed using a Wattera pump in combination with surging. All monitoring wells will be developed until well water runs clear of fine-grained materials. Note that the water in some monitoring wells does not clear with continued development. Typical limits placed on monitoring well development may include any one of the following:

- Clarity of water based on visual determination
- A maximum time period (typically one to two hours)
- Stability of pH, specific conductance, and temperature measurements (typically less than 10 percent variation between three successive measurements from different well volumes)
- Clarity based on turbidity measurements (typically less than 10 Nephelometric Turbidity Units [NTU])

A record of the monitoring well development will be completed to document the development process. Section 6.7 provides information on the use of monitoring and data collection equipment for water level measurements, pH, specific conductance, and temperature.

6.4 Groundwater Sample Collection

Permanent monitoring wells will be sampled via reduced flow rate methods. A peristaltic pump will be used to purge the monitoring wells and collect the samples. VOC loss through suction degassing is expected to be insignificant due to the very slow flow rates to be used. Baker personnel report observance of no to minimal bubbling in the groundwater stream during peristaltic pump use at ECBSOPQAM recommended flow rates. The procedure for collecting groundwater samples is detailed in this section, and is based on ECBSOPQAM procedures.

6.4.1 Selection of Water Quality Indicator Parameters

ECBSOPQAM SOPs call for the use of turbidity, pH, temperature, and specific conductance as water quality indicator parameters (WQPs) for stabilization. This investigation will include those WQPs plus dissolved oxygen. Use of dissolved oxygen has precedence in USEPA and other studies. Dissolved oxygen and turbidity are more sensitive indicators of "fresh" groundwater than pH, specific conductance, and temperature (Puls and Powell, 1992). Barcelona et. al., 1994, suggest that dissolved oxygen and specific conductance are good indicators of stabilization with respect to VOA sampling.

6.4.2 Purge Requirements

Consistent with ECBSOPQAM SOPs, a minimum of three well volumes will be purged.

6.4.3 Purging and Sampling Procedure

The following is a reduced flow rate purge and sampling procedure that will be used at Site 89:

1. The protective casing (for existing monitoring wells) will be unlocked, the well cap will be removed, and escaping gases will measured at the well head using a PID. This will determine the need for respiratory protection.

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

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

4. The sampling device intake (virgin, 1/4-inch ID polyethylene tubing) will be slowly lowered until the bottom end is 2 to 3 feet below the top of water level. Next, the water level probe will be placed into the monitoring well just above the water.

5. Purging will then begin with a peristaltic pump, if possible. The discharge rate will be measured using a stopwatch and calibrated container. Flow rates of less than 1 liter per minute (L/min) are expected at wells in the surficial aquifer, and 1 to 2 L/min at wells in the upper portion of the Castle Hayne aquifer.

6. The WQPs, including turbidity, pH, and specific conductance will be measured frequently (e.g., every 2 minutes). Temperature and oxidation-reduction potential (Eh) also will be measured.

7. Purging will be complete when a minimum of three well volumes have been removed and three successive WQP readings have stabilized within 10 percent (0.1 Standard Units for pH), or there is no further discernable upward or downward trend. It is Baker's experience that at low values, certain WQPs (such as turbidity) may vary by more than 10 percent, but have reached a stable plateau.

8. Upon WQP stabilization, groundwater samples will be collected from the end of the tubing into the sample container.

9. The following information will be recorded in the field logbook:

   Project location, date, and time
   Weather
   Sample location, number, round, and identification number
   Static water level
   Calculation of amount of water to be purged
   WQPs during purging
   Visual description of water (i.e., clear, cloudy, muddy, etc.)
   Names of sampling personnel
   Names of visitors on site
   Purging and sampling technique, procedure and equipment used
   Sampling remarks and observations
   QA/QC samples collected

10. The sample jars will be stored in a cooler with ice until laboratory shipment.

11. The samples will be packed for shipping. COC seals will be attached to the shipping package. COC/Sample Request Forms will be properly filled out and enclosed of attached (Section 7.0).

Sample preservation and handling procedures are outlined in Section 7.0. Appendix B presents a SOP for groundwater sampling.

6.5 Surface Water Sample Collection

Five surface water stations are to be sampled in Edwards Creek as part of this investigation (see Figure 4-1). Successful completion of this task will be dependent on the presence of water in the stream. Should water be present, the following procedure will be used to collect all surface water samples:

1. One surface water sample will be collected from each station. Surface water samples will be collected from mid-channel point. Given the shallow depth of the water in the stream, samples will be collected just below the water surface.

2. 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.

3. Samples will be collected by dipping a transfer bottle into the water. The unpreserved, virgin transfer bottle will be used to fill preserved VOC vials. Care will be taken when collecting samples for VOCs to avoid excessive agitation that could result in the loss of volatile organics. Sample containers will be labeled prior to collection.

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

5. It will be ensured that the previous sampling station markings will be in place and legible.

6. The following information will be recorded in the field logbook:

   - Project location, date, and time
   - Weather
   - Sample location, number, and identification number
   - Flow conditions (i.e., high, low, in flood, etc.)
   - On site water quality measurements
   - Visual description of water (i.e., clear, cloudy, muddy, etc.)
   - Sketch of sampling location including boundaries of the water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake
   - Names of sampling personnel
   - Names of visitors on site
   - Sampling technique, procedure, and equipment used
   - Sampling remarks and observations
   - QA/QC samples collected

An SOP for collection of surface water samples is included in Appendix C.

6.6 Sediment Sample Collection

Sediment samples will be collected from the same stations as surface water samples (described in Section 6.5). The following procedure will be used to collect all sediment samples:

1. Sediment samples 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. One sediment sample will be collected from each station, from 0- to 6-inches. Sediments will be removed from the streambed using a decontaminated core barrel sampler. Care will be taken to minimize sediment disturbance that could result in the loss of volatile organics.

4. Samples will be collected off the shovel with the Encore™ Samplers. The Encore™ Samplers will be used in the manner detailed in Section 6.1.2.

5. The following information will be recorded in the field logbook:

   - Project location, date, and Weather
   - Sample location, number, and identification number
   - Flow conditions (i.e., high, low, in flood, etc.)
   - On site water quality measurements
   - Visual description of water (i.e., clear, cloudy, muddy, etc.)
   - Sketch of sampling location including boundaries of the 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

   - The sample jars will be stored in a cooler with ice until laboratory shipment.

   - The samples will be packed for shipping. Chain-of-custody seals will be attached to the shipping package. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).

An SOP for collection of surface water samples is included in Appendix C.

6.7 In-Situ Slug Tests

Slug tests will be performed as necessary in select newly installed and existing monitoring wells at Site 89. Both falling head and rising head tests will be performed in the intermediate wells. Only rising head tests will be performed in the shallow monitoring wells. An In Situ, Inc. Hermit 3000 data logger will be used for these tests. The performance of slug tests will include the following procedure:

1. The initial static groundwater level and depth of monitoring well will be measured. All measurements will be recorded in the field logbook.

2. The parameters for the test in the data logger will be set. The coefficients for the specific transducer being used will be entered. Entries will be double-checked. Note that the rate for recording readings should be set on the logarithmic scale. This will collect readings at the fastest rate at the start of the test when changes in the groundwater level are the most rapid and significant in the analysis of the data.

3. The data logger transducer will be set in the monitoring well, approximately one foot from the bottom of the monitoring well.

4. The slug will be prepared by securing nylon cord to the top end and marking a point on the rope which will allow the slug to be completely submerged and will place the slug a minimum of one foot above the transducer.

The following procedures are for rising head tests only (for shallow monitoring wells):

5. The slug will be lowered into the monitoring well to the mark on the cord and groundwater equilibration will be allowed to occur. The water level can be monitored through the data logger. Also, the groundwater level measurement can be taken with a water level meter to verify the fall in water level towards static. Once the groundwater has reached the static level (or at least 90 percent of static), the rising head test may begin.

6. Simultaneously, the slug will be removed and the start button will be pressed to begin the test. The water level can be monitored through the data logger or during the test, groundwater level measurements can be taken with a water level meter to verify the rise in water level to static. Once the groundwater has reached the initial static level (or at least 90 percent of static), the test can be terminated.

7. The transducer and cable will be removed from the monitoring well and decontaminated with liquid Alconox soap and distilled water upon the completion of each monitoring well testing.

8. The data will be downloaded from the data logger through a laptop computer onto a diskette at the end of the day and printed. A backup disk will also be made of the slug test data files.

The following procedures are for falling head and rising head tests for intermediate monitoring wells:

9. Simultaneously, the slug will be lowered into the monitoring well to the mark on the cord and the start button will be pressed to begin the test. The water level can be monitored through the data logger or during the test, groundwater level measurements can be taken with a water level meter to verify the fall in water level towards static.

10. Continue the test until groundwater is within 90 percent of the initial static water level. Set the data logger to begin a step (as per the instrument instructions).

11. Immediately after beginning the step, remove the slug to begin the rising head test. The water level can be monitored through the data logger or during the test, groundwater level measurements can be taken with a water level meter to verify the rise in water level to static. Once the groundwater has reached the static level (or at least 90 percent of static), the test can be terminated.

12. The transducer and cable will be removed from the monitoring well and decontaminated with liquid Alconox soap and distilled water upon the completion of each monitoring well testing.

13. The data will be entered into a field logbook while each test is ongoing. The data will also be downloaded from the data logger through a laptop computer onto a diskette at the end of the day and printed. A backup disk will also be made of the slug test data files.

The data obtained from the in-situ slug tests will be used in conjunction with Geraghty & Miller's Aquifer Test Solver (AQTESOLV®) program to calculate hydraulic conductivity values at the specific monitoring wells tested. Appendix D presents a SOP for conducting slug tests.

6.8 Decontamination

Equipment and materials that require decontamination fall into two broad categories:

1. Field measurement, sampling, and monitoring equipment (e.g. water level meters, stainless-steel spoons, etc.)

2. Machinery, equipment, and materials (e.g. drilling rigs, backhoes, drilling equipment, monitoring well materials, etc.)

Appendices E and F detail procedures for decontaminating the two categories of equipment and materials, respectively.

6.9 Monitoring and Data Collection Equipment

Field support activities and investigations will require the use of monitoring and data collection equipment. Turbidity, dissolved oxygen, specific conductance, temperature, pH, and Eh readings will be recorded during groundwater sample collection. Dissolved oxygen, specific conductance, temperature, and pH readings will be recorded during surface water sample collection. Appendix G, On-Site Water Quality Testing provides specific procedures for collecting conductance, temperature, and pH readings.

Additional monitoring well information may be obtained using water level meters, water-product level meters, and well depth meters. The operation and various uses of this data collection equipment is provided in Appendix H.

Health and safety monitoring and environmental media screening will be conducted using a PID and an oxygen/combustible gas meter (O_2/LEL). The operation and use of the PID is described in Appendix I. The Bacharach O_2/LEL meter will also be used during the sampling program, primarily to monitor health and safety conditions. Appendix J provides a description of the Bacharach O_2/LEL meter and operating procedures.

6.10 Investigation Derived Waste Handling

The subsections that follow discuss the responsibilities, sources, containerization, sampling and analysis, and disposal of IDW. These wastes include soil from borings, groundwater from developing and purging of monitoring wells, decontamination fluids, and personal protection equipment.

6.10.1 Responsibilities

LANTDIV - Atlantic Division, Naval Facilities Engineering Command (LANTDIV) or the facility must ultimately be responsible for the final disposition of site wastes. As such, a LANTDIV or MCB Camp Lejeune representative will sign waste disposal manifests as the generator of the material in the event off-site disposal is required. However, it may be the responsibility of Baker, depending on the contingency discussions during execution of the investigation, to provide assistance to LANTDIV in arranging for final disposition and preparing manifests.

Baker Project Manager - It is the responsibility of the Baker Project Manager to work with the LANTDIV-Technical Representative in determining the final disposition of site investigation wastes. The Baker Project Manager will relay the results and implications of the chemical analysis of the IDW, and advise on the regulatory requirements and prudent measures appropriate to the disposition of the material. The Baker Project Manager also is responsible for ensuring that field personnel involved in site investigation waste handling are familiar with the procedures to be implemented in the field, and that all required field documentation has been completed.

Baker Field Team Leader - The Baker Field Team Leader or Site Manager is responsible for the on site supervision of the waste handling procedures during the site investigations. The Baker Field Team Leader also is responsible for ensuring that all other field personnel are familiar with these procedures.

6.10.2 Sources of Investigation Derived Wastes

Field investigation activities often result in the generation and handling of potentially contaminated materials that must be properly managed to protect the public and the environment, as well as to meet legal requirements. These wastes may be either hazardous or non-hazardous in nature. The nature of the waste (i.e., hazardous or non-hazardous) will determine how the wastes will be handled during the field investigation.

The sources of waste material depend on the site activities planned for the project. The following types of activities or sources may result in the generation of waste material that must be properly handled:

Subsurface soil sampling and monitoring well construction (soil cuttings)
Monitoring well development (development water)
Groundwater sampling (purge water)
Heavy equipment decontamination (decontamination fluids)
Sampling equipment decontamination (decontamination fluids)
Personal protection equipment (health and safety disposables)

6.10.3 Designation of Potentially Hazardous and Non-hazardous Investigation Derived Wastes

Wastes generated during the field investigation can be categorized as either potentially hazardous or non-hazardous in nature. The designation of such wastes will determine how the wastes are handled. The criteria for determining the nature of the waste and the subsequent handling of the waste is described below for each type of anticipated investigative waste.

6.10.3.1 Soil Cuttings

Soil cuttings will be generated during the augering of soil and well borings. Soil cuttings will be containerized in a lined roll-off box for analytical testing, temporary storage on site, and subsequent treatment and/or disposal.

6.10.3.2 Monitoring Well Development and Purge Water and Decontamination Fluids

All development and purge water will be containerized in one 1,000-gallon tank.
Equipment and personal decontamination fluids collected from decontamination/wash pads will also be containerized in the tank.

6.10.3.3 Personal Protective Equipment

All personal protective equipment (i.e., ***Tyvek*** Coveralls, gloves, and other health and safety disposables) will be placed in garbage bags and disposed of in trash dump boxes.

6.10.4 Investigation Derived Waste Sampling and Analysis

One composite sample will be collected from the roll-off box containing soil cuttings. This sample will be analyzed for full TCLP (organics and inorganic) and RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability).

One sample will be collected from the storage tank for full TCL organic and TAL total metal analyses, as well as TSS and TDS. Procedures for collecting wastewater samples are presented in Appendix K.

6.10.5 Labeling

The roll-off box and storage tank will be labeled by the field team during the site investigation. Information will be written on a plaque and affixed to the prominent side of the container. Container labels will include, at a minimum:

LANTDIV Contract Task Order (CTO) (number)
Camp Lejeune Point-of-Contact name and phone number
Project name
Contractor Name and Project Manager Name
Drum number
Date
Source
Contents

If laboratory analysis reveals that containerized materials are hazardous, additional labeling of containers may be required. Baker will be responsible for additional labeling procedures, with assistance from the Activity and/or LANTDIV as needed. These additional labeling procedures will be based upon the identification of material present; USEPA regulations applicable to

labeling hazardous and polychlorinated biphenyl (PCB) containing wastes are contained in 40 CFR Parts 261, 262, and 761.

6.10.6 Container Log

A container log will be maintained in the site logbook. The container log will contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample. MCB Camp Lejeune Installation Restoration, Environmental Management Department (EMD) will be informed of the status of all IDW storage containers on a regular basis.

6.10.7 Container Storage

Containers of site investigative wastes will be stored on site or in a specially designated secure area that is managed by the MCB Camp Lejeune EMD until disposition is determined.

If the laboratory analysis reveals that the roll-off box contains hazardous IDW, additional storage security may be implemented. Baker will coordinate, with LANTDIV and/or the Activity, any additional measures that may need to be taken to insure that the containerized IDW is secure and meets applicable Federal regulations.

Baker will assist LANTDIV in devising the storage requirements as required. Weekly inspections by facility personnel of the temporary storage area also may be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and whatever precipitation removal is necessary will be recorded in the site logbook.

6.10.8 Container Disposition

The disposition of the containers of site investigation generated wastes will be determined by LANTDIV, with the assistance of Baker, as necessary. Container disposition will be based on quantity of materials, types of materials, and analytical results. If necessary, specific samples of contained materials may be collected to identify further characteristics that may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results, which are usually not available until long after completion of the field investigation at the facility.

6.10.9 Disposal of Contaminated Materials

Actual disposal methods for IDW will be determined following receipt of chemical analyses. The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state, and local regulations will be observed. USEPA regulations applicable to generating, storing, and transporting hazardous wastes are contained in 40 CFR Parts 262, 263.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment will be evaluated for use as long-

term storage. Also, other site conditions, such as drainage control, security, and soil types must be considered in order to provide proper storage.

At Site 89, any soil determined to be non-hazardous will be returned to the site. Soil determined to be hazardous will be taken to a Treatment Storage and Disposal Facility to (TSDF). All water will be taken to one of the on-base groundwater treatment plants designed handle solvent and petroleum contamination.

SECTION 6.0 FIGURE

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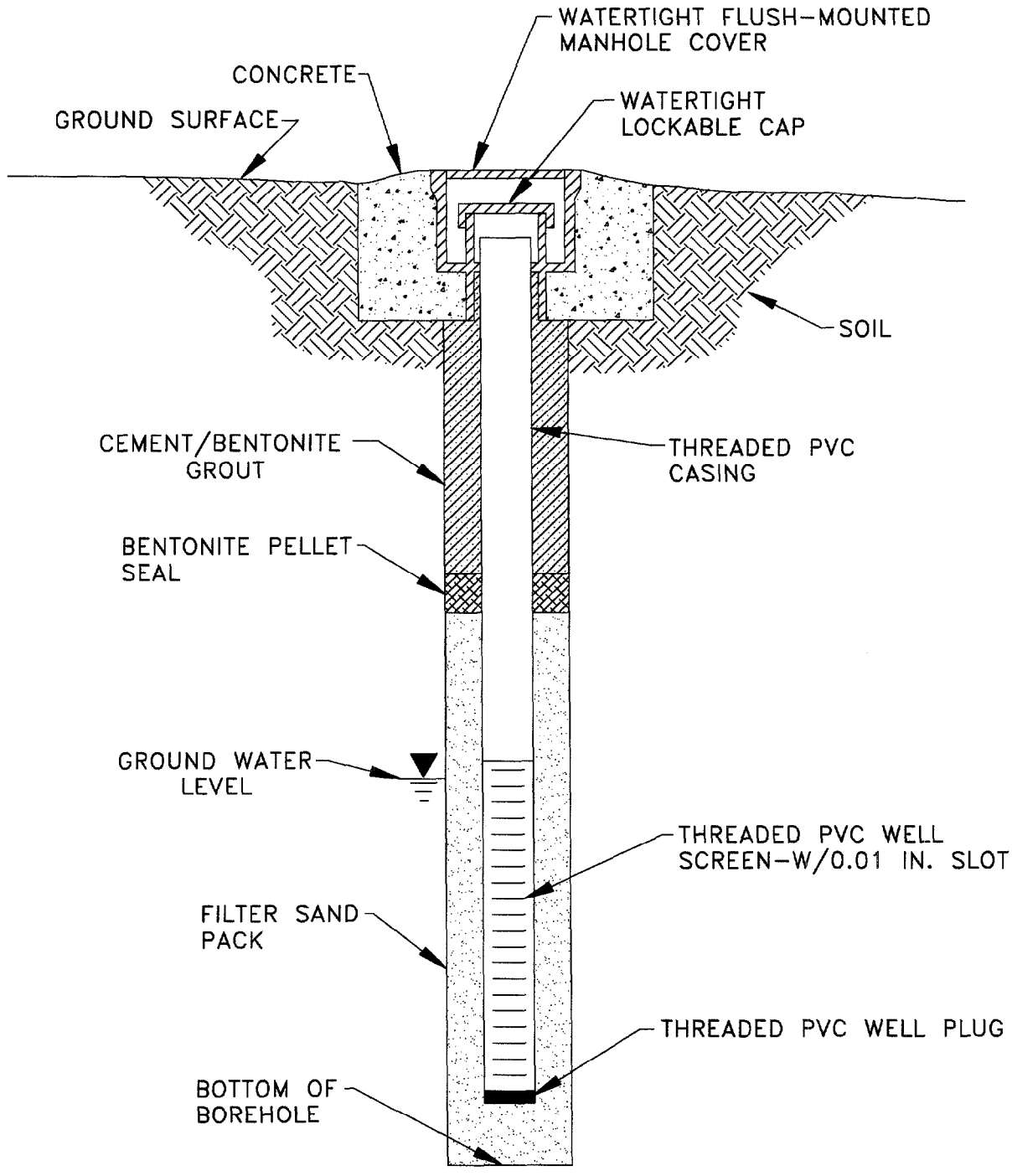

N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 6-1
TYPICAL SHALLOW AND INTERIMEDIATE FLUSH MOUNT GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM
CTO - 0181

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

7.0 SAMPLE HANDLING AND ANALYSIS

Field activities will be conducted in accordance with the USEPA Region IV ESD's ECBSOPQAM (1996, with 1997 revisions). Procedures for sample preservation, labeling, handling, and maintaining a field logbook are detailed in SOPs. Because these procedures are not specific to this project, they are provided as appendices, rather than detailed herein. Major components of sample handling and analysis are discussed in the following subsections.

The number of samples, analytical methods, data quality objectives, and laboratory turnaround times are presented in Table 7-1.

7.1 Sample Preservation and Handling

Sample preservation, sample bottle packing and shipping are important components to maintaining the integrity of the samples. Preservation and handling procedures to be used in this investigation are detailed in Appendix L and Section 6.1 of the QAPP.

7.2 Chain-of-Custody

COC is another important component to maintaining sample integrity. COC procedures to be followed during this investigation are detailed in Appendix M. This SOP details sample bottle labeling and chain-of-custody procedures.

COC procedures ensure a documented, traceable link between measurement results and the sample or parameter they represent. These procedures are intended to provide a legally acceptable record of sample collection, identification, preparation, storage, shipping, and analysis.

7.3 Field Logbook

Field logbooks will be used to record sampling activities and information. Entries will include general and specific sampling information so that site activities may be reconstructed. In addition to the logbook, field forms, such as boring and monitoring well development logs, will be completed as support documentation for the logbook. Appendix N describes a general format for the field logbook.

Each field person will have and maintain a logbook. Logbooks will be copied daily and stored at the field trailer as backup in case the original is lost or destroyed. Additionally, copies of completed logbooks will be filed in the project files.

SECTION 7.0 TABLE

TABLE 7-1

SUMMARY OF SAMPLING AND ANALYTICAL OBJECTIVES
SITE 89 SUPPLEMENTAL INVESTIGATION - CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Number of Samples (Not including QA/QC)	Analysis	Analytical Method	Data Quality Objective	Laboratory Turnaround
Site 89	Soil	40 Direct-Push Borings (5 samples each for 200 total samples)	Volatile Organics	SW846 8260B (modified for on-site analysis)	II	NA
		20 Samples	Volatile Organics	CLP/SOW	IV	21 Days
		5 Samples	Total Organic Carbon	EPA 415.1	III	21 Days
		10 Samples	SPLP	SW846 312	III	21 Days
		5 Samples	Grain Size	ASTM D-422	III	21 Days
		3 Samples	Permeability	ASTM D-5084	III	21 Days
	Groundwater	7 Shallow Monitoring Wells	Volatile Organics	CLP/SOW	IV	21 Days
		4 Intermediate Monitoring Wells	Volatile Organics	CLP/SOW	IV	21 Days
IDW	Surface Water	5 Locations	Volatile Organics	CLP/SOW	IV	21 Days
	Sediment	5 Locations	Volatile Organics	CLP/SOW	IV	21 Days
	Soil Cuttings	1 Composite Sample	TCLP VOA TCLP SVOA TCLP Metals Ignitability Corrosivity Reactive Cyanide Reactive Sulfide	SW846 1311/8260B SW846 1311/8270C SW846 1311/6010B/7470 SW846 1010/1030 SW846 1110 7.3.3.2/9010 7.3.4.2/9030	III	21 Days
	Purge/Develop. Water	1 Sample	TCL VOCs TCL SVOCs TAL Metals Ignitability Corrosivity Reactive Cyanide Reactive Sulfide Total Suspendend Solids Total Dissolved Solids	SW846 8260B SW846 8270C 6010B/7000 Series SW846 1010/1030 SW846 1110 7.3.3.2/9010 7.3.4.2/9030 EPA Method 160.2 EPA Method 160.1	III	21 Days

Notes:

CLP	Contract Laboratory Program
SOW	Statement of Work
TCLP	Toxicity Characteristic Leaching Procedure
TCL	Target Compound List
TAL	Target Analyte List
VOA	Volatile Organic Analysis
SVOA	Semivolatile Organic Analysis
SPLP	Synthetic Precipitation Leaching Procedure
QA/QC	Quality Assurance/Quality Control
IDW	Investigation Derived Waste
NA	Not Applicable

8.0 SITE MANAGEMENT

This section outlines the responsibilities and reporting requirements of on-site personnel.

8.1 Field Team Responsibilities

The field investigation portion of this project will consist of one field team. A Site Manager will coordinate all field activities. The Site Manager will ensure that all field activities are conducted in accordance with the project plans (the Work Plan, this FSAP, the QAPP, and the HASP).

The Field Team will employ one drilling rig for monitoring well installation and auger borings. The project geologist will supervise the drilling rig work. The Field Team will also employ one Geoprobe or Stratoprobe rig for the direct-push boring work. An assistant project geologist will supervise the direct-push work. One of the geologists will also serve as the Site Manager and Site Health and Safety Officer.

8.2 Reporting Requirements

The Site Manager will report a summary of each day's field activities to the Project Manager or his/her designee. This may be done by telephone or fax. The Site Manager will include, at a minimum, the following in his/her daily report:

Baker personnel on site
Other personnel on site
Major activities of the day
Subcontractor quantities (e.g., drilling footages)
Samples collected
Problems encountered
Planned activities

The Site Manager will receive direction from the Project Manager regarding changes in scope of the investigation. All changes in scope will be discussed and agreed upon by LANTDIV, Camp Lejeune EMD, USEPA Region IV, and the North Carolina Department of Environment and Natural Resources (DENR).

9.0 REFERENCES

Barcelona, et. al., 1994 Barcelona, M.J., Wehrmann, H.A., Varljen, M.D. Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Groundwater Sampling. Ground Water Vol. 32, No. 1. January-February, 1994.

Puls and Powel, 1992 Puls, R.W. and Powel, R.M. Acquisition of Representative Ground Water Quality Samples for Metals. Groundwater Monitoring and Remediation. Summer, 1992.

USEPA, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. February 1991.

USEPA, 1993 Guidance on Conducting for Non-Time-Critical Removal Actions Under CERCLA (EPA/540-R-93-057). USEPA, August 1993.

APPENDIX A
SOIL SAMPLE ACQUISITION

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ATTACHMENT A -- ASTM D1586-84 STANDARD METHOD FOR PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS

ATTACHMENT B -- ASTM D1587-83 STANDARD PRACTICE FOR THIN-WALLED TUBE SAMPLING OF SOILS

ATTACHMENT C -- ASTM D2113-83 (1987) STANDARD PRACTICE FOR DIAMOND CORE DRILLING FOR SITE INVESTIGATION

ATTACHMENT D -- ASTM D6282-98 STANDARD GUIDE FOR DIRECT PUSH SOIL SAMPLING FOR ENVIRONMENTAL SITE CHARACTERIZATIONS

SOIL AND ROCK SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this procedure is to describe the handling of rock cores and subsurface soil samples collected during drilling operations. Surface soil sampling also is described.

2.0 SCOPE

The methods described in this SOP are applicable for the recovery of subsurface soil and rock samples acquired by coring operations or soil sampling techniques such as split-barrel sampling and thin-walled tube sampling. Procedures for the collection of surface soil samples also are discussed. This SOP does not discuss drilling techniques or well installation procedures. ASTM procedures for "Penetration Test and Split-Barrel Sampling of Soils," "Thin-Walled Tube Sampling of Soils," and "Diamond Core Drilling for Site Investigation" have been included as Attachments A through C, respectively.

3.0 DEFINITIONS

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outer diameter (O.D.) and 18 to 54 inches length.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into unconsolidated materials using a drive weight mounted on the drilling string. A standard split-spoon sampler (used for performing Standard Penetration Tests) is two inches O.D. and 1-3/8-inches inner diameter (I.D.). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time.

Composite Samples - A sample collected over time that typically consists of a series of discrete samples which are combined or "composited." Two types of composite samples are listed below:

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Drilling Inspector - It is the responsibility of the drilling inspector to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The Drilling Inspector is responsible for the proper acquisition of rock cores and subsurface soil samples.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

5.0 PROCEDURES

Subsurface soil and rock samples are used to characterize the three-dimensional subsurface stratigraphy. This characterization can indicate the potential for migration of contaminants from various sites. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of subsurface soil samples. Where the remedial activities may include in-situ treatment, or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Surface soil samples serve to characterize the extent of surface contamination at various sites. These samples may be collected during initial site screening to determine gross contamination levels and levels of personal protection required as part of more intensive field sampling activities, to gather more detailed site data during design, or to determine the need for, or success of, cleanup actions.

Site construction activities may require that the engineering and physical properties of soil and rock be determined. Soil types, bearing strength, compressibility, permeability, plasticity, and moisture content are some of the geotechnical characteristics that may be determined by laboratory tests of soil samples. Rock quality, strength, stratigraphy, structure, etc. often are needed to design and construct deep foundations or remedial components.

5.1 Subsurface Soil Samples

This section discusses four methods for collecting subsurface soil samples: (1) split-spoon sampling; (2) shelby tube sampling; (3) bucket auger sampling; and direct push sampling. All four methods yield samples suitable for laboratory analysis. Copies of the ASTM procedures for split-spoon sampling, shelby-tube sampling and direct push sampling are provided in Attachments A, B and C, respectively.

5.1.1 Split-Barrel (Split-Spoon) Sampling

The following procedures are to be used for split-spoon, geotechnical soil sampling:

1. Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation.

2. Side-discharge or bottom-discharge bits are permissible. The process of jetting through the sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

3. The two-inch O.D. split-barrel (not for geotech) sampler should be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test.

4. Repeat this operation at intervals not longer than 5 feet in homogeneous strata, or as specified in the Sampling and Analysis Plan.

5. Record on the Field Test Boring Record or field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last one foot of penetration. (If less than one foot is penetrated, the logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24 inches, the sum of second and third six-inch increments will be used to calculate the penetration resistance. (Refusal of the Standard Penetration Test will be noted as 50 blows over an interval equal to or less than 6 inches; the interval driven will be noted with the blow count.)

6. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Describe carefully the recovery (length), composition, structure, consistency, color, condition, etc. of the recovered soil according to SOP F101; then put into jars without ramming. Jars with samples not taken for chemical analysis should be tightly closed, to prevent evaporation of the soil moisture. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see SOP F302). Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area.

In addition to collecting soils for geotechnical purposes, split-spoon sampling can be employed to obtain samples for environmental analytical analysis. The following procedures are to be used for split-spoon, environmental soil sampling:

1. Follow sample collection procedures 1 through 6 as outlined in Section 5.1.1.

2. After sample collection, remove the soil from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. Soil samples for volatile organic compounds should not be mixed. Further, sample containers for volatile organic compounds analyses should be filled completely without head space remaining in the container to minimize volatilization.

3. Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the Field Test Boring Record or field logbook. In addition, label, tag, and number the sample bottle(s).

4. Pack the samples for shipping (see SOP F301). Attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see SOP F302).

5. Decontaminate the split-spoon sample as described in SOP F501 and SOP F502. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

For obtaining composite soil samples (see Section 3.0), a slightly modified approach is employed. Each individual discrete soil sample from the desired sample interval will be placed into a stainless-steel, decontaminated bowl (or other appropriate container) prior to filling the laboratory sample containers. Special care should be taken to cover the bowl between samples with aluminum foil to minimize volatilization. Immediately after obtaining soils from the desired sampling interval, the sample to be analyzed for Volatile Organic Compounds (VOCs) should be collected. In the event that a composite sample is required, care should be taken to obtain a representative sampling of each sample interval. The remaining soils should be thoroughly mixed. Adequate mixing can be achieved by stirring in a circular fashion and occasionally turning the soils over. Once the remaining soils have been thoroughly combined, samples for analyses other than VOCs should be placed into the appropriate sampling containers.

5.1.2 Thin-Wall (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil for physical laboratory testing, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method applies:

1. Clean out the hole to the sampling elevation, being careful to minimize the chance for disturbance or contamination of the material to be sampled.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Only side discharge bits are permitted.

3. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. With the sampling tube resting on the bottom of the hole and the water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge.

5. After pushing the tube, the sample should sit 5 to 15 minutes prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.

6. Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil, from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place and then dip the ends in wax to seal them.

7. Affix labels to the tubes and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and indicate the top of the sample. Complete chain-of-custody and other required forms (see SOP F302). Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

8. From soil removed from the ends of the tube, make a careful description using the methods presented in SOP F101.

9. When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Other appropriate devices can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and, therefore, their use should be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least one sample can be obtained for classification purposes.

5.1.3 Bucket (Hand) Auger Sampling

Hand augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand auger extensions becomes so severe that in resistant materials powered methods must be used.

When a vertical sampling interval has been established, 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 decontaminated bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances 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 as outlined in SOP F502.

In addition to hand augering, powered augers can be used to advance a boring for subsurface soil collection. However, this type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sample depth, at which point a hand auger is usually used to collect the sample.

5.1.4 Direct Push Sampling

Direct push sampling has become a widely used technique for collecting environmental samples of soil and groundwater. There are multiple sampling devices and different sized samplers used in direct push methods. Please refer to ASTM standards in attachment D. This is a general procedure for sampling and could change depending on work plan and type of sampling being done.

1. The sampler should be driven to desired depth for sample.

2 Bring the sampler to the surface and remove soil sleeve. Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the Field Test Boring Record or field logbook. In addition, label, tag, and number the sample bottle(s). Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see SOP F302).

3. After sample collection, remove the soil from the sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. <u>Soil samples for volatile organic compounds should not be mixed.</u> Further, sample containers for volatile organic

compounds analyses should be filled completely without head space remaining in the container to minimize volatilization.

4. Pack the samples for shipping (see SOP F301). Attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see SOP F302).

5. Decontaminate the sampler as described in SOP F501 and SOP F502. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

5.2 Surface Soil Samples

Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. For loosely packed surface soils, stainless steel (organic analyses) or plastic (inorganic analyses) scoops or trowels, can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

1. Use a soil auger for deep samples (greater than 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collecting the sample.

2. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook (SOP F303) and on the sample log sheet, chain-of-custody record (SOP F302), and other required forms.

3. Classify and record a description of the sample, as discussed in SOP F101. Descriptions for surface soil samples should be recorded in the field logbook; descriptions for soil samples collected with power or hand augers shall be recorded on a Field Test Boring Record.

4. Store the sampling utensil in a plastic bag until decontamination or disposal. Use a new or freshly-decontaminated sampling utensil for each sample taken.

5. Pack and ship as described in SOP F301.

6. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site or on a sketch in the field logbook.

7. When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles should be full) should be placed in a stainless steel bucket (or other appropriate container), mixed thoroughly using a decontaminated stainless steel spatula or trowel, and a composite sample collected. In some cases, as delineated in project-specific sampling and analysis plans, laboratory compositing of the samples may be more appropriate than field

compositing. Samples to be analyzed for parameters sensitive to volatilization should be composited and placed into the appropriate sample bottles immediately upon collection.

5.3 Rock Cores

Once rock coring has been completed and the core recovered, the rock core must be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery, as well as the rock quality designation (RQD) (see SOP F101). If split-barrels are used, the core may be measured and classified in the split barrel after opening and then transferred to a core box.

Each core shall be described and classified on a Field Test Boring Record using a uniform system as presented in SOP F101. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of hydrated formations) or oxidation of the core, the core must be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores must be placed in the sequence of recovery in wooden or plastic core boxes provided by the drilling contractor. Rock cores from different borings shall not be placed in the same core box. The core boxes should be constructed to accommodate 10 to 20 linear feet of core and should be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and the run number shall be marked on the wooden partitions with indelible ink. The order of placing cores shall be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, any empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data pertaining to the box's contents. At a minimum, the following information must be included:

- Project name
- Date
- Boring number
- Footage (depths)
- Run number(s)
- Recovery
- Rock Quality Designation (RQD)
- Box number (x of x)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include project name, boring number, top and bottom depths of core and box number.

Due to the weight of the core, a filled core box should always be handled by two people. Core boxes stored on site should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible. Exposure to extreme heat or cold should be avoided whenever possible. Arrangements should be made to dispose of or return the core samples to the client for completion of the project.

6.0 QUALITY ASSURANCE RECORDS

Where applicable, Field Test Boring Records and Test Boring Records will serve as the quality assurance records for subsurface soil samples, rock cores and near surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Logbook as described in SOP F303. Chain-of-Custody records shall be completed for samples collected for laboratory analysis as described in SOP F101 and SOP F302.

7.0 REFERENCES

1. American Society for Testing and Materials, 1987. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM Method D1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

2. American Society for Testing and Materials, 1987. Standard Practice for Thin-Walled Tube Sampling of Soils. Method D1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

3. American Society for Testing and Materials, 1987. Standard Practice for Diamond Core Drilling for Site Investigation. Method D2113-83 (1987), Annual Book of Standards ASTM, Philadelphia, Pennsylvania.

4. U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

A DNAPL FIELD SCREENING PROCEDURE

The soil-water shake test involves the transfer of a soil sample to a clear centrifuge tube with an equal volume of water. The tube is stopped and the mixture shaken by hand. The DNAPL is identified by examination of the tube walls and bottom. This test can be enhanced by centrifugation of the mixture to facilitate the accumulation of the DNAPL at the bottom of the tube. It can also be enhanced by the addition of a small amount of hydrophobic dye such as red Sudan IV or Oil Red O to the mixture. (These dyes are insoluble in water, but are soluble in many organic liquids.) Any DNAPLs present in the sample thereby become red in color. The methods can be performed readily in the field during drilling and soil sampling activities.

Taken from Pankow, J. and Cherry, J. (1996) "Dense Chlorinated Solvents" Waterloo Press, Portland, Oregon, p. 414.

ATTACHMENT A

ASTM D1586-84
STANDARD METHOD FOR PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS

Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

ε1NOTE—Editorial changes were made throughout October 1992.

1. Scope

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 – 58 T. Last previous edition D 1586 – 67 (1974).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

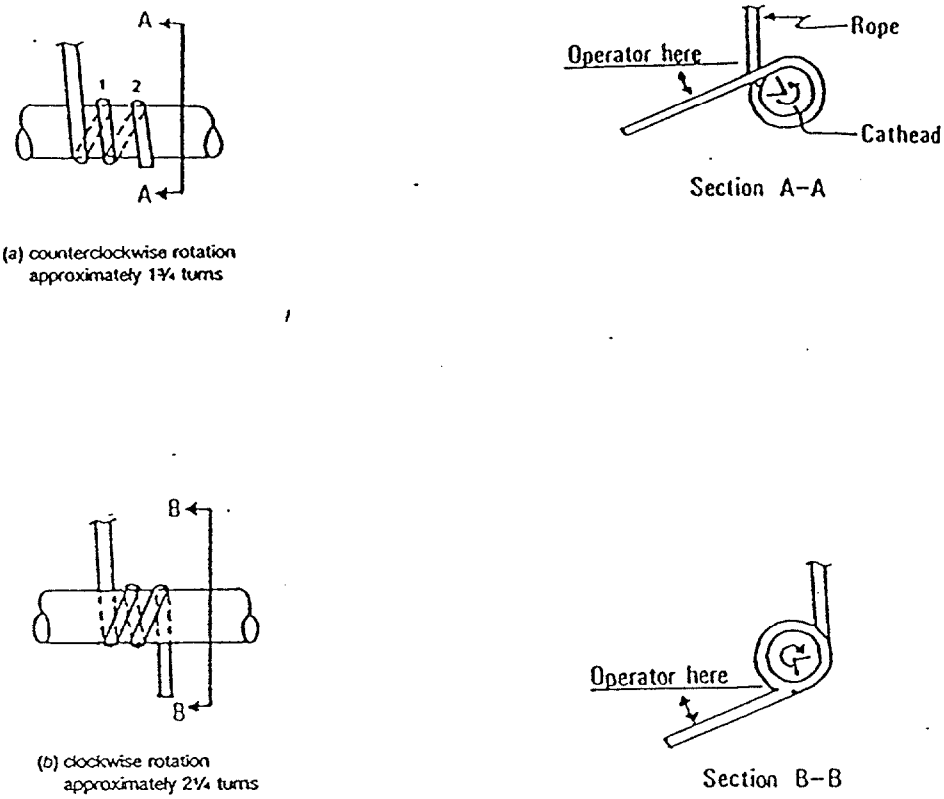


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

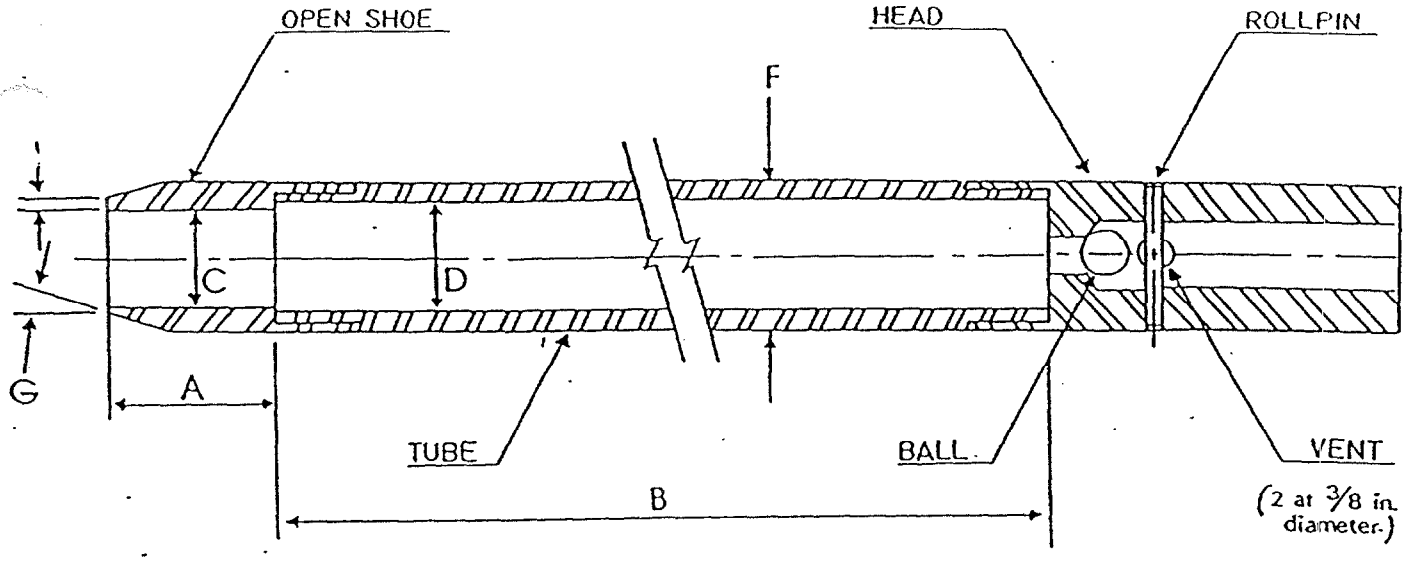
NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-

kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in N-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the mpler and adjusting N on the basis of comparative ies. A method for energy measurement and N-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

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ATTACHMENT B

ASTM D1587-83
STANDARD PRACTICE FOR THIN-WALLED TUBE SAMPLING OF SOILS

Standard Practice for Thin-Walled Tube Sampling of Soils[1]

This standard is issued under the fixed designation D 1587; 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.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes*, should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances*, shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio*, should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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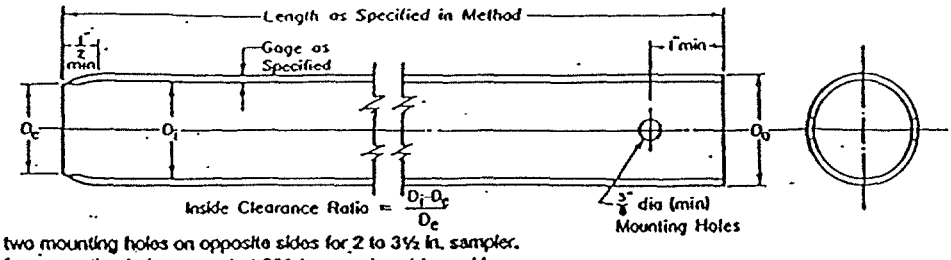
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
¼	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter:			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Clearance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 1[A] Tolerances, in.		
	2	3	5
Outside diameter	+0.007 −0.000	+0.010 −0.000	+0.015 −0.000
Inside diameter	+0.000 −0.007	+0.000 −0.010	+0.000 −0.015
Wall thickness	±0.007	±0.010	±0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.

NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the

markings or labels are adequate to survive transportation and storage.

Report

The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type of coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

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ATTACHMENT C

ASTM D2113-83 (1987)
STANDARD PRACTICE FOR DIAMOND CORE DRILLING FOR SITE INVESTIGATION

Standard Practice for Diamond Core Drilling for Site Investigation[1]

This standard is issued under the fixed designation D 2113; 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 practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

3. Significance and Use

3.1 This practice is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure and which are suitable for standard physical-properties tests and structural-integrity determination.

4. Apparatus

4.1 *Drilling Machine,* capable of providing rotation, feed, and retraction by hydraulic or mechanical means to the drill rods.

4.2 *Fluid Pump or Air Compressor,* capable of delivering sufficient volume and pressure for the diameter and depth of hole to be drilled.

4.3 *Core barrels,* as required:

4.3.1 *Single Tube Type, WG Design,* consisting of a hollow steel tube, with a head at one end threaded for drill rod, and a threaded connection for a reaming shell and core bit at the other end. A core lifter, or retainer located within the core bit is normal, but may be omitted at the discretion of the geologist or engineer.

4.3.2 *Double Tube, Swivel-Type, WG Design*—An assembly of two concentric steel tubes joined and supported at the upper end by means of a ball or roller-bearing swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube. The upper end of the outer tube, or removable head, is threaded for drill rod. A threaded connection is provided on the lower end of the outer tube for a reaming shell and core bit. A core lifter located within the core bit is normal but may be omitted at the discretion of the geologist or engineer.

4.3.3 *Double-Tube, Swivel-Type, WT Design,* is essentially the same as the double tube, swivel-type, WG design, except that the WT design has thinner tube walls, a reduced annular area between the tubes, and takes a larger core from the same diameter bore hole. The core lifter is located within the core bit.

4.3.4 *Double Tube, Swivel Type, WM Design,* is similar to the double tube, swivel-type, WG design, except that the inner tube is threaded at its lower end to receive a core lifter case that effectively extends the inner tube well into the core bit, thus minimizing exposure of the core to the drilling fluid. A core lifter is contained within the core lifter case on the inner tube.

4.3.5 *Double Tube Swivel-Type, Large-Diameter Design,* is similar to the double tube, swivel-type, WM design, with the addition of a ball valve, to control fluid flow, in all three available sizes and the addition of a sludge barrel, to catch heavy cuttings, on the two larger sizes. The large-diameter design double tube, swivel-type, core barrels are available in three core per hole sizes as follows: 2¾ in. (69.85 mm) by 3⅞ in. (98.43 mm), 4 in. (101.6 mm) by 5½ in. (139.7 mm), and 6 in. (152.4 mm) by 7¾ in. (196.85 mm). Their use is generally reserved for very detailed investigative work or where other methods do not yield adequate recovery.

4.3.6 *Double Tube, Swivel-Type, Retrievable Inner-Tube Method,* in which the core-laden inner-tube assembly is retrieved to the surface and an empty inner-tube assembly returned to the face of the borehole through the matching large-bore drill rods without need for withdrawal and replacement of the drill rods in the borehole. The inner-tube assembly consists of an inner tube with removable core lifter case and core lifter at one end and a removable inner-tube head, swivel bearing, suspension adjustment, and latching device with release mechanism on the opposite end. The inner-tube latching device locks into a complementary recess in the wall of the outer tube such that the outer tube may be rotated without causing rotation of the inner tube and such that the latch may be actuated and the inner-tube assembly transported by appropriate surface control. The outer tube is threaded for the matching, large-bore drill rod and internally configured to receive the inner-tube latching device at one end and threaded for a reaming shell and bit, or bit only, at the other end.

4.4 *Longitudinally Split Inner Tubes*—As opposed to conventional cylindrical inner tubes, allow inspection of, and access to, the core by simply removing one of the two halves. They are not standardized but are available for most core barrels including many of the retrievable inner-tube types.

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved June 24, 1983. Published August 1983. Originally published as D 2113 – 62 T. Last previous edition D 2113 – 70 (1976).

[2] *Annual Book of ASTM Standards,* Vol 04.08.

4.5 *Core Bits*—Core bits shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide slugs, or strips, hard-faced with various hard surfacing materials or furnished in saw-tooth form, all as appropriate to the formation being cored and with concurrence of the geologist or engineer. Bit matrix material, crown shape, water-way type, location and number of water ways, diamond size and carat weight, and bit facing materials shall be for general purpose use unless otherwise approved by the geologist or engineer. Nominal size of some bits is shown in Table 1.

NOTE 1—Size designation (letter symbols) used throughout the text and in Tables 1, 2, and 3 are those standardized by the Diamond Core Drill Manufacturers' Assoc. (DCDMA). Inch dimensions in the tables have been rounded to the nearest hundredth of an inch.

4.6 *Reaming Shells*, shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, all as appropriate to the formation being cored.

4.7 *Core Lifters*—Core lifters of the split-ring type, either thin or hard-faced, shall be furnished and maintained, along with core-lifter cases or inner-tube extensions or inner-tube shoes, in good condition. Basket or finger-type lifters, together with any necessary adapters, shall be on the job and available for use with each core barrel if so directed by the geologist or engineer.

4.8 *Casings:*

4.8.1 *Drive Pipe or Drive Casing*, shall be standard weight (schedule 40), extra-heavy (schedule 80), double extra-heavy (schedule 160) pipe or W-design flush-joint casing as required by the nature of the overburden or the placement method. Drive pipe or W-design casing shall be of sufficient diameter to pass the largest core barrel to be used, and it shall be driven to bed rock or to firm seating at an elevation below water-sensitive formation. A hardened drive shoe is to be used as a cutting edge and thread protection device on the bottom of the drive pipe or casing. The drive shoe inside diameter shall be large enough to pass the tools intended for use, and the shoe and pipe or casing shall be free from burrs or obstructions.

4.8.2 *Casing*—When necessary to case through formations already penetrated by the borehole or when no drive casing has been set, auxiliary casing shall be provided to fit inside the borehole to allow use of the next smaller core barrel. Standard sizes of telescoping casing are shown in Table 2. Casing bits have an obstruction in their interior and will not pass the next smaller casing size. Use a casing shoe if additional telescoping is anticipated.

4.8.3 *Casing Liner*—Plastic pipe or sheet-metal pipe may be used to line an existing large-diameter casing. Liners, so used, should not be driven, and care should be taken to maintain true alignment throughout the length of the liner.

4.8.4 *Hollow Stem Auger*—Hollow stem auger may be used as casing for coring.

4.9 *Drill Rods:*

4.9.1 *Drill Rods of Tubular Steel Construction* are normally used to transmit feed, rotation, and retraction forces from the drilling machine to the core barrel. Drill-rod sizes that are presently standardized are shown in Table 3.

4.9.2 Large bore drill rods used with retrievable inner-tube core barrels are not standardized. Drill rods used with retrievable inner-tube core barrels should be those manufactured by the core-barrel manufacturer specifically for the core barrel.

4.9.3 *Composite Drill Rods* are specifically constructed from two or more materials intended to provide specific properties such as light weight or electrical nonconductivity.

4.9.4 *Nonmagnetic Drill Rods* are manufactured of nonferrous materials such as aluminum or brass and are used primarily for hole survey work. Some nonmagnetic rods have left-hand threads in order to further their value in survey work. No standard exists for nonmagnetic rods.

4.10 *Auxiliary Equipment*, shall be furnished as required by the work and shall include: roller rock bits, drag bits, chopping bits, boulder busters, fishtail bits, pipe wrenches, core barrel wrenches, lubrication equipment, core boxes, and marking devices. Other recommended equipment includes:

TABLE 1 Core Bit Sizes

Size Designation	Outside Diameter		Inside Diameter	
	in.	mm	in.	mm
RWT	1.16	29.5	0.375	18.7
EWT	1.47	37.3	0.905	22.9
EWG, EWM	1.47	37.3	0.845	21.4
AWT	1.88	47.6	1.281	32.5
AWG, AWM	1.88	47.6	1.185	30.0
BWT	2.35	59.5	1.750	44.5
BWG, BWM	2.35	59.5	1.655	42.0
NWT	2.97	75.3	2.313	58.7
NWG, NWM	2.97	75.3	2.155	54.7
2¾ × 3⅞	3.84	97.5	2.69	68.3
HWT	3.89	98.8	3.187	80.9
HWG, . . .	3.89	98.8	3.000	76.2
4 × 5½	5.44	138.0	3.97	100.8
6 × 7¾	7.66	194.4	5.97	151.6

TABLE 2 Casing Sizes

Size Designation	Outside Diameter		Inside Diameter		Threads per in.	Will Fit Hole Drilled with Core Bit Size
	in.	mm	in.	mm		
RW	1.144	36.5	1.19	30.1	5	EWT, EWG, EWM
EW	1.81	46.0	1.50	38.1	4	AWT, AWG, AWM
AW	2.25	57.1	1.91	48.4	4	BWT, BWG, BWM
BW	2.88	73.0	2.38	60.3	4	NWT, NWG, NWM
NW	3.50	88.9	3.00	76.2	4	HWT, HWG
HW	4.50	114.3	4.00	101.6	4	4 × 5½
PW	5.50	139.7	5.00	127.0	3	6 × 7¾
SW	6.63	168.2	6.00	152.4	3	6 × 7¾
UW	7.63	193.6	7.00	177.8	2	. . .
ZW	8.63	219.0	8.00	203.2	2	. . .

TABLE 3 Drill Rods

Size Designation	Rod and Coupling Outside Diameter		Rod Inside Diameter		Coupling Bore, Threads		
	in.	mm	in.	mm	in.	mm	per in.
RW	1.09	27.7	0.72	18.2	0.41	10.3	4
EW	1.38	34.9	1.00	25.4	0.44	11.1	3
AW	1.72	43.6	1.34	34.1	0.63	16.0	3
BW	2.13	53.9	1.75	44.4	0.75	19.0	3
NW	2.63	66.6	2.25	57.1	1.38	34.9	3
HW	3.50	88.9	3.06	77.7	2.38	60.3	3

core splitter, rod wicking, pump-out tools or extruders, and hand sieve or strainer.

5. Transportation and Storage of Core Containers

5.1 *Core Boxes*, shall be constructed of wood or other durable material for the protection and storage of cores while enroute from the drill site to the laboratory or other processing point. All core boxes shall be provided with longitudinal separators and recovered cores shall be laid out as a book would read, from left to right and top to bottom, within the longitudinal separators. Spacer blocks or plugs shall be marked and inserted into the core column within the separators to indicate the beginning of each coring run. The beginning point of storage in each core box is the upper left-hand corner. The upper left-hand corner of a hinged core box is the left corner when the hinge is on the far side of the box and the box is right-side up. All hinged core boxes must be permanently marked on the outside to indicate the top and the bottom. All other core boxes must be permanently marked on the outside to indicate the top and the bottom and additionally, must be permanently marked internally to indicate the upper-left corner of the bottom with the letters UL or a splotch of red paint not less than 1 in.^{2} Lid or cover fitting(s) for core boxes must be of such quality as to ensure against mix up of the core in the event of impact or upsetting of the core box during transportation.

5.2 Transportation of cores from the drill site to the laboratory or other processing point shall be in durable core boxes so padded or suspended as to be isolated from shock or impact transmitted to the transporter by rough terrain or careless operation.

5.3 Storage of cores, after initial testing or inspection at the laboratory or other processing point, may be in cardboard or similar less costly boxes provided all layout and marking requirements as specified in 5.1 are followed. Additional spacer blocks or plugs shall be added if necessary at time of storage to explain missing core. Cores shall be stored for a period of time specified by the engineer but should not normally be discarded prior to completion of the project for which they were taken.

6. Procedure

6.1 Use core-drilling procedures when formations are encountered that are too hard to be sampled by soil-sampling methods. A 1-in. (25.4-mm) or less penetration for 50 blows in accordance with Method D 1586 or other criteria established by the geologist or engineer, shall indicate that soil-sampling methods are not applicable.

6.1.1 Seat the casing on bedrock or in a firm formation to event raveling of the borehole and to prevent loss of drilling fluid. Level the surface of the rock or hard formation at the bottom of the casing when necessary, using the appropriate bits. Casing may be omitted if the borehole will stand open without the casing.

6.1.2 Begin the core drilling using an N-size double-tube swivel-type core barrel or other size or type approved by the engineer. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled in. Remove the core barrel from the hole and disassemble it as necessary to remove the core. Reassemble the core barrel and return it to the hole. Resume coring.

6.1.3 Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box as described in 5.1. Continue boxing core with appropriate markings, spacers, and blocks as described in 5.1. Wrap soft or friable cores or those which change materially upon drying in plastic film or seal in wax, or both, when such treatment is required by the engineer. Use spacer blocks or slugs properly marked to indicate any noticeable gap in recovered core which might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.

6.1.4 Stop the core drilling when soft materials are encountered that produce less than 50 % recovery. If necessary, secure samples of soft materials in accordance with the procedures described in Method D 1586, Practice D 1587, or Practice D 3550, or by any other method acceptable to the geologist or engineer. Resume diamond core drilling when refusal materials as described in 6.1 are again encountered.

6.2 Subsurface structure, including the dip of strata, the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described. Take special care to obtain and record information about these features. If conditions prevent the continued advance of the core drilling, the hole should be cemented and redrilled, or reamed and cased, or cased and advanced with the next smaller-size core barrel, as required by the geologist or engineer.

6.3 Drilling mud or grouting techniques must be approved by the geologist or engineer prior to their use in the borehole.

6.4 *Compatibility of Equipment:*

6.4.1 Whenever possible, core barrels and drill rods should be selected from the same letter-size designation to ensure maximum efficiency. See Tables 1 and 3.

6.4.2 Never use a combination of pump, drill rod, and core barrel that yields a clear-water up-hole velocity of less than 120 ft/min.

6.4.3 Never use a combination of air compressor, drill rod, and core barrel that yields a clear-air up-hole velocity of less than 3000 ft/min.

7. Boring Log

7.1 The boring log shall include the following:

7.1.1 Project identification, boring number, location, date boring began, date boring completed, and driller's name.

7.1.2 Elevation of the ground surface.

7.1.3 Elevation of or depth to ground water and raising or lowering of level including the dates and the times measured.

7.1.4 Elevations or depths at which drilling fluid return was lost.

7.1.5 Size, type, and design of core barrel used. Size, type, and set of core bit and reaming shell used. Size, type, and length of all casing used. Description of any movements of the casing.

7.1.6 Length of each core run and the length or percentage, or both, of the core recovered.

7.1.7 Geologist's or engineer's description of the formation recovered in each run.

7.1.8 Driller's description, if no engineer or geologist is present, of the formation recovered in each run.

7.1.9 Subsurface structure description, including dip of strata and jointing, cavities, fissures, and any other observations made by the geologist or engineer that could yield information regarding the formation.

7.1.10 Depth, thickness, and apparent nature of the filling of each cavity or soft seam encountered, including opinions gained from the feel or appearance of the inside of the inner tube when core is lost. Record opinions as such.

7.1.11 Any change in the character of the drilling fluid or drilling fluid return.

7.1.12 Tidal and current information when the borehole is sufficiently close to a body of water to be affected.

7.1.13 Drilling time in minutes per foot and bit pressure in pound-force per square inch gage when applicable.

7.1.14 Notations of character of drilling, that is, soft, slow, easy, smooth, etc.

8. Precision and Bias

8.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and text references are included as a convenience to the user since the vast majority of tools in use do meet DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

SAMPLING EXCERPTS FROM SW-846 METHOD 5035

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

Refer to the introductory material in this chapter, Organic Analytes, Sec. 4.1, for general sample collection information. The low concentration portion of this method employs sample vials that are filled and weighed in the field and never opened during the analytical process. As a result, sampling personnel should be equipped with a portable balance capable of weighing to 0.01 g.

6.1 Preparation of sample vials

The specific preparation procedures for sample vials depend on the expected concentration range of the sample, with separate preparation procedures for low concentration soil samples and high concentration soil and solid waste samples. Sample vials should be prepared in a fixed laboratory or other controlled environment, sealed, and shipped to the field location. Gloves should be worn during the preparation steps.

6.1.1 Low concentration soil samples

The following steps apply to the preparation of vials used in the collection of low concentration soil samples to be analyzed by the closed-system purge-and-trap equipment described in Method 5035.

6.1.1.1 Add a clean magnetic stirring bar to each clean vial. If the purge-and-trap device (Sec. 4.2) employs a means of stirring the sample other than a magnetic stirrer (e.g., sonication or other mechanical means), then the stir bar is omitted.

6.1.1.2 Add preservative to each vial. The preservative is added to each vial prior to shipping the vial to the field. Add approximately 1 g of sodium bisulfate to each vial. If samples markedly smaller or larger than 5 g are to be collected, adjust the amount of preservative added to correspond to approximately 0.2 g of preservative for each 1 g of sample. Enough sodium bisulfate should be present to ensure a sample pH of ≤ 2.

6.1.1.3 Add 5 mL of organic-free reagent water to each vial. The water and the preservative will form an acid solution that will reduce or eliminate the majority of the biological activity in the sample, thereby preventing biodegradation of the volatile target analytes.

6.1.1.4 Seal the vial with the screw-cap and septum seal. If the double-ended, fritted, vials are used, seal both ends as recommended by the manufacturer.

6.1.1.5 Affix a label to each vial. This eliminates the need to label the vials in the field and assures that the tare weight of the vial includes the label. (The weight of any markings added to the label in the field is negligible).

6.1.1.6 Weigh the prepared vial to the nearest 0.01 g, record the tare weight, and write it on the label.

6.1.1.7 Because volatile organics will partition into the headspace of the vial from the aqueous solution and will be lost when the vial is opened, surrogates, matrix spikes, and internal standards (if applicable) should only be added to the vials after the sample has been added to the vial. These standards should be introduced back in the

laboratory, either manually by puncturing the septum with a small-gauge needle or automatically by the sample introduction system, just prior to analysis.

6.1.2 High concentration soil samples collected without a preservative

When high concentration samples are collected without a preservative, a variety of sample containers may be employed, including 60-mL glass vials with septum seals (see Sec. 4.4).

6.1.3 High concentration soil samples collected and preserved in the field

The following steps apply to the preparation of vials used in the collection of high concentration soil samples to be preserved in the field with methanol and analyzed by the aqueous purge-and-trap equipment described in Method 5030.

6.1.3.1 Add 10 mL of methanol to each vial.

6.1.3.2 Seal the vial with the screw-cap and septum seal.

6.1.3.3 Affix a label to each vial. This eliminates the need to label the vials in the field and assures that the tare weight of the vial includes the label. (The weight of any markings added to the label in the field is negligible).

6.1.3.4 Weigh the prepared vial to the nearest 0.01 g, record the tare weight, and write it on the label.

NOTE: Vials containing methanol should be weighed a second time on the day that they are to be used. Vials found to have lost methanol (reduction in weight of >0.01 g) should not be used for sample collection.

6.1.3.5 Surrogates, internal standards and matrix spikes (if applicable) should be added to the sample after it is returned to the laboratory and prior to analysis.

6.1.4 Oily waste samples

When oily waste samples are known to be soluble in methanol or PEG, sample vials may be prepared as described in Sec. 6.1.3, using the appropriate solvent. However, when the solubility of the waste is unknown, the sample should be collected without the use of a preservative, in a vial such as that described in Sec. 6.1.2.

6.2 Sample collection

Collect the sample according to the procedures outlined in the sampling plan. As with any sampling procedure for volatiles, care must be taken to minimize the disturbance of the sample in order to minimize the loss of the volatile components. Several techniques may be used to transfer a sample to the relatively narrow opening of the low concentration soil vial. These include devices such as the EnCore™ sampler, the Purge-and-Trap Soil Sampler ™, and a cut plastic syringe. Always wear gloves whenever handling the tared sample vials.

6.2.1 Low concentration soil samples

6.2.1.1 Using an appropriate sample collection device, collect approximately 5 g of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere: generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.

6.2.1.2 Using the sample collection device, add about 5 g (2 - 3 cm) of soil to the sample vial containing the preservative solution. Quickly brush any soil off the vial threads and immediately seal the vial with the septum and screw-cap. Store samples on ice at 4°C.

NOTE: Soil samples that contain carbonate minerals (either from natural sources or applied as an amendment) may effervesce upon contact with the acidic preservative solution in the low concentration sample vial. If the amount of gas generated is very small (i.e., several mL), any loss of volatiles as a result of such effervescence may be minimal if the vial is sealed quickly. However, if larger amounts of gas are generated, not only may the sample lose a significant amount of analyte, but the gas pressure may shatter the vial if the sample vial is sealed. Therefore, when samples are known or suspected to contain high levels of carbonates, a test sample should be collected, added to a vial, and checked for effervescence. If a rapid or vigorous reaction occurs, discard the sample and collect low concentration samples in vials that do not contain the preservative solution.

6.2.1.3 When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers employed (Sec. 4.5.5). Record the weight of the sealed vial containing the sample to the nearest 0.01 g.

6.2.1.4 Alternatively, collect several trial samples with plastic syringes. Weigh each trial sample and note the length of the soil column in the syringe. Use these data to determine the length of soil in the syringe that corresponds to 5.0 ± 0.5 g. Discard each trial sample.

6.2.1.5 As with the collection of aqueous samples for volatiles, collect at least two replicate samples. This will allow the laboratory an additional sample for reanalysis. The second sample should be taken from the same soil stratum or the same section of the solid waste being sampled, and within close proximity to the location from which the original sample was collected.

6.2.1.6 In addition, since the soil vial cannot be opened without compromising the integrity of the sample, at least one additional aliquot of sample must be collected for screening, dry weight determination, and high concentration analysis (if necessary). This third aliquot may be collected in a 60-mL glass vial or a third 40-mL soil sample vial. However, this third vial must *not* contain the sample preservative solution, as an aliquot will be used to determine dry weight. If high concentration samples are collected in vials containing methanol, then two additional aliquots should be collected, one for high concentration analysis collected in a vial containing methanol, and another for the dry weight determination in a vial without either methanol or the low concentration aqueous preservative solution.

6.2.1.7 If samples are known or expected to contain target analytes over a wide range of concentrations, thereby requiring the analyses of multiple sample aliquots, it may be advisable and practical to take an additional sample aliquot in a low concentration soil vial containing the preservative, but collecting only 1-2 g instead of the 5 g collected in Sec. 6.2.1.1. This aliquot may be used for those analytes that exceed the instrument calibration range in the 5-g analysis.

6.2.1.8 The EnCore™ sampler has not been thoroughly evaluated by EPA as a sample storage device. While preliminary results indicate that storage in the EnCore™ device may be appropriate for up to 48 hours, samples collected in this device should be transferred to the soil sample vials as soon as possible, or analyzed within 48 hours.

6.2.1.9 The collection of low concentration soil samples in vials that contain methanol is <u>not</u> appropriate for samples analyzed with the closed-system purge-and-trap equipment described in this method (see Sec. 6.2.2).

6.2.2 High concentration soil samples preserved in the field

The collection of soil samples in vials that contain methanol has been suggested by some as a combined preservation and extraction procedure. However, this procedure is <u>not</u> appropriate for use with the low concentration soil procedure described in this method.

<u>NOTE</u>: The use of methanol preservation has not been formally evaluated by EPA and analysts must be aware of two potential problems. First, the use of methanol as a preservative and extraction solvent introduces a significant dilution factor that will raise the method quantitation limit beyond the operating range of the low concentration direct purge-and-trap procedure (0.5-200 µg/kg). The exact dilution factor will depend on the masses of solvent and sample, but generally exceeds 1000, and may make it difficult to demonstrate compliance with regulatory limits or action levels for some analytes. Because the analytes of interest are volatile, the methanol extract cannot be concentrated to overcome the dilution problem. Thus, for samples of unknown composition, it may still be necessary to collect an aliquot for analysis by this closed-system procedure and another aliquot preserved in methanol and analyzed by other procedures. The second problem is that the addition of methanol to the sample is likely to cause the sample to fail the ignitability characteristic, thereby making the unused sample volume a hazardous waste.

6.2.2.1 When samples are <u>known</u> to contain volatiles at concentrations high enough that the dilution factor will not preclude obtaining results within the calibration range of the appropriate determinative method, a sample may be collected and immediately placed in a sample vial containing purge-and-trap grade methanol.

6.2.2.2 Using an appropriate sample collection device, collect approximately 5 g of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere: generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.

6.2.2.3 Using the sample collection device, add about 5 g (2 - 3 cm) of soil to the vial containing 10 mL of methanol. Quickly brush any soil off the vial threads and immediately seal the vial with the septum and screw-cap. Store samples on ice at 4°C.

6.2.2.4 When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers employed (Sec. 4.5.5). Record the weight of the sealed vial containing the sample to the nearest 0.01 g.

6.2.2.5 Alternatively, collect several trial samples with plastic syringes. Weigh each trial sample and note the length of the soil column in the syringe. Use these data to determine the length of soil in the syringe that corresponds to 5.0 ± 0.5 g. Discard each trial sample.

6.2.2.6 Other sample weights and volumes of methanol may be employed, provided that the analyst can demonstrate that the sensitivity of the overall analytical procedure is appropriate for the intended application.

6.2.2.7 The collection of at least one additional sample aliquot is required for the determination of the dry weight, as described in Sec. 6.2.1.6. Samples collected in methanol should be shipped as described in Sec. 6.3, and must be clearly labeled as containing methanol, so that the samples are not analyzed using the closed-system purge-and-trap equipment described in this procedure.

6.2.3 High concentration soil sample <u>not</u> preserved in the field

The collection of high concentration soil samples that are not preserved in the field generally follows similar procedures as for the other types of samples described in Secs. 6.2.1 and 6.2.2, with the obvious exception that the sample vials contain neither the aqueous preservative solution nor methanol. However, when field preservation is not employed, it is better to collect a larger volume sample, filling the sample container as full as practical in order to minimize the headspace. Such collection procedures generally do not require the collection of a separate aliquot for dry weight determination, but it may be advisable to collect a second sample aliquot for screening purposes, in order to minimize the loss of volatiles in either aliquot.

6.2.4 Oily waste samples

The collection procedures for oily samples depend on knowledge of the waste and its solubility in methanol or other solvents.

6.2.4.1 When an oily waste is <u>known</u> to be soluble in methanol or PEG, the sample may be collected in a vial containing such a solvent (see Sec. 6.1.4), using procedures similar to those described in Sec. 6.2.2.

6.2.4.2 When the solubility of the oily waste is <u>not</u> known, the sample should either be collected in a vial without a preservative, as described in Sec. 6.2.3, or the solubility of a trial sample should be tested in the field, using a vial containing solvent. If the trial sample is soluble in the solvent, then collect the oily waste sample as described in Sec. 6.2.2. Otherwise, collect an unpreserved sample as described in Sec. 6.2.3.

6.3 Sample handling and shipment

All samples for volatiles analysis should be cooled to approximately 4°C, packed in appropriate containers, and shipped to the laboratory on ice, as described in the sampling plan.

6.4 Sample storage

6.4.1 Once in the laboratory, store samples at 4°C until analysis. The sample storage area should be free of organic solvent vapors.

6.4.2 All samples should be analyzed as soon as practical, and within the designated holding time from collection. Samples not analyzed within the designated holding time must be noted and the data are considered minimum values.

6.4.3 When the low concentration samples are strongly alkaline or highly calcareous in nature, the sodium bisulfate preservative solution may not be strong enough to reduce the pH of the soil/water solution to below 2. Therefore, when low concentration soils to be sampled are known or suspected to be strongly alkaline or highly calcareous, additional steps may be required to preserve the samples. Such steps include: addition of larger amounts of the sodium bisulfate preservative to non-calcareous samples, storage of low concentration samples at -10°C (taking care not to fill the vials so full that the expansion of the water in the vial breaks the vial), or significantly reducing the maximum holding time for low concentration soil samples. Whichever steps are employed, they should be clearly described in the sampling and QA project plans and distributed to both the field and laboratory personnel. See Sec. 6.2.1.2 for additional information.

APPENDIX B
GROUNDWATER SAMPLE ACQUISITION

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ATTACHMENT A -- ASTM D4448-85A STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS

ATTACHMENT B -- ASTM D6001-96 STANDARD GUIDE FOR DIRECT PUSH WATER SAMPLING FOR GEOENVIRONMENTAL INVESTIGATIONS

ATTACHMENT C -- GROUNDWATER MONITORING GUIDANCE MANUAL, COMMONWEALTH OF PENNSYLVANIA, DEPARTMENT OF ENVIRONMENTAL PROTECTION, ACT 2, FEBRUARY 29, 1996

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 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in accordance with the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

5.0 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. Specific methods

shall be stated in the Sampling and Analysis Plan (SAP). Also refer to Attachment B which is ASTM D6001-96, Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations.

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 or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.

2. Wells that can be pumped or bailed 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.

5.1 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; turbidity 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, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary).

6. Pails: Plastic, graduated.

7. Decontamination equipment and materials: discussed in SOP F501 and F502.

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.

5.2 Calculations of Well Volume for Purging

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 inside diameter of well or casing (D).

3. Measure and record static water level (DW-depth to water below ground level or top of casing reference point) to the nearest 0.01-foot, using one of the methods described in Section 5.1 of SOP F202.

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 the volume of water in the casing:

$$V_W = \frac{\pi D_2}{4} (TD - DW)$$

$$V_{gal} = V_W \times 7.48 \text{ gallons/ft}^3$$

Where:

V_W=Volume of water standing in well in cubic feet (i.e., one well volume)
π=pi, 3.14
D=Inside diameter of well, in feet
TD=Total depth of well in feet (below ground surface or top of casing)
DW=Depth to water in feet (below ground surface or top of casing)

6. Calculate 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.)

$$V_{purge} = Vgal (\# \text{ Well Vol})$$

Where:

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)

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

TABLE 5-1
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

5.3 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 Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, turbidity, and water temperature until the values stabilize. Values are considered to have stabilized when deviation is less than 10 percent of the mean. 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.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.3.1 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.

Advantages of suction pumps include:

- Few limitations with regards to well diameter
- Inexpensive
- Portable
- Readily available
- Tubing can be dedicated or easily decontaminated

Limitations on the use of suction pumps include the following:

- External power source
- Vacuum will cause loss of dissolved gas, including volatile organics
- Restricted to areas with water levels within 10 to 25 feet of the ground surface
- Internal components of the 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.

5.4 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.

5.4.1 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 according to Section 5.2 of this SOP.

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. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.

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, pH, and turbidity 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 (see SOP F301). 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 (semi-volatiles 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 (see SOP F301). 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.

5.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. SOP F301 describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in USEPA Standard Operating Procedures and Quality Assurance Manual (USEPA, 1991) and SOP F301.

5.4.3 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. SOP F301 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Sample volume and preservation requirements shall follow those given in USEPA, 1991, and SOP F301.

5.4.4 Field Filtration

In general, preparation and preservation of water samples for dissolved inorganics involve some form of filtration. All samples will be filtered in the field the same day as collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

Filtration and preservation are to occur in the field on the same day as collected with the sample aliquot passing through a dedicated disposable 0.45 micron filter. Samples for organic analyses shall never be filtered.

5.4.5 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. Sample packing and transportation requirements are described in SOP F301.

5.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in USEPA, 1991, and SOP F301.

6.0 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. SOP F302 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

7.0 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, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

ATTACHMENT A

ASTM D4448-85A
STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS

Designation: D 4448 – 85a

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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.

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[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.

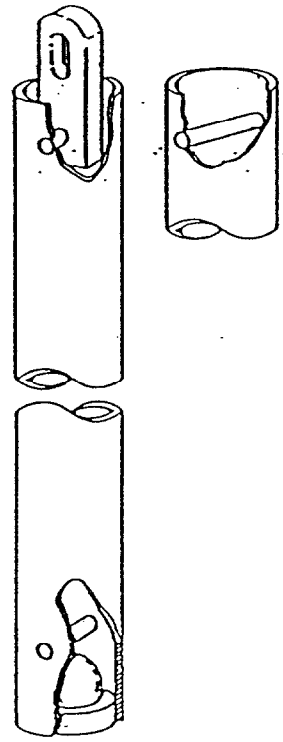
4. Well Flushing (Purging)

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 sample 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.

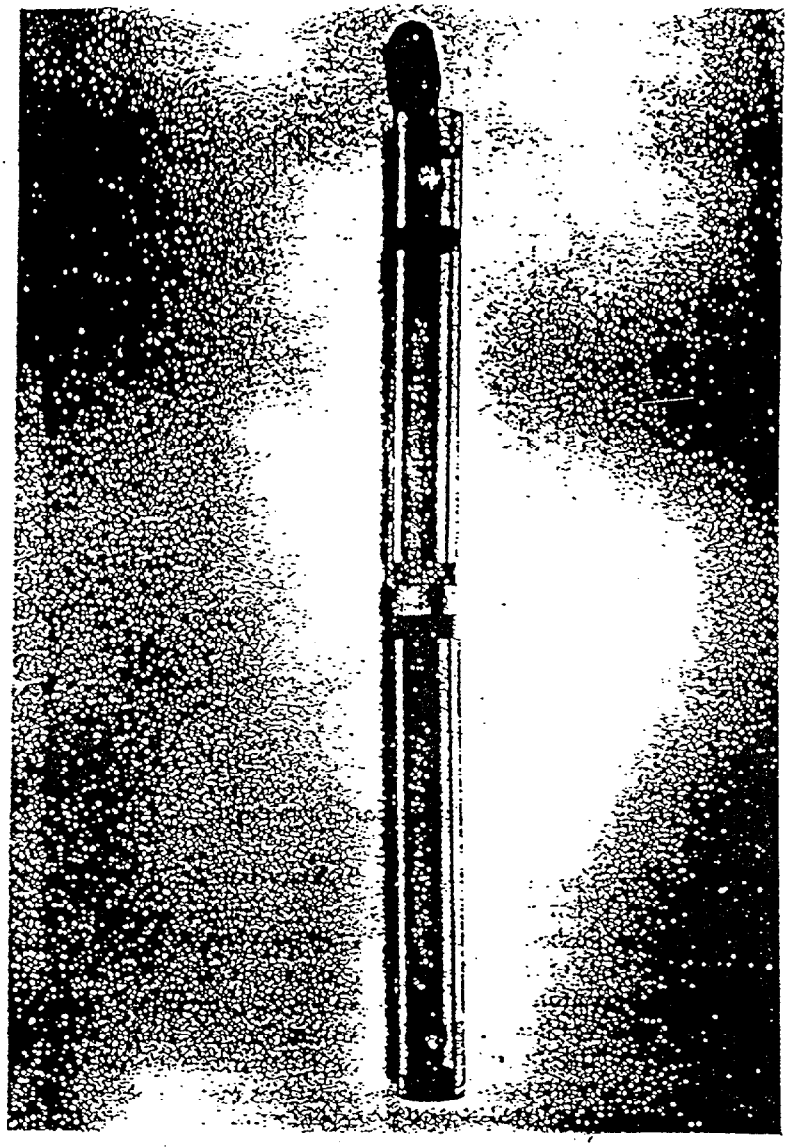
4.7 In any flushing approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around a well and can cause contaminants that were not present originally to be drawn into the well.

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

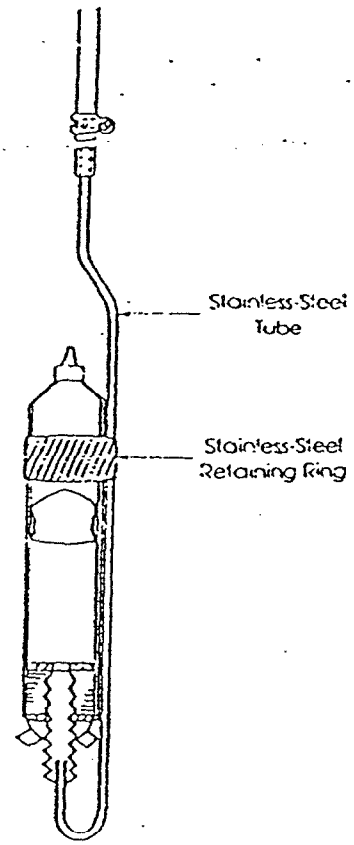
groundwater samples from monitoring well casings sealed with PVC solvent cement. Pollutant phthalate esters (8, 10) are often found in water samples at ppb levels; the EPA has found them on occasion at ppm levels in their samples. The ubiquitous presence of these phthalate esters is unexplained, except 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 in field. Stainless steel is strongly and easily machined to



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 nonplastic (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 evalua which should be useful in such environmental evaluati (10, 12).

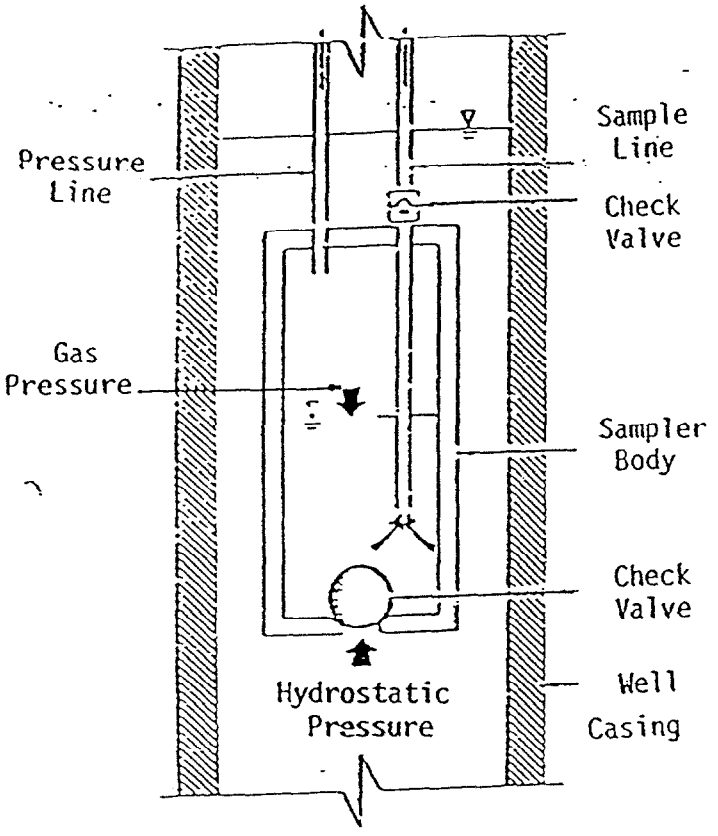
6. Sampling Equipment

6.1 There is a fairly large choice of equipment prese available for groundwater sampling from single scre wells and well clusters. The sampling devices can be ca 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 pr valid samples once the well has been flushed. They ar practical for removal of large volumes of water. T devices can be constructed in various shapes and sizes fr variety of materials. They do not subject the samp pressure extremes.

6.1.1.2 Bailers do expose part of the sample t atmosphere during withdrawal. Bailers used for sampli volatile organic compounds should have a sample co draft valve in or near the bottom of the sampler all withdrawal of a sample from the well below the ex surface of the water or the first few inches of the s should be discarded. Suspension lines for bailers and samplers should be kept off the ground and free of contaminating materials that could be carried into th Down-hole devices are not very practical for use i



NOTE—Taken from Ref (5).

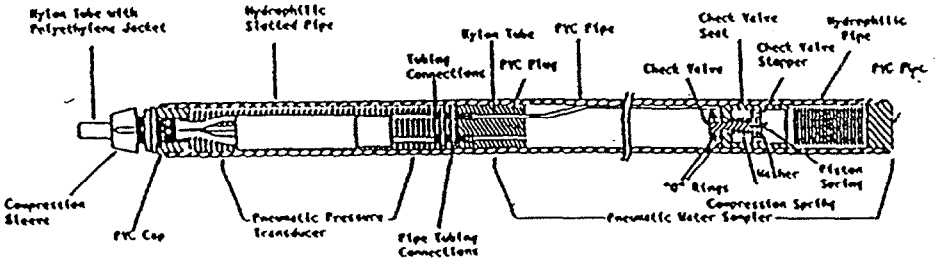
FIG. 4 The Principal of Gas Displacement Pumping

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).

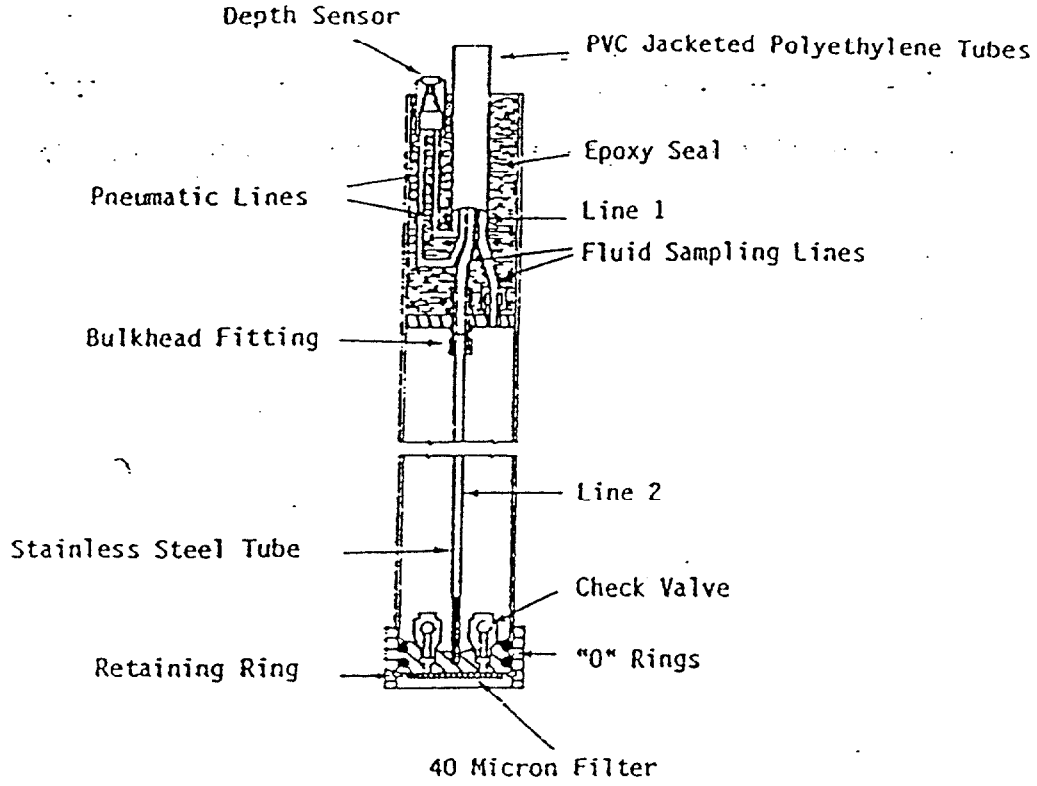
6.1.1.4 In operation, the single check valve bailer is lowered into the well, water enters the chamber through the bottom, and the weight of the water column closes the check valve upon bailer retrieval. The specific gravity of the ball should be about 1.4 to 2.0 so that the ball almost sits on the check 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.

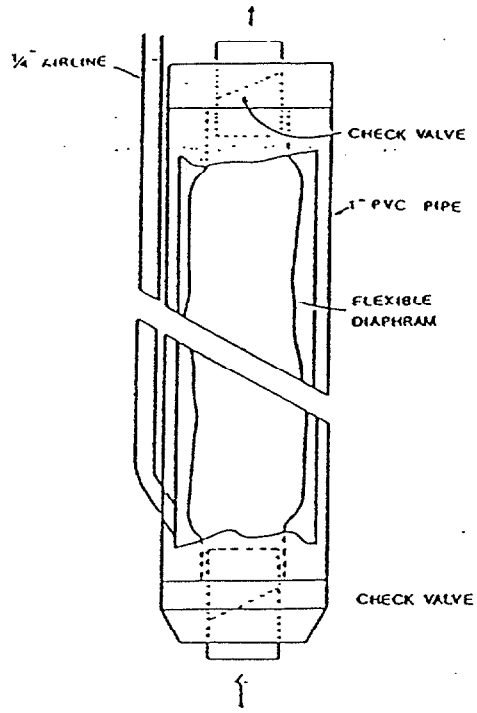
6.1.1.6 Another approach for obtaining point source samples employs a weighted messenger or pneumatic change to "trip" plugs at either end of an open tube (for example, tube water sampler or thief sampler) to close the chamber (18). Foerst, Kemmerer, and Bacon samplers are of this variety (14, 17, 19). 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 various materials and shapes.

6.1.2 *Suction Lift Pumps:*

6.1.2.1 Three types of suction lift pumps are the direct line, centrifugal, and peristaltic. A major disadvantage of any suction pump is that it is limited in its ability to raise water by the head available from atmospheric pressure. Thus, if the surface of the water is more than about 25 ft below the pump, water may not be withdrawn. The theoretical suction limit is about 34 ft, but most suction pumps are capable of maintaining a water lift of only 25 ft or less.

6.1.2.2 Many suction pumps draw the water through some sort of volute in which impellers, pistons, or other devices operate to induce a vacuum. Such pumps are probably unacceptable for most sampling purposes because they are usually constructed of common materials such as brass or mild steel and may expose samples to lubricants. They often induce very low pressures around rotating vanes or other such parts such that degassing or even cavitation may occur. They can mix air with the sample via small leaks in the casing, and they are difficult to adequately clean between uses. Such pumps are acceptable for purging of wells, but should not generally be used for sampling.

6.1.2.3 One exception to the above statements is a peristaltic pump. A peristaltic pump is a self-priming, low volume suction pump which consists of a rotor with ball bearing rollers (21). Flexible tubing is inserted around the pump rotor and squeezed by heads as they revolve in a circular pattern around the rotor. One end of the tubing is placed into the well while the other end can be connected



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 can then be drawn directly into the collection vessel without 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.

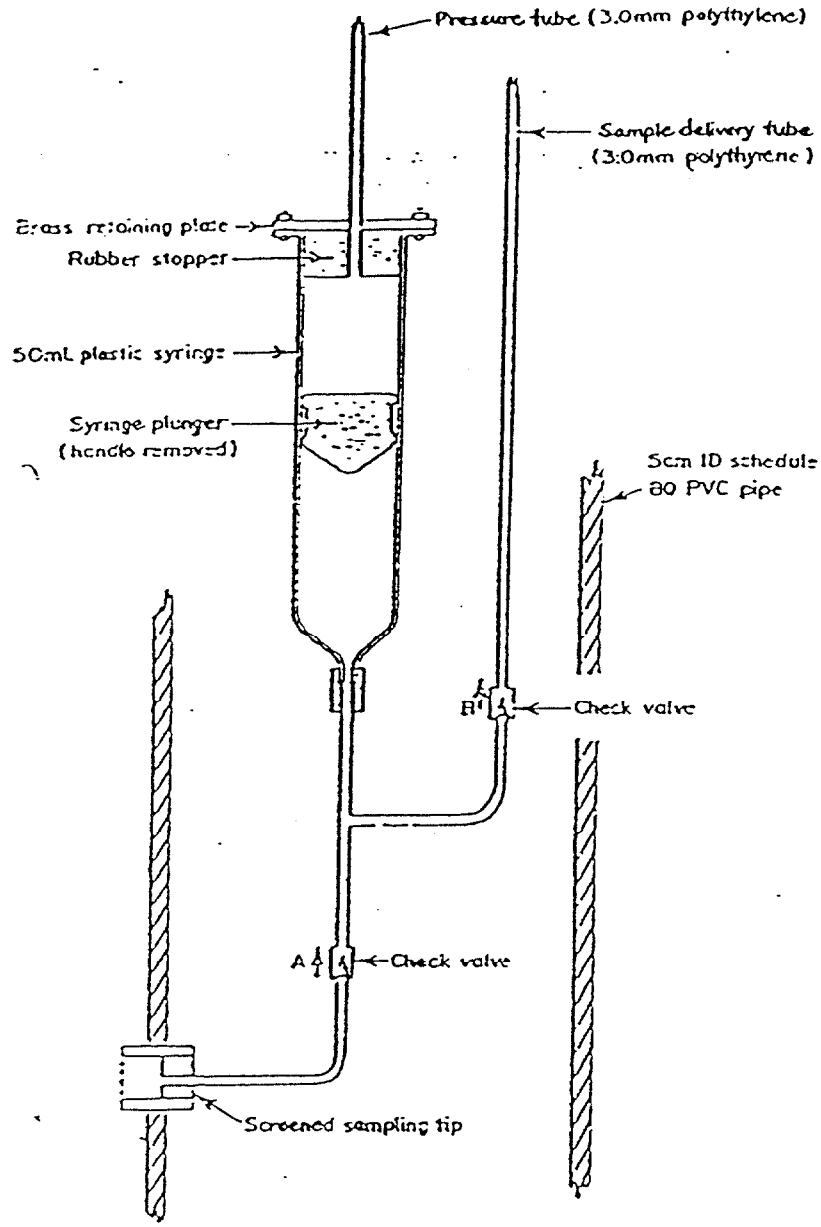
6.1.2.8 All three systems can be specially designed so that the water sample contacts only the TFE flourocarbon or silicone tubing prior to sample bottle entry. Separate tubing is recommended for each well or piezometer sampled.

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 discharge rates for water withdrawal at depths beyond suction

[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

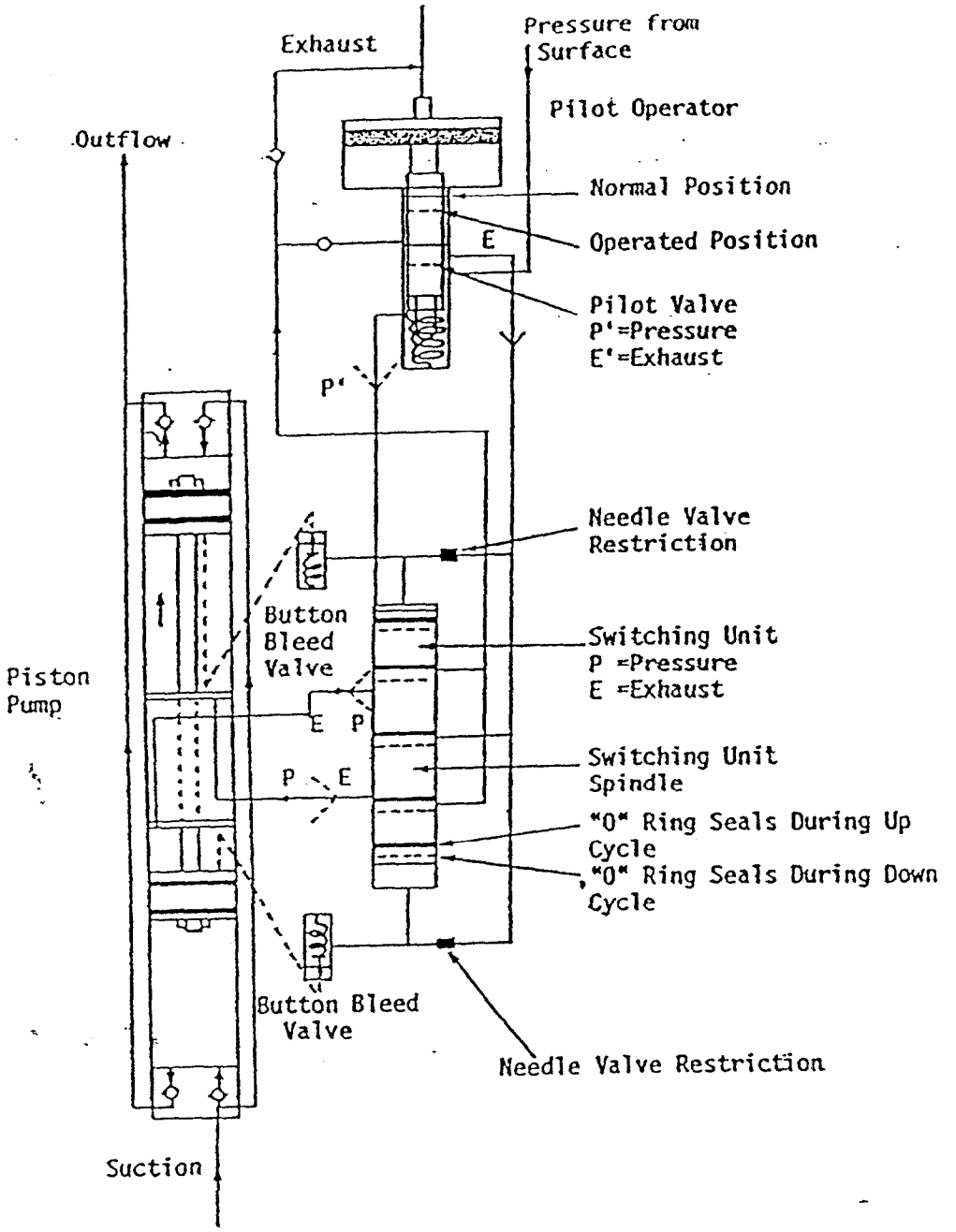
lift capabilities. A battery operated unit 3.6 cm (1.4 in.) in diameter and with a 4.5 Lpm (1.2 gpm) flow rate at 33.5 m (110 ft) has been developed (27). Another submersible pump has an outer diameter of 11.4 cm (4.5 in.) and can pump water from 91 m (300 ft). Pumping rates vary up to 53.0 Lpm (14 gpm) 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 water sample to the surface. Water is forced up an eductor pipe that may be the outer casing or a smaller diameter pipe inserted into the well annulus below the water level (30, 31).

6.1.4.2 A similar principle is used for a unit that consists of a small diameter plastic tube perforated in the lower end. This tube is placed within another tube of slightly larger diameter. Compressed air is injected into the inner tube; the air bubbles through the perforations, thereby lifting the water sample via the annulus between the outer and inner tubing (32). In practice, the eductor line should be submerged to a depth equal to 60 % of the total submerged eductor length during pumping (26). A 60 % ratio is considered optimal although a 30 % submergence ratio is adequate.



NOTE—Taken from Ref (49).

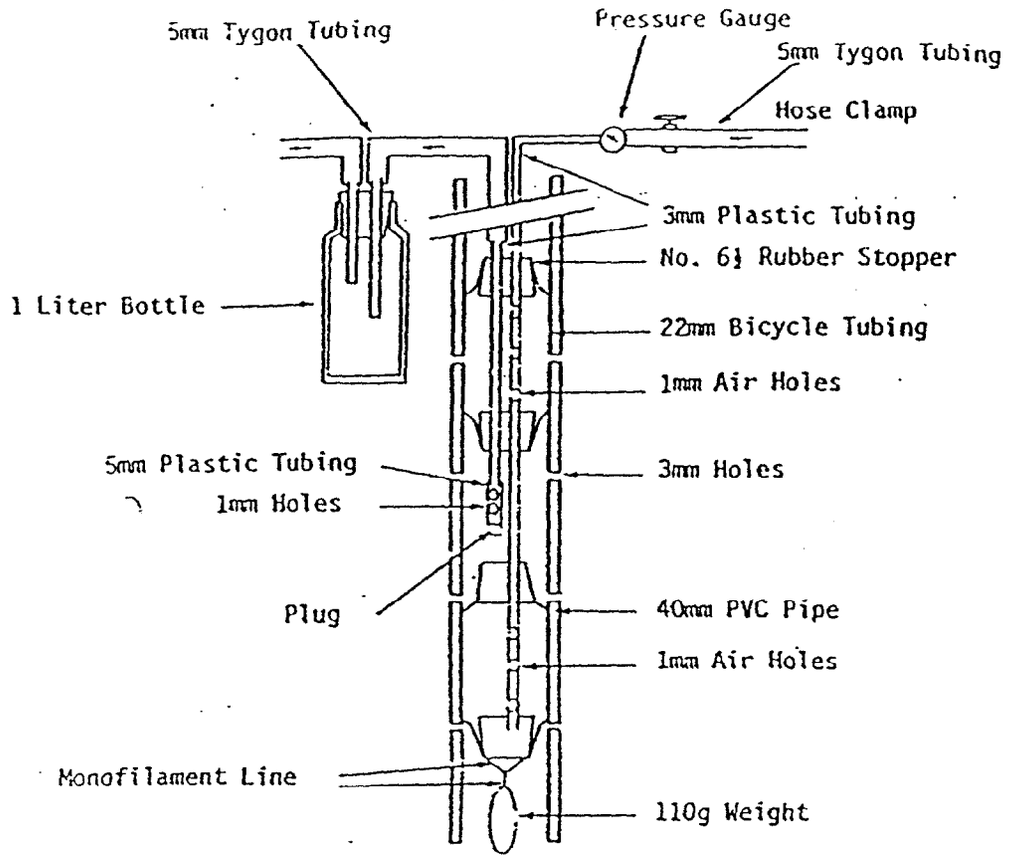
FIG. 9 Gas Driven Piston Pump

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 F[illegible]. Water fills the chamber. A positive pressure is applied t[illegible]



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-entering the bladder by the top check valve. The process is repeated to cycle the water to the surface. Samples taken from depths of 30.5 m (100 ft) have been reported.

6.1.6.2 A variety of design modifications and materials are available (43, 44). Bladder materials include neoprene rubber, ethylene propylene terpolymer (E.P.T.), nitrile, and the fluorocarbon Viton.[3] A bladder made of TFE-fluoro carbon is also under development (45). Automated sampling systems have been developed to control the time between pressurization cycles (46).

6.1.6.3 Bladder pumps provide an adaptable sampling tool due primarily to the number of bladder shapes that are feasible. These devices have a distinct advantage over gas displacement pumps in that there is no contact with the driving gas. Disadvantages include the large gas volume required, low pumping rates, and potential contamination from many of the bladder materials, the rigid housing, or 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 forrmost 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 special cases where it might be prudent to include a record thermometer in the sample shipment to verify the maximum 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 pre-cleaned, 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 laboratory coordinator beforehand. This is especially the case since some analyses and preservation measures must be performed 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 screw-cap 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 to be analyzed for acrolein or acrylonitrile (in which case they are to be analyzed within 3 days). For samples for solvent extractions (extractable organics-base neutrals, acids and

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 on the concentration of each specific dissolved component, not the total concentration of each. Samples for these types of measurements should be filtered through 0.45 μm membrane filters ideally in the field or possibly at an on-site laboratory as soon as possible. Analyses often requiring filtered samples include all metals, radioactivity parameters, total organic carbon, dissolved orthophosphate (if needed), and total dissolved phosphorous (if needed) (13, 14). If metals are to be analyzed, filter the sample prior to acid preservation. For TOC organics, the filter material should be tested to assure that it does not contribute to the TOC. The type or size of the filter to be used is not well understood. However, if results of metal, TOC or other parameters that could be effected by solids are to be compared, the same filtering procedure must be used in each case. Repeated analytical results should state whether the samples were filtered and how they were filtered.

7.8 Shipment and receipt of samples must be coordinated with the laboratory to minimize time in transit. All sample for organic analysis (and many other parameters), should arrive at the laboratory within one day after it is shipped and be maintained at about 4°C with wet ice. The best way to get them to the laboratory in good condition is to send them in sturdy insulated ice chests (coolers) equipped with bottle dividers. 24-h courier service is recommended, if personal 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) Lounsman, 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 f Data Acquisition and Data Quality Evaluation in Environment Chemistry," *Analytical Chemistry*, Vol 52, 1980, pp. 2242–2249

(13) *Procedures Manual for Ground Water Monitoring at Solid Wa Disposal Facilities*, EPA/530/SW-611, August 1977.

(14) *Handbook for Sampling and Sample Preservation of Water a Wastewater*, U.S. Dept. of Commerce NTIS PB-259 946, Se tember 1976.

(15) Timco Manufacturing Co., Inc., "Variable Capacity Bailer," *Tim Geotechnical Catalogue*, Prairie du Sac, WI, 1982.

(16) deVera, E., Simmons, B., Stephens, R., Storm, D., *Samplers a Sampling Procedures for Hazardous Waste Streams*, Envir mental Protection Agency, EPA-600/2-80-018, 1980, p. 51.

(17) Morrison, R., *Ground Water Monitoring Technology*, Tim Manufacturing Co., 1982, p. 276.

(18) Eijelkamp, "Equipment for Soil Research," *General Catalo* Geisbeek, The Netherlands, 1979, pp. 82–83.

(19) Wood, W., "Guidelines for Collection and Field Analysis Ground-Water Samples for Selected Unstable Constituents," *T niques of Water-Resources Investigations of the United St Geological Survey*, Chapter D2, 1976, p. 24.

(20) Gilham, R. W., "Syringe Devices for Groundwater Monitori *Ground Water Monitoring Review*, Vol 2 (2), Spring 1982, p.

(21) Masterflex, *Masterflex Pump Catalogue*, Barnant C Barrington, IL, 1981.

(22) "Guidelines for Contracting Sampling and Analyses for Pri Pollutants in Pulp and Paper Industry Effluents," *NCASI St Improvement Technical Bulletin*, No. 335, August 1980.

(23) Allison, L., "A Simple Device for Sampling Ground Wat Auger Holes," *Soil Science Society of America Proceeding* 844–45, 1971.

(24) Willardson, L., Meek, B., Huber, M., "A Flow Path Ground

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 for 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 197[illegible]

(55) *Federal Register*, Vol 44, No. 244, Dec. 18, 1979, pp. 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.

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APPENDIX C
SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION

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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. Such innovations shall be documented and presented in the Sampling and Analysis Plan.

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 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation for procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific surface water and/or sediment sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of surface water and sediment samples.

5.0 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.

5.1 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.

5.1.1 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.

5.1.2 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.

5.1.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the Sampling and Analysis Plan. 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.

5.2 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.

5.2.1 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.

5.2.2 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.

5.2.3 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.

5.2.4 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.

5.2.4.1 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.

5.2.4.2 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).

5.2.4.3 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.

5.2.5 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.

- All samples shall be handled as described in SOP F301.

- 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.

- All samples shall be handled as described in SOP F301.

- Items to be recorded in the field logbook are the same as those described above for small streams.

5.3 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.

5.3.1 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

5.3.1.1 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.

5.3.1.2 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.

5.3.1.3 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 as outlined in SOP F502.

5.3.1.4 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.

5.3.2 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.
- All samples shall be handled as described in SOP F301.
- 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.
- Description of sediment (refer to SOP F001).

6.0 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 as discussed in SOP F302.

7.0 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, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, USEPA 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.

APPENDIX D
IN-SITU SLUG TESTING

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WELL-HEAD TESTING (SLUG-TESTS)

1.0 PURPOSE

This SOP provides a general description of the technical methods and field procedures of a representative suite of well-head testing (slug tests) to approximate part of the aquifer parameters. The well-head tests are to be considered at all times as a reconnaissance of the aquifer parameters across an area (the site under investigation). Aquifer testing (pump-tests) to calculate these parameters is discussed in SOP F401. The descriptions herein are general in nature and do not apply to a specific well, well-field or project. Prior to designing well-head tests as part of a site investigation and during execution of the tests, the Project Manager, Site Manager and Program Hydrogeologist must consult on the appropriate procedures; these procedures must then be recorded in the project documents.

2.0 SCOPE

The well-head tests apply both to consolidated and unconsolidated strata; and to confined, semiconfined and phreatic conditions. The aquifer parameters subject to evaluation and approximate calculation are Transmissivity and Hydraulic Conductivity.

3.0 DEFINITIONS

The following definitions are extracted or abstracted from standard references (Section 7); further discussions are available in those references.

Hydraulic Conductivity (K) - A medium has a hydraulic conductivity (K) of unit length per unit time (for example, feet per day [ft/d]) if it will transmit in unit time a unit volume of groundwater at the prevailing viscosity through a cross-section of unit area, measured at right angles to the direction of flow, under a hydraulic gradient of unit change in head through unit length of flow (Lohman 1979).

Transmissivity (T) - The transmissivity (T) is the rate (for example, in gallons per day per foot of drawdown [gpd/ft]) at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman 1979). The transmissivity is mathematically equivalent to the hydraulic conductivity multiplied by the saturated thickness: $T = Kb$.

Saturated Thickness (b) - The saturated thickness (b) is the distance (for example, in feet [ft]) from the elevation of the upper groundwater surface in either a phreatic system (the water table) or a confined or semiconfined system (the lower boundary of the upper confining or semiconfining layer, but not the potentiometric surface in a well) to the elevation of the upper boundary of the lower confining or semiconfining layer for the aquifer or water-bearing layer.

Drawdown (s) - The drawdown in a well affected by a well-head test is the differential distance, usually in feet (ft), between the static (unstressed) water level in the well measured immediately prior to the test, and the (stressed) water level at the specified time during the test.

Falling-Head Test - The falling-head test is conducted where the static water level in the subject well is nearly instantaneously displaced vertically upward at the initiation of the test; the decay of this artificially impressed head is measured against time to provide data for the calculation of conductivity or transmissivity. The falling head test is valid only when the screen is fully submerged at static conditions.

Rising-Head Test - The rising-head test is conducted where the static water level in the subject well is nearly instantaneously displaced vertically downward at the initiation of the test; the decay of this artificially depressed head is measured against time to provide data for the calculation of conductivity or transmissivity.

Confined Conditions - Confined conditions in a water-bearing layer are found where the groundwater is bounded vertically by opposed surfaces or layers that are impermeable to water, and where the total head of the system at the upper surface of the groundwater is greater than atmospheric pressure. For a confined system, when a well is drilled below the bottom of the upper confining layer, the water level in the well rises to an elevation (at least) within or (possibly) above the upper confining layer.

Unconfined (Phreatic) Conditions - Unconfined conditions in a water-bearing layer are found where the groundwater is bounded vertically only by a single surface or layer at the bottom of the water-bearing layer that is impermeable or semipermeable to water, and where the total head of the system at the upper surface of the groundwater is equal to atmospheric pressure. For an unconfined or phreatic or water-table system, when a well is drilled below the upper surface of the groundwater, the water level in the well does not rise to a significantly higher elevation.

Semiconfined Conditions - Semiconfined conditions in a water-bearing layer are found where the groundwater is bounded vertically by opposed surfaces or layers that are less permeable to water than the water-bearing layer itself, and where the total head of the system is greater than atmospheric pressure. For a semiconfined system, when a well is drilled below the bottom of the upper semiconfining layer, the water level in the well rises to an elevation within or above the upper semiconfining layer. However, one or both of the semiconfining layers will be, in some fashion, in hydraulic and hydrologic communication with the water-bearing layer, and may contribute water to or receive water from that layer.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation procedures which deviate from those presented herein.

Site Manager - It is the responsibility of the Site Manager to ensure that the procedures herein are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Field Geologist - Responsible for determining the need for hydrogeologic testing and has overall responsibility for the planning and implementation of the test. Evaluation and interpretation of the data is also the responsibility of the Field Geologist.

Program Geologist - Responsible for QA/QC oversight of the planning and implementation of the test, along with the evaluation of data generated by the test.

5.0 PROCEDURES

The procedures presented in this section concern the administration and execution of well-head tests; the technical content of a given test will be established by the project and program management for each instance according to experience and best professional practice.

5.1 Overview

The well-head test will conform to the objectives of the investigation and to standards of good practice common in hydrogeologic investigations. Sufficient personnel, and sufficient standard and special equipment will be available for the intentions of the test. Data collection will conform to the practice described in SOP F202 (Water Level, Water/Product Level Measurements and Well Depth Measurements); additionally, time will be measured and recorded no less precisely than the nearest minute or half-minute, as appropriate, while conforming to the intent of the test. Containment and disposal of discharged liquids will conform to the practice described in SOP F504 (Handling of Site Investigation Wastes).

5.2 Applications

The well-head test will usually be divided into three stages:

1. Static measurement
2. Falling-head test
3. Rising-head test

Each stage will normally be run for no more than 30 minutes. The water level in the test well should recover to between 90 and 100 percent of static conditions before beginning the next stage. Should the recovery be less than acceptable after 30 minutes from the start of the first stage, or should other field conditions conspire adversely, the second stage will not be run. Measurements of recovery during the first stage may then be extended to 60 minutes.

5.2.1 Static Measurement

This stage of the well-head test provides the data on static conditions to be used in subsequent approximation of the aquifer parameters. The static water levels are to be measured no later than immediately prior to the first stage of the test, whether falling-head or rising-head. The levels should also have been measured once daily, if possible, for two or more days preceding the test; the optimal measurement program would provide continuous measurement and recording of levels in all wells to be used for a period of several weeks preceding well-head testing.

5.2.2 Falling-Head Test

The falling-head stage of the well-head test is usually conducted before the rising-head. This stage imposes a stress on the water-bearing layer by nearly instantaneously injecting water or introducing a solid slug of impermeable material at one point (the test well). This is usually repeated at a large number of the available wells in the well-field. The measurements of the rate of recovery of the drawdown in the well provides data used in approximation of the aquifer parameters. The falling head test is valid only when the screen is fully submerged at static conditions.

5.2.3 Rising-Head Test

The rising-head stage of the well-head test imposes a stress on the water-bearing layer by nearly instantaneously extracting water or removing a solid slug of impermeable material at one point (the test well). This is usually repeated at a large number of the available wells in the well-field. The measurements of the rate of recovery of the drawdown in the well provides data used in approximation of the aquifer parameters.

5.3 Measurements and Measurement Intervals

The measurement intervals for water levels in the test well during each stage will be modified from the following suggestions:

Time Since Start of Test (min)	Measurement Frequency (min)
0-5	0.5
5-10	1
10-20	2
20-60	5

The actual time and the test time for each reading will be recorded, with the water level measured to a precision of 0.01 ft.

The sequence of stations tested and the frequency of readings will be established by project and program management prior to the tests, and will be adjusted according to site conditions during the tests. The use of automatic data loggers is recommended due to the relatively fast recovery times of the small volume of water removed/introduced.

5.4 Calculation Methods

Calculation of the approximate values of the aquifer parameters will follow standard practice, with particular reference to the resources of Section 7, or as otherwise noted in the calculation sequence. A computer program, may also be used; if the computer program is used, an example that has previously been verified by traditional calculation will be run as part of the data from the subject site.

6.0 QUALITY ASSURANCE RECORDS

The readings made during the well-head test may be recorded in field books or on separate forms, according to management decisions. The field books will be stored according to SOP F303, with photocopies of the specific pages with test data included in the file for each test. The file for each test will include the field data, the calculations and graphs, and summaries with references for calculations by computer program.

7.0 REFERENCES

Chow, V.T. 1964. Handbook of Applied Hydrology. McGraw-Hill, New York.

Lohman, S.W. 1979. Ground-Water Hydraulics. Geological Survey Professional Paper 708. U.S. Government Printing Office.

Freeze, R.A. and Cherry, J.A. 1979. Groundwater. Prentice-Hall, Englewood Cliffs.

Driscoll, F.G., ed. 1986. Groundwater and Wells, 2nd ed. Johnson Filtration Systems, St. Paul.

Duffield, G.M., Rambaugh, J. O. 1989. AQTESOLV. Aquifer Test Solvert, Version 1.00 Documentation.

APPENDIX E
DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

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DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

1.0 PURPOSE

The purpose of this SOP is to provide a general methodology and protocol, and to reference information for the proper decontamination of field chemical sampling and analytical equipment.

2.0 SCOPE

This procedure applies to all field sampling equipment including, but not limited to, split-barrel soil samplers (split-spoons), direct push samplers, bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring field personnel performing decontamination activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURES

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site.

Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel must use disposable gloves and change them between sampling locations.

5.1 Sampling Equipment Decontamination Procedures

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following USEPA procedures.

USEPA

Prior to use, all sampling equipment should be carefully cleaned using the following procedure:

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.

2. Rinse thoroughly with tap water.

3. Rinse with 10 percent nitric acid rinse

4. Rinse thoroughly with distilled-deionized water and allow to air dry.

5. Rinse with methanol or hexane and allow to air dry.

6. Rinse thoroughly with distilled-deionized water and allow to air dry.

7. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported.

* Portable power augers (such as the Little Beaver®) or large soil boring/drill rigs should be cleaned before boring or drilling operations.

* For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure.

* If the samples will not be analyzed for metals, then steps 3 and 4 may be omitted; if samples will not be analyzed for organics, then step 5 may be omitted. All solvents must be pesticide-grade.

5.2 Field Analytical Equipment Decontamination

Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use, according to the procedures outlined in Section 5.1, unless manufacturers instructions indicate otherwise. Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water. Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.

6.0 QUALITY ASSURANCE RECORDS

Decontamination procedures are monitored through the collection of equipment rinsate samples and field blanks. Collection of these samples shall be specified in the project-specific Sampling and Analysis and Quality Assurance Plans. Documentation recorded in the field logbook also shall serve as a quality assurance record.

7.0 REFERENCES

U. S. EPA Office of Waste Program Enforcement, 1986. RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD). OSWER Directive 9950.1.

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA Environmental Services Division, Athens, Georgia.

Micham, J. T., R. Bellandi, E. C. Tifft, Jr., Spring 1989. "Equipment Decontamination Procedures for Ground Water and Vadose Zone Monitoring Programs: Status and Prospects." in Ground Water Monitoring Review.

APPENDIX F
DECONTAMINATION OF DRILL RIGS AND MONITORING WELL MATERIALS

FIELD EQUIPMENT OPERATION AND MAINTENANCE PROCEDURES - DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

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DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs and monitoring well materials used in the performance of field investigations.

2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure does not pertain to personnel decontamination, or to chemical sampling or field analytical equipment decontamination.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURE

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site.

5.1 Equipment

All drilling equipment involved in field sampling activities shall be decontaminated prior to drilling, excavation, or sampling activities. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated according to the procedures given in SOP F502, Decontamination of Sampling and Monitoring Equipment.

5.2 Decontamination Procedures

Prior to drilling, or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush and alconox/liquinox-water solution prior to steam cleaning to remove visible signs of contamination.

The steam cleaning area will be designed to contain decontamination wastes and waste waters, and can be a lined, excavated pit or a bermed concrete pad or asphalt pad. For the latter, a floor-drain must be provided which is connected to a holding sump. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts.
- Enclose steam cleaning operations. For example, augers and drilling rods can be steam cleaned in drums. Tarpaulins also can be placed around the steam cleaning area to control emissions.

Decontamination wastes will be collected and contained unless otherwise directed by the Regulatory Agency. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on-site treatment and/or transport off site to an approved treatment/disposal facility.

6.0 QUALITY ASSURANCE RECORDS

Rinsate samples may be collected from steam-cleaned equipment as quality assurance records. The frequency of rinsate samples from either drilling tools or well casings/screens shall be specified in the Sampling and Analysis and Quality Assurance Project Plans for a given project, as appropriate. Documentation in the field logbook also shall serve as a quality assurance record of decontamination activities.

7.0 REFERENCES

None.

APPENDIX G
ON-SITE WATER QUALITY TESTING

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ATTACHMENT A -- SPECIFIC CONDUCTANCE CONVERSION TABLE
ATTACHMENT B -- VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

ON-SITE WATER QUALITY TESTING (FIELD PARAMETERS)

1.0 PURPOSE

This SOP describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance/Salinity
- Temperature
- Dissolved Oxygen Concentration (DO)
- Turbidity (Secchi Disc)
- Oxidation Reduction Potential (ORP)

The first three are the usual field parameters; dissolved oxygen, and ORP, may be used in particular applications according to project requirements.

2.0 SCOPE

These procedures are applicable for use in an on-site water quality monitoring program to be conducted during a Remedial Investigation or Site Investigation at a hazardous or nonhazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 DEFINITIONS

Conductance - A measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The units of measurement for conductance (mhos) are the inverse of ohms, the unit commonly used to express resistance. Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration. The range of pH is 0 to 14 standard units.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference (in units of volts), I is the current (in units of Amperes), and R is the resistance (in units of ohms).

Turbidity - An optical property of water that causes light to be scattered or absorbed in the water, resulting in decrease in water transparency. It is a function of at least three variables: 1) dissolved chemicals, such as tannins, acids, or salts; 2) suspended particles, such as silt, clay, and organic matter; and, 3) density of microbial and planktonic life.

Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants.

ORP - Oxidation reduction occurs when electrons are transformed from one atom to another during a chemical reaction. The atom losing electrons is said to be "oxidized", while the atom gaining electrons is termed "reduced". ORP is typically measured using a platinum electrode, attached to a pH meter, which is set to read in millivolt mode.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for determining which on-site water quality measurements shall be made, the data quality objectives (DQOs) for these measurements, and for ensuring that these measurements are made in accordance with project-specific plans.

Field Team Leader - The Field Team Leader is responsible for determining that these water quality measurement procedures are implemented in the field in accordance with this SOP, or in accordance with project-specific plans, and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures for collecting on-site water quality measurements including instrument calibration, quality control and recording of results, as well as care and maintenance of the instruments in the field.

5.0 PROCEDURES

The following sections provide general procedures for collecting pH, specific conductance/salinity, temperature, dissolved oxygen concentration, turbidity and ORP measurements.

Note: Though there are "multi-parameter" meters on the market today that can simultaneously measure the following parameters, only measurement with "parameter specific" meters will be

discussed. If using a multi-parameter meter, all manufacturers instructions for that specific model will be followed for calibration, maintenance and care.

5.1 Measurement of pH

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment, such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH also can be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis; specific measurement techniques for solids are not described here.

5.1.1 Principles of Equipment Operation

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on the establishment of a potential difference across a glass or other type of membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.2 Equipment

The following equipment and reagents are needed for taking pH measurements:

- Laboratory-prepared buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.3 Measurement Techniques for Field Determination of pH

A. pH Meter

Standardization, calibration, and operation and maintenance shall be performed according to the manufacturers instructions for the "specific" model being used. The following general procedure is used for measuring pH with a pH meter:

1. The batteries shall be checked to make sure that they are fully charged and the instrument shall be calibrated prior to initiation of the field effort.

2. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage.

3. Turn meter on and allow it to stabilize for 3 to 5 minutes.

4. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s). Shake electrode as if a mercury thermometer to move air bubbles from the tip to the top.

5. Calibration procedures should be performed:
   - Following significant ambient temperature changes
   - When meter reads erratically
   - At beginning and middle of each day of use

6. When the meter is moved to a new sampling location, a single-point check/calibration should be performed with pH 7 buffer.

7. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

8. After adjusting the temperature compensator to the sample temperature, read and record the pH of the solution. The pH value shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature. All measurements shall be recorded in the Field Logbook.

9. Upon completion of measurement and removal of the electrode from the sample, the electrode shall be thoroughly rinsed with deionized water.

10. The electrode(s) shall remain immersed in storage solution provided, or pH buffer 4 water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution within the electrode, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted in the Field Logbook.

5.2 Measurement of Specific Conductance/Salinity

Conductance provides a measure of dissolved ionic species in water and can be used to suggest the direction and extent of migration of contaminants in groundwater or surface water. Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants. One basic measure of salinity is the ability of water to conduct electric current, and, therefore, a measurement of specific conductance provides a measurement of salinity and the same instrument can

be used. Salinity measurements are important in ecological field investigations because flora and fauna can be limited in their distribution based on the salinity of the sampled waters.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance and salinity measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.1 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions (cations) migrate toward the negative electrode (cathode), while the negatively charged ions (anions) migrate toward the positive electrode (anode). Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell also may be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.2.2 Equipment

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

5.2.3 Measurement Techniques for Specific Conductance/Salinity

Standardization, calibration, and operation and maintenance shall be performed according to manufacturers instructions for the "specific" model being used. The general steps involved in taking specific conductance and salinity measurements are listed below.

1. Check batteries to make sure they are fully charged and calibrate instrument before going into the field.

2. Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Calibration information shall be recorded in the field logbook.

3. Turn meter on and allow it to stabilize for 3 to 5 minutes.

4. Calibration procedures should be performed:
   - Following significant ambient temperature changes
   - When meter reads erratically
   - At beginning and middle of each day of use

5. Pour approximately 50 to 100 ml of sample into a rinsed plastic cup. Immerse the electrode in the sample and measure the conductivity and salinity. If specified, adjust the temperature setting to the sample temperature.

6. Read and record the results field in the logbook.

7. If the meter does not compensate for temperature variations, the corrections given in Attachment A shall be applied.

8. On some meters, specific conductivity and salinity measurements may need to be reported with the associated temperature measurement. If the conductivity and salinity has been corrected, the measurements shall be reported as "corrected to 25°C." (Attachment A)

   a. Do not take readings if the sample temperature is less than 10° C, because the calibration curve no longer follows a straight line below this temperature. If necessary, heat the sample in your vehicle to at least 10° C.

   b. Measure the sample temperature to the nearest 0.1° C to comply with SW-846.

   c. Only report results to the nearest two significant digits for the most circumstances, because of the inherent inaccuracy in the test and conversion procedure.

      examples:
      - a calculated reading of 2353 umhos/cm @ 25° C should be reported as 2400 umhos/cm @ 25° C
        - a calculated reading of 2325 should be reported as 2300
        - a calculated reading of 337 should be reported as 340
        - etc.

5.3 Measurement of Temperature

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field prior to sample collection. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.1 Equipment

Temperature measurements may be taken with Thermistor, alcohol-toluene, mercury or bimetal thermometers. In addition, most meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature can be performed.

5.3.2 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

1. Visually inspect thermometer to ensure that there is not a break in the mercury column. If there is a break, the spare thermometer will be visually inspected. If both thermometers have a break in the mercury, neither will be used until the break is corrected. This will be done by cooling the bulb until the mercury is contained within the bulb.

2. Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

3. Record values in a field logbook to the nearest 0.5 or 0.1 °C, depending on the measurement device used.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to the manufacturer's recommendations with an approved thermometer.

5.4 <u>Measurement of Dissolved Oxygen Concentration</u>

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms, as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time, if the sample is not adequately preserved. Other means of sample preservation may involve directing the sample flow, from the well, directly into a flow cell, which limits sample/air contact.

The method discussed here is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible. DO meters also are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.1 Principles of Equipment Operation

DO probes normally are electrochemical cells that have two solid metal electrodes of different potential immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of higher nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

DO probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not easily depolarized from the indicating electrode. If gaseous interference is suspected, it shall be noted in the Field Logbook and checked if possible. Temperature, pressure, and salinity variations also can cause interference. Automatic temperature compensation normally is provided by the manufacturer. Attachment B presents variations of DO in water as a fraction of temperature and pressure. Salinity should be compensated in accordance with the manufactures instructions.

5.4.2 Equipment

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

5.4.3 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions for the specific model being used to obtain an accurate reading. The following general steps shall be used to measure the DO concentration.

1. Calibrate equipment and check batteries before going to the field.
2. The probe shall be conditioned in a water sample for as long as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

3. The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a freshly air-saturated water sample of known temperature.

4. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers which are placed in wells should be moved up and down.

5. Record the dissolved oxygen content and temperature of the sample in a field logbook.

6. Recalibrate the probe when the membrane is replaced, or following similar maintenance, or as needed. Follow the manufacturer's instructions.

Note that in situ placement of the probe is preferable, since sample handling is not involved. This, however, may not always be practical. Be sure to record whether the liquid was analyzed in situ, or whether a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen dissolution and positive test interferences.

5.5 Measurement of Turbidity

Turbidity is caused by fine particles suspended in the water which cause light to scatter, rather than traveling in a straight line. Clay, silt, plankton, and other microorganisms are all examples of particulates that cause turbidity.

Most portable field turbidity meters display results in Nephelometric Turbidity Units (NTU's). This process determines the turbidity level of measuring the amount of light scattered 90° by the suspended particles, by a light of known strength beamed through the solution.

5.5.1 Equipment

A portable turbidity meter, sample vials, standard solutions, and sample cap are typically needed.

5.5.2 Measurement Techniques for Turbidity Measurement

Follow the manufacturers instructions, for the "specific" model being used. The following general steps shall be used to measure turbidity.

1. Calibrate equipment and check batteries, or charge status.

2. Turn on meter and allow to stabilize.

3. Fill a sample vial completely with sample to be obtained, and place cap on vial.

4. Insert vial into light chamber. (Align vial into chamber the same way each time, by making use of tick marks on vial lid). Cover vial with cap.

5. Switch meter to appropriate range and read. Record results into log book.

6. Rinse vials with distilled water between each sample.

7. Calibration procedures should be performed:
   - Following significant ambient temperature changes
   - When meter reads erratically
   - At beginning and middle of each day of use.

5.6 Measurement of Oxidation Reduction Potential

Oxidation reduction occurs when electrons are transformed from one atom to another during a chemical reaction. The atom losing electrons is said to be "oxidized", while the atom gaining electrons is termed "reduced". ORP is typically measured using a platinum electrode, attached to a pH meter, which is set to read in millivolt mode.

5.6.1 Equipment

Though there are ion specific meters for ORP on the market, their very small size and shape do not coincide well with typical multi-parameter set-ups in the field. Typically a pH meter, fitted with a special ORP electrode is used.

5.6.2 Measurement Techniques

At present, only a check solution is available on the market, which is used to verify the performance of the electrode. If the probe reads +/- a certain percentage of the solutions stated value then the electrode is assumed to be in proper working condition.

1. Check batteries and calibrate (check) meter/electrode before heading into the field.

2. Switch pH meter so that it's in the millivolt (mV) mode.

3. Place electrode in sample solution and read results in mV's. Record results in field log book.

4. Rinse electrode with distilled water.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records for on-site water quality management consists principally of observations and measurements recorded in the field logbook.

7.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

ATTACHMENT A

SPECIFIC CONDUCTANCE CONVERSION TABLE

ATTACHMENT A
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
10	1.402	12	1.330	14	1.266	16	1.208	20	1.106
10.1	1.398	12.1	1.327	14.1	1.263	16.1	1.205	20.1	1.103
10.2	1.394	12.2	1.324	14.2	1.260	16.2	1.202	20.2	1.101
10.3	1.390	12.3	1.320	14.3	1.257	16.3	1.199	20.3	1.099
10.4	1.387	12.4	1.317	14.4	1.254	16.4	1.197	20.4	1.096
10.5	1.383	12.5	1.314	14.5	1.251	16.5	1.194	20.5	1.094
10.6	1.379	12.6	1.310	14.6	1.248	16.6	1.191	20.6	1.092
10.7	1.376	12.7	1.307	14.7	1.245	16.7	1.188	20.7	1.089
10.8	1.372	12.8	1.304	14.8	1.242	16.8	1.186	20.8	1.087
10.9	1.369	12.9	1.301	14.9	1.239	16.9	1.183	20.9	1.085
11	1.365	13	1.297	15	1.236	17	1.180	21	1.083
11.1	1.361	13.1	1.294	15.1	1.233	17.1	1.178	21.1	1.080
11.2	1.358	13.2	1.291	15.2	1.230	17.2	1.175	21.2	1.078
11.3	1.354	13.3	1.288	15.3	1.227	17.3	1.172	21.3	1.076
11.4	1.351	13.4	1.285	15.4	1.225	17.4	1.170	21.4	1.074
11.5	1.347	13.5	1.281	15.5	1.222	17.5	1.167	21.5	1.072
11.6	1.344	13.6	1.278	15.6	1.219	17.6	1.165	21.6	1.069
11.7	1.341	13.7	1.275	15.7	1.216	17.7	1.162	21.7	1.067
11.8	1.337	13.8	1.272	15.8	1.213	17.8	1.159	21.8	1.065
11.9	1.334	13.9	1.269	15.9	1.210	17.9	1.157	21.9	1.063
22	1.061	24	1.019	26	0.981	28	0.946	30	0.913
22.1	1.059	24.1	1.017	26.1	0.979	28.1	0.944	30.1	0.911
22.2	1.057	24.2	1.016	26.2	0.978	28.2	0.942	30.2	0.910
22.3	1.054	24.3	1.014	26.3	0.976	28.3	0.941	30.3	0.908
22.4	1.052	24.4	1.012	26.4	0.974	28.4	0.939	30.4	0.907
22.5	1.050	24.5	1.010	26.5	0.972	28.5	0.937	30.5	0.905
22.6	1.048	24.6	1.008	26.6	0.970	28.6	0.936	30.6	0.903
22.7	1.046	24.7	1.006	26.7	0.969	28.7	0.934	30.7	0.902
22.8	1.044	24.8	1.004	26.8	0.967	28.8	0.932	30.8	0.900

ATTACHMENT A (Continued)
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
22.9	1.042	24.9	1.002	26.9	0.965	28.9	0.931	30.9	0.899
23	1.040	25	1.000	27	0.963	29	0.929	31	0.897
23.1	1.038	25.1	0.998	27.1	0.961	29.1	0.927	31.1	0.896
23.2	1.036	25.2	0.996	27.2	0.960	29.2	0.926	31.2	0.894
23.3	1.034	25.3	0.994	27.3	0.958	29.3	0.924	31.3	0.893
23.4	1.032	25.4	0.992	27.4	0.956	29.4	0.922	31.4	0.891
23.5	1.029	25.5	0.991	27.5	0.954	29.5	0.921	31.5	0.890
23.6	1.027	25.6	0.989	27.6	0.953	29.6	0.919	31.6	0.888
23.7	1.025	25.7	0.987	27.7	0.951	29.7	0.918	31.7	0.887
23.8	1.023	25.8	0.985	27.8	0.949	29.8	0.916	31.8	0.885
23.9	1.021	25.9	0.983	27.9	0.948	29.9	0.914	31.9	0.884

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals 1/(1+0.0191[t-25]).
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	2.Dissolved Oxygen mg/l 2.1.Chloride Concentration in Water 2.1.1.0 2.1.2.5,000 2.1.3.10,000 2.1.4.15,000 2.1.5.20,000 2.2.Difference/ 100 mg chloride					
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.106
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010

Temperature °C	2.Dissolved Oxygen mg/l 2.1.Chloride Concentration in Water 2.1.1.0 2.1.2.5,000 2.1.3.10,000 2.1.4.15,000 2.1.5.20,000 2.2.Difference/ 100 mg chloride					
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008

APPENDIX H
WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS AND WELL DEPTH MEASUREMENTS

FIELD EQUIPMENT OPERATION AND MAINTENANCE PROCEDURES - WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

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- 5.2 Groundwater-Product Interface Level Measurement
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6.0 QUALITY ASSURANCE RECORDS

WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

1.0 PURPOSE 1.0 PURPOSE

The purpose of this procedure is to describe the method of determining various down-hole measurements: groundwater levels and product (or non-aqueous phase liquid, NAPL) levels, if present, and total depth of groundwater monitoring wells and piezometers.

2.0 SCOPE

The methods described in this SOP generally are applicable to the measurement of groundwater levels, product or NAPL levels, and well depths in monitoring wells and piezometers.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed.

Field Team Leader - The Field Team Leader is responsible for ensuring that these procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of down-hole measurements.

5.0 PROCEDURES

Calculations of groundwater elevations and product or NAPL interface level measurements collected from a monitoring well give an indication of:

- The horizontal hydraulic gradient and the direction of groundwater flow.
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane).
- Floating or sinking product thicknesses which are also known as Light Non-Aqueous Phase Liquids (LNAPLs) and Dense Non-Aqueous Phase Liquids (DNAPLs), respectively.

This information, when combined with other site specific information such as hydraulic conductivity or transmissivity, extent of contamination, and product density, may be used to estimate the rate of contaminant movement or source areas, etc.

Well depth is one of the factors used to determine the zone that a well monitors. Well depth also is used in the calculation of purge volumes as discussed in SOP F104, Groundwater Sample Acquisition.

The following sections briefly discuss the procedures for measuring groundwater levels, product or NAPL levels, and well depth. For all of the procedures discussed, it is assumed that the measurement will be taken from the top of the PVC or stainless steel casing (though other measuring points can be used), and that horizontal and vertical control is available for each well through a site survey, such that measurements may be converted to elevations above Mean Sea Level (MSL) or some other consistent datum. A permanent notch, placed on the inner PVC or stainless steel casing by the surveyor will facilitate consistent water level measurements.

The manufacturer's instructions for all equipment referenced herein should be read by the equipment operator(s) and accompany the equipment to the field.

5.1 Water Level Measurement

Water levels in groundwater monitoring wells shall be measured from the permanent point indicated at the top of the inner casing (the surveyed elevation point, as marked by the surveyor), unless otherwise specified in the project plans, using an electronic water level measuring device (water level indicator). The point of measurement will be documented in the field logbook if different from the top of the inner casing. The reason for deviating from the measurement point should also be noted.

Water levels are measured by lowering the probe into the well until the device indicates that water has been encountered, usually with either a constant buzz, or a light, or both. The water level is recorded to the nearest foot (0.01) using the graduated markings on the water level indicator cord. This measurement, when subtracted from the measuring point elevation, yields the groundwater elevation.

Groundwater levels shall always be measured to the nearest 0.01 foot. However, reporting of water level elevations depends on the accuracy of the vertical control (typically either 0.1 or 0.01 foot).

5.2 Product or NAPL Level Measurements

The procedure for product or NAPL level measurement is nearly identical to that for groundwater elevation measurements. The only differences are the use of an interface probe that detects both NAPLs and water, and the indication signal given by the measurement device. Typically, encountering NAPLs in a monitoring well is indicated by a constant sound. When water is encountered, the signal becomes an alternating on/off beeping sound. This allows for the collection of measurements for both the top of the NAPL layer in a well and the water/NAPL interface.

The apparent water table elevation below the product level will be determined by subtracting the "depth to water" from the measuring point elevation. The corrected water table elevation will then be calculated using the following equation:

$$WTE_c = WTE_a + (\text{Free Product Thickness} \times 0.80)$$

Where:

WTE_c	=	Corrected water table elevation
WTE_a	=	Apparent water table elevation
0.80	=	Average value for the density of petroleum hydrocarbons. Site-specific data will be used where available.

5.3 Well Depth Measurements

Well depths typically are measured using a weighted measuring tape. A water level meter may also be used. The tape is lowered down the well until resistance is no longer felt, indicating that the weight has touched the bottom of the well. The weight should be moved in an up and down motion a few times so that obstructions, if present, may be bypassed. The slack in the tape then is collected until the tape is taut. The well depth measurement is read directly off of the measuring tape, at the top of the PVC or stainless steel casing, to the nearest 0.01-foot and recorded in the Field Logbook. If a water level indicator is used, add the distance from the bottom of the probe to the point where water levels are measured.

5.4 Decontamination of Measuring Devices

Water level indicators, interface probes and weighted measuring tapes that come in contact with groundwater must be decontaminated using the following steps after use in each well:

- Rinse with potable water
- Rinse with deionized water
- Rinse with Methanol or Isopropanol
- Rinse with deionized water

Portions of the water level indicators or other similar equipment that do not come into contact with groundwater, but may encounter incidental contact during use, need only undergo potable water and deionized water rinses.

6.0 QUALITY ASSURANCE RECORDS

The Field Logbook shall serve as the quality assurance record for water, product level or well depth measurements.

APPENDIX I
PHOTOIONIZATION DETECTOR (PID)
HNU MODELS PI 101 AND DL 101

FIELD EQUIPMENT OPERATION AND MAINTENANCE PROCEDURES - PHOTOIONIZATION DETECTOR (PID)

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SOP Number: F203
Effective Date: 04/94

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PHOTOIONIZATION DETECTOR (PID)
HNu MODELS PI 101 and DL 101

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the HNu Model PI 101 or DL 101 photoionization detector (PID), or an equivalent or similar instrument, in the field. Calibration and operation, along with field maintenance will be included in this SOP.

2.0 SCOPE

This procedure provides information on the field operation and general maintenance of the HNu PID. Application of the information contained herein will ensure that this type of field monitoring equipment will be used properly. Review of the manufacturer's instruction manual is necessary for more complete information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

3.0 DEFINITIONS

Ionization Potential - In this case, a numeric equivalent that expresses the amount of energy needed to replace an electron with a photon. This energy is further defined in terms of electron volts (eV).

PID - Photoionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook and the daily Realtime Air Monitoring Log during each field investigation.

5.0 PROCEDURES

The HNu PID utilizes the principle of photoionization whereby contaminant molecules enter the ion chamber and electrons are displaced by ultraviolet photons producing positive ions. These displaced positive ions are in turn collected on a special electrode. As the positive ions collect on the electrode, they create an electrical current which is amplified and displayed on the meter as a concentration in parts per million (ppm).

The HNu PID is only effective for contaminants that have ionization potentials (IP) of less than or equal to the electron volt (eV) capacity of the lamp (i.e., methane, having an IP of 12.98 eV, will not be detected at a lamp potential of 11.7 eV). The standard lamp is 10.2 eV with optional lamps of 9.5 eV and 11.7 eV, respectively. For the PI 101 the span settings should be as follows: 1.0 for 9.5 eV lamps; 9.8 for 10.2 eV lamps; and 5.0 for 11.7 eV lamps. During calibration, these span settings will be adjusted as necessary, using the span control knob.

The following subsections will discuss HNu PID calibration, operation, and maintenance. These sections, however, should not be used as a substitute for the manufacturer's instruction manual.

5.1 Calibration

For calibration purposes, the following items will be needed:

- Gas cylinder containing 95 to 100 parts per million (ppm) of isobutylene, balance in air.
- A 0.30 liters per minute regulator.
- Connector tubing.
- Screwdriver set.
- Photoionization Detector (PID) Calibration Form.

Prior to each use, make sure that the battery is fully charged, the ultraviolet lamp is working, and that the fan is operating and drawing air into the probe (fan operates at approximately 100-200 cc/minute for the PI 101 and 225 cc/minute for the DL 101). Procedures for completing these preliminary activities are given in the manufacturer's instruction manual.

PI 101

To calibrate the PI 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 3-5 in the manufacturer's instruction manual. The PI 101 should be calibrated on a daily basis.

- Turn the function control switch to the standby position and zero the instrument by turning the zero adjustment knob to align the indicator needle with zero on the readout meter.

- Set the range on the PI 101 and allow the instrument to warm up a few minutes before calibrating. Choices for range are 0-20, 0-200, and 0-2,000 ppm, respectively. Range choice must take into account the concentration of the calibration gas. For example, if you are using a concentration of 100 ppm isobutylene as the calibration gas, your range should be set on the 0-200 scale. If you have to zero the instrument in the desired range, record background if present.

- Attach tubing to the regulator

- Attach the free end of the tubing to the probe and turn on the calibration gas.

- Calibrate the PI 101 to benzene equivalents. Using the 10.2 eV (lamp) probe and 100 ppm isobutylene, the meter should read 56 units. Using the 11.7 eV (lamp) probe and 100 ppm isobutylene, the meter should read 65 units. If the reading on the meter is not ±5 percent of the concentration of the calibration gas, adjust the span setting knob until the meter reads accordingly. If after adjusting the span setting knob the readout meter is still not responding, refer to the manufacturer's instruction manual. Also, when the PI 101 is calibrated it should respond to a minimum of 90 percent of the concentration of the calibration gas within three seconds after introduction of that gas. If proper calibration cannot be obtained, internal calibration may be required. Note, only qualified personnel should perform internal calibrations.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form".

DL 101

To calibrate the DL 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 4.4 in the manufacturer's instruction manual.

- Press and release the POWER button on the keypad and wait for the screen to stabilize then press the CALIBRATE key until "Calibrate?" appears. At this point press the ENTER key until "Elec_Zero? Yes" appears on the screen in which case you will press the ENTER key, again, to confirm the electronic zero.

- The display will now read "CE/ENT/EXIT Conc = ____ ppm" which requires the concentration of the calibration gas (noted on the side of the calibration gas bottle) to be entered on the keypad. The display will prompt you to "Attach gas to probe and /ENTER/" so attach tubing to probe (use the calibration gas humidifier in high humidity environments), open valve, and press ENTER key. Press ENTER again when "Press ENTER when Ready: xxx ppm" appears on screen. This will cause "Calibrating...Please Wait" to appear on screen.

Note: This calibration is effective when the instrument is in the Survey Mode, which is the default mode. For calibrations other the one described, or if proper calibration cannot be obtained, refer to the manufacturer's instruction manual.

- For calibrations using an alternate gas or span values, refer to Section 4.5 of the manufacturer's instruction manual.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form" which accompanies each DL 101.

5.2 Operation

PI 101

Note: IMPORTANT - The PI 101 should be "zeroed" in a fresh air environment if at all possible. If there is a background concentration, it must be documented and then zeroed out.

- Prior to each use of the PI 101, check that the battery is fully charged by turning the dial to BATT and making sure that it is within range. Also make sure that the ultraviolet lamp and the fan are working properly.

- Select your desired range. PI 101 ranges consists of a 0-20, 0-200, and 0-2,000 ppm, respectively. Consult with the Field Team Leader for more information when choosing the appropriate range, however, in most instances the range will be set initially at 0-20.

- When PI 101 is used intermittently, turn knob to STANDBY to help in extending the life of the UV lamp when operating in a low humidity environment. Otherwise, leave the knob set to the range desired so that the UV lamp will "burn off" any accumulated moisture.

Note: When using the PI 101, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

DL 101

The DL 101 is designed to default to the survey mode when initially powered up, therefore once the calibration has been completed, the instrument is ready to go. Within the survey mode several options are available, briefly these options include:

1. The Site Function

The Site function assigns a number to a site that is being analyzed. Press the Site Key on the keypad to enter a specific site number, or press the gray button on the rear of the probe to increment a site number.

2. Logging Data

The Log function stores data in memory. To log data, press the Log key on the keypad or the Log button on the back of the probe. "Log" will appear in the upper right corner of the display when activated and disappears when not activated. To turn logging off, press either the Log key on the keypad or the red Log button on the rear of the probe.

- The DL 101 allows for the interchanging of different voltage lamps, however, refer to the manufacturer's instructions before attempting to change the lamp.

- The DL 101 also offers three other modes of operation, the Hazardous Waste Mode, the Industrial Hygiene Mode, and the Leak Detection Mode. Each of these modes increases the range of capabilities for this instrument which is covered in detail in the manufacturer's instruction manual.

Note: When using the DL 101, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

5.3 Interferences and Potential Problems

A number of factors can affect the response of the PI 101 and DL 101.

- High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when monitoring a soil gas well that is accessible to groundwater.

- High concentrations of methane can cause a downscale deflection of the meter.

- High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpines in wooded areas, will also affect instrument response.

5.4 Maintenance

The best way to keep an HNu PID operating properly is to keep it as clean as possible. HNu PID's should be decontaminated or wiped down daily or after each use, as appropriate.

Corrective Maintenance

- The ultraviolet lamp should be periodically cleaned using a special compound supplied by HNu Systems, Inc. for the 10.2 eV lamp, and a chlorinated solvent such as 1,1,1-trichloroethane for the 11.7 eV lamp. Consult the manufacturer's instruction manual for specific cleaning instructions.

- The ionization chamber can be periodically cleaned with methyl alcohol and a swab.

Note: UV lamp and ion chamber cleaning is accomplished by following the procedures outlined in Section 5.2, however, this should only be performed by trained personnel.

- Documenting the HNu PID's observed symptoms and then referring to the manufacturer's instruction manual section on troubleshooting (Section 6.0) also can be employed. If this does not work, the Field Team Leader should be consulted for an appropriate course of action.

Repair and Warranty Repair - HNu PID's have different warranties for different parts, so documenting the problem and sending it into the manufacturer assists in expediting repair time and obtaining appropriate warranty service.

5.5 Shipping and Handling

Following is information regarding the transport of the HNu PID meter and calibration gas.

- If the HNu PID is to be carried on aircraft, the calibration gas must be removed from the carrying case as cylinders of compressed gas are not permitted on passenger aircraft. The calibration gas should either be shipped to the site of its intended use, or purchased locally.

- Shipping of the calibration gas requires the completion of a form (specified by the shipping company) that identifies the package as a compressed gas. Compressed gas stickers must be affixed to the package.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, activity monitored, (surface water sampling, soil sampling, etc.) serial number, time, resulting concentration, comments and identity of air monitoring personnel.

- Field observations - Appearance of sampled media (if definable).

- Additional remarks (e.g., the HNu PID meter had wide range fluctuations during air monitoring activities).

7.0 REFERENCES

HNu Systems, Inc. Instruction Manual. Model PI 101, 1986.
HNu Systems, Inc. Operator's Manual. Model DL 101, 1991.

APPENDIX J
BACHARACH OXYGEN/ COMBUSTIBLE GAS METER

FIELD EQUIPMENT OPERATION AND MAINTENANCE PROCEDURES - BACHARACH COMBUSTIBLE GAS/ OXYGEN METER PERSONAL GAS MONITOR

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BACHARACH COMBUSTIBLE GAS/ OXYGEN METER AND PERSONAL GAS MONITOR

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the Bacharach Sentinel 4 and Bacharach Sniffer® 503-A meters in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

2.0 SCOPE

This procedure provides information into the field operation and general maintenance of the Sentinel 4 Sniffer and 503-A. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

3.0 DEFINITIONS

Carbon Monoxide Sensor - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Combustible Gas - Combustible gas is expressed as a percent of the lower explosive limit (LEL).

Hydrogen Sulfide Sensor - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

Sentinel 4 - Combustible Gas/Oxygen/Hydrogen Sulfide/Carbon Monoxide meter.

Sniffer 503-A - portable Combustible Gas and Oxygen Alarm instrument.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project -specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in the Field Logbook during each field investigation.

5.0 PROCEDURES

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A utilize the principle of detecting sensors. The following four paragraphs discuss theory of operation as it applies to each functional sensor.

The combustible gas sensor uses two elements that are wound with a platinum wire. One of the elements is impregnated with a catalyst to oxidize combustible gases. The other element is impregnated with material that will also oxidize combustible gases, but will respond to temperature and humidity conditions. When the meter is turned on, an electrical current is passed through the elements and wires. As a combustible gas enters the chamber the elements will oxidize the combustible gas, thus increasing the heat and resistance of the element. This change in resistance causes a system imbalance, which produces a measurable signal proportional to the combustible gas concentration.

The percent oxygen is measured utilizing an electrochemical sensor. As atmospheric oxygen enters the meter it diffuses into the sensor which converts the amount of oxygen in the sensor to a voltage signal. This voltage is directly proportional to percent oxygen in the atmosphere.

The concentration of hydrogen sulfide is measured utilizing an electrochemical sensor. As atmospheric hydrogen sulfide enters the meter it diffuses into the sensor which converts the amount of hydrogen sulfide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric hydrogen sulfide concentration.

The concentration of carbon monoxide as measured utilizing an electrochemical sensor. As atmospheric carbon monoxide enters the meter it diffuses into the sensor which converts the amount of carbon monoxide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric carbon monoxide concentration.

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A are intrinsically safe for use in Class I, Division 1, Groups A, B, C and D hazard areas. One fact that needs to be expressed is that this type of monitoring equipment utilizes internal oxidation of combustibles, if the meter is placed in an oxygen deficient atmosphere, the combustible reading may be affected. Review of each of the instruction manuals will aid in determining the percentage of oxygen that affects the combustible gas readings.

The following subsections will discuss Sentinel 4 and Sniffer 503-A calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

5.1 Calibration

Sentinel 4

Due to the numerous steps involved in calibration, it is recommended that you follow the calibration procedures (on a daily basis) as outlined in the instruction manual from pages 5-12 to 5-20.

NOTE: A calibration kit will be provided for each Sentinel 4. This kit contains a cylinder for the combustible gas sensor, one cylinder for the hydrogen sulfide sensor, and one cylinder for the carbon monoxide sensor. The oxygen sensor can be calibrated with (uncontaminated/fresh air environment) atmospheric air and does not need cylinder gas.

Note: When a single sensor doesn't zero, none of the sensors are zeroed.

Sniffer® 503-A

Oxygen Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if battery is in recharge zone instrument will need to be charged.

2. To zero the oxygen detector, turn function switch to "BATTERY TEST" position and press "TEST" switch and observe the O_2 meter indication. If indicator is zero, no further adjustment is necessary. If not, follow procedures in Section 5.4.1 of the Operations Manual.

3. To calibrate the oxygen detector, turn function switch to "BATTERY TEST" position. Unlock the "OXYGEN CALIB" knob and adjust it for an O2 meter indication of 21 or at the CAL mark. Relock "OXYGEN CALIB" knob. If using zero calibration gas, follow procedures in Section 5.4.2 of the Operator's Manual.

4. Record on Calibration Sheet.

% LEL Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if batter is in recharge zone, instrument will need to be charged. Allow 5 minutes for the instrument to warm up.

2. Turn function switch to the % LEL position.

   Note: To eliminate the annoyance of the audible alarm, cover the alarm with a hand or duct tape during calibration. The tape must be removed, prior to operation!!

3. Connect calibration gas (typically 30% of the LEL) and allow gas to flow for 1 minute.

Note: If calibration gas has a concentration value, not a % LEL value, the % LEL can be calculated as follows:

% calibration gas (i.e., methane) x 20% LEL (meter alarm setting) = % LEL calibration setting

If meter indication is within ±5% of LEL calibration gas, no further adjustment is required. If not, follow procedures in Section 5.5.4 of Operator's Manual.

Sniffer® 503-A

1. Connect sample probe and tubing to the instrument's sample inlet (refer to Sections 8.4 and 8.5 for the Operator's Manual for available hoses and probes.

2. Check that battery is in Operational Range.

3. Turn instrument to % LEL range and allow to warm up for 1 minute.

4. Check in a fresh air environment that % LEL reads 0% and that O_2 indicator reads 21% (calibration mark).

5. Sample air/gas from area to be tested, allow 30 seconds for readings to stabilize. When finished, allow at least 10 seconds (longer if extension line is used) to purge sample line.

6. If instrument is operating erratically, refer to "TROUBLESHOOTING" Section (Table 5-2) in Operator's Manual.

5.2 Operation

Sentinel 4

Due to the Sentinel 4 having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 6-1 to 6-34.

NOTE: Since the Sentinel 4 is capable of measuring four different parameters, an understanding of the alarm, error, and fault messages must be obtained. This can be done by reviewing the troubleshooting table found on pages 9-2 to 9-9.

5.3 Site Maintenance

After each use, the meters should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

5.4 Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.

- Field observations - Appearance of sampled media (if definable).

- Additional remarks (e.g., the Sentinel 4 or Sniffer 503-A had wide range fluctuations during air monitoring activities.)

  NOTE: The "Toxic Gas Meter Calibration Form" will be completed daily, prior to performing any air monitoring.

7.0 REFERENCES

Bacharach Installation, Operation, Maintenance Manual, Sentinel 4 Personal Gas Monitor, 1990.
Bacharach Installation, Operation, Maintenance Manual, Sniffer® 503-A, Rev. 3 - October, 1990.

APPENDIX K
WASTEWATER SAMPLE ACQUISITION

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WASTEWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for collecting wastewater samples.

2.0 SCOPE

This procedure provides information for the acquisition of waste water samples. Review of the information contained herein will ensure that sample acquisition is properly conducted.

3.0 DEFINITIONS

Sampling Plan - A "plan of action" that guides the implementation of methods that will lead to achieving the plans objective(s).

Grab Sample - An entire sample which is collected at one specific sample location at a specific point in time.

Composite Sample - A sample which is collected at several different locations and/or at different points in time.

Environmental Sample - Samples of naturally occurring materials; soil, sediment, air, water.

Waste Sample - Samples which are comprised of process wastes or other manmade waste material(s).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project specific plans are in accordance with procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the waste water sample acquisition techniques and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the Field Investigation personnel performing the sample acquisition activities have been briefed and trained to execute these procedures.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project specific procedures as outlined in the Work Plan and as directed by the Field Team Leader and Project Manager. The Field Investigation Personnel are responsible for documenting all wastewater sampling activities and ambient air monitoring results in the field log book.

5.0 PROCEDURES

This protocol outlines procedures and equipment for the collection of representative liquid samples and sediment/sludge samples from standing lakes, ponds and lagoons, and flowing streams, rivers, channels, sewers and leachate seeps.

The collection of samples from these sources presents a unique challenge. Often sampling can be quite easy and routine (e.g., collecting a surface water sample from a two foot deep stream). Other times, the nature of site specific conditions may dictate that: 1) special equipment is needed to access the sample, 2) appropriate health and safety measures are critical, 3) proper timing is essential due to waste release times or tidal fluctuations, and/or 4) wastewater flow rate is a factor for consideration.

Prior to sample collection, impoundment characteristics (size, depth, flow) should be recorded in the field log book. Sampling should proceed from downstream locations to upstream locations so that sediment disturbance (turbidity) caused by sampling does not affect sample quality. Additionally, if a sediment sample will be collected at the same location as a liquid sample, the liquid sample must be collected first to minimize sample turbidity.

If the Sampling Plan requires that samples are to be collected from the shore of an impoundment, specific health and safety considerations must be addressed. The person collecting the sample should be fitted with a safety harness and rope secured to a sturdy, immobile object on shore. Backup personnel should be available to assist in sample collection and should be prepared and able to pull the sampler to safety if unstable banks are encountered.

To more adequately characterize the content and/or quality of an impoundment, samples may be collected away from the shoreline, often at various depths. If the content of the impoundment is suspected to be highly hazardous, the risk to sampling personnel must be weighed against the need to collect the sample. If a barge or boat is used, each person on the vessel must be equipped with a life preserver and/or lifeline.

The sampling of liquids in lakes, ponds, lagoons, streams, rivers, channels, sewers and leachate seeps is generally accomplished through the use of one of the following samplers:

- Laboratory cleaned sample bottle
- Pond sampler
- Weighted bottle sampler
- Wheaton dip sampler
- Kemmerer Depth Sampler
- Bacon Bomb Sampler

The factors that will contribute to the selection of a sampler include the width, depth and flow of the location being sampled, and whether the sample will be collected from the shore or a vessel.

For flowing liquids, tidal influence on the collected sample is an additional concern and should be addressed in the Sampling Plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages as well as seasonally. Tidal information can be obtained from local bait shops, newspaper listings and/or local radio or television news reports.

Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast flowing rivers and steams it may be nearly impossible to collect a mid-channel sample at a specific point. Low flowing streams and leachate seeps present the opposite problem. In these cases the sampler should attempt to locate an area where flow is obstructed and a pool is created. If this is not possible, sediment may be dug with a decontaminated trowel to create a pooled area where sufficient liquid will accumulate for sampling.

5.1 On-Shore

If the banks are not sloped, sampling personnel may be able to collect the liquid directly into the sample bottle. In some instances where access is limited, a pond sampler, by virtue of its extension capabilities, may be necessary. For a stream, channel or river, collect the sample at mid-depth. For standing liquid, collect the sample from just below the surface or at mid-depth. Once the sample is obtained by sample vessel, transfer it directly into the sample bottle. If volatile organic compounds (VOCs) are to be analyzed, fill the appropriate sample containers for VOCs first, then fill sample containers for other chemical analyses. Decontaminate the sampling device following procedures outlined in the Sampling Plan and/or SOP F502 before obtaining the next sample.

5.2 Off-Shore

Collect a liquid sample using the sample bottle or decontaminated pond sampler, if necessary. If the liquid has stratified, a sample of each strata should be collected. One of the depth samplers listed above will allow collection of discrete representative liquid samples at various depths. Proper use of the chosen sampling device includes slowly lowering and careful retrieval of the sample, immediate transfer of the liquid into the appropriate sampling container, and logbook notation of the depth at which the sample was collected. After collection, the sampling device must be decontaminated prior to obtaining the next sample.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records shall consist of recording sample date and acquisition time(s), sample number, sample location(s), sample depth(s), name of the Field Investigation Personnel collecting the sample(s), and Service Order Number in the field logbook. The type of container used to hold the sample and preservative agent, if needed, also will be documented, as will the method of sampling equipment decontamination. In addition, if photographs are taken of the sample site, the photograph number and direction of view shall be recorded as well.

7.0 REFERENCES

Field Sampling Procedures Manual. Chapter 8. New Jersey Department of Environmental Protection and Energy, Trenton, New Jersey. May 1992.

Sampling and Analysis Methods. Compilation of EPA's Sampling and Analysis Methods, USEPA, Washington, D.C. 1991.

Characterization of Hazardous Waste Sites. USEPA, Washington, D. C. 1990.

APPENDIX L
SAMPLE PRESERVATION AND HANDLING

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ATTACHMENT A -- REQUIRED CONTAINER, PRESERVATION TECHNIQUES, AND HOLDING TIMES

ATTACHMENT B -- SAMPLE SHIPPING PROCEDURES

SAMPLE PRESERVATION AND HANDLING

1.0 PURPOSE

This SOP describes the appropriate containers for samples of particular matrices, and the steps necessary to preserve those samples when shipped off site for chemical analysis. It also identifies the qualifications for individuals responsible for the transportation of hazardous materials and samples and the regulations set forth by the Department of Transportation regarding the same.

2.0 SCOPE

Some chemicals react with sample containers made of certain materials; for example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the integrity of the sample prior to analysis.

Many water and soil samples are unstable and may change in chemical character during shipment. Therefore, preservation of the sample may be necessary when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s). While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that may occur after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/freezing. Their purposes are to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

Typical sample container and preservation requirements for this project are provided in Attachment A of this SOP. Note that sample container requirements (i.e., volumes) may vary by laboratory.

The Department of Transportation, Code of Federal Regulations (CFR) Title 49 establishes regulations for all materials offered for transportation. The transportation of environmental samples for analysis is regulated by Code of Federal Regulations Title 40 (Protection of the Environment), along with 49 CFR Part 172 Subpart H. The transportation of chemicals used as preservatives and samples identified as hazardous (as defined by 49 CFR Part 171.8) are regulated by 49 CFR Part 172.

3.0 DEFINITIONS

HCl - Hydrochloric Acid

H_2SO_4- Sulfuric Acid

HNO_3 - Nitric Acid

NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalents per liter, where an equivalent is the amount of a substance containing one mole of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one mole of H, is "one-normal," while a one molar solution of H_2SO_4 containing two moles of H, is "two-normal."

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is also responsible for proper certification of individuals responsible for transportation of samples of hazardous substances.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures. The Field Team Leader is responsible to ensure all samples and/or hazardous substances are properly identified, labeled, and packaged prior to transportation.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate sample preservation and handling. It is also the responsibility of the field sampling personnel to understand and adhere to the requirements for proper transportation of samples and/or hazardous substances.

5.0 PROCEDURES

The following procedures discuss sample containerization and preservation techniques that are to be followed when collecting environmental samples for laboratory analysis.

5.1 Sample Containers

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be measured is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then glass or plastic containers may be used. Containers shall be kept out of direct sunlight (to minimize biological or photo-oxidation/photolysis of constituents) until they reach the analytical laboratory. The sample container shall have approximately five to ten percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (one liter of water at 4°C expands by 15 milliliters if heated to 130°F/55°C); however, head space for volatile organic analyses shall be omitted.

The analytical laboratory shall provide sample containers that have been certified clean according to USEPA procedures. Shipping containers for samples, consisting of sturdy ice chests, are to be provided by the laboratory.

Once opened, the sample container must be used at once for storage of a particular sample. Unused, but opened, containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing liners (if required for the container) shall be discarded.

General sample container, preservative, and holding time requirements are listed in Attachment A.

5.2 Preservation Techniques

The preservation techniques to be used for various analytes are listed in Attachment A. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or added in the field using laboratory supplied preservatives. Some of the more commonly used sample preservation techniques include storage of sample at a temperature of 4°C, acidification of water samples, and storage of samples in dark (i.e. amber) containers to prevent the samples from being exposed to light.

All samples shall be stored at a temperature of 4°C. Additional preservation techniques shall be applied to water samples as follows:

- Water samples to be analyzed for volatile organics shall be acidified.
- Water samples to be analyzed for semivolatile organics shall be stored in dark containers.
- Water samples to be analyzed for pesticides/PCBs shall be stored in dark containers.
- Water samples to be analyzed for inorganic compounds shall be acidified.

These preservation techniques generally apply to samples of low-level contamination. The preservation techniques utilized for samples may vary. However, unless documented otherwise in the project plans, all samples shall be considered low concentration. All samples preserved with chemicals shall be clearly identified by indicating on the sample label that the sample is preserved.

5.3 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses is considered the holding time and must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for routine sample collection are provided in Attachment A.

6.0 SAMPLE HANDLING AND TRANSPORTATION

After collection, the outside of all sample containers will be wiped clean with a damp paper towel; however sample handling should be minimized. Personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination and loss of sample labels. Sealable plastic bags, (zipper-type bags), should be used when glass sample containers are placed in ice chests to prevent cross-contamination, if breakage should occur.

Samples may be hand delivered to the laboratory or they may be shipped by common carrier. Relevant regulations for the storage and shipping of samples are contained in 40 CFR 261.4(d). Parallel state regulations may also be relevant. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Standard procedures for shipping environmental samples are given in Attachment B.

7.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

USEPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. USEPA EMSL, Cincinnati, Ohio.

USEPA, Region IV, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

Protection of the Environment, Code of Federal Regulation, Title 40, Parts 260 to 299.

Transportation, Code of Federal Regulation, Title 49, Parts 100 to 177.

ATTACHMENT A

REQUIRED CONTAINER, PRESERVATION TECHNIQUES AND HOLDING TIMES

ATTACHMENT A

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time [1]	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
PCB/Pesticides	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
Cyanide	plastic/glass	NaOH to pH>12 Cool to 4°C	14 days	CLP EPA 335.2	1 x 1 liter
Metals (TAL)	plastic/glass	HNO_3 to pH <2	180 days except Mercury is 26 days	CLP	1 x 1 liter
Total Organic Carbon	glass, teflon lined cap	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 415.1	2 x 40 ml
Total Organic Halogen	plastic/glass	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 450.1	250 ml
Chloride	plastic/glass	none required	28 days	EPA 325.2/325.3	250 ml
Sulfate	plastic/glass	Cool to 4°C	28 days	EPA 375.4	250 ml
Alkalinity	plastic/glass	Cool to 4°C	14 days	EPA 310.1/310.2	250 ml
Gross alpha/gross beta	plastic/glass	HNO_3 to pH <2	6 months	9310	1 gallon
Chlorinated herbicides	glass, teflon lined cap	Cool to 4°C	14/28 days	EPA 515.1	1000 ml
Hardness	plastic/glass	HNO_3 to pH <2	6 months	EPA 130.2	150 ml

[1] Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT A (Continued)

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time [1]	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C	10 days	CLP	1 x 50 gm
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 250 gm
PCB/Pesticides	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 50 gm
Metals (TAL)	plastic/glass	Cool to 4°C	Mercury is 26 days 180 days	CLP	1 x 50 gm
Cyanide	plastic/glass	Cool to 4°C	14 days	CLP EPA 335.2M	1 x 50 gm

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

Introduction

Samples collected during field investigations or in response to a hazardous materials incident must be classified by the project leader, prior to shipping by air, as either environmental or hazardous substances. The guidance for complying with U.S. DOT regulations in shipping environmental laboratory samples is given in the "National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Pertinent regulations for the shipping of environmental samples is given in 40 CFR 261.4(d). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods/hazardous substance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the United Nations International Civil Aviation Organization (UN/ICAO),which is equivalent to IATA.

Individuals responsible for transportation of environmental samples or dangerous goods/hazardous substances must be tested and certified by their employer. This is required by 49 CFR Part 172 Subpart H Docket HM-126 to assure the required qualifications for individuals offering materials for transportation.

Environmental samples shall be packed prior to shipment by commercial air carrier using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape. Line the cooler with a large heavy duty plastic bag. This practice keeps the inside of the cooler clean and minimizes cleanup at the laboratory after samples are removed.

2. Allow sufficient headspace (ullage) in all bottles (except VOAs) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

3. Be sure the lids on all bottles are tight (will not leak). In many regions custody seals are also applied to sample container lids. The reason for this practice is two-fold: to maintain integrity of samples and keep lid on the container should the lid loosen during shipment. Check with the appropriate regional procedures prior to field work. In many cases, the laboratory manager of the analytical lot to be used on a particular project can also provide this information.

4. It is good practice to wrap all glass containers in bubblewrap or other suitable packing material prior to placing in plastic bags.

5. Place all bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape, unless the bag is a zipper-type bag). Up to three VOA bottles, separately wrapped in bubblewrap, may be packed in one plastic bag.

6. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite.

7. Place two to four inches of vermiculite (ground corn cob, or other inert packing material) in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the addition of more vermiculite between the bottles and cans.

8. Put frozen "blue ice" (or ice that has been placed in properly sealed, double-bagged, heavy duty polyethylene bags) on top of and between the samples. Fill all remaining space between the bottles or cans with packing material. Fold and securely fasten the top of the large heavy duty plastic bag with tape (preferably electrical or duct).

9. Place the Chain-of-Custody Record and the Request for Analysis Form (if applicable) into a plastic bag, tape the bag to the inner side of the cooler lid, and then close the cooler and securely tape (preferably with fiber tape) the top of the cooler unit. Wrap the tape three to four times around each side of the cooler unit. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

10. Each cooler (if multiple coolers) should have its own Chain-of-Custody Record reflecting the samples shipped in that cooler.

11. Label according to 40 CFR 261.4(d). The shipping containers should be marked "THIS END UP," and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper and laboratory shall be placed on the outside of the container. It is good practice to secure this label with clear plastic tape to prevent removal during shipment by blurring of important information should the label become wet. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill, which is secured to the top of the shipping container. Please note several coolers/shipping containers may be shipped under one airbill. However, each cooler must be labeled as "Cooler 1 of 3, Cooler 2 of 3, etc.", prior to shipping. Additionally it is good practice to label each COC form to correspond to each cooler (i.e., 1 of 3, 2 of 3, etc.).

APPENDIX M
CHAIN-OF-CUSTODY

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ATTACHMENT A -- EXAMPLE CLIENT (SAMPLE) LABEL
ATTACHMENT B -- EXAMPLE CHAIN-OF-CUSTODY RECORD

CHAIN-OF-CUSTODY

1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody procedures to be used to document sample handling.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 DEFINITIONS

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file. An example of a Chain-of-Custody Record Form is presented in Attachment B.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

5.0 PROCEDURES

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, record keeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.1 Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s)
- Project and Task Number
- Project Sample Number
- Sample location or sampling station number
- Date and time of sample collection and/or measurement
- Field observations
- Equipment used to collect samples and measurements
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

5.1.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions,

depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project and Task Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/85).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 am., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

5.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.

5.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below.

- Enter header information (Project and Task number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner.

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening so that it would be broken if the container was to be opened.

- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

6.0 QUALITY ASSURANCE RECORDS

Once samples have been packaged and shipped, the COC copy and airbill receipt becomes part of the Quality Assurance Record.

7.0 REFERENCES

1. USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

ATTACHMENT A

EXAMPLE CLIENT (SAMPLE) LABEL

ATTACHMENT A

EXAMPLE SAMPLE LABEL

Baker

Baker Environmental Inc.
Airport Office Park, Bldg. 3
420 Rouser Road
Coraopolis, PA 15108

Project: 19026-SRN CTO No.: 0026

Sample Description: Groundwater

Date: 09/17/92 Sampler: ABC

Time: 0944

Analysis: TAL Metals (CAP) Preservation: HNO_3

Project Sample No.: CAX-GW-04

Note: Typically, sample labels are provided by the analytical laboratory and may be used instead of the above. However, samplers should make sure all pertinent information can be affixed to the label used.

ATTACHMENT B

EXAMPLE CHAIN-OF-CUSTODY RECORD

Baker Environmental, Inc.

Airport Office Park, Bldg. 3
420 Rouser Road
Coraopolis, PA 15108
412-269-6000
412-269-6097 (fax)

CHAIN-OF-CUSTODY RECORD

Project Number: _____
Project Name: _____
Field Team: _____
SEND RESULTS TO: _____

Sample Number	Date	Time	Sample Location	Matrix Type (1) GB (2)	Matrix Type (1) COM. (2)	Analytical Methods / Preservatives												General Comments / Remarks
						Type of Container(s) (3)												
						Number of Container(s)												

Relinquished By: _____ Date: _____ Time: _____
Received By: _____ Date: _____ Time: _____
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ _____

Relinquished By: _____ Date: _____ Time: _____
Received By: _____ Date: _____ Time: _____
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ _____

Relinquished By: _____ Date: _____ Time: _____
Received By: _____ Date: _____ Time: _____
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ _____

Sample Stored at 4°C: Yes ☐ No ☐
Chain-of-custody seal on cooler: Yes ☐ Number: _____ No ☐
Analysis turnaround: Priority ☐ _____ hrs. Regular ☐
See Work Order ☐
See Analysis Request Form ☐
Sample Disposal: Return to Baker ☐ Lab Disposal ☐
Archive until: _____ (date)

NOTES:

(1) A - Air; GW - Groundwater; S - Spring; SO - Soil; SW - Surface water; W - Waste; WP - Wipe; WW - Wastewater

(2) GB - Grab; COM - Composite

(3) P - Plastic; G - Glass

ATTACHMENT C

EXAMPLE CUSTODY SEAL

ATTACHMENT C

EXAMPLE CUSTODY SEAL

Baker ____/____/____ Date _____ Signature CUSTODY SEAL	Baker ____/____/____ Date _____ Signature CUSTODY SEAL

APPENDIX N
FIELD LOGBOOK

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FIELD LOGBOOK FIELD LOGBOOK

1.0 PURPOSE

This SOP describes the process for maintaining a field logbook.

2.0 SCOPE

The field logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the field logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The field logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The field logbook becomes part of the permanent site file. Because information contained in the field logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

3.0 DEFINITIONS

Field logbook - The field logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the crew members participation in the project.

5.0 PROCEDURES

The following sections present some of the information that must be recorded in the field logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Project and Task Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential field logbook number

It is good practice to list important phone numbers and points of contact here.

5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other field logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes the following:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required
- Photograph log
- Drum log
- Other pertinent information

All entries should be made in indelible ink; all pages numbered consecutively; and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

5.3 Photographs

If photographs are permitted at the site, the record shall be maintained in the field logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image-enhancement techniques also must be noted in the field logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the field logbook entries.

6.0 QUALITY ASSURANCE RECORDS

Once on-site activities have been completed, the field logbook shall be considered a quality assurance record.

7.0 REFERENCES

None.

FINAL

SUPPLEMENTAL FIELD INVESTIGATION

QUALITY ASSURANCE PROJECT PLAN

SITE 89, OPERABLE UNIT 16

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0181

APRIL 2001

Prepared for:

DEPARTMENT OF THE NAVY
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Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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4-1 Project Organization

ACRONYMS AND ABBREVIATIONS

AA	Atomic Absorption
Baker	Baker Environmental, Inc.
BFB	p-bromofluorobenzene
CCC	Calibration Check Compound
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract Laboratory Program
COC	Chain-of-Custody
CRDL	Contract Required Detection Limit
DFTPP	decafluorotriphenylphosphine
DQO	Data Quality Objectives
DoN	Department of Navy
FSAP	Field Sampling and Analysis Plan
GC/MS	Gas Chromatograph/Mass Spectroscopy
ICP	Inductively Coupled Plasma
IDW	Investigation Derived Waste
LANTDIV	DoN, Atlantic Division
MCB	Marine Corps Base
MDL	Method Detection Limit
NCRs	NFESC Contract Representatives
NFESC	Naval Facilities Engineering Service Center
NTR	Navy Technical Representative
OU	Operable Unit
PCBs	Polychlorinated biphenyls
PEMs	Performance Evaluation Mixtures
PID	Photo Ionization Detection
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RPD	Relative Percent Difference
RRF	Relative Response Factor
SI	Supplemental Investigation
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure

ACRONYMS AND ABBREVIATIONS
(Continued)

TOC	total organic carbon
USEPA	U.S. Environmental Protection Agency
VOCs (VOC)	Volatile Organic Compounds

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been developed for the Supplemental Investigation (SI) at Site 89, Operable Unit (OU) No. 16 at Marine Corps Base (MCB), Camp Lejeune, North Carolina. The purpose of this SI is to further delineate the extent of VOC contamination in the southern portion of Site 89 and to collect data necessary to evaluate remedial actions in the source area.

The preparation of this Work Plan, and other related project plans, is being performed under the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62470-95-D-6007, Contract Task Order 0181. Baker Environmental, Inc., (Baker) is subcontracted to CH2MHill for the implementation of this project.

This QAPP addresses the quality assurance and quality control steps and procedures that will be implemented for sample collection and analysis for this SI. Detailed information regarding sample handling and analytical methods are provided in Sections 6.0 and 9.0, respectively. Sample collection procedures are provided in the Field Sampling and Analysis Plan (FSAP).

The structure of this QAPP and the QA elements addressed are:

- QAPP Scope
- Project Description
- Project Organization
- QA Objectives for Data Measurement
- Sampling Procedures
- Sample and Document Custody
- Calibration Procedures and Frequency
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal QC Checks
- Performance and System Audits
- Preventive Maintenance
- Data Measurement Assessment Procedures
- Corrective Action
- QA Reports to Management

2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN

This QAPP addresses sample collection and analysis to be conducted for the field investigation at Site 89. The QAPP has been developed for the Department of Navy (DoN) in accordance with U.S. Environmental Protection Agency (USEPA) guidelines. Contractors will follow quality control/quality assurance (QA/QC) practices and procedures, including chain-of-custody procedures, while conducting all sample collection and analysis activities.

In order to provide adequate QA/QC, this investigation will require:

1. The use of Naval Facilities Engineering Service Center (NFESC)-certified analytical laboratories;

2. The use of accepted analytical methods for the samples discussed in the FSAP. Analysis of samples for hazardous constituent parameters will be performed in accordance with the following documents:

   - "Statement of Work for Organic Analysis," USEPA, OLM04.2, May 1999
   - "Statement of Work for Inorganic Analysis," USEPA, ILM04.1, 1990
   - "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
   - "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
   - "Test Methods for Evaluating Solid Waste," USEPA SW846, 3rd Edition 1997
   - "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

3.0 PROJECT DESCRIPTION

An introduction to the field investigation for Site 89 describing the project objectives and scope are provided in Sections 1.0 and 4.0 of the SI Work Plan, respectively. These sections discuss the objectives of the SI, and the various field sampling and analytical programs. A detailed description of the field investigations, including sample location and designation and sampling procedures and frequency, is presented in Sections 4.0, 5.0, and 6.0 of the FSAP.

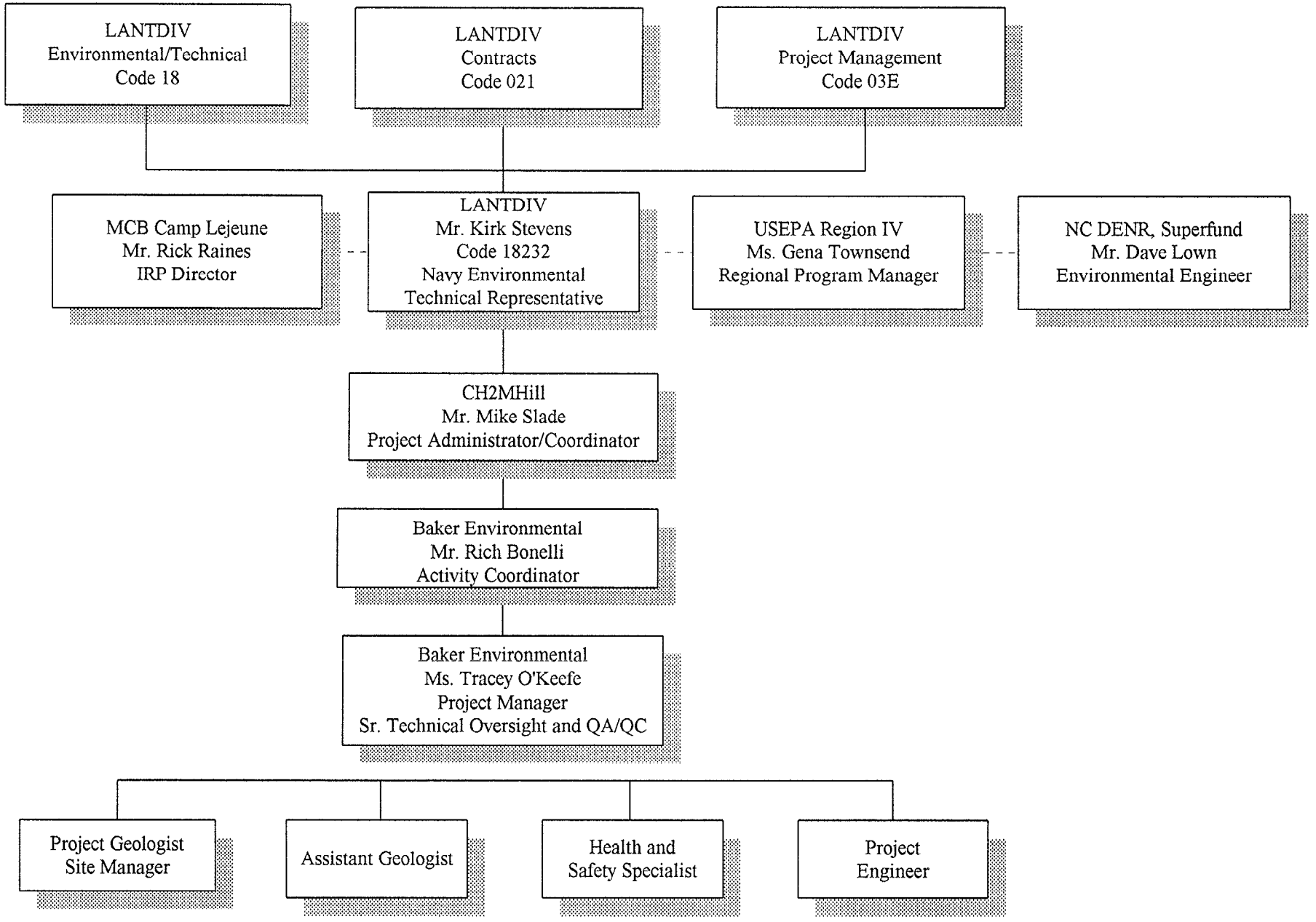
4.0 PROJECT ORGANIZATION

Technical performance of the investigation for Site 89 and key personnel responsible for quality assurance throughout its duration are described in Section 5.0 of the SI Work Plan. The contractor will utilize subcontractors to perform laboratory analysis, data validation, drilling, monitoring well installation, and surveying. Specific subcontractors have not yet been identified. Figure 4-1 shows the project organization, lines of authority, and support personnel/organizations.

SECTION 4.0 FIGURE

FIGURE 4-1

PROJECT ORGANIZATION
SITE 89 SUPPLEMENTAL INVESTIGATION - CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA



5.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The purpose of a QA Program is to establish policies for the implementation of regulatory requirements and to provide an internal means for control and review so that the work performed is of the highest professional standards.

5.1 Project Quality Assurance Objectives

The following is a list of QA objectives that will be implemented at Site 89:

- Obtain scientific data of a quality sufficient to meet scientific and legal scrutiny.
- Gather/develop data in accordance with procedures appropriate for its intended use.
- Ensure that data is of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment and correction where:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of skilled, qualified personnel.
- Assessment of all quality assurance sampling reports furnished by the contract laboratory.
- Assessment of data through data validation, and of procedures through laboratory and field audits.
- Correction for prevention of reoccurrence of conditions adverse to quality.

This QAPP, prepared in direct response to these goals, describes the QA Program to be implemented and the QC procedures to be followed by field and laboratory personnel during the course of the project.

This QAPP presents the project organization and specifies or references technical procedures, documentation requirements, sample custody requirements, audit, and corrective action provisions to be applied to provide confidence that all activities meet the intent of the QA program. This QAPP has been prepared in accordance with USEPA guidance as presented in "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80.

The procedures contained or referred to herein have been taken from:

- "Statement of Work for Organic Analysis," USEPA, OLM04.2, May 1999
- "Statement of Work for Inorganic Analysis," USEPA, ILM04.1, 1990
- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136

- "Test Methods for Evaluating Solid Waste," USEPA SW846, 3rd Edition, 1997

- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

- "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," USEPA, (QAMS 005/80).

5.2 Data Quality Objectives

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data users to specify the quality of data needed from a particular data collection activity to support a specific decision. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, and comparability. Definitions for these terms, as well as for the more general term uncertainty, are given in Table 5-1. A detailed discussion of DQOs for this project is presented in Section 3.0 of the Work Plan.

The intended use of the data, analytical measurements, and the availability of resources are integral in development of DQOs. DQOs define the level of uncertainty in the data that is acceptable for each specific activity during the investigation. This uncertainty includes both field sampling error and analytical instrument error. Ideally, zero uncertainty is the goal; however, the variables associated with sampling and analysis contribute to a degree of uncertainty in any data generated. It is an overall program objective to keep the total uncertainty within an acceptable range, so as not to hinder the intended use of the data. To achieve this objective, specific data quality requirements such as detection limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The data collected will be used:

- To further evaluate the extent of contamination resulting from previous disposal activities in the southern portion of Site 89

- To assess potential contaminant migration and exposure pathways

- To monitor health and safety conditions during field activities

- To identify releases or suspected releases of hazardous waste and/or constituents

All soil and groundwater samples will be analyzed and reported by the laboratory as Level IV data (NFESC Level D). Level IV was selected to provide the highest level of confidence in data quality to be used in the streamed-lined risk evaluation of the SI. All Investigation Derived Waste (IDW) samples will be analyzed and reported by the laboratory as Level III data (NFESC Level C). Field parameters, including temperature, pH, specific conductance, turbidity, and oxidation/reduction potential will be Level I (NFESC Level A) data quality.

SECTION 5.0 TABLE

TABLE 5-1

DEFINITIONS OF DATA QUALITY INDICATORS
SITE 89 EE/CA INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

PRECISION - A measure of mutual agreement among individual measurements of the sample property, usually under prescribed similar conditions. Precision is expressed in terms of the standard deviation. Comparison of replicate values is best expressed as the relative percent difference (RPD). Various measures of precision exist depending upon the "prescribed similar conditions".

ACCURACY - The degree of agreement of a measurement (or an average of replicate measurements), X, with an accepted reference or true value, T, expressed as the difference between the two values, X-T. Accuracy is a measure of the bias in a system.

REPRESENTATIVENESS - Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental concern.

COMPLETENESS - A measure of the amount of the valid data obtained from the measurement system compared to the amount that was expected under "normal" conditions.

COMPARABILITY - Expresses the confidence with which one data set can be compared with another.

UNCERTAINTY - The unlikelihood of all types of errors associated with a particular decision.

6.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES

Sample custody procedures outlined in this section have been developed from "User's Guide to the Contract Laboratory Program," December 1988, OSWER Directive No. 9240.0-01. These procedures are in accordance with "EPA NEIC Policies and Procedure Manual," May 1978, revised November 1984, EPA 330-78-001-R and "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," December 1980, QAMS-005/80.

The purpose of this section is to outline the sample handling and sample documentation procedures to be used during implementation of the FSAP. The objective of the sample handling procedures is to deliver representative samples to the laboratories for analysis. The objectives of the sample documentation procedures are to:

- Ensure complete analysis of the requested parameters within the required turnaround times
- Document the sample from the point of collection to the final data report.

Descriptions of the procedures to be used for sampling the groundwater and soil at the site are provided in Section 6.0 of the FSAP. The number of samples, sampling locations, and sampling rationale by media are presented in Section 4.0 of the FSAP.

6.1 Sampling Handling

The laboratory will provide new polyethylene or glass bottles containing the proper preservatives for sample collection. In addition to the chemical preservatives, samples will be stored on ice at 4°C in a waterproof metal or sturdy plastic cooler, if required. Tables 6-1 and 6-2 provide summaries of containers, preservation, and holding times for water and solids, respectively.

6.2 Chain-of-Custody Procedures

A sample is considered to be in an individual's possession if:

- It is in the sampler's possession or it is in the sampler's view after being in his or her possession.
- It was in the sampler's possession and then locked or sealed to prevent tampering.
- It is in a secure area.

Five kinds of documentation will be used in tracking and shipping the analytical samples:

- Field log book
- Sample labels
- Chain-of-Custody (COC) records
- Custody seals
- Commercial carrier airbills

At a minimum, the label for each sample bottle will contain the following information:

- Site name
- Sample number

- Date and time of collection
- Sample type (grab or composite)
- Matrix
- Sampler's initials

The sample information, as well as the analysis to be performed on the sample, will be entered in the field logbook for each sampling point. Additionally, the following items will be entered:

- Dates and times of entry
- Names of field personnel on site
- Names of visitors on site
- Field conditions
- Description of activities
- Sampling remarks and observations
- QA/QC samples collected
- List of photographs taken
- Sketch of site conditions

Custody of the samples will be maintained by field personnel from the time of sampling until the time they are forwarded to the analytical laboratory.

The sample custody is documented using COC records. Field personnel will complete a COC record, in waterproof ink, to accompany each cooler forwarded from the site to the laboratory. Chemical reagents used to preserve the samples will be recorded on the COC record. Any errors on the COC records will not be erased; instead, a line will be drawn through the error and initialed by the person completing the form. The original copy will be placed in a sealable plastic bag and put inside the appropriate cooler, secured to the cooler lid.

If the sample cooler is to be shipped by commercial air carrier, the cooler must be secured with custody seals so that the seals would be broken if the cooler was opened. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill.

If the sample shipment is hand delivered to the laboratory by field personnel or retrieved by laboratory personnel at the site, then the custody seals are not necessary. The laboratory sample custodian, or his/her designee accepting the sample shipment, whether it is from the air carrier or the field personnel, signs and dates the COC record upon sample receipt. The original COC record will be returned along with the final data report. The laboratory will be responsible for maintaining internal logbooks and records that provide a custody record during sample preparation and analysis.

Laboratory Chain-of-Custody Procedures

Upon sample receipt the steps below will be performed:

- Samples will be received and unpacked in the laboratory where the staff checks for bottle integrity (loose caps, broken bottles, etc.).

- Samples will be verified with incoming paperwork (COC, etc.) by type of bottle and stabilizer. The paperwork must be either signed or initialed.

- Information concerning the sample (from the sampling record, COC, and observation) will be recorded along with parameters to be analyzed, date of sampling, and date the sample is received in the laboratory.

- Samples will be placed in an appropriate secured storage area until analysis.

- When analysis is complete, samples will be stored for a 30-day period unless otherwise specified.

If collected samples arrive without COC or incorrect COC records, the following steps will be taken:

- The laboratory will prepare a nonconformance form stating the problem.

- The site supervisor and Project Manager will be notified.

- If the field staff cannot provide the missing information, the affected samples will not be analyzed.

Primary considerations for sample storage are:

- Secured storage.

- Maintain prescribed temperature, if required, which is typically four degrees Celsius.

- Extract and/or analyze samples within the prescribed holding time for the parameters of interest.

6.3 Document Custody Procedures

Project records are necessary to support the validity of the work and to furnish documentary evidence of quality. The evidentiary value of data is dependent upon the proper maintenance and retrieval of quality assurance records. Therefore, procedures will be established to assure that all documents attesting to the validity of work can be accounted for when the work is completed.

Records must be legible, filled out completely, and adequately identified as to the item or activity involved. Records will be considered valid only if initialed, signed, or otherwise authenticated and dated by authorized personnel. These records may either be originals or reproduced copies. Records submitted to the files, with the exception of correspondence, will be bound, placed in folders or binders, or otherwise secured for filing.

Following receipt of information from external sources, completion of analyses, and issuance of reports or other transmittals, associated records will be submitted to the proper file. In addition, transmitted records must be adequately protected from damage and loss during transfer (e.g, hand carrying or making copies prior to shipment).

The following documents will be transferred to the proper files during the course of the project: calculations and check prints; reports and other data transmittals; copies of proposals, purchase orders for project services, and contracts; correspondence including incoming and outgoing letters, memoranda, e-mails, and telephone records; and reference material.

All individuals on the project staff will be responsible for reporting obsolete or superseded project-related information to the Project Manager. In turn, the Project Manager will notify the project and laboratory staffs of the resulting status change in project documents, such as drawings and project procedures.

In general, outdated drawings and other documents will be marked "void." However, the Project Manager may request the copies be destroyed. One copy of void documents is maintained in the project files with the reasons, and date of voiding clearly indicated.

Documents will be marked "preliminary" to denote calculations and other material which have not been formally checked, or based on information which has not been checked, or do not contribute to final project information.

SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Container	Preservation	Holding Time
TCL Volatile Organic Compounds	Three 40-ml vials with teflon septum caps	Cool, 4°C HCl pH <2	14 days (7 days if unpreserved)
TCL Semivolatile Organic Compounds	Two 1-liter amber glass bottle with teflon caps	Cool, 4°C	7 days to extraction; 40 days from extraction to analysis
TAL Metals	1-500 ml polyethylene bottle	Cool 4°C HNO_3 pH<2	6 months; Mercury 28 days
TSS	1-500 ml polyethylene bottle	Cool, 4°C	2 days
TDS	1-500 ml polyethylene bottle	Cool, 4°C	7 days
TPH – GRO	Three 40-ml vials with teflon septum caps	Cool, 4°C HCI pH < 2	14 days
TPH – DRO	Two 1-liter amber glass bottle with teflon caps	Cool, 4°C	7 days
Corrosivity	One 120-ml polyethylene bottle	Cool, 4°C	Analyze ASAP
Ignitability	One 100-ml polyethylene bottle	Cool, 4°C	Analyze ASAP
Reactivity (sulfide)	One 500 ml polyethylene bottle	Cool, 4°C	14 days
Reactivity (cyanide)	One 250 ml polyethylene bottle	Cool, 4°C	14 days

Notes:

TCL - Target Contaminant List
TAL - Target Analyte List
TSS - Total Suspended Solids
TDS - Total Dissolved Solids

TABLE 6-2

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOLID SAMPLES
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Container	Preservation	Holding Time
TCL Volatile Organic Compounds (SW-846 Method 5035)	Three-ml Encore™ Samplers	Cool, 4°C	48 hours
TCLP Semivolatile Organic Compounds	One 250-ml wide-mouth glass jar	Cool, 4°C	14 days
TCLP Volatile Organic Compounds	One 125-ml amber wide-mouth jar	Cool, 4°C	14 days
TCLP Metals	Two 8-ounce wide-mouth glass jars	Cool, 4°C	14 days
Corrosivity	One 4-ounce wide-mouth glass jar	Cool, 4°C	10 days
Ignitability	One 4-ounce wide-mouth glass jar	Cool, 4°C	14 days
Reactivity	One 4-ounce wide-mouth glass jar	Cool, 4°C	10 days
TOC	One 4-ounce wide-mouth glass jar	Cool, 4°C	10 days
Grain Size	One 4-ounce wide-mouth glass jar	Cool, 4°C	N/A
SPLP (VOCs)	One 4-ounce wide-mouth glass jar	Cool, 4°C	14 days
Laboratory Permeability	Shelby Tube	N/A	N/A

Notes:

TCL - Target Contaminant List
TAL - Target Analyte List
TCLP - Toxicity Characteristic Leaching Procedure
TOC - Total Organic Carbon
SPLP - Synthetic Precipitation Leaching Procedure
N/A - Not Applicable

7.0 CALIBRATION PROCEDURES AND FREQUENCY

The subsections that follow describe calibration procedures and frequency.

7.1 Field Instruments

Two field instruments will be used for health and safety monitoring, the H-Nu System portable Photo Ionization Detection (PID) and the Bacharach O_2/LEL Meter. These instruments will be calibrated on site daily according to the manufacturer's instructions. In addition a factory calibration will be performed prior to the start of site sampling. The calibration standards will be recorded in the field logbook.

A multi-parameter meter will be used to analyze groundwater samples. Multi-parameter meters are capable of measuring temperature, pH, Eh, specific conductance, and turbidity. Manufacturer written calibration methodology will be followed. Specific procedures for the calibration of water quality instruments are presented in the FSAP.

7.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures will be conducted according to the protocols presented in the following documents:

- "Statement of Work for Organic Analysis," USEPA, OLM04.2, May 1999
- "Statement of Work for Inorganic Analysis," USEPA, ILM04.1, 1990
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", USEPA, July 1982
- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
- "Test Methods for Evaluating Solid Waste," USEPA SW846, 3rd Edition 1997
- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

Formal calibration procedures will be established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures will apply to all instruments and equipment quantities. All calibrations will be performed by laboratory personnel or external agencies using standard reference materials.

All calibrations will be recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data will be recorded for all calibrations: the date, target readings, actual readings, instrument identification number, and the analyst's initials. Other data may be recorded depending upon the calibration performed.

Only properly calibrated and operating equipment and instrumentation will be used. Equipment and instrumentation not meeting the specified calibration criteria will be segregated from active equipment whenever possible. Such equipment will be repaired and recalibrated before reuse.

All equipment will be uniquely identified, either by serial number or internal calibration number, to allow traceability between equipment and calibration records. Recognized procedures (ASTM, USEPA, or manufacturer's procedures) will be used for calibration whenever available.

7.2.1 Method Calibration

Method calibration will be performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves will be prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves will be prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

7.2.2 GC/MS System Calibration Procedure

This section outlines the requirements for the calibration of gas chromatograph/mass spectroscopy (GC/MS) systems for the determination of organic compounds. The following operations will be performed in support of these requirements:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time monitoring

Tuning and Mass Calibration

It will be necessary to establish that a given GC/MS system meets the standard mass spectral abundance criteria prior to initiating data collection. This will be accomplished through the analysis of p-bromofluorobenzene (BFB) for volatile compounds or decafluorotri-phenylphosphine (DFTPP) for semivolatile compounds. The BFB or DFTPP criteria must be met before any blanks, standards, or samples are analyzed.

A GC/MS system used for organic compound analysis will be tuned to meet the criteria specified for BFB analysis (volatile compounds) or DFTPP (semivolatile compounds) for an injection of 50 nanograms (ng) of BFB or DFTPP. The analysis must be performed separately from standard or blank analysis. These criteria will be demonstrated every 12 hours of operation. Professional judgment must be used to determine whether background subtraction is required to eliminate column bleed or instrument background (i.e., noise). Calibration documentation will be in the form of a bar graph spectrum and a mass listing.

GC/MS System Calibration

After tuning criteria have been met and prior to sample analysis, the GC/MS system is initially calibrated at five concentrations utilizing the compounds to be analyzed to determine the linearity of response. Internal and surrogate standards will be used with each calibration standard. Standards will be analyzed under the same conditions as the samples.

- Relative Response Factor (RRF) Calculation - The USEPA specifies the internal standard to be used on a compound-by-compound basis for quantification. The RRF will be calculated for each compound at each concentration level.

- Continuing Calibration - A calibration check standard containing all semivolatile or volatile compounds and surrogates will be run every 12 hours of analysis. A system performance check will also be performed. The criteria will be the same as the initial calibration system

performance check. A calibration check will also be performed. The percent difference will be determined for each Calibration Check Compound (CCC).

The percent Difference for each CCC must be less than or equal to 25.0 percent. The system performance check and calibration check criteria must be met before sample analysis can be performed. The continuing calibration will be recorded on the continuing calibration forms.

7.2.3 System Calibration Procedure for Metals Analysis

This section outlines the requirements for the calibration of atomic absorption (AA) and Inductively Coupled Plasma (ICP) systems for the determination of metals. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The AA system utilized for direct aspiration technique analysis will be initially calibrated with a calibration blank and five calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration near, but above, the Method Detection Limit (MDL). The other concentrations will correspond to the expected range of concentrations found in the actual samples. This five-point calibration must be performed daily.

The AA system utilized for graphite furnace technique analysis will be initially calibrated with a calibration blank and three calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration at the Contract Required Detection Limit (CRDL). The other concentrations will correspond to the expected range of concentrations found in the actual samples. This three-point calibration must be performed daily.

For AA systems, the calibration standards will be prepared fresh each time an analysis is to be performed and discarded after use. The standards contain the same reagents at the same concentrations as will result in the samples following preparation.

The ICP system will be calibrated initially with a calibration blank and one calibration standard. This calibration must be performed daily. In addition, ICP systems must undergo quarterly linearity checks.

Correlation Coefficient Calculation

The data points of the blank and the five calibration standards will be utilized to calculate the slope, the intercept, and the correlation coefficient of the best-fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be >0.995 for AA analyses and >0.995 for ICP analysis.

Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of one mid-range calibration standard. The calibration verification acceptance criterion will be as follows:

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 to 120 percent of true value

When measurements exceed the control limits, the analysis will be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

7.2.4 System Calibration Procedure for Inorganic Analyses

This section outlines the requirements that will be used for calibration of calorimetric systems for analyses of inorganic parameters. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The system will be initially calibrated with a blank and five calibration standards. Standard concentrations will be at a concentration near, but above, the MDL with additional concentrations corresponding to the expected range of concentrations found in actual samples. Standards contain the same reagents at the same concentrations as will be present in samples following preparation.

Correlation Coefficient Calculation

Data points of the blank and five calibration standards will be utilized to calculate slope, intercept, and correlation coefficient of a best-fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be >0.995 for all systems.

Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of two calibration standards.

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 - 120 percent of true value

When measurements exceed control limits, analysis will be terminated, the problem will be corrected, the instrument will be recalibrated, and calibration will be reverified.

7.2.5 Periodic Calibration

Periodic calibration must be performed on equipment required in analyses but not routinely calibrated as part of the analytical methodology. Equipment that falls within this category includes ovens, refrigerators, and balances. The calibration will be recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration must be performed.

- Balances will be calibrated weekly with class S weights.

- The pH meter will be calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.

- The temperatures of the refrigerators will be recorded daily.

- All liquid in glass thermometers will be calibrated annually with the N.B.S. certified thermometer. Dial thermometers will be calibrated quarterly.

- The N.B.S. Certified Thermometer will be checked annually at the ice point.

The following equipment must maintain the following temperatures:

- Sample Storage and Refrigerators - within 2 degrees of 4 degrees Celsius
- Water Bath, Mercury - within 2 degrees of 95 degrees Celsius

8.0 ANALYTICAL PROCEDURES

The subsections that follow present analytical procedures.

8.1 Field Analysis

An H-Nu PI-101 meter, used to detect total organic vapors, will be used to analyze ambient air for health and safety monitoring, as well as to screen soil during the soil sampling. An O_2/LEL meter measures the oxygen content in the work atmosphere, as well as concentrations of combustible gases relative to explosive limits. This meter will be used for health and safety monitoring. Both the H-Nu and O_2/LEL instruments will be operated in accordance with the manufacturer's instructions.

The pH, temperature, and specific conductivity of aqueous samples also will be measured in the field. These analyses will be obtained in accordance with "Handbook for Sampling and Sample Preservation of Water and Wastewater," September 1982, EPA/600/4-82-029.

8.2 Laboratory Analysis

The samples that will be collected during the investigation and performed by the fixed-base laboratory will be analyzed for constituents listed in Tables 8-1 through 8-4. Parameters will be analyzed using USEPA methods (with corresponding method performance limits) as noted in Tables 8-1 through 8-4.

All soil and groundwater samples will be analyzed for VOCs. Selected soil samples will be analyzed for grain size, total organic carbon (TOC), and naturally leachable VOCs by synthetic precipitation leaching procedure (SPLP). Liquid IDW will be analyzed for Target Compound List VOCs and semivolatile organic compounds (SVOCs), Target Analyte List Metals, Total Suspended Solids, and Total Dissolved Solids. Solid IDW will be analyzed for Toxicity Characteristics Leaching Procedure VOCs, SVOCs, and metals, corrosivity, ignitability, and reactive cyanide and sulfate.

SECTION 8.0 TABLES

TABLE 8-1

ORGANICS METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Compound	Water CRQL[1] (µg/L)	Soil/Sediment CRQL[1] (µg/kg)	Method
Volatiles			CLP/SOW[2]
Chloromethane	10	10	
Bromomethane	10	10	
Vinyl Chloride	10	10	
Chloroethane	10	10	
Methylene Chloride	10	10	
Acetone	10	10	
Carbon Disulfide	10	10	
1,1 -Dichloroethene	10	10	
1,1 -Dichloroethane	10	10	
1,2 -Dichloroethene	10	10	
Chloroform	10	10	
1,2 -Dichloroethane	10	10	
2-Butanone	10	10	
1,1,1-Trichloroethane	10	10	
Carbon Tetrachloride	10	10	
Bromodichloromethane	10	10	
1,2-Dichloropropane	10	10	
cis-1,3-Dichloropropene	10	10	
Trichloroethene	10	10	
Dibromochloromethane	10	10	
1,1,2-Trichloroethane	10	10	
Benzene	10	10	
trans-1,3-Dichloropropene	10	10	
Bromoform	10	10	
4-Methyl-2-pentanone	10	10	
2-Hexanone	10	10	
Tetrachloroethene	10	10	
Toluene	10	10	
1,1,2,2-Tetrachloroethane	10	10	
Chlorobenzene	10	10	
Ethylbenzene	10	10	
Styrene	10	10	
Xylenes (total)	10	10	

Notes:

(1) Contract Required Quantitation Limit
(2) "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM4.2.

TABLE 8-1 (Continued)

ORGANIC METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Compound	Water CRQL[1] (µg/L)	Soil/Sediment CRQL[1] (µg/kg)	Method
Semivolatiles			
Phenol	10	330	CLP/SOW[2]
bis(2-Chloroethyl)ether	10	330	
2-Chlorophenol	10	330	
1,3-Dichlorobenzene	10	330	
1,4-Dichlorobenzene	10	330	
Benzyl alcohol	10	330	
1,2-Dichlorobenzene	10	330	
2-Methylphenol	10	330	
bis(2-Chloroisopropyl)ether	10	330	
4-Methylphenol	10	330	
N-Nitroso-di-n-dipropylamine	10	330	
Hexachloroethane	10	330	
Nitrobenzene	10	330	
Isophorone	10	330	
2-Nitrophenol	10	330	
2,4-Dimethylphenol	10	330	
Benzoic acid	25	1600	
bis(2-Chloroethoxyl)methane	10	330	
2,4-Dichlorophenol	10	330	
1,2,4-Trichlorobenzene	10	330	
Naphthalene	10	330	
4-Chloroaniline	10	330	
Hexachlorobutadiene	10	330	
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	10	330	
2-Methylnaphthalene	10	330	
Hexachlorocyclopentadiene	10	330	
2,4,6-Trichlorophenol	10	330	
2,4,5-Trichlorophenol	25	1600	
2-Chloronaphthalene	10	330	
2-Nitroaniline	25	1600	
Dimethylphthalate	10	330	
Acenaphthylene	10	330	

Notes:

(1) Contract Required Quantitation Limit
(2) "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM3.1.

TABLE 8-2

INORGANIC METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	CRDL[1] (µg/L)	Method Number[2,3,4]	Method Description
Metals			
Aluminum	200	200.7	Inductively Coupled Plasma
Antimony	60	200.7 204.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Arsenic	10	200.7 206.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Barium	200	200.7	Inductively Coupled Plasma
Beryllium	5	200.7 210.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cadmium	5	200.7 213.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Calcium	5,000	200.7 215.1	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Chromium	10	200.7 218.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cobalt	50	200.7	Inductively Coupled Plasma
Copper	25	200.7	Inductively Coupled Plasma
Iron	100	200.7	Inductively Coupled Plasma
Lead	3	200.7 239.2	Inductively Coupled Plasma Atomic Absorption, Furnace Technique

Notes:

(1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM04.1
(2) Contract Required Detection Limit
(3) Extraction method for arsenic, lead, selenium, and thallium taken from USEPA Method 3020, "Test Methods for Evaluating Sold Waste," USEPA, 3rd Edition, 1997
(4) Extraction method for all other metals taken from USEPA Method 3010, "Test Methods for Evaluating Solid Waste," USEPA, 3rd Edition, 1997
(5) N/A = Not Applicable

TABLE 8-2
(Continued)

INORGANIC METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Method Number[2,3,4]	CRDL[1] (µg/L)	Method Description
Metals (Continued)			
Magnesium	200.7 242.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Manganese	200.7	15	Inductively Coupled Plasma
Mercury	245.1 245.2 245.5	0.2	Water by manual cold vapor technique Water by automated cold vapor technique Soil/sediment by manual cold vapor technique
Nickel	200.7	40	Inductively Coupled Plasma
Potassium	200.7 258.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Selenium	200.7 270.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Silver	200.7 272.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Sodium	200.7 273.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Thallium	200.7 279.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Vanadium	200.7	50	Inductively Coupled Plasma
Zinc	200.7	20	Inductively Coupled Plasma

Notes:

(1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM04.1
(2) Contract Required Detection Limit
(3) Extraction method for arsenic, lead, selenium, and thallium taken from USEPA Method 3020, "Test Methods for Evaluating Sold Waste," USEPA, 3rd Edition, 1997
(4) Extraction method for all other metals taken from USEPA Method 3010, "Test Methods for Evaluating Solid Waste," USEPA, 3rd Edition, 1997
(5) N/A = Not Applicable

TABLE 8-2
(Continued)

INORGANIC METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Method Number	CRDL[1] (µg/L)	Method Description
Inorganics			
Total Dissolved Solids	EPA 160.1	N/A	N/A
Total Suspended Solids	EPA 160.2	N/A	N/A

Notes:

(1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM04.1
(2) Contract Required Detection Limit
(3) Extraction method for arsenic, lead, selenium, and thallium taken from USEPA Method 3020, "Test Methods for Evaluating Sold Waste," USEPA, 3rd Edition, 1997
(4) Extraction method for all other metals taken from USEPA Method 3010, "Test Methods for Evaluating Solid Waste," USEPA, 3rd Edition, 1997
(5) N/A = Not Applicable

TABLE 8-3

TCLP METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Aqueous PQL[1] (µg/l)	Solid PQL[1] (µg/kg)	Method
TCLP Volatiles			EPA Method 3550/ EPA Method 8240
Benzene	5	10	
Carbon Tetrachloride	5	5	
Chloroform	5	5	
1,2-Dichloroethane	5	5	
1,1-Dichloroethylene	5	5	
Methyl ethyl ketone	NA	NA	
Tetrachloroethylene	5	5	
Trichloroethylne	5	5	
Vinyl Chloride	10	10	
TCLP Semivolatiles			EPA Method 3550/ EPA Method 8240
o-Cresol	10	660	
m-Cresol	10	660	
p-Cresol	10	660	
Cresol	10	660	
1,4-Dichlorobenzene	10	660	
2.4-Dinitrotoluene	10	660	
Hexachlorobenzene	10	660	
Hexachlorobutadiene	10	660	
Hexachloroethane	10	660	
Nitrobenzene	10	660	
Pentachlorophenol	50	3,300	
Pyridine	50	660	
2,4,5-Trichlorophenol	10	660	
2,4,6-Trichlorophenol	10	660	

Notes:

(1) Practical Quantitation Limit, taken from "Test Methods for Evaluating Sold Waste," USEPA, 3rd Edition, 1997.

Note: These methods will be used to analyze the Toxicity Characteristic Leaching Procedure (TCLP) extract. The extract will be prepared using Method 1311, described in "Hazardous Waste Management Systems; Identification and Listing of Hazardous Waste; Toxicity Characteristics revision; Final Rule," USEPA, 52FR 26886.

TABLE 8-3
(Continued)

TCLP METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Water PQL[1] (µg/L)	Soil PQL[1] (mg/kg)	Method	Method Description
TCLP Metals				
Arsenic	10	30	6010A 7060	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Barium	20	1	6010A	Inductively Coupled Plasma
Cadmium	1	2	6010A 7131A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Chromium	20	4	6010A 7191A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Lead	10	2	6010A 7421A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Mercury	2	0.002	7470A	Water by manual cold vapor technique Water by automated cold vapor technique
Selenium	20	40	6010A 7740A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Silver	2	4	6010A 7760A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique

Notes:

(1) Practical Quantitation Limit, taken from "Test Methods for Evaluating Sold Waste," USEPA, November 1986 and 1996 updates.

Note: These methods will be used to analyze the Toxicity Characteristic Leaching Procedure (TCLP) extract. The extract will be prepared using Method 1311, described in "Hazardous Waste Management Systems; Identification and Listing of Hazardous Waste; Toxicity Characteristics revision; Final Rule," USEPA, 52FR 26886.

TABLE 8-4

RCRA/ENGINEERING PARAMETERS METHOD PERFORMANCE LIMITS
SITE 89 SUPPLEMENTAL INVESTIGATION – CTO-0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Aqueous PQL(1)	Solid PQL(1)	Method
RCRA			
pH/Corrosivity	N/A(1)	N/A(1)	SW-846 9010
Ignitability	N/A(1)	N/A(1)	SW-846 1010
Reactive Cyanide	10 mg/l(1)	10 mg/l(1)	SW-846 9012
Reactive Sulfide	50 mg/l(1)	50 mg/kg(1)	SW-846 9030
Engineering Parameters			
SPLP (VOCs)	N/A	(2)	SW-846 1312
Total Organic Carbon	N/A	500 mg/kg	SW-846 9060 (Modified) or ASTM D3178 (Modified)
Grain Size	N/A	N/A	ASTM D421/422
Laboratory Permeability	N/A	N/A	ASTM D5084

Notes:

(1) Practical Quantitation Limit, taken from "Test Methods for Evaluating Sold Waste," USEPA, 3rd Edition, 1997.
(2) Same limits for VOCs as presented on Table 8-1.

N/A - Not Applicable
SPLP - Synthetic Precipitation Leaching Procedure

9.0 DATA REDUCTION, VALIDATION AND REPORTING

The subsections that follow present data reduction, validation, and reporting procedures.

9.1 Field Data Procedures

Data validation practices will be followed as described by:

- "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses," USEPA, June 1988.

- "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses - Draft," USEPA, June 1991

The purpose of these practices is to insure that raw data are not altered and that an audit trail is developed for those data that require reduction. The documentation of sample collection will include the use of bound field logbooks in which all information on sample collection will be entered in indelible ink. Appropriate information will be entered to reconstruct the sampling event, including site name (top of each page), sample identification, brief description of sample, date and time of collection, sampling methodology, field measurements and observations, and sampler's initials (bottom of each page, and dated).

A rigorous data control program will insure that all documents for the investigations are accounted for when they are completed. Accountable documents include items such as log books, field data records, correspondence, chain-of-custody records, analytical reports, data packages, photographs, computer disks, and reports. The project manager will be responsible for maintaining a project file in which all accountable documents will be inventoried. The project records will be retained for a period of three years after project closeout; then the files will be forwarded to the Navy.

All the field data, such as those generated during field measurements, observations and field instrument calibrations, will be entered directly into a bound field notebook. Each project team member will be responsible for proofing all data transfers made and the Project Manager or his designee will proof at least ten percent of all data transfers.

9.2 Laboratory Data Procedures

The following procedures summarize the practices routinely used by laboratory staff for data reduction, validation, and reporting. Numerical analyses, including manual calculations, will be documented and subjected to quality control review. Records of numerical analyses must be legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator.

9.2.1 Laboratory Data Validation

Data validation begins with data reduction and continues through to the reporting of data.

Data processing will be checked by an individual other than the analyst who performed the data processing. The checker will review the data for the following:

- Utilization of the proper equations
- Correctness of numerical input

- Correctness of computations
- Correct interpretation of raw data (chromatographs, strip charts, etc.)

The checking process will be sufficient thorough enough to verify the results.

All entries made in bench books, data sheets, computation sheets, input sheets, etc. will be made in ink. No entry will be rendered unreadable.

9.2.2 Analytical Reports

The items listed below will be required of analytical reports.

- Data will be presented in a tabular format.
- Analytical reports will be approved by appropriate laboratory personnel.
- The following information will be included on the report: client name and address, report date, sample date, analysis dates, number of samples, purchase order number, project number, and project type. All pages must be numbered.
- The sample numbers and corresponding laboratory numbers will be identified.
- The parameters analyzed, report units, and values will be identified.
- Method, trip, and field blank results will be reported.
- Matrix spike, matrix spike duplicate, and replicate recoveries will be reported.
- Calibration summaries will be reported.
- Surrogate recoveries will be reported.
- Holding times and sample analysis dates will be reported.
- The detection limit of the procedure will be identified.
- Consistent significant figures will be used.
- Referenced footnotes will be used when applicable.
- A letter of transmittal will accompany the report if any anomalies are associated with the data.

9.3 Independent (Third Party) Data Validation

Review of all pertinent analytical data will be performed by Baker personnel and an independent third party data validator.

A preliminary review will be performed by the Project Manager or designee to verify that all-necessary paperwork (e.g., COC forms, traffic reports, analytical reports, and laboratory personnel signatures) and deliverables are present. A detailed and independent data validation

will be performed by a data validation subcontractor to verify the qualitative and quantitative reliability of the data presented and adherence to stated analytical protocols. This review will include a detailed review and interpretation of all data generated by the laboratory for ***Level IV*** deliverables. The primary tools that will be used by experienced data validation personnel will be analytical method operating practices, statements of work (for Contract Laboratory Program [CLP]), guidance documents, established criteria, and professional judgment.

During the data review, a data support documentation package will be prepared which will provide the back-up information that will accompany all qualifying statements present in the quality assurance review.

CLP data will be validated per the CLP criteria as outlined in the following documents:

- USEPA, Hazardous Site Control Division, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, 1994.

- USEPA, Hazardous Site Evaluation Division, Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, 1994.

All other data will be validated in accordance with method of analysis using the National Functional Guidelines as a reference.

10.0 INTERNAL QUALITY CONTROL CHECKS

The following section describes internal quality control checks.

10.1 Field Quality Control Checks

Four types of field QA/QC samples will be submitted to the laboratory, including trip blanks, equipment rinsates, field blanks, and field duplicates. The results from the field quality control samples will be used by the data validator to determine the overall quality of the data. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 10-1. A summary of the number of environmental and QA/QC samples to be submitted for analysis will be given in the FSAP.

Field Blanks

Field blanks consist of the source water used in decontamination, steam cleaning, and drilling. At a minimum, one field blank from each vent and each source of water must be collected and analyzed for the same parameters as the related samples. Organic-free deionized water is taken to the field in sealed containers and poured into the appropriate sample containers at predesignated locations. This will be done to determine if any contaminants present in the area may have an affect on the sample integrity.

Trip Blank

Analysis of trip blanks will be performed to monitor possible contamination during shipment and collection of samples. Trip blanks are initiated in the laboratory prior to the shipping of sample packs. A corresponding trip blank will be prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples will be prepared by adding four drops of concentrated hydrochloric acid and then filling the container with organic-free deionized water. The trip blanks accompany the samples through shipment to the sample site, sample collection, shipment to the laboratory, and storage of the samples.

If the analyses indicate contamination of the trip blank, the sample sources may be resampled. If the extent and nature of the contamination does not warrant such actions, the data will be accepted as valid.

Field Duplicates

Duplicates for soil samples are collected, homogenized, and split. All samples except volatile organic compounds (VOCs) are homogenized, and split. VOC samples are not mixed, but select segments of the soil are taken from the length of the core by the Encore™ Sampler. Cores may be sealed and shipped to the laboratory for subsampling if the project deems this appropriate. The duplicate for water samples should be collected simultaneously. Field duplicates should be collected at a frequency of 10% per sample matrix for Levels III and IV. All the duplicates should be sent to the primary laboratory responsible for analysis. The same samples used for field duplicates shall be split by the laboratory and used by the laboratory as the laboratory duplicate or matrix spike. This means that for the duplicate sample, there will be analyses of the normal sample, the field duplicate, and the laboratory matrix spike/duplicate.

Equipment Rinsates

Equipment rinsates are the final organic-free deionized water rinse from equipment cleaning collected during a sampling event. The results of the blanks will be used to flag or assess levels of analytes in the samples. This comparison is made during validation. The rinsates are analyzed for the same parameters as the related samples.

10.2 Laboratory Quality Control Checks

This section provides descriptions of the laboratory quality control checks.

Method Blank

Analysis of method blanks will be performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks will be initiated by the analyst prior to the preparation, and/or analysis of the sample set. A method blank consists of a volume of organic-free deionized water equal to the sample volume that is carried through the entire analytical procedure. For solid samples to be analyzed by GC/MS, the method blank consists of a purified solid matrix approximately equal to the sample weight. A method blank will be analyzed with each set of samples or at the very least, daily. If the analytical data of the method blank indicates excessive contamination, the source of contaminant will be determined. The samples may be re-analyzed or the data may be processed "as is" depending upon the nature and extent of the contamination.

Replicate Sample Analysis

Replicate sample analysis will be performed to demonstrate the precision of an analysis. An inter-laboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure. The frequency of inter-laboratory replicate analysis for each analyte is summarized in Table 10-2.

Spike Analysis

Spike analysis will be performed to demonstrate the accuracy of an analysis. The analyst initiates the spike prior to sample preparation and analysis by adding a known amount of analyte(s) to a sample. The spike sample is carried through the entire analytical procedure. The frequency of spike analysis for each analyte(s) is summarized in Table 10-2.

Surrogate Standards

Surrogate standard analysis will be performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC/MS and GC are fortified with a surrogate spiking solution prior to extraction or purging.

Internal Standards

Internal standard analyses will be performed to monitor system stability. Prior to injection or purging, internal standards are added to all blanks and samples analyzed by GC/MS (refer to Section 5.1.1).

Matrix Spikes and Matrix Spike Duplicates

A matrix spike is an aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery. A matrix spike duplicate is a second aliquot of the same matrix as the matrix spike that is spiked in order to determine the precision of the method. A matrix spike and matrix spike duplicate will be performed at a frequency of 1 per 20 samples for organics.

10.3 Laboratory Control Limits

Control limits will be established for QC checks (spikes, duplicates, blanks, etc.). CLP control limits for surrogate standards spikes, and duplicates associated with GC/MS analyses and pesticides/PCB analyses will be applied. Control limits for spikes, duplicates, and reference samples will be determined internally through statistical analysis.

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions must be taken.

Method Blanks

For metals analyses, the criteria below are used for method blank analysis:

- If the concentration of the method blank is less than or equal to the detection level, no correction of sample results is performed.

- If the concentration of the blank is above the detection level for any group of samples associated with a particular blank, the concentration of the sample with the least concentrated analyte must be ten times the blank concentration. Otherwise, all samples associated with the blank and less than ten times the blank concentration must be redigested (reprepared) and reanalyzed, if possible. If the affected samples cannot be reprepared and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.

For GC/MS, GC analyses, the criteria below are used for method blank analysis:

- A method blank for volatile organic analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, 2-butanone, and chloroform).

- A method blank for semivolatile organics analysis must contain no greater than five times the detection limit of common phthalate esters.

- For all other compounds not listed above, the method blank must contain less than the detection limit of any single compound. If a method blank exceeds the criteria, the analytical system is considered to be out of control. The source of the contamination is investigated and appropriate corrective measures are taken and documented before sample analysis proceeds. All samples processed with a method blank that is out of control (i.e., contaminated), are reextracted/repurged and reanalyzed, when possible. If the affected samples cannot be reextracted/repurged and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.

- No positive result for pesticides/PCBs should be reported unless the concentration of the compound exceeds five times the amount in the blank.

- A method blank for pesticides/PCBs must contain no greater than five times the detection limit for any pesticides/PCBs.

Surrogate Standards

For method blank surrogate standard analysis, corrective action will be taken if any one of the conditions below exist:

- Recovery of any one surrogate compound in the volatile fraction is outside the required surrogate standard recovery limit.

- Recovery of any one surrogate compound in the semivolatile fraction is outside surrogate standard recovery limits.

Corrective action will include steps listed below:

- A check of: the calculations for errors; the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and instrument performance.

- Recalculation or reinjection/repurging of the blank or extract if the above corrective actions fail to solve the problem.

- Reextraction and reanalysis of the blank. For sample surrogate standard analysis, corrective action will be taken if any one of the following conditions exist:

  - Recovery of any one surrogate compound in the volatile fraction is outside the surrogate spike recovery limits;

  - Recovery of any one surrogate compound in either semivolatile fraction is below ten percent; or

  - Recoveries of two or more surrogate compounds in either semivolatile fraction are outside surrogate spike recovery limits.

Corrective action will include the steps listed below.

- A check of: the calculations for errors; of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and of instrument performance.

- Recalculating or reanalysis the sample or extract if the above corrective action fails to solve the problem.

- Reextraction and reanalysis of the sample if none of the above are a problem.

SECTION 10.0 TABLES

TABLE 10-1

QA/QC SAMPLE FREQUENCY
SITE 89 SUPPLEMENTAL INVESTIGATION - CTO 0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Type of Sample	Metal	Organic
Trip Blank (for volatiles only)	NA[1]	One per cooler or one per shipping day
Equipment Rinsate[2]	NA	One per sampling method
Field Blank	One per source per event[3]	One per source per event[3]
Field Duplicate[4]	10%	10%

Notes:

(1) Not Applicable

(2) Samples are collected daily; however, only samples from every other day are analyzed. Other samples are held and analyzed only if evidence of contamination exists.

(3) Source water includes water used in decontamination, steam cleaning, and drilling.

(4) The duplicate must be taken from the sample which will become the laboratory matrix spike/matrix spike duplicate for organics or for the sample used as a duplicate in inorganic analysis.

TABLE 10-2

QA/QC ANALYSIS FREQUENCY
SITE 89 SUPPLEMENTAL INVESTIGATION - CTO 0181
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Replicate	Spike
Organic		
All analyses by GC/MS	5%	5%
All analyses by GC	5%	5%
Metals		
Liquids by flame AA or ICP	5%	5%
Solids by flame AA or ICP	5%	10%
All analyses by furnace AA	5%	10%

11.0 PREVENTIVE MAINTENANCE

The following section outlines preventative maintenance.

11.1 Field Maintenance

The H-Nu PI-101 meter is to be used in site characterization and will be maintained as described by the manufacturer's instructions. The pH and specific conductance meters to be used during sampling will be maintained according to Baker's Standard Operating Procedure (SOP) F201. A full set of SOPs will be maintained in the field trailer.

11.2 Laboratory Maintenance

Preventive maintenance is an organized program of actions to prevent instruments and equipment from failing during use and to maintain proper performance of equipment and instruments. A comprehensive preventive maintenance program is implemented to increase the reliability of the measurement system. The preventive maintenance program will address the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime.

- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Troubleshooting, maintenance, and spare parts inventory will be recorded in the logs. Instruments and equipment will be maintained periodically in accordance with procedures described in individual analytical methods, manufacturer's recommendation, and/or service contracts.

The modern analytical laboratory depends heavily upon instrumentation and equipment; therefore, cleaning and preventive maintenance are primary considerations in the sustained production of satisfactory data. Specific requirements for proper care of laboratory instrumentation and equipment are contained in the manufacturer's instructions; however, some general guidelines are considered, and are listed below.

- Special precautions must be taken to avoid spillage of corrosive chemicals on or around equipment and instrumentation not only to extend the life of the item, but also to eliminate contamination.

- Where available, covers must be placed on instrumentation when not in use.

- Instrument parts must be cleaned as required (i.e., mirrors, probes, detector cells).

12.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

The subsections that follow outline data measurement assessment procedures.

12.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives. By maintaining thorough documentation of all decisions made during each phase of sampling, performing field and laboratory audits, thoroughly reviewing the analytical data as they are generated by the laboratory, and providing appropriate feedback as problems arise in the field or at the laboratory, data accuracy, precision, and completeness will be closely monitored.

12.2 Field Quality Assessment

To assure that all field data are collected accurately and correctly, specific written instructions will be issued to all personnel involved in field data acquisition by the Project Manager. The evaluation (data review) of field blanks, and other field QC samples will provide definitive indications of the data quality. If a problem that can be isolated arises, corrective actions can be instituted for future field efforts.

12.3 Laboratory Data Quality Assessment

As part of the analytical QA/QC program, the laboratory applies precision and accuracy criteria for each parameter that is analyzed. When analysis of a sample set is completed, QC data generated will be reviewed and evaluated to ensure acceptance criteria are met. These criteria will be method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results will be evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents are checked for contamination and the analysis of future samples halted until the system can be brought under control. A high background is defined as a background value sufficient to result in a difference in the sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid. A method blank must contain no greater than two times the parameter detection limit for most parameters.

- Trip Blank Evaluation - Trip blank results will be evaluated for high readings similar to the method blanks described above. If high trip blank readings are encountered (i.e. a value sufficient to result in a difference in sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid), procedures for sample collection, shipment, and laboratory analysis are reviewed. If both the method and the trip blanks exhibit significant background contamination, the source of contamination is probably within the laboratory. Ambient air in the laboratory and reagents will be checked as possible sources of contamination.

- Standard Calibration Curve Verification - The calibration curve or midpoint calibration standard (check standard) will be evaluated daily to determine curve linearity through its full range and that sample values are within the range defined by the low and high standards. If the curve is not linear, sample values are corrected. If average response factors are used to calculate sample concentrations, these factors are verified on a daily basis. Verification of calibration curves and response factors will be accomplished when the evaluated response for

any parameter varies from the calibrated response by less than ranges specified in Section 7.0.

- Duplicate Sample Analyses - Duplicate sample analyses will be used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples will be analyzed for this project, field, and laboratory. Duplicate results will be used to calculate precision as defined by the relative percent difference (RPD). If laboratory duplicate values exceed the control limit, the sample set may be reanalyzed for the parameter in question. Precision limits will be updated periodically following review of data.

- Reference Sample Analyses - The results of reference sample analysis will be compared with true values, and the percent recovery of the reference sample will be calculated. If correction is required (excessive or inadequate percent recovery), the reference sample must be reanalyzed to demonstrate that the corrective action has been successful.

- Surrogate Standard Analyses - Surrogate standard determinations will be performed on all samples and blanks for GC/MS analyses. All samples and blanks are fortified with surrogate spiking compounds before purging or extraction to monitor preparation and analysis of samples. Recoveries must meet specific criteria. If acceptance criteria are not met, corrective action must be taken to correct the problem and the affected sample must be reanalyzed.

- Matrix Spike Analyses - The observed recovery of spike versus theoretical spike recovery will be used to calculate accuracy as defined by the percent recovery. If the accuracy value exceeds the control limit for the given parameter, the appropriate laboratory personnel notified and corrective action will be taken before the sample set is reanalyzed for the parameter in question.

For completeness, it is expected that the methodology proposed for chemical characterization of the samples will meet QC acceptance criteria for at least 95 percent of all sample data. To ensure this completeness goal, data that does not meet the acceptance criteria will be recollected, reextracted, or reanalyzed, if necessary.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis performed within the allowed holding times. Comparability is a qualitative characteristic of the data. By using standard methods for sampling and analyses, data generated in past or future investigations will be comparable with this investigation data.

13.0 CORRECTIVE ACTION

Corrective action will be taken whenever a nonconformance occurs. A nonconformance will be defined as an event that is beyond the limits established for a particular operation by the plan. Nonconformances can occur in a number of activities. Such activities include sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

The following personnel will be responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses.
- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities.

13.1 Limits of Operation

The limits of operation that are used to identify nonconformances will be established by the contents of the Work Plan, QAPP, and FSAP. Inter-laboratory control limits produced by statistical analyses will also be considered as limits of operation.

13.2 Corrective Action

Nonconformances will be identified and communicated to Baker to avoid delays with respect to project schedules and prevent the submission of non-valid data. Documentation will include the following:

- Personnel identifying the nonconformance(s) will be identified.
- The nonconformance(s) will be described and communicated to the Baker Project Manager.
- For serious nonconformances, the site supervisor will have the authority to initiate corrective action.
- For less serious nonconformances, corrective action will be decided upon and signatures will be obtained prior to implementation of corrective action.
- All nonconformances and corrective actions will be documented and reside with the Baker Activity Coordinator. This documentation will be available to DoN, Atlantic Division (LANTDIV).

The Baker Project Manager will be notified of laboratory or field nonconformances and corrective actions taken if:

- A nonconformance causes a delay in work beyond the schedule completion date.
- A nonconformance affects information already reported.
- A nonconformance affects the validity of the data.

If the nonconformance(s) are serious and corrective action cannot resolve the problem(s), NFESC Contract Representatives (NCRs) and the LANTDIV NTR may be notified by Baker.

14.0 QUALITY ASSURANCE REPORTING PROCEDURES

The Project Manager will be responsible for assessing the performance of measurement systems and data quality related to the field investigation. A written record will be maintained of: the results of laboratory QC reports and other periodic assessments of measurement, data accuracy, precision, and completeness; performance and system audits; and any significant QA problems and recommended solutions. Each deliverable will contain a QA/QC assessment section. Also, a QA/QC assessment will be performed any time a significant problem is identified.

The Project Manager will keep in contact with the LANTDIV NTR through informal, verbal reports during the project as well as through monthly progress reports.

FINAL

SUPPLEMENTAL FIELD INVESTIGATION

HEALTH AND SAFETY PLAN

SITE 89, OPERABLE UNIT 16

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0181

APRIL 2001

Prepared for:

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

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EXECUTIVE SUMMARY

This Health and Safety Plan (HASP) addresses the upcoming Supplemental Investigation (SI) at Site 89 of Operable Unit (OU) No. 16, Marine Corps Base (MCB), Camp Lejeune, North Carolina. The SI is a follow on action to the Time-Critical Removal Action (TCRA) being conducted in the third and fourth quarters of 2000. The TCRA addressed the contaminant source zone in unsaturated soils (vadose zone). The SI will address the contaminant source zone in the uppermost water-bearing zone. The goals of the SI include defining the stratigraphy and the extent of contamination in the source zone, identifying the objectives of the remedial action, analyzing the various alternatives that may be used to satisfy the objectives for cost, effectiveness, and implementability. The field portion of the SI will include the completion of soil borings to characterize stratigraphy and delineate Dense Non-Aqueous Phase Liquid (DNAPL)/source zone below the groundwater table and the installation of monitoring wells to define the extent of groundwater contamination. The primary chemical hazards associated with the tasks at this site are expected to include potential exposures to varying levels of chlorinated volatile organic compounds (VOCs).

The physical hazards are expected to include working around heavy equipment, underground/overhead utilities, uneven/sloped terrain, and thermal stress. The environmental hazards may include potentially hazardous flora and fauna. Each of these hazards is described in Section 3.0.

Section 5.0 describes the environmental monitoring requirements which consist of using a photoionization detector (PID), Draeger hand pump with detector tubes, and oxygen/combustible gas meter.

The level of personal protection assigned for work tasks and other operations will be Levels D through C with protection upgrades/downgrades dependent on monitoring results and the Site Health and Safety Officer's discretion. Section 6.0 describes the personal protective equipment to be used. Section 8.0 describes emergency procedures, which includes Figure 8-1, showing the route to the nearest public hospital, and Figure 8-2 identifying the written directions to the hospital, along with first aid procedures, communication procedures, and other site concerns. Table 8-1 identifies the emergency phone numbers.

1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been developed by Baker Environmental, Inc. (Baker) to accompany the Project Plans, which include a Work Plan, Field Sampling Plan, Quality Assurance Plan, and HASP, for Contract Task Order (CTO) 0181. The objective of the project is to conduct a Supplemental Investigation (SI) at Site 89, Marine Corps Base (MCB) Camp Lejeune, North Carolina. The purpose of this HASP is to comply with the safety and health regulations of the OSHA General Industry and Construction Standards and to define the requirements and designate protocols to be followed during the SI activities involving dense non-aqueous phase liquid (DNAPL), contaminated soils, and contaminated groundwater. The HASP is considered an operational document which is subject to revisions in response to various site-specific conditions which may be encountered. It may be amended by the Site Health and Safety Officer (SHSO) as needed, after consulting with the Project Health and Safety Officer (PHSO). The Site Manager and Project Manager will remain informed of any changes that may affect site operations.

1.1 Policy

It is the policy of Baker Environmental, Inc. (Baker) that all on-site hazardous waste management activities be performed in conformance with a site-specific HASP. The HASP is written based on the anticipated hazards and expected work conditions and applies to field activities to be performed under this CTO. Applicability of this HASP extends to all Baker employees, Baker's subcontractors, and visitors entering the site. However, subcontractors are expected to provide their own HASP and relevant Standard Operating Procedures (SOPs) that pertain to the activities they are contracted to perform on the site. This information will then become part of the site HASP. All personnel must review the HASP and sign an agreement to comply with its provisions prior to commencing any on-site work. The HASP is considered an operational document which is subject to revisions in response to various site-specific conditions which may be encountered. However, it may be modified/updated only with the approval of the Project Health and Safety Officer (PHSO) and Project Manager. Proper notification will be given to the Atlantic Division (LANTDIV) Naval Facilities Engineering Command Navy Technical Representative (NTR) when significant changes to the HASP are implemented.

1.2 Scope

The provisions of this HASP are applicable to Baker personnel involved with the SI field activities. This site-specific HASP has been prepared in accordance with the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER)Standard, 29 CFR 1910.120 and 1925.65.

1.3 Site Description

Site 89, located near the intersection of "G" and Eighth Streets, is the larger of two sites within Operable Unit 16 of MCB, Camp Lejeune. It encompasses a significant portion of Camp Geiger and includes all of the DRMO and additional area to the south and east. The DRMO is operated by the Defense Logistics Agency (DLA), with the primary function of managing scrap and surplus metal. The SI Investigation will be conducted in the southern portion of the DRMO, which was formerly used for heavy vehicle storage and maintenance.

A portion of Site 89 is currently used as a storage yard for the DRMO. Asphalt roads and gravel parking areas cover most of the western portion of Site 89. The eastern portion of the site is heavily wooded, as is the area immediately south of the DRMO. Edwards Creek, the nearest surface water body, is located along the western and southern portions of the site. The land surface of Site 89 gently slopes in the direction of Edwards Creek, which begins as a series of drainage ditches within Camp Geiger. The creek begins near Eighth Street and flows south for a short distance before turning east, where it tends to widen as it flows through the wooded area of Site 89. The eastern portion of the creek flows through a low-lying swampy area. A housing development lies to the southeast of the site. The wooded area to the east of the DRMO is designated a Hunting Area 1A.

The site is bordered by the former Seaboard Coastline Railroad and wooded areas to the east, Edwards Creek to the south, the current motor pool to the north, and Camp Geiger to the west.

1.4 Project Description

The work tasks that will be conducted during the SI activities by Baker personnel include the following:

- Advancement of soil borings using direct push techniques.
- Advancement of soil borings using hollow stem auger drilling techniques and collection of soil samples using split-spoon sampling devices.
- Installation of monitoring wells and collection of groundwater samples.
- Conduct slug tests in completed monitoring wells.

1.5 References

The following publications have been referenced in the development and implementation of this HASP:

- ACGIH Threshold Limit Values for Chemical Substances 2000.
- OSHA Federal Regulation. 29 CFR 1910 and 1926. 1995.
- OSHA/NIOSH/EPA/USCG Occupational Health and Safety Guidance Manual for Hazardous Waste Site Activities. October 1985.
- NIOSH Pocket Guide to Chemical Hazards. June 1997.
- Genium Publishing Corp, Genium's Reference Collection, MSDSs
- EPA Standard Operating Safety Guidelines. June 1992.
- Lewis, Richard J., Sr. Hazardous Chemicals Desk Reference. 1991.

2.0 SITE ORGANIZATION AND COORDINATION

The following personnel have direct responsibility for health and safety management at the sites under investigation, are identified as follows:

- **Project Manager - Ms. Tracey O'Keefe** - The Baker Project Manager has the responsibility to ensure that the elements of the Work Plan are implemented in a safe and healthy manner in accordance with the HASP.

- **Project Health and Safety Officer - Mr. Brian Karlovich** - The PHSO is responsible for the preparation, review, and approval of the HASP. The PHSO is also responsible for resolving issues that arise in the field with respect to interpretation or implementation of the HASP.

- **Site Manager - Mr. Mark DeJohn** - The Site Manager is responsible for assuring that day-to-day activities are conducted in accordance with the HASP. The Site Manager has the immediate authority to suspend field activities if conditions/activities develop or exist that present an immediate health or safety risk to the employees.

- **Site Health and Safety Officer - Mark DeJohn** - The SHSO will be responsible for continually evaluating safety on the site and ensuring adherence to the HASP. The SHSO, upon consultation with the PHSO, has authority to modify the existing HASP procedures as conditions warrant. The SHSO will also be responsible for the preparation of daily reports which include the day's events from a health and safety standpoint, for documentation of measurements taken for health and safety purposes, and for reporting accidents and other relevant health and safety issues.

- **Field Team Members - (to be determined)** - Field Team Members will be responsible for familiarity and compliance with the HASP. Field Team Members will also be responsible for remaining alert to identified and unidentified hazards and reporting the unidentified hazards to the SHSO and Site Manager, and offering suggestions or recommendations that may improve or enhance site safety.

Subcontractor personnel are responsible for:

- Complying with the conditions outlined under "Field Team Members", and familiarity and compliance with the contents of this HASP.

- Complying with all OSHA regulations relevant to their work, and having a competent safety monitor on site.

- Obtaining the appropriate training and medical surveillance requirements under 29 CFR 1910.120, 1926.65, and 1910.134, at a minimum, and providing this documentation to the Site Manager prior to or during site mobilization.

- Providing to Baker Activity Hazard Analyses (AHAs), as available, for each task they will perform.

Subcontractor Companies Contracted to Work under this CTO:

- Drilling Operations: (to be determined)
- Survey Operations: (to be determined)
- Analytical Services: (to be determined)

LANTDIV Representatives:

- Kirk Stevens, NTR (804) 322-4818

MCB Camp Lejeune Representatives:

- Mr. Neal Paul (910) 451-9518
- Mr. Rick Raines (910) 451-9461

Federal/State/Local Representatives:

- Ms. Gena Townsend (Region IV) (404) 562-8538
- Mr. David Lown (NC DEHNR) (919) 733-2801 ext. 278

3.0 SITE CHARACTERIZATION

This section provides information on the site history, previous investigations, and health and safety concerns for the physical and health hazards associated with this site.

3.1 Site History

Historical records for the area indicate that the Base Motor Pool operated on the site until approximately 1988. The Base Motor Pool was then relocated to its current location, an asphalt paved area immediately north of the DRMO facility. The Base Motor Pool reportedly used solvents for parts cleaning during this time, including acetone, trichloroethene (TCE), and 2-butanone.

Originally, the focus of investigations at the site was a small area within the DRMO that formerly contained an underground storage tank (UST) identified as STC-868, which was a 550-gallon steel tank located between Building STC-867 (a soil storage facility) and an elevated wash rack. The tank was installed in 1983 and was used to store waste oil. This UST reportedly was removed in 1993. The initial UST investigation at Site 89 detected chlorinated solvents in the groundwater. As chlorinated solvents are not normally associated with a petroleum UST site, their discovery in groundwater lead to the inclusion of Site 89 into MCB, Camp Lejeune's IR Program. Subsequent studies have identified organic contaminants in surface water, sediment, and soil. As a result, Site 89 has expanded to include more than the former UST area. The area currently includes the entire DRMO and additional areas outside the DRMO fence, including the wooded areas to the south and east.

3.2 Previous Investigations

Previous investigations and actions at Site 89 include the following:

- An initial assessment study (IAS) conducted by Water and Air Research, Inc., in 1983
- A Well Site Check conducted by R.E. Wright Environmental, Inc. in 1994
- An RI/FS conducted by Baker in 1996 and 1997
- Continuing Long-Term Monitoring (LTM) initiated by Baker in April 1999
- Immediate Response field efforts conducted by Baker in June/July 1999
- Soil contamination delineation conducted by Baker in October 1999 and December 1999
- Additional delineation of soil and groundwater contamination conducted by Baker in March 2000
- Pre-construction soil delineation conducted by Baker in April 2000
- Time-Critical Removal Action Site 89 of vadose zone soils
- Conducted by the IT Group during 2000

Findings of the previous investigations are detailed in the following Baker reports: Final Remedial Investigation Report, Operable Unit No. 16 (Sites 89 and 93) (1998), and Final Action Memorandum for Time-Critical Removal Action Site 89, Operable Unit 16 (2000).

The immediate response field efforts focused on soil contamination in the vadose zone and groundwater contamination related to that soil contamination. The findings from these investigations indicated that contaminants including 1,1,2,2-tetrachloroethane (PCA), tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride (VC) exceed screening criteria in soil, groundwater, surface water, and sediment. The findings also indicate that a contaminant source zone is present below the water table, and this contamination is in a DNAPL phase.

3.3 Physical Hazards

The identified potential physical hazards associated with this project during the site activities include thermal stress, explosion and fire, contact with utilities, heavy equipment operations, and noise. The following presents a description of these potential hazards. General physical hazards that may be present during the project activities are listed in the following subsections.

3.3.1 Thermal Stress

Provisions for monitoring for thermal stress are included in Attachment A - Baker Safety SOPs.

3.3.2 Explosion and Fire

In general, the following items present potential explosion or fire hazards and will be monitored closely as they pertain to each area under investigation:

- Heavy equipment malfunction or re-fueling operations
- Penetration into underground utility/service lines (gas, electric, fuel)
- Ignition of trapped flammable vapors
- Vehicular accidents
- Puncturing of drums, tanks, or other containers during drilling operations
- Ignition of flammables or combustibles from open flames during welding or cutting (where needed during well installations)

Hazard Prevention

Explosion and/or fire hazards can be prevented by proper grounding, approved safety cans, compressed gas cylinder safety, leak repair, vehicle maintenance, availability of fire extinguishers, no smoking, and no incendiary or igniter devices.

Site personnel should be trained in the proper use of portable fire extinguishing equipment. Site personnel should respond to fires as follows:

- Evacuate all personnel
- Call 911
- If the fire is small or confined, attempts to fight the fire with portable fire extinguishers is authorized
- Support the Fire Department response forces as appropriate (e.g., providing information regarding site activities, hazards, and missing personnel, if any)

3.3.3 Utilities

Underground utility clearance must be obtained before any intrusive activities are performed; this clearance will be provided by a local contractor. If underground utilities are identified in these areas, the ground above the utility lines are to be physically marked, such as, with spray paint or flags. The local contractor is to be notified at least three days prior to soil intrusive activities to acquire a utility clearance. A 24-inch minimum clearance must be used for work near underground utilities.

Energized overhead electric lines may present a risk of electrocution. OSHA standards require that equipment maintain certain distances from power lines. For lines 0 to 50 kilovolts (kV), a minimum distance of 10 feet must be maintained. Lines carrying over 50 kV require that the equipment location be at least 10 feet plus an additional 0.4 inch for each 1 kV over 50.

3.3.4 Heavy Equipment

One of the primary physical hazards associated with the site work is the use of heavy equipment, which may include the use of a drill rig for permanent monitoring wells and/or hydraulic-operated direct push equipment for select borings. Only operators trained, qualified, and authorized will be permitted to operate the heavy equipment.

Hazards generally associated with drilling operations include the following:

- Motor vehicle exhaust products (e.g., carbon monoxide and nitrogen oxides) from the drill rig engine
- Overhead utility wires, (i.e., electrical and telephone), can be hazardous when the drill rig boom is in the upright position
- Underground pipelines and utility lines can be ruptured or damaged during active drilling operations
- Moving parts, i.e., augers, on the drill rig may catch clothing. Free or falling parts from the cat head may cause head injury

- Moving the drill rig over uneven terrain may cause the vehicle to roll over or become stuck in a rut or mud. Be aware of hazards associated with moving heavy machinery and other associated injury

- High pressure hydraulic lines and air lines used on drill rigs are hazardous when they are leaking, worn or incorrectly assembled

Hazard Prevention

- Review the contaminants suspected to be on site and perform air monitoring as required. Shut down drill rig and/or divert exhaust fumes.

- All chains, lines, and cables should be inspected daily for weak spots, frays, etc.

- Ear muffs and/or ear plugs effectively reduce noise levels.

- At a minimum, personal protective equipment will include safety boots, eye protection, and hard hats, which will be worn at all times while working around a drill rig. Secure loose clothing. Check boom prior to approaching drill rig.

- To avoid contact with any overhead lines, the drill rig boom should be lowered prior to moving the rig. Overhead utilities should be considered "live" until determined to be otherwise.

- The rig mast should not be erected within 10 feet of an overhead electrical line until the line is deenergized, grounded, or shielded and an electrician has certified that arcing cannot occur.

- A thorough underground utilities search should be conducted before the commencement of a drilling project. Proper utility clearances must be obtained prior to intrusive work.

- All high pressure lines should be checked prior to and during use.

- The subcontracting drilling company's site supervisor is to provide, during the HASP briefing, a description of cautions to be observed when working around the drill rig.

- Hand signals will be prearranged between the operator and personnel working around the drill rig.

- Personnel are to remain in the field of vision of the operator and remain clear of moving parts, especially where loose-fitting clothing can become entangled.

- Personnel working near a drill rig are to be aware of the location and operation of the emergency shut off devices.

- Establish appropriate work zone around the drill rig of a radius of at least equal to the height of the drill boom, and delineate work zone with construction warning tape, barricades, cones, or the like.

3.3.5 Noise

Elevated noise levels may be produced during drilling and other heavy equipment operations; therefore, hearing protection may be required. The SHSO is responsible for making this determination based on past experience with the type of equipment in use, and the proximity of personnel to the equipment.

3.4 Chemical Hazards

Hazardous chemicals can be absorbed into the body through various pathways, such as:

- Accidental inhalation of vapors, gases, or particulates
- Accidental ingestion of contaminated material from hand-to-mouth contact
- Accidental dermal and eye absorption from direct, unprotected contact

The identification of the primary chemical hazards that may be encountered at the site is based on previous soil and groundwater investigations. Previous investigations at Site 89 identified soils and/or groundwater contaminated with the following contaminants (concentrations indicated in parentheses): oil and grease, 1,2-dichloroethene (260 mg/kg), 1,1,2,2-tetrachloroethane (87,000 mg/kg), tetrachloroethene (150 mg/kg), 1,1,2-trichloroethane (270 mg/kg), trichloroethene (3,000 mg/kg), vinyl chloride (0.28 mg/kg), chlorobenzene (29 mg/kg), methylene chloride (in groundwater only - 2.3 mg/L), acetone (170 mg/kg), benzene (1 mg/kg), toluene (4.1 mg/kg), ethylbenzene (1.2 mg/kg), and xylenes (6.8 mg/kg). Of these constituents, the two that have been identified in the greatest concentrations in soil and groundwater are 1,1,2,2-tetrachloroethane and trichloroethene. Due to the extremely high concentration of these constituents, it is suspected that these compounds are also present as dense non-aqueous phase liquid (DNAPL) beneath the site.

During each sampling event or well installation, an effort will be made to eliminate or reduce potential routes of exposure through the use of engineering controls (e.g., performing investigative activities in an upwind location according to safe sampling techniques), administrative controls (e.g., effective training programs), and the proper use of PPE.

Tables 3-1, located in the "Tables" section at the end of this HASP, identifies chemical/physical properties of the constituents detected during previous investigations at Site 89. A Material Safety Data Sheet (MSDS) is available in Attachment B for each of the chemicals listed in Table 3-1. It is important to note that the information presented in each MSDS reflects the chemical and toxicological properties of the specific compound in a pure, undiluted, and untransformed condition. As such, when these compounds are detected in environmental media the hazards are anticipated to be substantially less that those associated with exposure to "pure" compounds. Therefore, the data presented in the MSDS will be utilized as reference information when questions arise as to a constituents's chemical, physical, and toxicological properties, or measures to be employed in an emergency situation.

Other chemical hazards that may be present include preservatives (e.g., hydrochloric acid) to be added to specified sample containers, decontamination fluids, and materials brought to the site by the subcontractors. For the aforementioned materials, an MSDS will be obtained and made readily available to the field team members at the site, in compliance with 29 CFR 1910.1200.

3.5 Environmental Hazards

The following paragraphs identify the potential hazards associated with flora and fauna at Site 89. If additional concerns are identified, they will be added to this HASP.

3.5.1 Hazardous Flora

Incidence of contact by individuals to poisonous/thorny plants is high; therefore, bare skin should be covered (i.e., long pants and shirt, steel toe boots, leather or cotton gloves, safety glasses, and head protection) as much as practical when working in forested or densely vegetated areas. Personnel should avoid entering an area in the direct path of known poisonous flora (i.e., poison ivy, poison oak, or poison sumac); a secondary route should be selected. Care should also be taken when walking in such areas as uneven terrain or vines may present a tripping hazard.

While attempting to cut into dense underbrush, hazards exist from the sharp machete and gas-powered weed cutter, therefore, care should be taken when using such devices. (Note: Hearing protection, steel toe boots, gloves, and safety glasses are required when using weed cutters.) Rashes or other injuries will be reported to the SHSO as soon as they occur or are recognized.

3.5.2 Hazardous Fauna

Mosquitoes and gnats pose a nuisance and physical hazard to field personnel; they distract workers, leading to accidents, and pose a physical threat by transmitting live microorganisms. Avoiding the use of perfumes and scented deodorants and donning light colored clothing is preferable. The use of Avon's "Skin So Soft" or other insect repellent is encouraged and will be provided, as needed in the Baker Field Trailer.

Poisonous snakes such as the rattlesnake, copperhead, and cottonmouth (water moccasin), all known as pit vipers, are common to the United States. Snakes typically do not attack people but will bite when provoked, angered, or accidentally injured (as when stepped on). When encountering a snake, avoid quick/jerky motions, loud noises, and retreat slowly; do not provoke the snake. If bitten, follow emergency procedures outlined in Section 8.8.3.

There is a potential to come in contact with other dangerous insects; these include fire ants, chiggers, bees, wasps, hornets, mites, fleas, spiders, and ticks.

If a tick is found embedded in the skin, do not squash or burn it. Grasp the tick with fine-tipped tweezers, as close to the skin as possible, and pull slowly. Once the tick is removed, wash the area immediately with soap and water. Apply an antiseptic or antibiotic ointment if available. Observe the bite area periodically for signs of a rash around the site. Also, keep alert for flu like symptoms; these may be symptoms of Lyme Disease.

Insect bites are characterized by localized pain, potential stinger, swelling, and a possible allergic reaction. Care for an insect bite by scraping away stingers, wash wound, cover with sterile gauze, apply a cold pack, and watch for signals of allergic reactions.

All personnel should perform "checks" on each other periodically and at the end of the work shift, especially when working in grassy or forested areas. All insect bites must be reported to the SHSO.

If a spider bite by a black widow or brown recluse is suspected, follow emergency procedures in Section 8.8.4.

Prior to initiating site activities, each individual shall be questioned as to any known sensitivities to the previously mentioned organisms or agents.

3.6 Task-Specific Hazards

Listed below are summaries for the hazards associated with each potential task for an area under investigation. Levels of protection outlined in Section 6.0 were selected based on this task-specific hazard identification, information obtained from previous investigations and site visits, and previous experience with similar investigations or activities.

3.6.1 Soil Boring Advancement and Subsurface Soil Sampling

Chemical

- Potential for DNAPL and contaminated mud, soil, or groundwater to be splashed onto body or in eyes.
- Skin contact with potentially-contaminated materials.
- Ingestion of potentially-contaminated materials from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants.

Physical/Environmental

- Elevated noise levels from heavy equipment operations.
- Muscle strain and heat exhaustion while lifting heavy objects.
- Biting insects.
- Skin irritation from contact with vegetation.
- Contact with underground utilities.
- Interaction with native and feral animal life.
- Heavy objects landing on foot/toe or head.
- Slips/trips/falls from sloped, uneven terrain; crawling over and under obstacles.

3.6.2 Monitoring Well Installation

Chemical

- DNAPL and potentially-contaminated mud, soil, or groundwater to be splashed onto body or in eyes.
- Ingestion of contaminated materials from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants.
- Absorption of DNAPL and impacted groundwater through the skin.

Physical/Environmental

- Heavy objects landing on foot/toe or head.
- Elevated noise levels from heavy equipment operation.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Biting insects.
- Skin irritation from contact with vegetation.
- Overhead hazards from drill rig operations.
- Interaction with native and feral animal life.
- Contact with underground utility lines.
- Muscle strain and heat exhaustion from lifting.

3.6.3 Monitoring Well Development

Chemical

- Potential for DNAPL and impacted groundwater to be splashed onto body or in eyes.
- Ingestion of contaminated materials from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants.
- Adsorption of DNAPL and impacted groundwater through the skin.

Physical/Environmental

- Slips/trips/falls - sloped, uneven terrain.
- Biting insects.
- Skin irritation from contact with vegetation.
- Interaction with native and feral animal life.
- Muscle strain and heat exhaustion.

3.6.4 Groundwater Sampling

Chemical

- Potential for DNAPL and contaminated groundwater to be splashed onto body or in eyes.
- Ingestion of contaminated materials from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants emitting from the well opening.
- Adsorption of DNAPL and impacted groundwater through the skin.

Physical/Environmental

- Cuts from sharp edges of the well casing.
- Biting insects.
- Muscle strain and heat exhaustion during sampling.
- Skin irritation from contact with vegetation.
- Cuts from using knives to cut tubing.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Interaction with native and feral animal life.

3.6.5 Aquifer Slug Testing

Chemical

- Potential for DNAPL and contaminated groundwater to be splashed onto body or in eyes.
- Ingestion of contaminated materials from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants emitting from the well opening.
- Adsorption of DNAPL and impacted groundwater through the skin.

Physical/Environmental

- Cuts from sharp edges of the well casing.
- Biting insects.
- Muscle strain and heat exhaustion during sampling.
- Skin irritation from contact with vegetation.
- Cuts from using knives to cut slug rope.
- Slips/trips/falls - sloped, uneven terrain; crawling over and under obstacles.
- Interaction with native and feral animal life.

3.6.6 Equipment Decontamination

Chemical

- Potential for DNAPL and contaminated mud, soil, or groundwater to be splashed onto body or in eyes.
- Skin contact with potentially-contaminated materials.
- Ingestion of potentially-contaminated soils from hand-to-mouth contact.
- Inhalation of volatile contaminants or volatile fraction of semivolatile contaminants.

Physical/Environmental

- Slips/trips/falls
- Biting insects.
- Muscle strain and heat exhaustion from lifting and bending.
- Heavy object (i.e., split spoon) landing on fingers, hand, toes, foot and/or leg.

SECTION 3.0 TABLE

TABLE 3-1
CHEMICAL/PHYSICAL PROPERTIES OF CHEMICALS DETECTED AT SITE 89
MCB CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

Chemical Compound (a)	Hazard Rating (b) H F R	Volatility (c)	Skin Absorption (d)	Carcinogen (e)	Exposure Limit (f)	STEL (g)	IDLH (h)	IP (i)
Volatiles:								
Acetone	1 3 0	180	No	No	500 ppm	750 ppm	2500 ppm	9.69
Benzene	2 3 0	75	Yes	Yes	0.5 ppm	5 ppm	500 ppm	9.25
Chlorobenzene	2 3 0	9	No	--	10 ppm	NA	1000 ppm	9.07
1,2-Dichloroethene	2 3 2	180-265	No	--	200 ppm	NA	1000 ppm	9.65
Ethylbenzene	2 3 0	7	No	--	100 ppm	125 ppm	800 ppm	8.76
Methylene Chloride	2 1 0	350	No	--	25 ppm	125 ppm	NA	11.35
1,1,2,2-Tetrachloroethane	2 0 0	5	Yes	--	1 ppm	NA	100 ppm	11.10
Tetrachloroethene	2 0 0	14	No	--	25 ppm	100 ppm	150 ppm	9.32
1,1,2-Trichloroethane	2 1 0	19	Yes	--	10 ppm	NA	100 ppm	11.00
Trichloroethene	2 1 0	58	No	--	50 ppm	100 ppm	1000 ppm	9.45
Toluene	2 3 0	21	Yes	--	50 ppm	NA	500 ppm	8.82
Vinyl Chloride	2 4 2	2508	o	--	1 ppm	NA	NA	10.00
Xylenes	2 3 0	9	No	--	100 ppm	150 ppm	900 ppm	8.56

Notes:

(a) Chemical compound of potential concern as indicated by the previous investigation.
(b) Hazard Rating - based upon Health (H), Fire (F), or Reactivity (R) hazard from NFPA 704 Standard Rating System (0 = no hazard, 4 = high hazard)
(c) Volatility Rating - based upon vapor pressure in mm Hg at 68° F, 20° C
(d) Skin Absorption - "Yes" indicates potential exposure through skin and mucous membranes, either by airborne or, more particularly, by direct contact - ACGIH 2000
(e) Carcinogen - "Yes" indicates a compound is a confirmed human carcinogen by the IARC, NTP, or ACGIH
(f) Exposure Limit - Based on the Time Weighted Average from the 2000 ACGIH Threshold Limit Value (TLV) or OSHA Permissible Exposure Limits (PEL); whichever is lower
(g) Short Term Exposure Limit - "STEL" denotes a 15 minute time weighted average which may not be exceeded - OSHA or ACGIH 2000
(h) IDLH - Immediately Dangerous to Life and Health.
(i) Ionization Potential - expressed in electron volts (eV)

NA = Not Applicable

4.0 SITE CONTROL

The Site Manager is designated to control access and security on site. The Site Manager will establish site security in accordance with job locations. The following identifies the PPE level assigned to the site activities and the site control measures that accompany them. Refer to Section 6.0 for a definition of the protection level requirements.

4.1 Level D/D+

Work Zones for activities conducted in Level D or Level D+ protection level will be monitored by the SHSO to restrict unauthorized personnel from entering the area during well installation and sampling events. In populated areas, work zones shall be established in such a manner as to preclude unauthorized personnel from entering the investigative area. A boundary will be established to separate the work zone from the support zone using equipment such as natural boundaries (e.g., buildings, structures, fences), signs/placards, boundary tapes, and barricades. In unpopulated areas, the aforementioned procedures may not be necessary due to the secluded nature of the site, the short duration of the activity, and the low risk to outside populations. The Senior Field Team Member or SHSO is responsible for making this determination.

4.2 Level C/B

For activities that are conducted in Level C/B attire, the boundaries for the following work zones will be defined as follows:

- Work Zone - The area immediately around the work area, such as the drill rig boom radius.
- Hotline - The boundary between the Work Zone and the Contaminant Reduction Zone (CRZ).
- CRZ - The area between the Work Zone and the Support Zone (located upwind of the site investigative activities).
- Contamination Control Line - The boundary between the CRZ and the Support Zone.
- Support Zone - The outermost area next to the CRZ and upwind of the site investigative activities.

These boundaries will be demarcated using colored boundary tape, cones, or equivalent.

Unauthorized personnel will not be permitted in the work areas.

4.3 Site Access

The Site Manager is designated to coordinate overall access and security at each area under investigation. Perimeters for activities to be conducted at Site 89 will be established based on the information presented in Section 4.3, local conditions, the items listed below, and Navy Activity requirements.

- Personnel will not be permitted within the Work Zone (i.e., Exclusion Zone) or Contamination Reduction Zone without proper authorization from the SHSO.

- All personnel arriving or departing the site will be documented in the site log book.
- All activities on site must be cleared through the Site Manager and documented in the site log book.
- The on-site Command Post will be established at the Baker Field Trailer, which will be in the Support Zone and oriented upwind from all Work Zones.

4.4 Buddy System

All site activities that involve hazards and/or the potential for contact with hazardous materials will be performed by a work team of no fewer than two people (i.e., Buddy System).

4.5 Safe Work Practices

Routine safe work practices may consist of:

- Conducting operations in a manner to reduce exposure of personnel and equipment.
- Implementing appropriate decontamination procedures.
- Conducting sampling activities from an upwind location.
- Adherence to applicable safety regulations in OSHA Standards 29 CFR 1910 and 1926.
- Setting up barriers to exclude unauthorized personnel from contaminated areas.
- Minimizing the number of personnel and equipment at each area under investigation.
- Establishing work zones within each area under investigation.
- Establishing control points for ingress to and egress from work zones.

4.5.1 Heavy Equipment

The following safe work practices will be adhered to if heavy equipment operations take place.

- Hard hats will be worn when working in a work zone with heavy equipment.
- Heavy equipment requiring an operator will not be permitted to run unattended.
- Heavy equipment will not be operated in a manner that will endanger persons or property nor will the safe operating speeds or loads be exceeded.
- Heavy equipment will be shut down and positive means taken to prevent its operation while repairs or fueling are being performed.

- Personnel, other than the operator, should not ride on equipment.
- A "spotter" will be used to help direct the heavy equipment operator.
- Personnel are to remain in the field of vision of the operator and remain clear of moving parts.
- Hand signals will be prearranged between operator and personnel working around the heavy equipment.
- Hearing protection will be used.
- Backup alarms must operate properly on the heavy equipment.

4.5.2 Drilling Operations

The following safe work practices will be adhered to if drilling operations occur.

- Hand signals will be prearranged between operator and personnel working around the drill rig.
- Personnel are to remain in the field of vision of the operator and remain clear of moving parts where protective clothing can be entangled, i.e., Tyvek caught in the auger.
- Personnel working near a drill rig are to be aware of the location and operation of the emergency shut off devices.
- Utility clearances must be secured prior to digging (see Section 3.3.3).
- The drill rig boom is to remain a minimum of 10 feet from power lines (see Section 3.3.3).
- During the HASP briefing, the supervisor of the drilling company will provide additional precautions to be observed when working around the drill rig.

4.6 Sanitation Procedures/Site Precautions

Provisions for sanitation procedures and site precautions to be followed on site are outlined below.

- A supply of clearly marked potable water, tightly closed, and equipped with a tap.
- Single service disposal cups.
- Outlets for non-potable water, clearly marked, for fire fighting or other purposes. Cross-contamination of the potable supply shall be prevented.
- One toilet facility for up to 20 personnel which is either chemical, recirculating, combustion, or flush, depending on local code requirements. Two toilet facilities will be required for greater than 20 personnel.

- A place for food handling meeting applicable laws or suitable alternatives to such facilities will be provided (i.e., nearby restaurants).

- Clean wash water will be available in the decontamination zone during Level C activities, each Baker Field Vehicle and the Baker Field Trailer. Disposable towelettes and/or handwash stations will also be available in each Baker Field Vehicle for periodic cleanups.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in the EZ or CRZ. Smoking will also not be allowed in areas where flammable materials are present. Hands and face must be thoroughly washed before breaking for meals and upon leaving the site. "Contaminated" work garments are not to be worn off site.

- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.

- The use of contact lenses is not recommended.

- Facial hair, which interferes with a satisfactory fit of the mask-to-face seal, is not permitted on personnel who are or may be required to wear respirators.

- Contact with contaminated or potentially-contaminated surfaces should be avoided. Wherever possible, do not walk through puddles, leachate, discolored surfaces, lean, sit or place equipment on drums/containers.

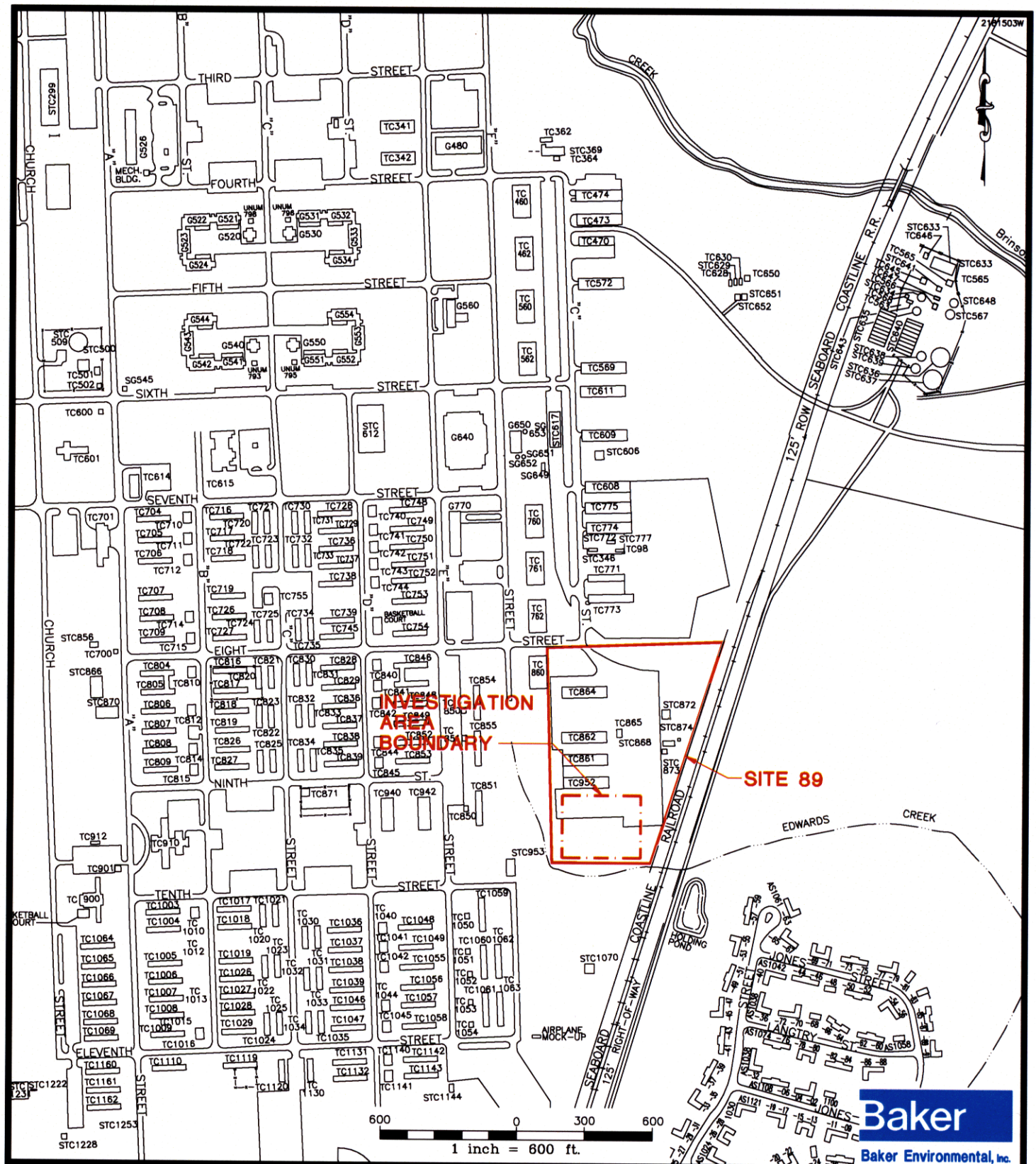
- Medicine and alcohol can potentiate the effects of exposure to toxic chemicals, therefore, prescribed drugs should only be taken by personnel when approved by a qualified physician. Alcoholic beverage intake should be minimized or avoided during after-hour operations.

- Alcoholic beverages and firearms are prohibited on site.

- All site personnel will observe any posted sign, warning, fence, or barrier posted around contaminated areas.

- Site personnel must wear the proper attire while on site. At a minimum, this will include steel-toed boots, work pants (e.g., jeans or other durable material), and work shirt (e.g., short or long-sleeved, made of a durable material). Tank tops, muscle shirts, and sweat pants are not permitted.

SECTION 4.0 FIGURES



LEGEND

- TC1162 BUILDING
- RAILROAD TRACKS
- SITE BOUNDARY
- INVESTIGATION AREA BOUNDARY

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 4-1
SITE 89 INVESTIGATION AREA
CTO- 0181

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

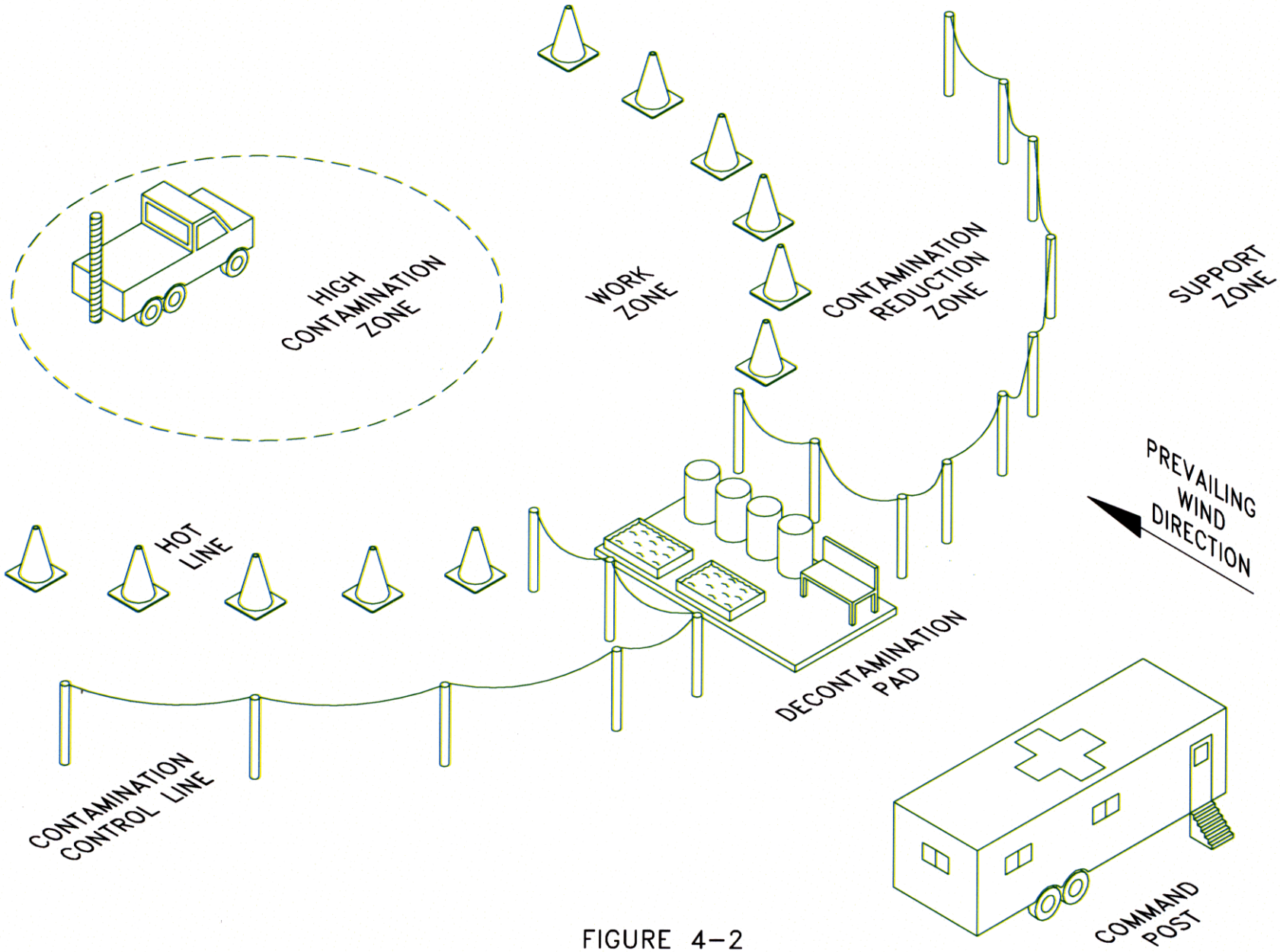


FIGURE 4-2
SCHEMATIC DIAGRAM
GENERAL CONTAMINATION
REDUCTION ZONE LAYOUT

Baker
Baker Environmental, Inc.

21B1506W

5.0 EXPOSURE MONITORING

Environmental monitoring will be performed at each area under investigation; the level and degree of monitoring will be dependent on each field activity. Due to the short duration and variability of field tasks only realtime air monitoring (versus integrated air monitoring) will be used to assess action levels. The instruments that will be used include a photo-ionization detector (PID) with an 11.7 electron volt (eV) lamp, an oxygen / lower explosive limit meter (O_2/LEL meter) and a Draeger hand pump with vinyl chloride detector tubes. Draeger detector tubes for trichloroethylene, chlorobenzene, and methylene chloride shall be available on site and shall be used at the discretion of the SHSO. The action level for the PID, as specified in Section 5.1 below, is based on a "worst-case" 8-hour TWA-PEL of 1 ppm (1,1,2,2-tetrachloroethane), and is consistent with that listed by the USEPA in Section 6.9, of the Standard Operating Safety Guides (June, 1992). Monitoring equipment and frequency for each field Activity can be found in Table 5-1.

5.1 Breathing Zone

Action levels based on breathing zone air monitoring are described here.

If PID readings in the breathing zone exceed 1 ppm for more than 1 continuous minute, all work will cease. A Draeger hand pump with vinyl chloride detector tubes shall be used to assess vinyl chloride levels. If two consecutive breathing zone readings, taken no more than 5 minutes apart, indicate vinyl chloride levels that are less than 1 ppm, PPE will be upgraded to Level C prior to resuming work (for activities that are initiated in Level C, workers are to remain in Level C). If two consecutive readings, taken no more than 5 minutes apart, indicate vinyl chloride levels that exceed 1 ppm, PPE will be upgraded to Level B prior to resuming work. In either case, the SHSO and PHSO will be notified prior to resuming work.

If PID readings in the breathing zone exceed 5 ppm for more than 1 continuous minute, all work will cease, and PPE will be upgraded to Level B prior to resuming work. The SHSO and PHSO will be notified prior to resuming work.

If PID readings in the breathing zone exceed 25 ppm above background for a period greater than 1 continuous minute, personnel will stop work and leave the work area. The SHSO and PHSO shall be consulted.

5.2 Point Source Monitoring

The PID will be used to monitor the point source during the investigative activities. Point source monitoring is defined as monitoring performed at the source of the work activity. Instantaneous readings greater than 50 ppm will result in an immediate evacuation of the area until levels return to normal. If point source PID readings are detected above background, breathing zone monitoring will also be conducted.

In addition to the PID, the O_2/LEL meter will be used during investigation activities that are conducted using a drill rig. The following action levels will be observed.

Oxygen Meter[1]

- 19.5% to 23.5% = Safe operating level
- <19.5% or >23.5% = Unsafe operating level; stop work and consult the SHSO and PHSO

LEL Meter[2]

- <10% of the LEL = Safe operating level
- ≥10% of the LEL = Unsafe operating level; stop work and consult the SHSO and PHSO

[1] Used to evaluate physical safety in conjunction with the PID.
[2] Assigned action levels are for non-confined space entry operations.

5.3 Perimeter Monitoring

A PID will be used to monitor the perimeter of the work area to determine safe areas during a work stoppage if concentrations meet the work stoppage criteria identified in Sections 5.1 and 5.2.

5.4 Equipment Calibration

Equipment calibration of the PID and O_2/LEL meters will be completed daily before, and after use. The calibration will be performed in accordance with the manufacturer's requirements. The calibration information will be logged on a field calibration form. These forms will be placed in the project files upon completion of the field activities.

5.5 Monitoring Documentation

As the air monitoring is performed, documentation of the results will be entered into a field log book by the individual performing the monitoring. Documentation is to include date, time, instrument result, work area, weather (temperature and humidity), and specific location, such as, background, point source and breathing zone. This air monitoring documentation will be placed in the project files upon completion of the field activities.

A summary of each day's air monitoring results will be posted in the Baker field trailer at the end of each day, and shall remain posted for one day.

SECTION 5.0 TABLE

TABLE 5-1

MONITORING EQUIPMENT AND FREQUENCY FOR EACH FIELD ACTIVITY CONDUCTED AT SITE 89

Field Activity	PID[1]	Vinyl Chloride Detector Tubes[2]	Oxygen/Combustible Gas Meter [1]
Hollow stem auger soil boring advancement and soil sampling	C	If PID > 1ppm above background	I&P
Direct push soil boring advancement	I&P	If PID > 1ppm above background	I&P
Monitoring well installation	C	If PID > 1ppm above background	I&P
Monitoring well development, purging, and sampling	I&P	If PID > 1ppm above background	
Slug testing	D	If PID > 1ppm above background	
Equipment decontamination	D	If PID > 1ppm above background	

I = Initially - At start of job task to confirm designated protection level.
P = Periodically - when site condition/set-up changes or a new area is entered.
C = Continuously - Monitor levels continuously.
D = At the discretion of the SHSO.
PID = Photoionization Detector

Note: As air concentrations are measured, they shall be documented in the individual's field logbook. In the case of continuous monitoring, every 15 minutes.

(1) Refer to the manufacturer's operating manual and Baker SOP prior to operation.
(2) Use Draeger hand pump with vinyl chloride detector tubes if PID > 1ppm above background for more than one continuous minute. Collect a second sample within 5 minutes of the first sample to confirm the initial result.

6.0 PERSONAL PROTECTIVE EQUIPMENT

The Level of Protection selected is based upon the following:

- Measured concentration of a chemical substance or substances in the ambient atmosphere
- Potential for exposure to substances in air, liquids, or direct contact with material because of work activities
- Knowledge of chemicals on-site along with properties such as toxicity, route of exposure, and contaminant matrix

6.1 Levels of Protection

Based on the information provided in Section 3.0, Site Characterization, the levels of protection and corresponding personal protective equipment have been designated for the following field activities.

Job Task	Level of Protection				
	A	B	C	D+	D
General site activities (such as, Mobilization/Demobilization)					X
Hollow stem auger soil boring advancement and soil sampling			X		
Direct push soil boring advancement				X	
Monitoring well installation			X		
Monitoring well development, purging and sampling				X	
Slug Testing				X	
Equipment Decontamination				X	

X - Level of protection for the task identified

The SHSO will upgrade the level of protection based on the results of the air monitoring as per Section 5.0, or based on his or her professional judgement according to observations of site activities.

For the hollow stem auger soil boring advancement and monitoring well installation activities, the SHSO may permit respirators to be removed for a given boring/well if intrusive activities for that well are completed (i.e. boring will not be advanced further) and if air monitoring results were acceptable during the intrusive activities for that boring/well.

Protective ensembles are described below:

Level D

- Normal work clothes*
- Steel toe boots
- Work gloves (as needed)
- Safety glasses (as needed)

* Long or short-sleeved shirt and long pants (made of a sturdy material)

Level D+

- Normal work clothes
- Chemical-resistant suits (optional)
- Gloves, chemical-resistant (nitrile)
- Steel toe boots
- Safety glasses
- Hard Hat (during heavy equipment activities)
- Hearing protection (as necessary)

Level C

- Air-purifying respirator, half-face, with organic vapor cartridges
- Chemical-resistant suits with attached over-boots (resistant to chlorinated solvents, such as Tychem 9400)
- Outer gloves, chemical resistant (4H, Silvershield, or nitrile)
- Inner gloves, chemical resistant (nitrile)
- Steel toe boots
- Safety glasses

- Hard Hat (during heavy equipment activities)
- Hearing protection (as necessary and during hammering of split spoon sampling device)

Level B

- Full facepiece supplied air respirator operated in pressure demand mode
- Chemical-resistant suits with attached over-boots (resistant to chlorinated solvents, such as Tychem 9400)
- Outer gloves, chemical resistant (4H, Silvershield, or nitrile)
- Inner gloves, chemical resistant (nitrile)
- Steel toe boots
- Safety glasses
- Hard Hat (during heavy equipment activities)
- Hearing protection (as necessary and during hammering of split spoon sampling device)

Notes:

No single combination of personal protective equipment is capable of protection against all hazards. PPE should be used in conjunction with safe work practices, effective decontamination, and good personal hygiene. Chemical protective clothing should be replaced when it becomes damaged or when chemical breakthrough is detected.

Respirator cartridges should be changed out at least daily. Cartridges will be changed out on a more frequent basis depending on the levels of airborne contaminants that are encountered. The frequency of change out will be determined by the PHSO. Respirator cartridges shall also be changed out when chemical taste or odors are noticed or if breathing becomes difficult.

CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE AT THE DIRECTION OF THE SHSO, PHSO, AND THE SITE MANAGER.

6.2 Reassessment of Protection Program

The Level of Protection shall be upgraded or downgraded based on changes in site conditions or findings of investigations.

6.3 Care and Cleaning of Personal Protective Equipment

Provisions for the care and cleaning of PPE used on site can be found in Attachment A - Baker Safety SOPs.

7.0 DECONTAMINATION PROCEDURES

The following presents the information for personnel and equipment decontamination requirements as well as handling of materials generated during decontamination.

7.1 Personnel Decontamination

Decontamination involves the orderly, controlled removal of contaminants. Standard decontamination sequences are presented in the table below. All site personnel should minimize contact with contaminants in order to minimize the need for extensive decontamination.

Level D/D+	Level C/B
1. Equipment drop	1. Equipment drop
2. Boot wash and rinse*	2. Outer glove removal and disposal
3. Protective suit removal (if worn)	3. Over boot (attached to protective suit) wash and rinse
4. Glove removal and disposal	4. Protective suit removal (disposal if contaminated)
5. Hand and face wash	4. Respirator removal
	5. Inner glove removal and disposal
	6. Hand and face wash
	7. Respirator cleaning/sanitizing

*Optional - depends on degree of contamination and type of PPE used.

The following decontamination equipment is required for Level C and higher protection levels and recommended for Level D+ protection:

- Two small tubs (one set of wash and rinse water)
- Scrub brush
- Towels*
- Disposable wipes*
- Pressurized sprayers for rinsing
- Contaminated clothing disposal bag or drum*
- Contaminated liquids disposal drum

- Respirator cleaning solution
- Liquinox and water as the decontamination solution

*Minimum for Level D decontamination.

The decontamination liquids and clothing will be contained and disposed according to policy defined in the Field Sampling and Analysis Plan (FSAP).

7.2 Effectiveness of Personnel Decontamination

The effectiveness of site decontamination methods will be evaluated by the SHSO on a periodic basis. This evaluation may include the observation of personnel decontamination techniques, inspection of PPE before and after decontamination, and the questioning of site personnel for signs and symptoms of exposure. Additional measures may also be employed by the SHSO at their discretion.

7.3 Equipment Decontamination

Provisions for the decontamination of equipment will be based on the size and type of equipment used. Specific decontamination procedures for OU No. 16 are found in the FSAP.

7.4 Decontamination Materials

The protocols outlined in the FSAP for the handling of materials used for decontamination such as packaging, storing, and disposing will be followed to: (1) minimize the risk of off-site exposures that could endanger public health; and (2) limit the potential for liabilities associated with handling, containment, storage, and transportation of contaminated materials. These protocols comply with Baker's SOP on "Handling of Site Investigation-Derived Waste," located in the Standard Operating Procedures for Administrative, Field, and Technical Activities Manual.

8.0 EMERGENCY PROCEDURES

8.1 Scope

Emergencies such as fire, personal injury, or releases of contaminants to air, water, or soil may occur. If so, local emergency response groups will be called in to handle the incident, as necessary.

8.2 Pre-Emergency Planning

All applicable Navy/local emergency response contacts (On-Scene Commander, Fire Department, Security, Ambulance, Hospital, etc.) at MCB, Camp Lejeune will be contacted prior to or during site mobilization activities. This notification will be performed by the SHSO and/or Site Manager. The information discussed may include:

- A description of site activities.
- Anticipated site hazards.
- Hazardous chemicals/materials brought on site.
- Expected length of time on site.
- Specific requirements the emergency response facilities may require.
- Confirmation of emergency phone numbers.
- Security measures that must be followed by site personnel.

Specific points of contact, where applicable, will be established and added to the HASP. If requested, MSDSs for hazardous chemicals/materials brought on site (which are maintained at the Baker Field Trailer), will be provided at this time.

8.3 Emergency Coordinator

The SHSO acting as the Emergency Coordinator is responsible for field implementation of these Emergency Procedures. The Emergency Coordinator is responsible for reacting (not responding) to emergencies. As the Emergency Coordinator, specific duties include:

- Familiarizing all on-site personnel with the emergency procedures and the emergency coordinator's authority.
- Identifying the nearest telephone in the event of an emergency.
- Communicating site emergency procedures and requirements to all Baker and subcontractor personnel.
- Specifying the Site Manager as the backup/alternate Emergency Coordinator.

- Controlling activities of subcontractors and contacting the emergency response groups, as necessary.

- Anticipating, identifying, and assessing fires, explosions, chemical releases, and other emergency situations to the best of the coordinator's ability, and providing this information to the emergency group(s) responding.

- Familiarity with site personnel trained in emergency first aid and adult CPR.

All on-site personnel, whether involved in emergency response or not, will be notified of their responsibilities during the initial HASP briefing. They will be familiar with the emergency procedures and the Emergency Coordinator's authority.

8.4 Communications/Telephone Numbers

Internal communications will rely on direct communication (via verbal or two-way radios) between site personnel. External communications will employ a telephone located in the Baker Field Trailer, a mobile telephone for emergency use, and various telephones located throughout the Base (near the investigation areas). Telephone communication at the Command Post will be established during site mobilization.

The "Buddy System" will be in effect at all times; any failure of communication requires an evaluation of whether personnel should discontinue activities.

Air horns will be used for communication during emergency evacuation of personnel. One long (3 second) air horn blast is the emergency signal to indicate that all personnel should evacuate the Work Zone.

Coordination between Baker and subcontractor personnel is the responsibility of the Site Manager. The best means for securing the lines of communication will be determined at the pre-entry briefing.

Hand signals, as outlined below, will be used in the event that radio communications fail:

Hand gripping throat (typically Level C/B activities)	Can't breathe
Grip partner's wrist or both hands around waist	Leave area immediately
Hands on top of head	Need assistance
Thumbs up	OK, I am all right, I understand
Thumbs down	I do not understand

Emergency telephone numbers will be posted in the Baker Field Trailer and maintained in each Baker Field Vehicle. The list of emergency phone numbers is presented in Table 8-1, located in the "Tables" section at the end of this HASP.

8.5 Assembly Area

In the event of an emergency, personnel will be instructed to meet initially at the Baker Field Vehicle and eventually at the Baker Field Trailer. Where applicable, personnel will exit the work area through the contamination reduction zone. If either location is inappropriate, an alternate assembly area will be designated by the Emergency Coordinator in an upwind location from the site. At this location, emergency needs will be provided such as:

- Assembly for evacuated personnel
- First aid for injured personnel
- Decontamination material
- Communications

8.6 Emergency Hospital Route

An emergency hospital route map (Figure 8-1) and written directions to the hospital (Figure 8-2) will be posted in the Baker Field Trailer and maintained in the Baker Field Vehicle. Personnel will be informed of the location of the map and the directions to the hospital during the pre-entry briefing.

8.7 Emergency Medical Treatment

This section provides information on the nearest emergency medical facility and corresponding emergency telephone numbers.

Emergency Medical Services

For chemical and nonchemical exposure incidents, the nearest public hospital is:

Name	Onslow County Memorial Hospital
Address	317 Western Boulevard, Jacksonville, North Carolina
On-Base Telephone No.	(*9) 577-2240
Off-Base Telephone No.	(910) 577-2240

Local ambulance service is available from the Naval Ambulance Service and the Onslow County Ambulance Dispatch:

Name	Naval Ambulance Service
On-Base Telephone No	911
Off-Base Telephone No	(910) 451-3004 or 911

Name	Onslow County Ambulance Dispatch
On-Base Telephone No	911
Off-Base Telephone No	(910) 455-9119 or 911

Contact will be made with emergency personnel prior to the start of activities (see Section 8.2).

8.8 Injuries

If injuries are not serious or life threatening, affected personnel may be transported by other site personnel to the local medical facility, if necessary. Emergency medical response personnel will be contacted in the event of serious or multiple injuries. Medical personnel will be provided with all available information regarding the nature of the incident, chemicals involved, etc. Instances requiring treatment beyond "first aid" will be handled at appropriate facilities and reported to the Project Manager and PHSO within 24 hours.

There will be a minimum of two persons on-site during field activities that will be trained in standard first aid and adult CPR. These personnel will also be familiar with Baker's program for potential exposure to bloodborne pathogens as outlined in the Baker Safety SOPs in Attachment A. Subcontractors will be responsible for securing proper medical attention for their employees. Baker may assist the subcontractor as necessary.

8.8.1 Physical Injury

If an employee working in a contaminated area is physically injured, first aid procedures are to be followed. If the employee can be moved, he/she will be taken to the edge of the work area and decontaminated, if necessary (refer to Section 8.9). Depending on the severity of the injury, emergency medical response from the local ambulance service may be sought to stabilize the victim for transport to public hospitals. Emergency first aid may be administered by Baker personnel prior to transporting to an awaiting ambulance or to a local emergency medical facility, as appropriate.

8.8.2 Chemical Injury

If the injury to a worker is chemical in nature (e.g., direct contact/exposure), the following first aid procedures are to be instituted:

- Eye Exposure - If contaminated solid or liquid gets into the eyes, wash the eyes immediately at the 15-minute emergency eyewash station (or with the personal eye wash bottle when an eye wash station is not immediately available). Obtain medical attention immediately. The emergency eyewash unit meets ANSI Standard Z358.1-1990.

NOTE: The wearing of contact lenses is not recommended.

- Skin Exposure - If contaminated solid or liquid gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solids or liquids penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Obtain medical attention immediately.

- Swallowing - If contaminated solid or liquid has been swallowed, immediately contact Carolina's Poison Center at 1-800-848-1697. Do not induce vomiting in an unconscious person. Obtain medical attention as directed by the Poison Center.

- Breathing - If a person has difficulty breathing, move the exposed person to fresh air at once. If breathing is not evident, check for pulse and perform appropriate first aid, either rescue breathing or CPR, depending on the condition. Obtain medical attention immediately.

Procedures to follow in the event of a chemical exposure are included in Attachment C.

8.8.3 Snakebite Injury

In the event of a snakebite injury, the following procedures will be followed.

Look for signs and symptoms such as the characteristic appearance of two small holes, usually about a half inch apart, with surrounding discoloration, swelling, and pain. Systemic signs (which may or may not occur) include weakness, sweating, faintness, and signs of shock.

Provide treatment as follows:

1. Calm the victim and keep affected area still.

2. Contact ambulance if you cannot provide victim with transportation to the nearest hospital.

3. Wash the wound.

4. Keep the affected area below the level of the heart if bite is on the arm or leg.

5. Treat for shock.

6. Monitor airway, breathing, and circulation.

7. Obtain physical description of snake, if possible.

8. Provide the emergency medical responder (either the ambulance attendant or the emergency room at the hospital) with all pertinent information such as how long ago the bite occurred, the type of snake (if known), any known allergic conditions (if known), etc.

9. Inform the SHSO as soon as possible.

8.8.4 Spider Bite Injury

There are two spiders commonly found in the United States whose bite can be serious: the black widow spider and the brown recluse spider. These bites may be serious, even life-threatening. Many other spiders will bite, but they do not produce serious complications. The black widow spider measures approximately 1 inch long with its legs extended. It is glossy black in color and has a distinctive yellow-orange marking in the shape of an hourglass on its belly. On its back, however, there is no marking, and unless you happen to turn the spider over, you cannot see this mark. The danger of the black widow spider bite lies in its systemic manifestations. The venom from this spider attacks the nervous system, resulting in severe muscle cramps with board-like rigidity of the abdominal muscles, tightness in the chest, and difficulty in breathing. Sweating, nausea, and vomiting will also occur.

The emergency treatment for the black widow spider bite is basic life support. Sometimes the individual is not even aware of having been bitten, or where. Apply cold to the site of the bite if it can be identified. There is a specific antivenom for this spider bite that must be administered by a physician. It is particularly important to identify the spider, and bring it in, if you can.

The brown recluse spider is a little bit smaller than the black widow spider and is dull brown in color. It has a violin-shaped mark on its back, which can be seen when you are looking at the spider from above. The spider gets its name because it tends to live in dark areas, corners, and old unused buildings. The bite from this animal produces local rather than systemic manifestations. The venom of the brown recluse spider causes severe local tissue damage and can lead to an ulcer and gangrene. The bitten area becomes red, swollen, and tender within a few hours after the bite. A small blister forms, and several days later, this may form a large scab, covering a deep ulcer. Death is rarely reported, but these bites need local surgical treatment, and these patients should be brought to the hospital. Again, if possible, identification of the spider should be carried out.

8.9 Emergency Decontamination Procedures

In the event of a medical emergency, patients are to be adequately decontaminated before transfer (if possible) to prevent contamination of the medical transport vehicle and medical facility. Emergency personnel decontamination will include the following, depending on the level of protection.*

Level D/D+	Level C/B
• Equipment drop • Protective suit removal (if worn) • Glove removal and disposal	• Equipment drop • Outer glove removal and disposal • Protective suit removal • Respirator removal • Inner glove removal and disposal

* If circumstances dictate that contaminated clothing cannot be readily removed, then remove gross contamination and wrap injured personnel with clean garments/blankets to avoid contaminating other personnel or transporting equipment. All emergency personnel are to be immediately informed of the injured person's condition, potential contaminants, and provided with all pertinent chemical data.

If necessary, one of the site personnel equipped with appropriate PPE may accompany the injured worker and perform decontamination with supervision of medical personnel.

8.10 Personal Protection and First Aid Equipment

PPE available for emergency response will include the following:

- Tychem 9400 protective suits with attached boots
- Silvershield, 4H, or nitrile gloves

- Face shields and goggles

- Full facepiece supplied air respirator operated in the pressure demand mode

PPE and first aid equipment will be available in the support zone (i.e., Baker Field Vehicle and Baker Field Trailer).

Emergency and first aid equipment can be found at the following locations:

Fire Extinguisher:	Baker Field Trailer and Contractor Field Vehicle
First aid kit:	Baker Field Trailer and Baker Field Vehicle
Air Horn:	With Personnel
15-minute Emergency Eye Wash Station	Near Area With Greatest Potential for Chemical Splash/Exposure

8.11 Notification

If the Emergency Coordinator determines that the site has an uncontrolled situation, such as a spill, fire, or explosion, that could threaten human health or the environment, the coordinator will immediately call the Navy On-Scene Coordinator, the Activity Contact, the Project Manager, and the NTR as soon as possible. The notification report will include:

- Description of incident (e.g., release, fire).

- Name and telephone number of individual reporting the emergency.

- Location of incident.

- Name and quantity of material (s) involved (if known).

- The extent of injuries and number of casualties.

- The possible hazards to human health or the environment and recommended cleanup procedures.

- Assistance that is requested.

8.12 Hazard Assessment

The Emergency Coordinator will assess possible hazards to human health or the environment that may result from an uncontrolled situation, to the best of the individual's abilities, incorporating the following steps, as appropriate.

- Assess the immediate need to protect human health and safety.

- Identify the materials involved in the incident including exposure and/or release pathways and the quantities of materials involved.

- Inform appropriate personnel, as identified in Section 8.11, who will determine if release of material(s) meets USEPA requirements for reportable quantities for spills under the RCRA or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

This assessment may consider both the direct and indirect effects of the chemical release, fire, explosion, or severe weather conditions (e.g., the effects of any toxic, irritating, or asphyxiating gases that are liberated).

8.13 Security

During activation of these Emergency Procedures, the Emergency Coordinator or his/her designated representative will control access to the site and maintain an incident log until the appropriate personnel, such as the Navy On-Scene Commander, arrives and takes control. The incident log will include:

- Activities that have occurred since the incident was first reported.
- Tasks currently being performed and where.
- Rescue and response equipment used.
- Protective equipment being used.

8.14 Emergency Alerting

This section outlines the emergency alerting procedures according to the location and type of emergency.

Personnel Injury in the Work Zone:

- Initiate a verbal warning or one long airhorn blast and move all unaffected site personnel to the support zone (for Level D/D+) or the CRZ (for Level C or higher).
- Send the rescue team into the Work Zone (if required) to remove the injured person to the hotline.
- Have the SHSO and/or Site Manager evaluate the nature of the injury and assure that the affected person is decontaminated according to Section 8.9.
- If required, contact an ambulance and/or the designated medical facility.

In all situations when an on-site emergency results in evacuation of the Work Zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed.
3. The HASP has been reviewed and, if appropriate, modified.
4. Site personnel have been briefed on any changes in the HASP.

Personnel Injury in the Support Zone:

- The Site Manager and SHSO will assess the nature of the injury; if the cause of the injury or loss of the injured person does not affect the performance of other site personnel, operations may continue.

- If the injury increases the risk to others, a verbal warning or one long airhorn blast shall be sounded and all remaining site personnel will move to the command post for further instructions.

- Activities on site will stop until the added risk is mitigated.

Fire/Explosion:

- Initiate a verbal warning or one long airhorn blast and move all site personnel to the support zone (for Level D/D+) or the CRZ (for Level C or higher).

- Alert the fire and security departments and move all nonessential personnel to the Baker Command Post to await further instructions.

- Activities will stop until the added risk is mitigated.

Personal Protective Equipment Failure:

- If any site worker experiences difficulty, failure, or alteration of protective equipment that affects the protection factor, that person and his/her buddy shall immediately cease work activities, leave the Work Zone, and repair or replace the defective equipment.

- Reentry will not be permitted until the equipment has been repaired or replaced.

Other Equipment Failure:

- If any other equipment on site fails to operate properly, the Field Team Leader shall notify the Site Manager and SHSO to determine the effect of this failure on site operations. If the failure affects the safety of site personnel, work with the equipment will cease until the situation is evaluated and appropriate actions taken.

8.15 Training

Site personnel will read the details in the Emergency Procedures prior to the pre-entry briefing. The Emergency Procedures will be reviewed by site personnel during the pre-entry briefing.

8.16 Spill Containment Procedures

In the event that a small (less than the reportable quantity), easily-controlled spill of hazardous substances (e.g., gasoline, oil, etc.) occurs during the implementation of field activities, spill containment will be utilized to prevent the additional migration of contaminants through the site area. Large, uncontrolled spills will be handled by qualified response organizations under the direction of qualified Base personnel and/or Navy On-Scene Commander. Any release to soils or surface waters

equaling or exceeding the reportable quantities under CERCLA or the USEPA Clean Water Act will be reported to the MCB Camp Lejeune 911 emergency number and the Environmental Management Department who in turn will report it to the appropriate authorities.

Specific spill containment procedures will be dependent on the type of materials spilled and the type of environment affected. Potential spill containment procedures may include diking with absorbent material/pads, then removal or containment of the contaminated materials. Spill containment materials will be located within close proximity to the storage area of the hazardous substances in a manner such that the pathway remains accessible and free of obstructions. Spill containment materials available on site may include:

- Vermiculite
- Ground corn cobs
- Dirt or sand
- Shovel

8.17 Exercise and Critique of Emergency Procedures

Site personnel shall periodically participate in a mock emergency and follow the procedures described in Section 8.0. After completion of the mock emergency, the elements of the emergency procedures shall be critiqued. Modifications to the written emergency procedures shall be made, as necessary. The scope of this practice and critique will be commensurate with emergency situations likely to arise given the work to be performed and site conditions.

SECTION 8.0 TABLE

TABLE 8-1

EMERGENCY TELEPHONE NUMBERS

Facility	Phone Number On-Base Phone[1]	Phone Number Off-Base Phone[2]	Contact*
Security	911 or 3004	911 or (910) 451-3004	Response Operator
Fire (Camp Geiger)	0538	(910) 450-0538	Response Operator
Fire (MCAS)	911 or 6620	911 or (910) 450-6620	Response Operator
Fire (Hot Work Permit)	3004	(910) 451-3004	Fire Alarm Operator
Ambulance (On-Base)	911	911 or (910) 451-3004	Response Operator
Ambulance (Off Base)	(*9) 455-9119	(910) 455-9119 or 911	Response Operator
Hospital Emergency Room (On-Base)	911 or 4840, 4841, 4842	450-4840 450-4841 450-4842	Ms. Jeanne Sleiertin or charge nurse of the day
Onslow County Hospital (Off Base)	(*9) 577-2240	(910) 577-2240	Response Operator
Emergency (One Call)	911	911	Response Operator
On-Scene Coordinator	911	(910) 451-5815	Fire Chief
Environmental Management Division (EMD)	5068	(910) 451-5068	Mr. Neal Paul
JPL Buried Facility Locating	NA	(910) 938-8312	Mr. Les Craft
Carolina's Poison Center	(*2) 1-800-848-6946	1-800-848-6946	Response Operator
National Response Center	1-800-424-8802	1-800-424-8802	Response Operator
CHEMTREC	1-800-424-9300	1-800-424-9300	Response Operator
ATSDR	1-404-639-0615	1-404-639-0615	Response Operator

(1) The following prefixes apply when using on-base telephones:
*2 - operator assisted calls including 800 numbers
*8 - long distance calls
*9 - local calls

(2) When using the mobile phone, which is programmed for the Pittsburgh area, use the phone numbers (including area codes) for an off-base phone.

SECTION 8.0 FIGURES

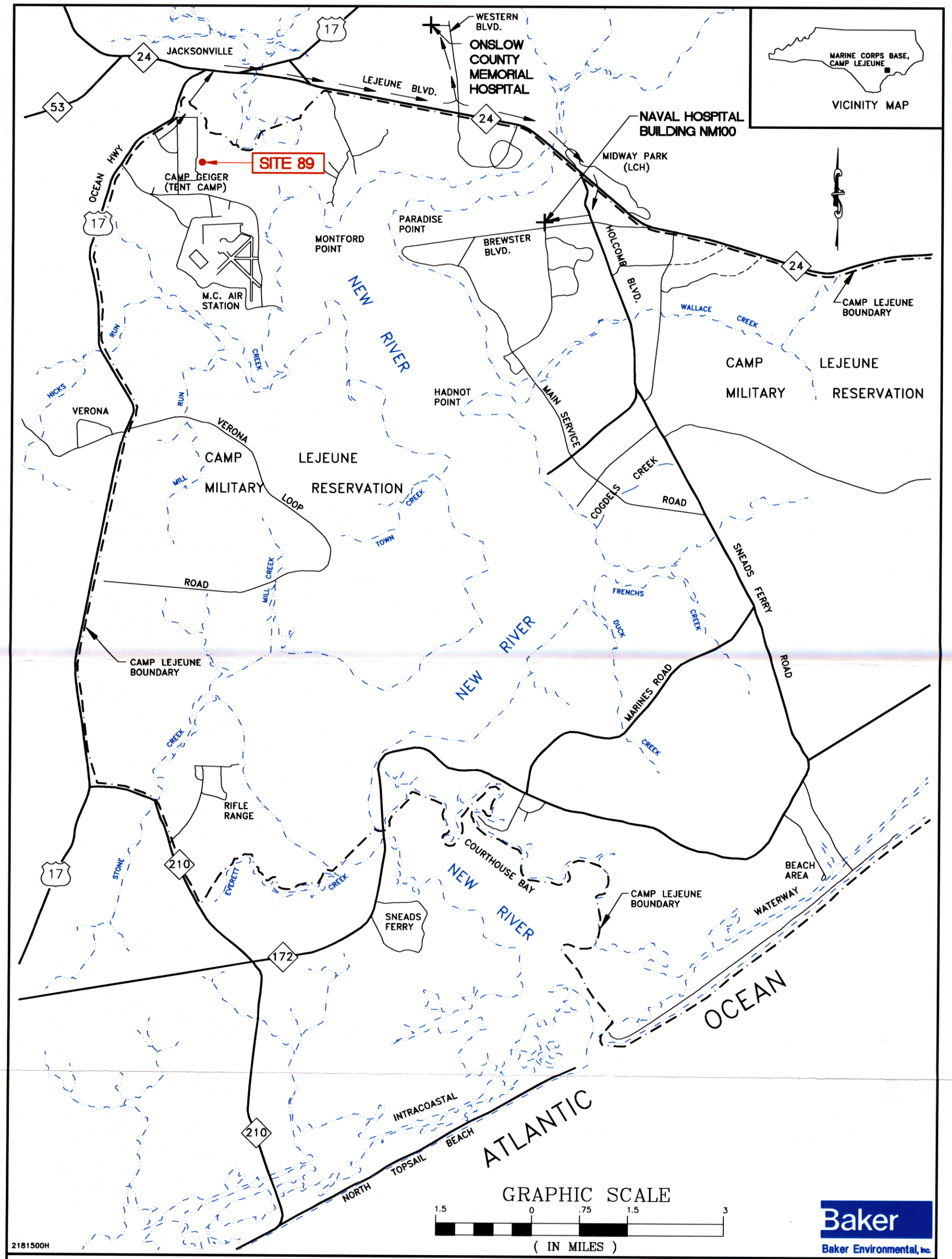


FIGURE 8-1
EMERGENCY HOSPITAL ROUTE
SITE 89

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

FIGURE 8-2

DIRECTIONS TO HOSPITAL FROM SITE 89

Directions to Onslow County Memorial Hospital are as follows:

1. Proceed through the Camp Geiger main gate to Ocean Highway (Route 17).
2. Proceed north on Route 17 until intersecting with Lejeune Boulevard (Route 24).
3. Travel east on Route 24 until intersecting with Western Boulevard.
4. Turn left onto Western Boulevard and proceed north until the fifth stoplight (approximately 1.5 miles).
5. Look for hospital on left.
6. Follow directions to emergency room entrance.

9.0 TRAINING AND HAZARD COMMUNICATION REQUIREMENTS

Training requirements for site personnel are outlined in the following subsections. Table 9-1 provides the appropriate OSHA training history for Baker project personnel.

9.1 General Worker Training

OSHA requires that personnel who will work on-site to be trained according to the requirements of 29 CFR 1910.120. Initial training must be a 40-hour course and three days of actual field experience under the direction of a trained, experienced supervisor. In addition to the initial training, personnel must attend 8-hour annual refresher courses to ensure that personnel retain the basic knowledge necessary for their safety when involved with hazardous waste site operations.

9.2 Supervisor Training

Supervisory personnel must attend 8-hour supervisory training sessions in addition to the basic 40-hour training described above. This training provides instruction in the management aspects of health and safety at hazardous waste sites. The SHSO will be qualified as a supervisor.

9.3 Site Specific Training

The SHSO will brief all individuals who will enter the site on the contents of this HASP. Each individual must certify that he or she has received the briefing, and that he or she understands the health and safety precautions to be taken by signing the Health and Safety Training Record.

9.4 Hazard Communication

In order to comply with 29 CFR 1910.1200, Hazard Communication Standard, the Baker written Hazard Communication Program will be available to site personnel upon request.

All containers of hazardous materials received on site will be inspected to ensure the following: (1) all containers will be clearly labeled as to the contents; (2) the appropriate hazard warnings will be noted; (3) the name and address of the manufacturer will be listed.

All secondary containers will be labeled with either an extra copy of the original manufacturer's label or with generic labels which have a block for identity and blocks for the hazard warnings.

Copies of MSDSs for all hazardous chemicals known or suspected to be on site will be maintained in the work area. MSDSs will be available to all employees for review during each work shift.

9.5 Recordkeeping

Training records relevant to safe operation of the site will be maintained by the SHSO for all Baker employees at the site.

SECTION 9.0 TABLE

TABLE 9-1

OSHA TRAINING HISTORY OF BAKER PROJECT PERSONNEL*

Personnel	Title/Role	Training Status
Tracey O'Keefe	• Project Manager	• 40-hr. training completed:06/83 • Supervisory training: NA • 8-hr. refresher completed:10/98 • First Aid Training: 10/98 • CPR Training: 10/98 • Medical surveillance: 07/99
Brian Karlovich	• Project Health and Safety Officer	• 40-hr. training completed:07/93 • Supervisory training: NA • 8-hr. refresher completed:09/99 • First Aid Training: 08/00 • CPR Training: 08/00 • Medical surveillance: 08/00
Mark DeJohn	• Site Manager	• 40-hr. training completed:05/88 • Supervisory training: 07/89 • 8-hr. refresher completed:09/99 • First Aid Training: 06/97 • CPR Training: 06/97 • Medical surveillance: 10/99
(to be determined)	• Site Health and Safety Officer/ Field Team Leader	• 40-hr. training completed: • Supervisory training: • 8-hr. refresher completed: • First Aid Training: • CPR Training: • Medical surveillance:

TABLE 9-1 (Continued)

OSHA TRAINING HISTORY OF BAKER PROJECT PERSONNEL*

Personnel	Title/Role	Training Status
(to be determined)	• Environmental Scientist	• 40-hr. training completed: • Supervisory training: • 8-hr. refresher completed: • First Aid Training: • CPR Training: • Medical surveillance:
(to be determined)	• Geologist	• 40-hr. training completed: • Supervisory training: • 8-hr. refresher completed: • First Aid Training: • CPR Training: • Medical surveillance:

* Training and medical surveillance documentation for Baker and subcontractor personnel will be maintained at the Command Post.

NA - Not Applicable

10.0 MEDICAL SURVEILLANCE REQUIREMENTS

10.1 General

All personnel who may be exposed to materials having potentially adverse and deleterious health effects, obtain medical clearance from Baker's Board Certified Occupational Health Physician in accordance with 29 CFR 1910.120(f) prior to entry onto any site. Baker's corporate medical surveillance program establishes a medical baseline and monitors for symptoms of overexposure for individuals who participate in Preliminary Assessments, Site Inspections, Remedial Investigations, Feasibility Studies, and construction-phase services at sites covered by the Department of Labor, OSHA, Hazardous Waste Operations and Emergency Response Standard, 29 CFR 1910.120. The program will include a medical and work history and is intended to determine the individual's capability for performing on-site work, including wearing chemical protective clothing and respiratory protective equipment in a thermally-stressed environment.

All Baker employees that will be engaged in site activities covered by the 29 CFR 1910.120 standard receive a Group III physical examination by an occupational health physician who has provided information on the individual's site activities and exposure or anticipated exposure levels. This exam is received initially upon hire, then once every 12 months thereafter. More frequent medical examinations, consultations, and/or laboratory testing will be provided if the occupational health physician determines that an increased frequency of examination is required. A complete Group III medical exam includes parameters such as height, weight, vision, temperature, blood pressure, and a complete review of occupational and medical histories. Other tests in a Group III exam include chest x-rays, electrocardiogram, spirometry, urinalysis, and blood tests. Table 10-1, located in the "Tables" section at the back of this HASP, describes the medical surveillance testing parameters performed annually on Baker employees. The need for additional monitoring depending on site conditions will be evaluated on a case-by-case basis.

10.2 Site Specific

Prior to entry onto the site, all personnel, including subcontractors, will be required to provide medical clearance to the SHSO from their company physician in accordance with 29 CFR 1910.120(f), stating that they are physically capable of performing the activities required of them. The need for additional monitoring, dependent on information obtained during the site characterization, will be evaluated on a case-by-case basis. However, in the event that site employees are injured, receive a health impairment, develop signs or symptoms which may have resulted from exposure to hazardous substances resulting from an emergency incident, or are exposed during an emergency incident to hazardous substances at concentrations that are or may be above the permissible exposure limits or the published exposure levels without the necessary personal protective equipment being used, medical examinations and/or consultations shall be performed according to the following schedule:

1. As soon as possible following the emergency incident or development of signs/symptoms.

2. At additional times, if the examining physician determines that follow-up examinations or consultations are medically necessary.

Procedures to follow in the event of an exposure to a hazardous material/chemical are provided in Attachment C.

SECTION 10.0 TABLE

TABLE 10-1

MEDICAL SURVEILLANCE TESTING PARAMETERS*

Group II - Individuals Occasionally in the Field (10-30 days/year)

- Medical History (Physical Exam)
- Eye Exam
- EKG (baseline and for individuals over 40 years of age)
- Chest X-ray (baseline then every 5 years)
- Spirometry
- CBC with differential
- SMA 12 or 26 (liver enzyme scan)

Group III - Individuals Frequently in the Field (>30 days/year)

- Medical History (Physical Exam)
- Eye Exam
- EKG (baseline then annually for individuals over 40 years of age)
- Audiometry
- Chest X-ray (baseline then every 3 years)
- Spirometry
- CBC with differential
- SMA 12 or 26 (liver enzyme scan)
- Urinalysis (glucose scan)
- Specific Blood and Urine Tests (dependent on field exposure)**

Group III with Asbestos - Individuals frequently in the field whom also work with asbestos

- Group III testing with the Asbestos Medical Questionnaire w/Pulmonary Function Test ($FVC_{1.0}$ and $FEV_{1.0}$)

* The occupational health physician has the right to reduce or expand the medical monitoring on an annual basis as he/she deems necessary.

** To be performed for individuals identified by the occupational health physician as being chronically exposed to organic compounds.

11.0 HEALTH AND SAFETY PLAN APPROVAL

This HASP for the SI Investigation activities at MCB Camp Lejeune Site 89 has been reviewed by the following personnel prior to the start of field activities.

Mr. Brian Karlovich	PHSO	
Name (Print)	Title	Signature
Ms. Tracey O'Keefe	Project Manager	
Name (Print)	Title	Signature
Mr. Mark DeJohn	Site Manager	
Name (Print)	Title	Signature

12.0 DECLARATION OF HEALTH AND SAFETY PLAN REVIEW*

All site personnel indicated below have reviewed and are familiar with this HASP developed for the SI Investigation at MCB Camp Lejeune, Site 89.

(Name-Print)	(Company)
(Signature)	(Date/Time)
(Name-Print)	(Company)
(Signature)	(Date/Time)
(Name-Print)	(Company)
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*This page is to be reproduced to accommodate the numbers of personnel who receive training prior to performing activities or visiting a site, and is to remain in the Baker Field Trailer until demobilization.

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ATTACHMENT A
BAKER SAFETY STANDARD OPERATING PROCEDURES

ATTACHMENT A

BAKER ENVIRONMENTAL, INC.
SAFETY STANDARD OPERATING PROCEDURES

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1.0 PURPOSE

This program has been designed to comply with the Occupational Safety and Health Administration (OSHA) 29 Code of the Federal Register (CFR) 1910.134, Respiratory Protection. This respiratory protection program has been developed to provide guidance that will assist Baker Environmental, Inc. (Baker) employees while wearing respiratory protection, in order to safeguard health and life from dangerous atmospheres.

2.0 SCOPE

The purpose of the Baker Respiratory Protection Program is to govern the selection and use of respiratory protective equipment by Baker personnel. This program is also designed to meet requirements of the Occupational Safety and Health Administration (OSHA) regulations 29 CFR 1910.134 and 1926.103, Respiratory Protection. This program is applicable to those Baker employees who may be involved with potential respiratory hazards as part of their work tasks. The program outlines the procedures to follow when respiratory protective equipment is required.

3.0 RESPONSIBILITIES

3.1 Respiratory Protection Program Manager

Mr. Ronald Krivan, CSP, is the designated Respiratory Program Officer (RPO) for Baker Environmental, Inc. The RPO responsibilities are to insure that:

- Written procedures for the safe and proper use of respirators are developed and communicated.
- The effectiveness of the respirator program is evaluated at least annually, and written operating procedures modified as necessary to reflect the evaluation results.
- Project Manager's, Site Manager's, Site Safety and Health Officers, and employees are trained in the proper selection, use, and maintenance of respirators.
- Medical professionals are assisted in obtaining the necessary information for a thorough medical evaluation.
- Counsel is provided for any revisions/changes that become necessary or scheduled by regulatory changes.
- The Respirator Medical Evaluation Questionnaire (Attachment A) is administered.
- The proper selection of respirators is made which will be suited for the hazard(s) and determined using the Respirator Hazard Evaluation Form (Attachment C).

3.2 Medical Facility

The medical facility used for respirator medical evaluations is:

Allegheny Medical Center
2000 Cliff Mine Road

Park West 2, Suite 110
Pittsburgh, PA 15275

The expected services from this facility regarding respirator medical evaluations include:

- Review and evaluate each employee's Respirator Medical Evaluation Questionnaire.
- Assess if employees are physically able to perform their work while using the respirator.
- Conduct required medical testing protocols (e.g., pulmonary Function Test (PFT) or similar protocol) as defined by the physician.
- All reviews of all employees receiving a respirator are accomplished and any additional requirements are met to continue the employee in the program.

3.3 Project Managers

Project Managers are responsible for insuring that all personnel working under their projects are:

- Compliant with all provisions and instructions contained in this program.
- Knowledgeable of the respiratory protection program requirements in regards to each project.

3.4 Site Managers

Site Managers are responsible for insuring that all personnel working under their control are:

- Knowledgeable of the respiratory protection program requirements within their work areas.
- Compliant with all facets of this respiratory protection program.
- Properly using, cleaning, maintaining, and storing their respiratory protective equipment.
- Physically evaluated, fit-tested, and trained prior to assignment in a job/area requiring the use of respiratory protection.

3.5 Site Health and Safety Officers

Site Health and Safety Officers are responsible for the following:

- Perform periodic audits to ensure compliance (e.g., proper fitting, cleaning, and storage) by anyone issued any type of approved respirator. The audit inspections are to be documented (Attachment B).
- Upgrade or downgrade the level of respiratory protection or the type of respirator/cartridge based on information gathered at the site, which may not have been available during the selection of the respiratory protective devices.

3.6 Employees

Employees are required to:

- Wear the appropriate respiratory protection whenever necessary or required.
- Maintain and use respiratory equipment as directed by this program and pertinent operating instruction (including proper fitting, equipment conservation, cleaning, storage and documentation as required by regulatory standards and company policy and procedure).
- Coordinate with the Site Managers and the Site Health and Safety Officer when making a request for respirators for a specific job.
- Report to their Site Managers or the Site Health and Safety Officer any unusual conditions or problems, which may reduce the effectiveness of the protective equipment used, and/or increase the hazard to which employees may be exposed.
- Undergo the required PFT (or similar protocol as determined by a qualified medical professional) and QFT directed by this procedure and applicable statutes.
- Ensure their respirator, if not routinely used, is inspected monthly. Respirators used regularly are to be inspected before and after each use. The inspections are to be documented (Attachment B). Any worn or deteriorated parts will be replaced immediately.
- Not loan respirators to anyone.

4.0 SELECTION AND USE

4.1 Respirator Selection and Use

Respirator selection is conducted by the RPO. The type of contaminant and contaminant concentration will dictate the type of respirator that must be worn. Respirators will be NIOSH certified and selection will be based upon consideration from various sources, such as:

- Respirator Hazard Evaluation Form (Attachment C)
- Respirator Selection Criteria (Attachment D)
- The NIOSH Respirator Decision Logic flowchart (Attachment E)

Since Baker's services involve a variety of environmental and industrial hygiene tasks, it is not practical to identify every possible hazard to which Baker employees could be exposed within the scope of this document. Therefore, it is essential that a task-specific assessment be conducted prior to the initiation of any activities on a given project. This task-specific assessment will be part of the site-specific Health and Safety Plan (HASP).

After a task-specific assessment is completed and it is determined that there is a potential for airborne exposure concentrations to exceed the recommended limits, respirators will be selected on the following basis:

- Toxicity
- Maximum Expected Concentrations
- Oxygen Levels
- Warning Properties of the Substance(s) involved
- Sorbent Limitations
- Face Piece Fit
- Mobility Requirements
- Type of use (Routine, Escape, or Emergency Entry)
- Possibility of Ingestion of Toxic Materials
- Respirator Attributes

An employee may request to wear a respirator, even where an exposure hazard does not exist or has not been determined to exist. The employee will be provided with an appropriately designed and fitted respirator based on the potential for hazard exposure in the area of work concerned. A medical evaluation must be completed prior to fit testing and the employee shall be allowed to wear the equipment only if they are medically capable of doing so.

4.2 Cartridge Replacement

Cartridge replacement is based on the workload and use of the respirator. If individuals anticipate large volumes of work (continuous painting for more than four hours), the cartridges will be changed at least daily or as often as needed. If workloads are lighter, the cartridges may be used for a maximum of one week.

Baker employees are also instructed to leave the respirator use area if they detect vapor or gas breakthrough or changes in breathing resistance. The respirator cartridges will be replaced prior to re-entering the work area.

4.3 Available Respirators

Assignment of specific respirators (i.e., manufacturer, model and size) will be based upon the results of the fit testing procedures. Employees must use the specific model and size respirator assigned by the RPO. Baker will provide only as many respirator choices as necessary to obtain acceptable fits among employees. Respirators currently available for use by Baker employees are as follows:

- North Half-Face (Model 7700) Air-Purifying Respirators
- Full-Face (Model 7600) Air-Purifying Respirators
- North Positive Pressure 30-Minute Self Contained Breathing Apparatus (SCBA) (Model 800)
- North Positive Pressure Supplied Airline Respirators with 5-Minute Escape Air Cylinders (Model 85500)
- MSA Ultra Twin Full-Face Respirators
- MSA Comfo II Half-Face Respirator

Only certified respiratory equipment (NIOSH, MSHA, etc.) will be distributed to Baker employees, in accordance with Title 30, Part II of the Code of Federal Regulations. Baker employees will be issued their own respiratory protective equipment, if they regularly perform tasks involving respiratory hazards, provided the employee can achieve a proper fit and is medically capable of wearing the equipment.

4.4 Air Quality

Compressed air used for respiration will be of high purity. Compressed breathing air shall meet at least the requirements for Grade D breathing air described in ANSI/Compressed Gas Association Commodity Specification for Air, G-7.1-

1989.

Baker has air cylinders tested as prescribed in the Shipping Container Specification Regulations of the Department of Transportation (49 CFR Part 173 and Part 178) through outside sources.

Breathing gas containers (air cylinders) shall be marked in accordance with the NIOSH respirator certification standard, 49 CFR part 84.

5.0 TRAINING

Employees will undergo respirator training prior to being required to use a respirator in the workplace. All employees wearing respirators will receive instructions and training on the proper use of respirators and their limitations. At minimum the training will include the requirements of OSHA as follows:

- Appropriate hazard communication - why respirators are needed, the nature of the hazards, and possible consequences if respirators are not used
- Limitations for the types of respirators in use
- How to use the respirator effectively in emergency situations
- Procedures for respirator inspecting, maintenance, donning and wearing, and performing fit checks
- Qualitative fit test procedures
- How to sanitize and store respirators to prevent deterioration and contamination
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators
- The general requirements of the OSHA and Baker respiratory protection programs
- Opportunity to wear respiratory equipment in normal air for an adequate timeframe and to wear it in a test atmosphere such as, one generated by smoke tubes or isoamyl acetate

Employees will be evaluated at the conclusion of the training to ensure they fully understand the requirements of the program. All respiratory training will be repeated annually, and training documentation will be retained by the RPO.

New employees must undergo a medical evaluation, training, and fit testing prior to being issued a personal respirator or being staffed on a project with the potential to use a respirator. The new employee will undergo initial Baker Respiratory Protection Program training regardless whether he/she has received training by a previous employer within the last 12 months.

Current Baker employees who have attended the 40-hour OSHA training in accordance with 29 CFR 1910.120, and who annually attend the 8-hour refresher course, will not be required to attend the annual respiratory protection program training, since respirator use is covered in the course content. These employees will have to report for annual fit testing by a qualified Baker administrator.

6.0 RESPIRATOR FIT TESTING

Baker employees who are required to wear respirators, as part of their work tasks, will receive a fit test administered using an OSHA-accepted qualitative or quantitative protocol set forth in OSHA 1910.134 - Appendix A - Mandatory

Fit Testing Procedures. Fit testing will be conducted only after the medical evaluation and training have been completed. All negative and positive-pressure respirators will be fit tested prior to use in the workplace. Dust/mist respirators are not required to be fit tested. A qualified Baker employee will perform fit testing at the following intervals:

- At, or before initial assignment to an area requiring the use of a respirator
- At least annually, unless specific regulations state otherwise
- Whenever the employee suspects inadequate fit or if there are variances in physical condition
- Based upon the results of respirator program evaluations by the RPO or designee

Test results are documented using the form in Attachment F and retained by the RPO. When a satisfactory fit cannot be achieved with the respirators selected, the RPO will be contacted in order the make provisions to fit the worker with an alternative approved respirator or the worker will be assigned to an area where a respirator is not required.

7.0 INSPECTION, MAINTENANCE, CLEANING, DISINFECTION, AND STORAGE

7.1 Inspection and Maintenance

All respirators will be inspected before and after each use. Inspections will include a check of respirator function, tightness of connections, and conditions of various parts, such as, the face piece, head straps, valves, other elastomeric parts for cleanliness, cracks, deterioration, and/or distortion. Cartridges and filters will be inspected for dents and cracks. Employees will correct any part not functioning properly or notify the RPO prior to use. Replacement and spare respirator parts will be available from the RPO.

7.2 Cleaning and Disinfecting

Respirators are to be cleaned and disinfected by the respirator wearer using the procedures recommended by the respirator manufacturer or by OSHA requirements in 1910.134 Appendix B-2. These cleaning and disinfecting requirements will be presented during training and are outlined in Attachment G.

The respirators will be cleaned and disinfected at the following intervals:

- Respirators issued for the exclusive use of an employee will be cleaned and disinfected as often as necessary to be maintained in a sanitary condition.
- Respirators issued to more than one employee will be cleaned and disinfected before being worn by different individuals.
- Respirators used in fit testing and training will be cleaned and disinfected after each use.
- Respirators that come into contact with contaminated materials will be cleaned and disinfected immediately after contact.

7.3 Storage

When not in use, respirators will be stored in clean, dry storage area, such as the employee's locker, or department to protect them from damage, contamination, dust, sunlight, temperature extremes, excessive moisture, and damaging chemicals. Site Managers will ensure these procedures are followed.

8.0 MEDICAL EVALUATION

All employees requiring (or requesting) a respirator will undergo a medical evaluation through the following local medical facility:

Allegheny Medical Center
2000 Cliff Mine Road
Park West 2, Suite 110
Pittsburgh, PA 15275

Prior to fit testing, all persons using respirators will be given an initial medical evaluation to determine if they are physically able to perform the work and use the required equipment (such as, negative pressure respirators).

Requirements for medical evaluations of respirator wearers will include at least completing the questionnaire in Attachment A and having it reviewed by an occupational physician at the local medical facility. Routine medical examinations and special testing will be conducted as the physician deems necessary.

The following information will be provided to the physician conducting the medical evaluation:

- The type and weight of the respirator to be used by the employee
- The duration and frequency of respirator use
- The expected physical work effort
- Additional protective equipment to be worn
- Temperature and humidity extremes that may be encountered
- A copy of this program and a copy of 29 CFR 1910.134

The RPO, with assistance from Allegheny Medical Center, will establish the specific health protocols necessary to ensure adequate compliance with this procedure. Specific OSHA standards will be followed for contaminants (such as, asbestos, lead, arsenic, etc.), as appropriate.

At a minimum, Baker will provide additional medical evaluations if:

- An employee reports medical signs or symptoms that are related to ability to use a respirator
- A physician determines an employee needs to be reevaluated
- An employee gives a positive response to any question among questions 1 through 8 in Section 2, Part A of Appendix A or whose initial medical examination demonstrates the need for a follow-up medical examination
- A change occurs in workplace conditions (such as, physical work effort, protective clothing, temperature)

that may result in a substantial increase in the physiological burden placed on an employee

9.0 SPECIAL RESPIRATOR ITEMS

- All employees assigned to jobs/tasks requiring the use of respirators will be clean shaven. Any facial hair that interferes with proper respirator fit is prohibited.
- Contact lenses are permitted with the use of a respirator. Baker will supply corrective lenses if they are necessary for the employee.

10.0 WORKPLACE SURVEILLANCE

Employee exposure monitoring will be conducted whenever there is a chance of significant employee exposure to dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors (including process changes or modifications). Significant worker exposure will include airborne levels in the workers breathing zone at or above the OSHA PELS, ACGIH TLV, NIOSH recommendations, or information from other competent authorities. Respirator selection should be reevaluated after exposure monitoring is completed to ensure the respirator and cartridge are appropriate for the exposure level experienced by the employee. Employees should be issued the appropriate respirator and cartridges if needed.

If the RPO deems a significant exposure is possible, initial employee monitoring will be conducted as soon as possible. Respirator selection will be, in part, based on these and follow-up results.

11.0 SUB-CONTRACTOR REQUIREMENTS

In compliance with Baker's Respiratory Protection Program, all sub-contractors under the direction of Baker personnel will be expected to comply with OSHA standards 1910.134 and 1926.103. Additionally, the sub-contractors will be required to:

- Provide documentation that their employees have been medically certified to wear a respirator, have been properly trained, and have been fit tested within the past 12 months.

12.0 PROGRAM EVALUATION

The RPO will review and update the respirator program at least annually, or whenever new areas requiring respiratory protection have been identified, before proposed process changes, or when the need arises to revise respirator selection logic (e.g., a reduction in PELs). The evaluation will include a review of respirator usage as pertaining to this program. A written copy of the evaluation and any pertinent program changes will be kept on file by the RPO's. If required, revisions to the respirator program and specific written operating procedures will be made as soon as possible.

13.0 RECORDKEEPING

Records and written information regarding medical evaluations, fit testing, and the respirator program shall be retained in accordance with OSHA 1910.134. Medical records will be retained by the Human Resource Department in each employees personnel file, which is kept confidential. Fit testing records will be maintained by the RPO, along with a copy of the respiratory protection program. Program records will be made available to affected employees upon request.

ATTACHMENT A
MEDICAL EVALUATION QUESTIONNAIRE

APPENDIX A
Respirator Medical Evaluation Questionnaire

*To the employer: Answers to questions in Section 1, and to question 9 in Section 2 of Part A, do not require a medical examination.

*To the employee:
*Can you read (circle one): Yes/No

*Your employer must allow you to answer this questionnaire during normal working hours, or at a time and place that is convenient to you. To maintain your confidentiality, your employer or supervisor must not look at or review your answers, and your employer must tell you how to deliver or send this questionnaire to the health care professional who will review it.

*Part A. Section 1. (Mandatory) The following information must be provided by every employee who has been selected to use any type of respirator (please print).
*1. Today's date:_____ *2. Your Name:_____

*3. Your age (to nearest year):_____*4. Sex (circle one): Male/Female

*5. Your height: _____ ft. _____ in. *6. Your weight: _____ lbs.

*7. Your job title:_____

*8. A phone number where you can be reached by the health care professional who reviews this questionnaire (include the Area Code): _____

*9. The best time to phone you at this number: _____

*10. Has your employer told you how to contact the health care professional who will review this questionnaire (circle one): Yes/No

*11. Check the type of respirator you will use (you can check more than one category):
*a. _____ N, R, or P disposable respirator (filter-mask, non- cartridge type only).
*b. _____ Other type (for example, half- or full-facepiece type, powered-air purifying, supplied-air, self-contained breathing apparatus).

*12. Have you worn a respirator (circle one): Yes/No

* If "yes," what type(s):_____
_____

*Part A. Section 2. (Mandatory) Questions 1 through 9 below must be answered by every employee who has been selected to use any type of respirator (please circle "yes" or "no").

*1. Do you currently smoke tobacco, or have you smoked tobacco in the last month: Yes/No

*2. Have you ever had any of the following conditions?
*a. Seizures (fits): Yes/No
*b. Diabetes (sugar disease): Yes/No
*c. Allergic reactions that interfere with your breathing: Yes/No

*d. Claustrophobia (fear of closed-in places): Yes/No
*e. Trouble smelling odors: Yes/No

*3. Have you ever had any of the following pulmonary or lung problems?
*a. Asbestosis: Yes/No
*b. Asthma: Yes/No
*c. Chronic bronchitis: Yes/No
*d. Emphysema: Yes/No
*e. Pneumonia: Yes/No
*f. Tuberculosis: Yes/No
*g. Silicosis: Yes/No
*h. Pneumothorax (collapsed lung): Yes/No
*i. Lung cancer: Yes/No
*j. Broken ribs: Yes/No
*k. Any chest injuries or surgeries: Yes/No
*l. Any other lung problem that you've been told about: Yes/No

*4. Do you currently have any of the following symptoms of pulmonary or lung illness?
*a. Shortness of breath: Yes/No
*b. Shortness of breath when walking fast on level ground or walking up a slight hill or incline: Yes/No
*c. Shortness of breath when walking with other people at an ordinary pace on level ground: Yes/No
d. Have to stop for breath when walking at your own pace on level ground: Yes/No
*e. Shortness of breath when washing or dressing yourself: Yes/No
*f. Shortness of breath that interferes with your job: Yes/No
*g. Coughing that produces phlegm (thick sputum): Yes/No
*h. Coughing that wakes you early in the morning: Yes/No
*i. Coughing that occurs mostly when you are lying down: Yes/No
*j. Coughing up blood in the last month: Yes/No
*k. Wheezing: Yes/No
*l. Wheezing that interferes with your job: Yes/No
*m. Chest pain when you breathe deeply: Yes/No
*n. Any other symptoms that you think may be related to lung problems: Yes/No

*5. Have you ever had any of the following cardiovascular or heart problems?
*a. Heart attack: Yes/No
*b. Stroke: Yes/No
*c. Angina: Yes/No
*d. Heart failure: Yes/No
*e. Swelling in your legs or feet (not caused by walking): Yes/No
*f. Heart arrhythmia (heart beating irregularly): Yes/No
*g. High blood pressure: Yes/No
*h. Any other heart problem that you've been told about: Yes/No

*6. Have you ever had any of the following cardiovascular or heart symptoms?
*a. Frequent pain or tightness in your chest: Yes/No
*b. Pain or tightness in your chest during physical activity: Yes/No
*c. Pain or tightness in your chest that interferes with your job: Yes/No
*d. In the past two years, have you noticed your heart skipping or missing a beat: Yes/No
*e. Heartburn or indigestion that is not related to eating: Yes/ No
*f. Any other symptoms that you think may be related to heart or circulation problems: Yes/No

*7. Do you currently take medication for any of the following problems?
*a. Breathing or lung problems: Yes/No
*b. Heart trouble: Yes/No
*c. Blood pressure: Yes/No
*d. Seizures (fits): Yes/No

*8. If you've used a respirator, have you ever had any of the following problems? (If you've never used a respirator, check the following space and go to question 9:)
*a. Eye irritation: Yes/No
*b. Skin allergies or rashes: Yes/No
*c. Anxiety: Yes/No
*d. General weakness or fatigue: Yes/No
*e. Any other problem that interferes with your use of a respirator: Yes/No

*9. Would you like to talk to the health care professional who will review this questionnaire about your answers to this questionnaire: Yes/No

*Questions 10 to 15 below must be answered by every employee who has been selected to use either a full-facepiece respirator or a self-contained breathing apparatus (SCBA). For employees who have been selected to use other types of respirators, answering these questions is voluntary.

*10. Have you ever lost vision in either eye (temporarily or permanently): Yes/No

*11. Do you currently have any of the following vision problems?
*a. Wear contact lenses: Yes/No
*b. Wear glasses: Yes/No
*c. Color blind: Yes/No
*e. Any other eye or vision problem: Yes/No

*12. Have you ever had an injury to your ears, including a broken ear drum: Yes/No

*13. Do you currently have any of the following hearing problems?
*a. Difficulty hearing: Yes/No
*b. Wear a hearing aid: Yes/No
*c. Any other hearing or ear problem: Yes/No

*14. Have you ever had a back injury: Yes/No

*15. Do you currently have any of the following musculoskeletal problems?
*a. Weakness in any of your arms, hands, legs, or feet: Yes/No
*b. Back pain: Yes/No
*c. Difficulty fully moving your arms and legs: Yes/No
*d. Pain or stiffness when you lean forward or backward at the waist: Yes/No
*e. Difficulty fully moving your head up or down: Yes/No
*f. Difficulty fully moving your head side to side: Yes/No
*g. Difficulty bending at your knees: Yes/No
*h. Difficulty squatting to the ground: Yes/No
*i. Climbing a flight of stairs or a ladder carrying more than 25 lbs: Yes/No
*j. Any other muscle or skeletal problem that interferes with using a respirator: Yes/No

*Part B Any of the following questions, and other questions not listed, may be added to the questionnaire at the discretion of the health care professional who will review the questionnaire.

*1. In your present job, are you working at high altitudes (over 5,000 feet) or in a place that has lower than normal amounts of oxygen: Yes/No
If "yes," do you have feelings of dizziness, shortness of breath, pounding in your chest, or other symptoms when you're working under these conditions: Yes/No

*2. At work or at home, have you ever been exposed to hazardous solvents, hazardous airborne chemicals (e.g., gases, fumes, or dust), or have you come into skin contact with hazardous chemicals: Yes/No
If "yes," name the chemicals if you know them:_____
_____
_____

*3. Have you ever worked with any of the materials, or under any of the conditions, listed below:
a. Asbestos: Yes/No
b. Silica (e.g., in sandblasting): Yes/No
c. Tungsten/cobalt (e.g., grinding or welding this material): Yes/No
d. Beryllium: Yes/No
e. Aluminum: Yes/No
f. Coal (for example, mining): Yes/No
g. Iron: Yes/No
h. Tin: Yes/No
i. Dusty environments: Yes/No
j. Any other hazardous exposures: Yes/No
If "yes," describe these exposures:_____
_____
_____

*4. List any second jobs or side businesses you have:_____
_____

*5. List your previous occupations:_____
_____

*6. List your current and previous hobbies:_____
_____

*7. Have you been in the military services? Yes/No
If "yes," were you exposed to biological or chemical agents (either in training or combat): Yes/No

*8. Have you ever worked on a HAZMAT team? Yes/No

*9. Other than medications for breathing and lung problems, heart trouble, blood pressure, and seizures mentioned earlier in this questionnaire, are you taking any other medications for any reason (including over-the-counter medications): Yes/No
If "yes," name the medications if you know them:_____

*10. Will you be using any of the following items with your respirator(s)?
a. HEPA Filters: Yes/No
b. Canisters (for example, gas masks): Yes/No
c. Cartridges: Yes/No

*11. How often are you expected to use the respirator(s) (circle "yes" or "no" for all answers that apply to you)?:
a. Escape only (no rescue): Yes/No
b. Emergency rescue only: Yes/No
c. Less than 5 hours per week: Yes/No
d. Less than 2 hours per day: Yes/No
e. 2 to 4 hours per day: Yes/No
f. Over 4 hours per day: Yes/No

*12. During the period you are using the respirator(s), is your work effort:
a. Light (less than 200 kcal per hour): Yes/No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of a light work effort are sitting while writing, typing, drafting, or performing light assembly work; or standing while operating a drill press (1-3 lbs.) or controlling machines.

b. Moderate (200 to 350 kcal per hour): Yes/No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of moderate work effort are sitting while nailing or filing; driving a truck or bus in urban traffic; standing while drilling, nailing, performing assembly work, or transferring a moderate load (about 35 lbs.) at trunk level; walking on a level surface about 2 mph or down a 5-degree grade about 3 mph; or pushing a wheelbarrow with a heavy load (about 100 lbs.) on a level surface.

c. Heavy (above 350 kcal per hour): Yes/No
If "yes," how long does this period last during the average shift:_____hrs._____mins.
Examples of heavy work are lifting a heavy load (about 50 lbs.) from the floor to your waist or shoulder; working on a loading dock; shoveling; standing while bricklaying or chipping castings; walking up an 8-degree grade about 2 mph; climbing stairs with a heavy load (about 50 lbs.).

*13. Will you be wearing protective clothing and/or equipment (other than the respirator) when you're using your respirator: Yes/No
If "yes," describe this protective clothing and/or equipment:_____
_____

*14. Will you be working under hot conditions (temperature exceeding 77 deg. F): Yes/No

*15. Will you be working under humid conditions: Yes/No

*16. Describe the work you'll be doing while you're using your respirator(s):
_____
_____

*17. Describe any special or hazardous conditions you might encounter when you're using your respirator(s) (for example, confined spaces, life-threatening gases):
_____
_____

*18. Provide the following information, if you know it, for each toxic substance that you'll be exposed to when you're using your respirator(s):

Name of the first toxic substance:_____

Estimated maximum exposure level per shift:_____

Duration of exposure per shift_____

Name of the second toxic substance:_____

Estimated maximum exposure level per shift:_____

Duration of exposure per shift:_____

Name of the third toxic substance:_____

Estimated maximum exposure level per shift:_____

Duration of exposure per shift:_____

The name of any other toxic substances that you'll be exposed to while using your respirator:

_____

_____

_____

*19. Describe any special responsibilities you'll have while using your respirator(s) that may affect the safety and well-being of others (for example, rescue, security):

_____

ATTACHMENT B
RESPIRATOR INSPECTION AUDIT

RESPIRATOR INSPECTION AUDIT CHECKLIST
BAKER ENVIRONMENTAL, INC. RESPIRATORY PROTECTION PROGRAM

Employee Name _____ Social Security # _____

Plant and Area _____ Crew Chief _____

STORAGE AREA:

Where is the Respirator stored? _____

Is the storage unit acceptable?_____ YES _____ NO ___

Is the storage unit clean? YES _____ NO ___

TYPE AND CONDITION OF RESPIRATOR:

Type of Respirator, Cartridge, and Filter _____

Facepiece? (damaged, distorted, vision impaired, cracks) YES _____ NO ___

Straps? (damaged, stretched, frayed, missing) YES _____ NO ___

Inhalation and exhalation valves? (cracked, improper seated, missing) YES _____ NO ___

Filters and/or cartridges? (proper type, dirty, damaged) YES _____ NO ___

How is overall condition? (clean, good condition) YES _____ NO ___

WORK AREA CONDITIONS:

Has work area changed in a way that may effect the proper use of respirator? YES _____ NO ___

If yes, explain _____

How often is the respirator used? _____

What are the hazards the respirator is used for? _____

Any other comments? _____

Investigator _____ Date _____

ATTACHMENT C
RESPIRATOR HAZARD EVALUATION FORM

RESPIRATORY HAZARD EVALUATION FORM

EVAL. NO. _____

SITE: _____ LOCATION/BUILDING: _____

WORK AREA: _____ SPECIFIC TASK: _____

TOTAL NUMBER OF EMPLOYEES EXPOSED: _____ DISTRIBUTION: 1ST SHIFT _____ 2ND SHIFT _____ 3RD SHIFT _____

Potential Contaminant	Chemical State			Physical Form						Air Monitoring Results			Protection Factor Req'd.	Warning Propertes?
	Liquid	Gas	Solid	Vapor	Gas	Mist	Dust	Fume	Fiber	<PEL/TLV	>PEL/TLV	IDLH		
_____	__	__	__	__	__	__	__	__	__	____	____	____	_____	Y N
_____	__	__	__	__	__	__	__	__	__	____	____	____	_____	Y N
_____	__	__	__	__	__	__	__	__	__	____	____	____	_____	Y N

LIMITING PROTECTION FACTOR (Highest): _____ FOR DUSTS - IS PARTICLE SIZE KNOWN? (circle) Yes No

FILTER CLASSIFICATION (if required): (circle) N R P (circle) 95 99 99.9

OXYGEN LEVEL ADEQUATE? Yes No IDLH Levels Present? Yes No

RESPIRATOR TYPE: AIR PURIFYING: _____ DISPOSABLE DUST/MIST/FUME

_____ REUSABLE STYLE (circle) HALF FACE FULL FACE PAPR

CARTRIDGE TYPE: _____ CHANGE SCHEDULE: _____

FILTER TYPE: _____

AIR SUPPLIED: _____ AIRLINE (circle) HALF FACE FULL FACE HOOD HELMET

_____ SCBA

RESPIRATOR: BRAND: _____ MODEL NO. _____ NIOSH TC# _____

CARTRIDGE and/or FILTER TC# _____

Person Performing Evaluation: _____ Date: _____

ATTACHMENT D
RESPIRATOR SELECTION CRITERIA

SELECTION CRITERIA

The following items are to be considered when selecting respirators:

1. Is protection needed for oxygen deficient or enriched atmospheres? Only air supplying respirators can be used in such areas.

2. Is protection needed for airborne contaminants?

3. What are the contaminants?

4. What are the contaminant warnings? Inadequate-warning propertiesCsuch as not being able to detect the contaminant by smell, taste or irritation below the permissible exposure limitsCrequire air supplying respirators.

5. What is the permissible exposure limit, action level, ceiling, short term and/or excursion limits for each contaminant?

6. What are the contaminant's physical properties?

7. What are the contaminant's chemical properties?

8. What health effects can be caused by exposure?

9. Is the onset of symptoms delayed?

10. What are the employee exposure levels?

11. What are the maximum possible exposures?

12. How long are employees exposed?

13. Where is the work being conducted? Work in a confined space requires air supplying respirators and additional safety precautions.

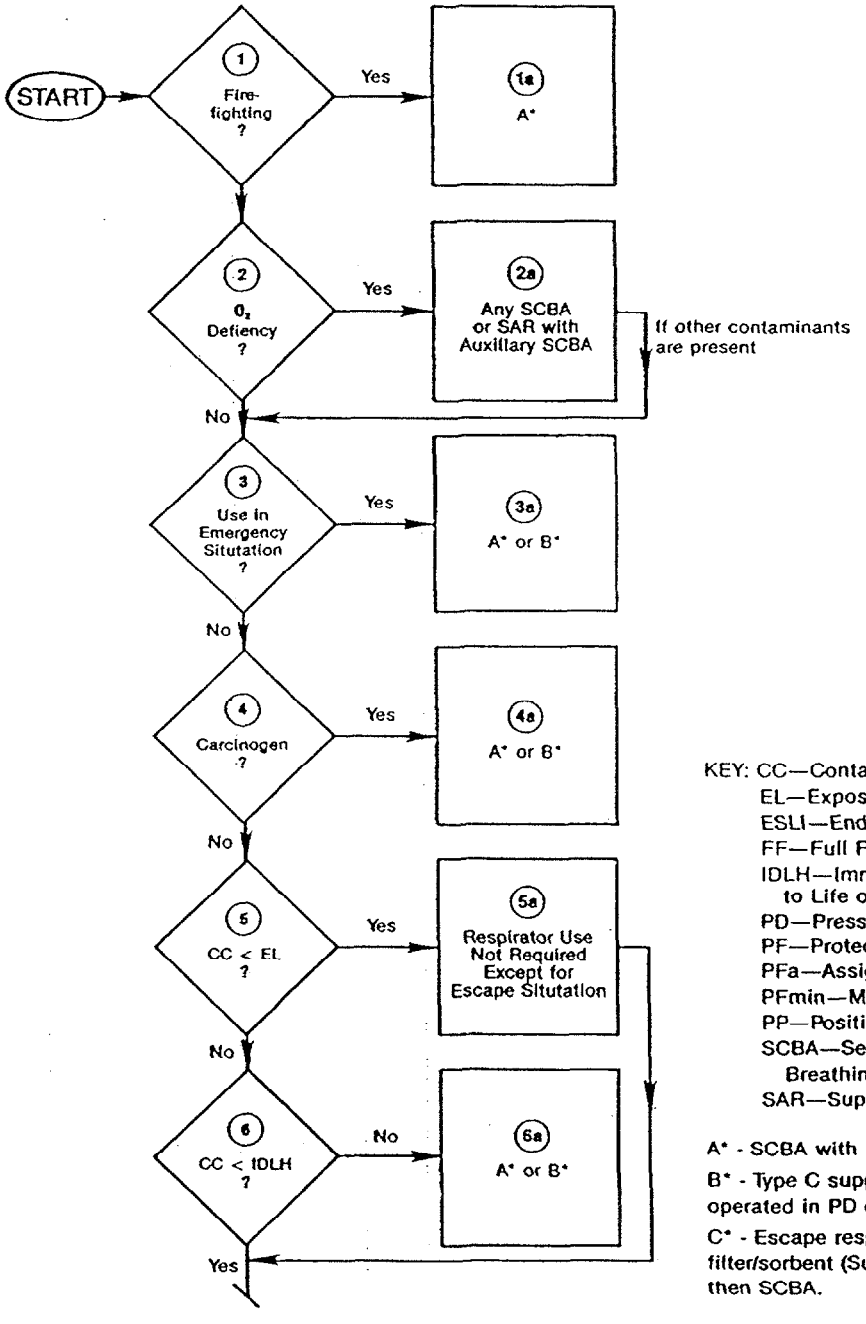
14. What physical work activity is being conducted?

15. What other protective equipment is being worn?

16. What is the health status of the employees? Some employees may have to be excluded from using respiratory equipment because of pulmonary or other medical disorders.

ATTACHMENT E
NIOSH DECISION LOGIC FLOWCHART

The Respirator Decision Logic Sequence is presented in Figure 1 in the form of a flow chart. This flow chart can be used to identify suitable classes of respirators for adequate protection against specific environmental conditions. Refer to the corresponding narrative section for additional information pertaining to a specific part of the flow chart.



KEY: CC—Contaminant Concentration
EL—Exposure Limit
ESLI—End of Service Life Indicator
FF—Full Facepiece
IDLH—Immediately Dangerous to Life or Health
PD—Pressure Demand
PF—Protection Factor
PFa—Assigned PF
PFmin—Minimum PF
PP—Positive Pressure
SCBA—Self-Contained Breathing Apparatus
SAR—Supplied-Air Respirator

A* - SCBA with FF operated in PD or PP mode.

B* - Type C supplied-air respirator (airline) operated in PD or PP mode with auxiliary SCBA.

C* - Escape respirator or gas mask with appropriate filter/sorbent (Subparagraph 5); if O_2 deficient, then SCBA.

Figure 1. — Flow Chart of Respirator Decision Logic Sequence

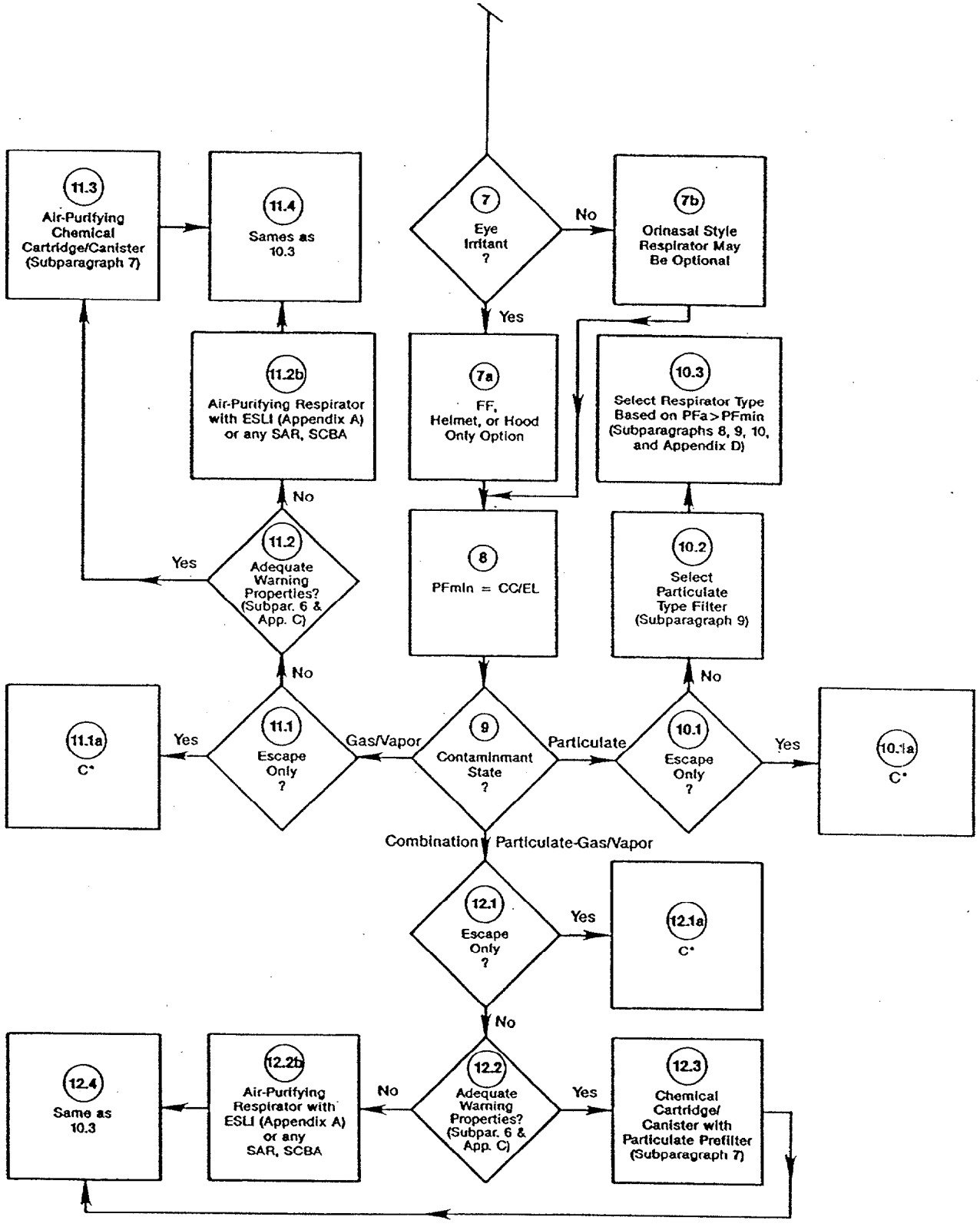


Figure 1. — Flow Chart of Respirator Decision Logic Sequence — Continued

ATTACHMENT F
QUALITATIVE FIT-TEST RECORD

BAKER ENVIRONMENTAL, INC.
QUALITATIVE RESPIRATOR FIT TEST RECORD

TEST SUBJECT NAME _____
(last) (first) (initial)

DATE _____ SOCIAL SECURITY NUMBER _____

SEX (M/F) _____ AGE _____ DEPARTMENT _____

RESPIRATOR MEDICAL DATE _____ RESPIRATOR TRAINING DATE _____

SPECIAL/UNUSUAL CONDITIONS/CONSIDERATIONS:

Yes	No		Yes	No	
9	9	Claustrophobia	9	9	Scars
9	9	Facial hair	9	9	Broken or crooked nose
9	9	Eyeglasses	9	9	Extreme facial dimensions
9	9	Contacts9	9	Wrinkles	
9	9	Other: _____			

RESPIRATOR SELECTION

Manufacturer/Model	Size	Style	Result
	S_____ M_____ L _____	Half _____ Full_____	Pass _____ Fail_____
	S_____ M_____ L _____	Half _____ Full_____	Pass _____ Fail_____
	S_____ M_____ L _____	Half _____ Full_____	Pass _____ Fail_____

Testing	Pass Qualitative Test	Pass Sensitivity Check
Isoamyl Acetate	Yes _____ No_____	Yes _____ No_____
Irritant Smoke	Yes _____ No_____	Yes _____ No_____
Other: _____	Yes _____ No_____	Yes _____ No_____

TEST EXERCISES
(Complete list, all must be performed)

Normal Breathing	_____	Talking	_____
Deep Breathing	_____	Bending	_____
Head, Side to Side	_____	Jaw Movements	_____
Head, Up and Down	_____	Rainbow Passage	_____

COMMENTS: _____

Signed: _____ Signed:_
(Test Subject) (Instructor)

ATTACHMENT G
CLEANING AND DISINFECTING

CLEANING AND DISINFECTING

These cleaning and disinfecting requirements will be presented during training and are outlined below:

- Remove filters and cartridges. Disassemble facepieces by removing speaking diaphragms, demand and pressure- demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.

- Wash components in warm (43 deg. C [110 deg. F] maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.

- Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water.

- When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in one of the following:

1. Hypochlorite solution (50 ppm of chlorine) made by adding approximately one milliliter of laundry bleach to one liter of water at 43 deg. C (110 deg. F); or,

2. Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45% alcohol) to one liter of water at 43 deg. C (110 deg. F); or,

3. Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer.

- Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water .and drain. Detergents or disinfectants that dry on facepieces may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

- Components are to be hand-dried with a clean lint-free cloth or air-dried.

- Reassemble facepiece, replacing filters, cartridges, and canisters where necessary.

- Test the respirator to ensure that all components work properly.

Chain of Training

Respiratory Protection Program

Baker

Name:		Job Title:	
Department:		Date:	

The following must be completed prior to the above employee being authorized to wear respiratory protection during normal field activities:

Criteria	Authorized Person	Date
Medical Evaluation Complete and Results Permit Employee to Wear Respiratory Protection:	Gail Weihaus, Training Coordinator	
OSHA 40 Hour Training/8 Hour Refresher Training Complete:	Gail Weihaus, Training Coordinator	
Annual Respiratory Protection Program T ·ning Complete:	Health and Safety Office	
Qualitative Fit Test Performed and Employee is Authorized to Wear a Respirator During Normal Field Operations:	Darrin Hupe, Equipment Manager	

cc: Original-GWeihaus, CDott, DHupe, Employee

BAKER ENVIRONMENTAL, INC.
PERSONNEL PROTECTIVE EQUIPMENT (PPE) PROGRAM

BAKER ENVIRONMENTAL, INC.
PERSONAL PROTECTIVE EQUIPMENT (PPE) PROGRAM

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3.0 RESPONSIBILITIES 2

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4.1.3 Foot Protection 3
4.1.4 Hand Protection 3
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5.0 TRAINING 4

5.1 Personnel Training 4
5.2 Record keeping 4

APPENDIX

General Guidelines for Choosing Personal Protective Equipment

PERSONAL PROTECTIVE EQUIPMENT (PPE) PROGRAM

1.0 INTRODUCTION

The objective of the Personal Protective Equipment (PPE) Program is to protect employees from risk of injury or death by creating a barrier against workplace hazards. PPE is not a substitute for good engineering or administrative controls or good work practices, but should be used in conjunction with these controls to ensure the safety and health of employees. This program addresses eye, face, head, foot, hand and body protection in accordance with 29 CFR 1910.132. Separate programs exist for respiratory and hearing protection.

Federal OSHA standards require that employers perform a hazard assessment of the workplace to determine the nature of the hazards and ensure that appropriate PPE is available to employees. The standards require that employees be trained in the proper use, care and limitations of PPE.

2.0 SCOPE

The scope of this program is to specify the PPE requirements of Baker Environmental, Inc (Baker), which include:

- Types of PPE available
- PPE inspection procedures
- Guidelines for specifying the appropriate PPE

3.0 RESPONSIBILITIES

This program includes the responsibilities of the Baker Health and Safety Coordinator, Project Manager, Site Manager, Site Health and Safety Officer (SHSO), and employees. The responsibilities of these individuals are presented in the Responsibilities section of this manual. Additional responsibilities are outlined below.

The Project Manager and Site Manager are responsible for ensuring that a hazard assessment is conducted and the specified PPE is provided and used by site personnel. The SHSO's duties include:

- Issuing appropriate PPE
- Removing and replacing defective or damaged equipment

4.0 PROCEDURES

A Hazard Assessment Determination of each project is conducted to determine the nature of hazards that may be present and the selection of appropriate PPE requirements. Specifics of the hazard assessment conducted by Baker are presented in the site-specific health and safety plans.

4.1 Protective Equipment

The various types of PPE available is discussed in this section.

4.1.1 Eye and Face Protection

Eye and face protective equipment is required by OSHA where there is a reasonable probability of preventing injury when such equipment is used. Employers must provide a type of protector suitable for work to be performed and employees must use the protectors. These stipulations also apply to all personnel on site and include visitors while they are in hazardous areas.

Suitable protectors will be used when employees are exposed to hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. Side protectors will be used when there is a hazard from flying objects. Goggles will be used when there is a hazard from chemical splashes. Equipment fitted with appropriate filter lenses will be used to protect against light radiation. Eye and face protectors will meet all provisions contained in the ANSI standard (ANSI Z87.1-1989).

For employees who wear prescription lenses, eye protectors will either incorporate the prescription in the design or fit properly over the prescription lenses.

4.1.2 Head Protection

Protective hats will be worn when hazards from falling or fixed objects, or electrical shock are present. Protective hats will meet all provisions contained in the ANSI standard (ANSI Z89.1-1969).

4.1.3 Foot Protection

Safety shoes will be worn when falling, rolling, puncture, or electrical hazards are present. Safety shoes will meet all provisions contained in the ANSI standard (ANSI Z41.1-1967).

4.1.4 Hand Protection

Suitable gloves will be worn when hazards from chemicals, cuts, lacerations, abrasions, punctures, burns, and harmful temperature extremes are present. Glove selection will be based on performance characteristics, conditions, duration of use, and hazards present.

4.1.5 Dermal Protection

Suitable protective clothing will be worn when hazards from chemicals, cuts, lacerations, abrasions, punctures, burns, and harmful temperature extremes are present. Material/fabric selection will be based on performance characteristics, conditions, duration of use, and hazards present.

For additional information on specific types and classes of PPE, see Appendix A, General Guidelines for Choosing Personal Protective Equipment.

4.2 Cleaning/Disposal

PPE will be cleaned or disposed in accordance with the Project specific Health and Safety Plan and applicable local/state/federal regulation. Non disposable PPE is not to be shared between employees until it has been properly cleaned and sanitized. Disposable PPE is not to be shared between employees.

5.0 TRAINING

Personnel training and record keeping requirements are presented in this section.

5.1 Personnel Training

Baker employee PPE training will be conducted during the 40-hour OSHA training and updated during the mandatory 8-hour annual refreshers. In addition, PPE training will be conducted during project related on-site health and safety briefings. The training will include, but not necessarily be limited to, the following subjects:

- When, and where, PPE is necessary to be worn
- What PPE is necessary
- How to properly don, doff, adjust, and wear PPE
- The limitations of the PPE
- The proper care, maintenance, useful life and disposal of the PPE
- Demonstration that the employee understands the training material and is able to use PPE properly

5.2 Record Keeping

Written records of OSHA mandated training will be kept of the names of persons trained, the type of training provided, and the dates when training occurred. The records will be maintained in the employees permanent file. Project specific training will be recorded in the Project File. Original Training Certificates will be presented to the employee.

APPENDIX A
GENERAL GUIDELINES FOR CHOOSING PERSONAL PROTECTIVE EQUIPMENT

Table of Contents

1.0 Eye Protection
2.0 Head Protection
3.0 Feet Protection
4.0 Hand Protection
5.0 Dermal Protection

1.0 Eye PROTECTION

Protective eye wear is required when flying particles, dusts, fumes, vapors or harmful rays could expose an employee to potential eye injury.

1.1 Safety Glasses

Standard safety glasses look very much like normal glasses, but are designed to protect against flying particles. Safety glasses have lenses that are impact resistant and frames that are far stronger than regular eyeglasses. Safety glasses must meet the standards of the American National Standards Institute (ANSI). Safety glasses are also available in prescription form for those persons who need corrective lenses. Safety glasses can be equipped with side shields, cups, or tinted lenses to offer additional protection.

1.2 Safety Goggles

Like safety glasses, goggles are impact resistant and are available in tinted lenses. Goggles should provide a secure shield around the entire eye area to protect against hazards coming from many directions. Goggles are provided on project sites when a potential of chemical splashing exists and/or at the request of any site personnel.

2.0 HEAD PROTECTION

Head injuries can be caused by falling or flying objects, or by bumping the head against a fixed object. Head protectors, in the form of protective hats, must resist penetration and absorb the shock of a blow. The shell of the protective hat should be hard enough to resist the blow and the headband and crown straps should keep the shell away from the wearer's skull. Protective hats can also protect against electrical shock. Protective hats are made in the following types and classes:

- Type 1 - helmets with a full brim, not less than 1 and 1/4 inches wide
- Type 2 - brimless helmets with a peak extending forward from the crown

For industrial purposes, three classes are recognized:

- Class A - general service, limited voltage protection;
- Class B - utility service, high-voltage helmets; and
- Class C - special service, no voltage protection.

3.0 FOOT PROTECTION

Footwear requirements on Baker projects must meet established safety standards. This is located by checking for the American National Standards Institute (ANSI) label inside each shoe.

3.1 Steel-Reinforced Safety Shoes

These shoes are designed to protect an employee's feet from common machinery hazards such as falling or rolling objects, cuts, and punctures. The entire toe box and insole are reinforced with steel, and the instep is protected by steel, aluminum, or plastic materials. Safety shoes are also designed to insulate against temperature extremes and may be equipped with special soles to guard against slips, chemicals, and/or electrical hazards.

3.2 Safety Boots

Baker requires the use of safety boots by Baker employees when splash or spark hazards (chemicals, molten materials) are present. This includes the following:

- When working with corrosives, caustics, cutting oils, and petroleum products, neoprene or nitrile boots or similar are required to prevent penetration.

- When working with electricity, special electrical hazard boots which are designed with no conductive materials other than the steel toe (which is properly insulated).

4.0 HAND PROTECTION

When protective hand wear is required for job performance, the gloves must fit well, are comfortable to wear, and are rated to guard against the particular hand hazards present.

The following is a guide to the most common types of protective work gloves and the types of hazards they can guard against.

4.1 Disposable Gloves

Disposable gloves used on Baker project sites are usually made of light-weight plastic and are used to help guard against mild irritants.

4.2 Fabric Gloves

Gloves made of cotton or fabric blends are generally used to improve grip when handling slippery objects. They can also help insulate hands from mild heat or cold.

4.3 Leather Gloves

These gloves are used to guard against injuries from sparks or scraping against rough surfaces. They are also used in combination with an insulated liner when working with electricity.

4.4 Metal Mesh Gloves

These gloves are used to protect hands from accidental cuts and scratches. They are used most commonly by persons working with cutting tools or other sharp instruments.

4.6 Chemical Resistance Gloves

These gloves may be made of rubber, neoprene, polyvinyl alcohol, vinyl, or a variety of other material. The gloves protect hands from chemical exposure such as, corrosives, oils, and solvents. When selecting chemical resistant gloves, the manufacturers' recommendations should be consulted.

5.0 DERMAL PROTECTION

The following is a brief description of a few types of protective clothing and the types of hazards they can guard against. This list is not inclusive, there are numerous types and styles of possible protective coveralls designed to offer various degrees of protection.

5.1 Tyvex Coveralls

Tyvex coveralls are inexpensive, disposable spun-bonded, nonwoven polyethylene fiber jumpsuits produced by DuPont. Tyvex provides reasonable tear, puncture, and abrasion resistance protection and excellent protection against particulate contaminants. However, it offers little protection against hazardous liquid or vapor contaminants.

5.2 Saranex Coveralls

While more expensive than Tyvex, Saranex coveralls provide a greater level of protection against both physical and chemical contaminants

5.3 Polyethylene coated Tyvex Coveralls

When used as a coating on polyolefin material such as Tyvex, polyethylene increases resistance to acids, bases, and salts.

BAKER ENVIRONMENTAL, INC.
BLOODBORNE PATHOGENS PROGRAM

BAKER ENVIRONMENTAL, INC.
BLOODBORNE PATHOGENS PROGRAM

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4.3.2 Standard Work Practices.
4.4 Medical Monitoring
4.5 Post-Exposure Procedures and Follow-Up Management

5.0 REFERENCES

ATTACHMENT

A. BLOODBORNE PATHOGENS TRAINING OUTLINE

BLOODBORNE PATHOGENS PROGRAM

1.0 INTRODUCTION

The purpose of the Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens Standard, Title 29 CFR Part 1910.1030, is to protect workers from bloodborne pathogens such as the human immunodeficiency virus (HIV) and hepatitis B virus (HBV) by reducing or eliminating workers' exposure to blood and other potentially infectious materials. Although HIV and HBV are specifically mentioned by OSHA, the standard includes any bloodborne pathogen, such as Hepatitis C, malaria, and syphilis. The standard requires the employer to develop a written exposure control plan that will reduce or eliminate employee exposure, thus reducing their risk of infection.

1.1 Purpose

The purpose of the Baker Environmental (Baker) exposure control plan is to minimize the possibility of transmission of bloodborne pathogens in the workplace and protect employees. This is accomplished by:

1.) Reducing potential exposure

2.) Establishing procedures for the safe handling of first-aid, injury, and/or illness incidents that may expose personnel to blood or other potentially infectious materials

3.) Establishing a means of providing post-exposure evaluation if an exposure incident occurs

1.2 Definitions

Bloodborne Pathogens - Pathogenic microorganisms that may be present in human blood, having the potential to cause disease in humans. Two examples of bloodborne pathogens include, (HIV) and (HBV).

Contaminated - Means the presence or the reasonably anticipated presence of blood or other potentially infectious materials on an item or surface.

Decontamination - Physically or chemically removing, inactivating, or destroying bloodborne pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles, so that the surface or item is rendered safe for handling, use, or disposal.

Exposure Incident - A specific eye, mouth, other mucous membrane, non-intact skin, or parenteral contact with blood or other potentially infectious materials that result from the performance of an employee's duties.

Occupational Exposure - Reasonably anticipated skin, eye, mouth, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of

an employee's duties.

Other Potentially Infectious Materials - Includes the following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids; any unfixed tissue or organ (other than intact skin) from a human; and HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

Parenteral - Piercing of the mucous membranes or the skin barrier through such events as human bites, cuts, and abrasions.

Regulated Waste - OSHA defines a regulated waste as a liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or other potentially infectious materials in a liquid state if compressed; items caked with dried blood or other potentially infectious materials that are capable of release of these materials during handling; contaminated sharps; and pathological and microbiological wastes containing blood or other potentially infectious materials.

2.0 SCOPE

Baker personnel who may be exposed to blood or other potentially infectious materials as part of their job duties (e.g., those certified in Standard First Aid) are required to follow the guidelines set forth in this procedure. The exposure control plan will be reviewed and updated at least annually, to reflect new or modified tasks and procedures that affect occupational exposure, and to reflect new or revised employee positions with occupational exposure.

3.0 RESPONSIBILITY

This program includes the responsibilities of the Baker Health and Safety Coordinator, Project Manager, Site Manager, Site Health and Safety Officer, and employees. The responsibilities of these individuals are presented in the Responsibilities section of this manual. In addition to the standard responsibilities for these individuals, there are requirements specific to this program and are outlined below.

3.1 Health and Safety Coordinator

The HSC is also responsible for performing the activities outlined in the Baker Incident Reporting and Investigation Program.

3.2 Project Manager/Site Manager

The delegated responsibilities of the Project Manager to the Site Manager include:

- Determining if an exposure incident occurs

- Notifying EMR and setting-up a post-evaluation appointment
- Completing the Baker Incident Investigation Form
- Notifying the Project Manager and the HSM or HSC if an exposure incident occurs

4.0 PROCEDURES FOR EXPOSURE TO BLOODBORNE PATHOGENS

The sections below will discuss the means by which Baker personnel can determine exposure potential, modes of transmission, methods of compliance, medical monitoring, and post exposure procedures.

4.1 Exposure Determination

The exposure determination is based upon the job classifications with occupational exposure potential, and the activities in which these exposures can occur, as follows.

Job Classifications

- Site Manager/Site Safety and Health Officer
- Environmental Scientists
- Geologists
- Other Baker Field Personnel

Exposure Activities

- Response to first-aid, injury, and/or illness incidents involving site personnel
- Decontamination of personnel, personal protective equipment, work surfaces, and equipment potentially exposed to blood or other potentially infectious materials

4.2 Modes of Virus Transmission in the Workplace

Modes of virus transmission are similar for the viruses of concern. Primarily, virus transmission occurs as the result of direct blood contact from contact with an open wound, non-intact skin (e.g., chapped, abraded, or dermatitis), or mucous membranes to blood, blood-contaminated body fluids, or concentrated virus. Protective measures for workers will focus on preventing exposure to blood and other body fluids that can result from an injury or sudden illness.

4.3 Methods of Compliance

4.3.1 Universal Precautions

The unpredictable and emergent nature of exposures likely to be encountered on a site may make identification between hazardous body fluids and those that are not hazardous difficult. Thus, all

employees will observe "Universal Precautions" to prevent contact with blood or other potentially infectious materials. These "Universal Precautions" stress that all blood or other potentially infectious materials will be treated as if they are infectious.
The universal precautions will include:

(1) Cover the skin, especially open cuts, scrapes, skin rashes, or other broken skin.

(2) Don't touch objects that could be contaminated, such as blood-covered surfaces, clothing or linens.

(3) Cover mucous membranes (i.e., mouth, nose, and eyes).

(4) Clean and decontaminate surfaces, containers, and equipment that may have been exposed to blood or other body fluids.

4.3.2 Standard Work Practices

Standard work practices are to be implemented at all times by all employees who may be exposed to blood or other potentially infectious materials. Work practices are defined as specific policies or procedures whose purpose is to reduce the potential for employee exposure to bloodborne pathogens. Work practices for use by site personnel are described in the balance of this section.

Personal Hygiene

All exposed employees will observe the following hygienic practices:

- During or immediately after exposure to blood or other potentially infectious materials: do not eat, drink, chew gum, chew tobacco, smoke, apply cosmetics, balms or medications, or any other activity that increases the potential for hand-to-mouth, mucous membrane, or skin contact.

- Following exposure to blood or other potentially infectious materials, personnel will wash their hands and any other exposed skin with a disinfectant soap and water after removal of chemical-protective gloves or other personal protective equipment (PPE). This will be performed before eating, urinating, defecating, applying makeup, smoking or undertaking any activity that may result in increased potential for hand to mouth, mucous membrane, or skin contact.

Personal Protective Equipment

Appropriate PPE protects site personnel from exposure to blood and other potentially infectious materials. Appropriate PPE will be made available to all site personnel.

The PPE will be present in the site trailer and field vehicles. The PPE should be used in accordance with the level of exposure encountered. Minor lacerations or small amounts of blood do not merit the same extent of PPE use as required for massive arterial bleeding. Management of the patient who is not bleeding, and has no bloody body fluids, should not routinely require the use of PPE.

The following PPE will be present in each Baker Field Vehicle and/or the Baker Site Trailer:

1. Disposable chemical-protective gloves (such as, nitrile or latex)
2. Resuscitation equipment*
3. Safety glasses or goggles

* Resuscitation Equipment - Because the risk of salivary transmission of infectious disease during artificial ventilation of trauma victims, pocket mouth-to-mouth resuscitation masks will be present in the first aid kits. The pocket mouth-to-mouth resuscitation masks are designed to isolate response personnel from contact with the victims' blood and blood-contaminated saliva, respiratory secretions, and vomitus.

Decontamination procedures will follow those outlined in each site HASP.

Training and Education

All employees with the potential for occupational exposure will receive initial training on the safe handling of first-aid, injury, or illness incidents during first-aid/CPR Instruction, and subsequently during HASP briefings.

4.4 Medical Monitoring

All Baker personnel will follow the medical monitoring guidelines established by Baker's Board Certified Occupational Health Physician in association with EMR, Inc. Also, refer to Baker's Medical Surveillance Program, located within the Baker Health and Safety Programs and Procedures Manual.

4.5 Post-Exposure Procedures and Follow-Up Management

The following subsections present the procedures to follow when a first-aid, injury, or illness incident occurs involving the presence of blood or other potentially infectious material; specific steps need to be taken to safeguard the health of Baker site personnel.

Incident Report

If there is a reasonable cause to believe that a potential exposure to blood or other potentially infectious material has been experienced, the employee must complete the steps listed below. These steps are required when non-HBV vaccinated first aid responders participate and regardless of whether an actual "exposure incident" occurred.

1. Immediately notify the Site Manager and/or SHSO. The Site Manager and/or SHSO will determine whether an "exposure incident" occurred.

2. Wash area of contamination and remove contaminated clothing to ensure that no further contamination will occur.

3. Assist with the completion of the Baker Incident Report Form.

Baker employees who render first aid where blood or other potentially infectious materials are present must be seen by a designated EMR physician within 24 hours (or as-soon-as-possible) of the incident. The employee must take a copy of the Supervisors Incident Report Form and a copy of OSHA Standard 1910.1030 to the physician. EMR can be notified as follows:

EMR phone number 1-800-229-3674
Baker's EMR Client Service Representative - Marilyn McDonald Brooks ext. 440
or follow recorded message procedure if after hours.

Employees who respond to first aid incidents involving the presence of blood or other potentially infectious materials where the determination was made that an "exposure incident" occurred, have, according to OSHA regulation, at least 90 days following baseline blood level collection to decide if they wish to have their blood tested for HIV.

The confidential medical evaluation and follow-up will include:

1. The circumstances of the exposure.

2. If consent has been obtained, testing of the source individual's blood to determine HIV and/or HBV infectivity. If consent is not obtained, it will be documented in writing.

3. If consent has been obtained, the exposed employee's blood will be tested.

4. Availability of the hepatitis B vaccine and vaccination series.

The occupational health physician will provide the employer with a confidential written opinion that includes verification that the employee has been informed of the results of the evaluation and recommendation for further evaluation or treatment. A copy of this written opinion will be provided within 15 days following the medical evaluation.

5.0 REFERENCES

OSHA Title 29 CFR Part 1910.1030

U.S. Department of Labor, U.S. Department of Health and Human Services. Joint Advisory Notice: protection against occupational exposure to Hepatitis B virus and human immunodeficiency virus. Federal Register 1987; 52:41818-24.

Centers for Disease Control. Update on hepatitis B prevention. MMWR 1987; 36:353-360,366.

Centers for Disease Control. Update: Acquired immunodeficiency syndrome and human immunodeficiency virus infection among health-care workers. MMWR 1988; 37:229-34, 239.

OSHA Instruction CPL 2-2.44, February 13, 1992, Enforcement Procedures for the Occupational Exposure to Bloodborne Pathogens Standard.

Appendix A
BLOODBORNE PATHOGENS TRAINING OUTLINE

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A. Types
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B. Plan availability
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F. Medical monitoring
   1. Baker medical monitoring program
   2. Post exposure evaluation procedures
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      b. HBV and non-HBV vaccinated responders
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BAKER ENVIRONMENTAL, INC.
HEAT STRESS PREVENTION PROGRAM

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HEAT STRESS PREVENTION PROGRAM

1.0 INTRODUCTION

Heat stress is a result of the total heat load exceeding the bodies capacities to maintain normal body functions without excessive strain. In the environmental industry the threat is often accompanied by protective clothing decreasing natural body ventilation. If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physiological reactions can occur, ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal.

2.0 SCOPE

This Heat Stress Prevention Program is designed to protect field site employees through regular monitoring and preventive measures. This program present the minimum limits of implementation requirements and also provides an informative reference to recognize, avoid, and treat various forms of heat stress. This is accomplished through the following provisions:

- Causes and Symptoms
- Prevention
- Avoidance Monitoring
- Caring for Heat-Related Illness

3.0 RESPONSIBILITIES

This section will outline the responsibilities of Baker site employees, Project Managers, and Site Managers/Field Team Leaders in regards to implementing this program.

3.1 Project Manager/Site Manager/Field Team Leader

Project Managers/Site Managers or Field Team Leaders are responsible for the implementation of this Heat Stress Prevention Program for all projects involving site personnel. The individuals will direct site personnel to follow the appropriate procedure provided in the Health and Safety Plan or as determined as necessary based on site and environmental conditions.

3.2 Site Health and Safety Officer (SHSO)

The SHSO is responsible for evaluating work tasks and environmental conditions at a field site during the entire duration of the field program. The SHSO will provide the necessary precautions to implement specific site requirements, determine appropriate measures, discuss with the Site Manager and Field Team Leader or contact the Project Manager for assistance.

3.3 Site Employee

It is the employee's responsibility to take proper preventative precautions to avoid a heat stress situation (such as, adequate fluid intake and appropriate rest cycles, monitoring fellow employees and/or following the avoidance monitoring requirements initiated at a specific site. The employee is also responsible to be aware of heat stress conditions and actions as outlined in the 40-hour Occupational Safety and Health hazardous waste worker training.

4.0 PROCEDURES

A prevention and monitoring action will be implemented for Baker employees when the temperature at a site is above 70°F (21°C). The method used will be determined by the Project Manager with assistance from a Baker health and safety professional and will be included in the site HASP. This method can be evaluated based on monitoring results and adjusted as pertinent.

The following procedures can be used as a guide of heat stress prevention methods. The particular prevention action at a site should be evaluated based on site and environmental conditions in conjunction with work tasks involved.

4.1 Signs, Symptoms, and Conditions

The following heat stress causes and symptoms are provided for buddy monitoring purposes. Site personnel must realize that monitoring the physical condition of fellow personnel in Levels D+ through B protective ensembles will be more difficult.

1. *Heat rash* results from continuous exposure to heat or humid air and chafing clothes. The condition decreases the ability to tolerate heat. Symptoms include a mild red rash.

2. *Heat cramps* are caused by heavy sweating and inadequate fluid intake. Symptoms include muscle spasms and pain in the hands, feet, and abdomen.

3. *Heat exhaustion* occurs when body organs attempt to keep the body cool, due to inadequate fluid intake and personnel not acclimated to the environment. Symptoms include pale, cool, moist skin; heavy sweating; dizziness, headaches, disorientation, abnormal behavior, and vomiting.

4. *Heat stroke* is the most serious form of heat stress. It is a MEDICAL EMERGENCY. Symptoms are red, hot, dry skin; lack of perspiration; nausea; dizziness and confusion; strong, rapid pulse rate; and coma.

The need to seek medical attention and the urgency in seeking medical attention depends on the symptoms and the severity of the symptoms displayed by the affected individual. If *heat stroke* is noted or suspected, medical attention must be sought IMMEDIATELY. Efforts should be taken to cool the body to prevent serious injury or death.

4.2 Caring For Heat-Related Illness

To care for heat-related illness provide the following:

- Remove victim from heat.
- Loosen tight clothing.
- Apply cool, wet cloths to the skin.
- Fan the victim.
- If victim is conscious, give cool water to drink.
- Call for an ambulance or transport to hospital if heat stroke is suspected, victim refuses water, vomits, or starts to lose consciousness.

4.3 Prevention

Because heat stress is a common and potentially serious illnesses at environmental sites, regular monitoring and other preventive measures are vital. Site workers must learn to recognize and treat the various forms of heat stress. The best approach is preventive heat stress management. In general:

- Monitor for signs of heat stress.

- Fluid intake should be increased during rest schedules to prevent dehydration. Drinking cool water (maintained at 50 to 60°F) is satisfactory when light sweating occurs and temperatures are moderate to cool; however, diluted electrolyte solutions (i.e., Gatorade, Sqwincher, or equivalent) must be used in addition to water under one or all of the following conditions: continued or heavy sweating, moderate to high ambient temperatures, or heavy work loads. The intake of coffee during working hours is discouraged.

- Acclimate workers to site work conditions by slowly increasing workloads (i.e., do not begin site work activities with extremely demanding activities).

- Use cooling devices to aid natural body ventilation. These devices, however, add weight and their use should be balanced against worker efficiency. An example of a cooling aid is a cooling vest that can be worn under protective clothing, but not against the skin.

- In extremely hot weather, conduct field activities in the early morning and evening.

- Ensure that adequate shelter is available to protect personnel against heat that can decrease physical efficiency and increase the threat of heat stress. If possible, set up the command post in a shaded area, and encourage breaks in shaded areas.

- In hot weather, rotate shifts of workers wearing impervious clothing.

- Good hygienic standards must be maintained by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult the SHSO.

- Develop a suitable work/rest schedule.

4.4 Avoidance Monitoring

Provisions for monitoring for heat stress will be determined by the SHSO and performed as outlined below. Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored.

4.4.1 Permeable Clothing Monitoring

For workers wearing permeable clothing (e.g., standard cotton or synthetic work clothes), the following is a guideline to prevent heat stress situations:

1. Increased awareness of heat stress symptoms and use buddy system to monitor for signs, symptoms, and conditions outlined in Section 4.1.

2. Fluid intake discipline.

3. Self monitoring of fluid input vs output.

4. Attention to work-rest intervals.

Special Considerations

- Acclimatization – After approximately one to two weeks, workers should be acclimated to their environment.

- Fitness – Physically fit workers will adjust more readily to a change in environment.

- Medication – Some medications can predispose individuals to heat-induced illnesses.

4.4.2 Semipermeable/Impermeable Clothing Monitoring

Baker employees wearing semipermeable or impermeable clothing encapsulating ensembles will be monitored when the temperature in the work area is above 70°F (21°C). The method used will be determined by the Project Manager with assistance from a Baker Health and Safety Professional. This method can be evaluated based on monitoring results and adjusted as appropriate.

Conduct initial monitoring for heat stress at the start of a project. If conditions remain similar and levels are below the criteria described below in heart rate and oral temperature presented below then use one or more of the items described in Section 4.3.1:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.
  - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
  - If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.
- Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
  - If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.
  - If oral temperatures still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.
  - Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

- Body water loss. Measure weight on a scale at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or preferably in underwear only. The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work. The length of work cycle will be governed by the frequency of the required physiological monitoring.

5.0 REFERENCES

1. American Conference of Governmental Hygienists, 1995 - 1996 Threshold Limit Values for Chemical Substances and Physical Agents

2. National Institute for Occupational Safety and Health, Occupational Exposure to Hot Environments, 1986

3. American Red Cross, Community First -Aid and Safety, 1993

BAKER ENVIRONMENTAL, INC.
COLD STRESS PREVENTION PROGRAM

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COLD STRESS

1.0 INTRODUCTION

The potential exists for either frostbite or hypothermia to occur when conducting work activities in an environment where air temperatures may fall below freezing or where wind-chill factors lower air temperatures below freezing. A brief description of the exposure symptoms (for both hypothermia and frostbite) and methods of prevention are listed in the sections below:

2.0 SCOPE

This Cold Stress Prevention Program is designed to protect field site employees through regular monitoring and preventive measures. This program present the minimum limits of implementation requirements and also provides an informative reference to recognize, avoid, and treat various forms of cold stress. This is accomplished through the following provisions:

- Causes and Symptoms
- Prevention
- Avoidance Monitoring
- Caring for Cold-Related Illness

3.0 RESPONSIBILITIES

This program includes the responsibilities of Baker site employees, Project Managers, and Site Managers/Field Team Leaders in regards to implementing this program. The responsibilities of these individuals are presented in the Responsibilities section of this manual.

4.0 CAUSES AND SYMPTOMS

The following cold stress causes and symptoms are provided for buddy monitoring purposes. Site personnel must realize that monitoring the physical condition of fellow personnel in Levels D+ through B protective ensembles will be more difficult.

4.1 Frostbite

Frostbite is a condition in which there is a freezing or partial freezing of some part of the body. Individuals previously exposed to frostbite are more susceptible to contracting it

again. Vasoconstrictors, which include tobacco products and caffeine, constrict blood vessels, and can accelerate frostbite. The three stages of frostbite include: (1) frostnip- the beginnings of frostbite whereby the skin begins to turn white; (2) superficial - similar to frostnip except the skin begins to turn numb; and (3) deep - the affected area is frozen to the bone, cold, numb, and very hard.

4.2 Hypothermia

Hypothermia is a condition in which the body loses heat faster than it is produced. At a body temperature of 95°F, an average man is considered to be hypothermia. Vasodilators, which include alcohol and drugs, allow the body to lose heat faster which can accelerate hypothermia. The five stages of hypothermia include:

(1) shivering
(2) apathy, listlessness, or sleepiness
(3) unconsciousness, glassy stare, slow pulse or slow respiratory rate
(4) freezing of the extremities
(5) death

5.0 PROCEDURES

5.1 Prevention

To prevent conditions from occurring have personnel:

- Dress in a minimum of three layers:

  (1) a skin layer to absorb moisture and keep skin dry
  (2) an insulating layer
  (3) an outer layer of nylon/wind-breaking material or chemical-protective layer

- Avoid touching cold surfaces (especially metal) with bare skin, minimize exposed skin surfaces.

- Keep active, use warm and dry shelter areas during rest cycles; use wind breaks whenever possible.

- Maintain body fluids by consuming warm, sweet, caffeine-free, non-alcoholic drinks.

- Avoid alcohol and medications that interfere with normal body regulation or reduce tolerance to cold.

5.2 Caring for Cold-Related Illness

The need to seek medical attention and the urgency in seeking medical attention depends on the symptoms and the severity of the symptoms displayed by the affected individual. If the latent conditions of hypothermia or frostbite are noted or suspected, medical attention must be sought IMMEDIATELY to prevent permanent injury or death.

The following lists the general guidelines to care for cold-related injuries:

- Start by treating any life-threatening problems.
- Call the local emergency number for help or transport the victim to the nearest hospital.
- Move the victim to a warm place, if possible.
- Remove any wet clothing and dry the victim.
- Warm the victim slowly by wrapping in blankets or putting on dry clothing.

DO NOT:

- Rub the frostbitten part.
- Use ice, snow, or anything cold on the frostbitten area.
- Use heat lamps or hot water bottles to rewarm the frostbitten area.
- Place the frostbitten area near a hot stove.

5.3 Monitoring

In cold weather, monitor the outdoor temperature and wind speed to determine wind chill conditions, with work periods adjusted accordingly. The following table details the wind chill effects and relative danger of combined cold and wind conditions. It is important to note that the wearing of PPE in cold environments may introduce the possibility of heat stress; therefore, symptoms of heat stress should also be considered during monitoring.

WIND CHILL INDEX[1]

Wind Speed	*Actual Thermometer Reading (°F)*									
	50	40	30	20	10	0	-10	-20	-30	-40
(in mph)	*Equivalent Chill Temperature (°F)*									
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-36	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116
Over 40 mph (little added effect)	LITTLE DANGER (for properly clothed person)				INCREASING DANGER (Danger from freezing of exposed flesh)			GREAT DANGER (Danger from freezing of exposed flesh)		

[1] Source: Fundamentals of Industrial Hygiene, Third Edition. Plog, B.A., G. S. Benjamin, M. A. Kerwin, National Safety Council, 1988.

ATTACHMENT B
MATERIAL SAFETY DATA SHEETS

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Section 1. Material Identification

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Acetone (CH_3COCH_3) Description: Derived by the dehydrogenation or oxidation of isopropyl alcohol with a metallic catalyst, the oxidation of cumene, the vapor phase oxidation of butane; and as a by-product of synthetic glycerol production. Used as a solvent for paint, varnish, lacquer, fat, oil, wax, resin, rubber, plastic, and rubber cement; to clean and dry parts of precision equipment; in the manufacture of chemicals (methyl isobutyl ketone, methyl isobutyl carbinol, methyl methacrylate, bisphenol-A, acetic acid (ketene process), mesityl oxide, diacetone alcohol, chloroform, iodoform, bromoform), explosives, aeroplane dopes, rayon, photographic films, isoprene; acetylene gas storage cylinders; in purifying paraffin; in nail polish remover; in the extraction of various principles from animal and plant substances; in hardening and dehydrating tissues; in cellulose acetate (especially as spinning solvent); as a solvent for potassium iodide and permanganate; as a delusterant for cellulose acetate fibers; in the specification testing of vulcanized rubber products.

R 1
I 1
S 1*
K 3
* Slight skin absorption

NFPA
3
1 0
–

HMIS
H 1
F 3
R 0
PPE*
* Sec. 8

Other Designations: CAS No. 67-64-1, AI3-01238, Chevron acetone, dimethylformaldehyde, dimethylketal, dimethyl ketone, β-ketopropane, methyl ketone, propanone, 2-propanone, pyroacetic acid, pyroacetic ether.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Acetone vapor is a dangerous fire and explosion hazard. High vapor concentrations may produce narcosis (unconsciousness). Prolonged or repeated skin contact causes dryness, irritation, and mild dermatitis.

Section 2. Ingredients and Occupational Exposure Limits

Acetone, 99.5% plus 0.5% water

1991 OSHA PELs *
8-hr TWA: 750 ppm (1800 mg/m^3)
15-min STEL: 1000 ppm (2400 mg/m^3)

1990 IDLH Level
20,000 ppm

1990 NIOSH REL
TWA: 250 ppm (590 mg/m^3)

1992-93 ACGIH TLVs
TWA: 750 ppm (1780 mg/m^3)
STEL: 1000 ppm (2380 mg/m^3)

1990 DFG (Germany) MAK
1000 ppm (2400 mg/m^3)
Category IV: Substances eliciting very weak effects (MAK >500 mL/m^3)
Peak: 2000 ppm, 60 min, momentary value†, 3 peaks/shift

1985-86 Toxicity Data ‡
Human, eye: 500 ppm
Human, inhalation, TC_{Lo}: 500 ppm produced olfaction effects, conjunctival irritation, and other changes involving the lungs, thorax, or respiration.
Rat, oral, LD_{50}: 5800 mg/kg altered sleep time and produced tremors.
Mammal, inhalation, TC_{Lo}: 31500 μg/m^3/24 hr administered to pregnant female from the 1st to 13th day of gestation produced effects on fertility (post-implantation mortality).

* In the cellulose acetate fiber industry, enforcement of the OSHA TWA for "doffers" was stayed on 9/5/89 until 9/1/90; the OSHA STEL *does not* apply to that industry.
† Momentary value is a level which the concentration should never exceed.
‡ See NIOSH, *RTECS* (AL3150000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 133.2 °F (56.2 °C) at 760 mm Hg
Freezing Point: -139.6 °F (-95.35 °C)
Vapor Pressure: 180 mm Hg at 68 °F (20 °C), 400 mm Hg at 103.1 °F (39.5 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3, 0.075 lb/ft^3): 1.48 kg/m^3, .093 lb/ft^3
Refractive Index: 1.3588 at 20 °C
Appearance and Odor: Colorless, highly volatile liquid; sweetish odor.
Molecular Weight: 58.08
Specific Gravity: 0.7899 at 20 °C/4 °C
Water Solubility: Soluble
Other Solubilities: Alcohol, benzene, dimethyl formamide, chloroform, ether, and most oils.
Odor Threshold: 47.5 mg/m^3 (low), 1613.9 mg/m^3 (high)*

* Odor thresholds recorded as a range from the lowest to the highest concentration.

Section 4. Fire and Explosion Data

Flash Point: 0 °F (-18 °C), CC	Autoignition Temperature: 869 °F (465 °C)	LEL: 2.6% v/v	UEL: 12.8% v/v

Extinguishing Media: *Do not* extinguish fire unless flow can be stopped. For small fires, use dry chemical, carbon dioxide (CO_2), water spray or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam. Use water in flooding quantities as fog because solid streams may be ineffective. **Unusual Fire or Explosion Hazards:** Acetone is a dangerous fire and explosion hazard; it is a Class IB flammable liquid. Vapors may travel to a source of ignition and flash back, fire-exposed containers may explode, and a vapor explosion hazard may exist indoors, outdoors, or in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. If feasible, remove all fire-exposed containers. Otherwise, apply cooling water to sides of containers until well after fire is extinguished. If the fire becomes uncontrollable or container is exposed to direct flame, consider evacuation of a one-third mile radius. In case of rising sound from venting safety device or any discoloration of tank during fire, withdraw immediately. For massive cargo fires, use unmanned hose holder or monitor nozzles. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Acetone is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Acetone may form explosive mixtures with hydrogen peroxide, acetic acid, nitric acid, nitric acid + sulfuric acid, chromic anhydride, chromyl chloride, nitrosyl chloride, hexachloromelamine, nitrosyl perchlorate, nitryl perchlorate, permonosulfuric acid, thiodiglycol + hydrogen peroxide. Acetone reacts vigorously with oxidizing materials and ignites on contact with activated carbon, chromium trioxide, dioxygen difluoride + carbon dioxide, and potassium-*tert*-butoxide. Other incompatibles include air, bromoform, bromine, chloroform + alkalies, trichloromelamine, and sulfur dichloride. **Conditions to Avoid:** Keep acetone away from plastic eyeglass frames, jewelry, pens, pencils, and rayon garments. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of acetone can produce CO_2 and carbon monoxide (CO).

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list acetone as a carcinogen. **Summary of Risks:** Acetone has been placed among solvents of comparatively low acute and chronic toxicities. In industry, the most common effects reported are headache from prolonged vapor inhalation and skin irritation resulting from its defatting action. Exposures to less than 1000 ppm acetone vapor produces only slight eye, nose, and throat irritation. Acetone does not have sufficient warning properties to prevent repeated exposures. It is narcotic at high concentrations, i.e., above 2000 ppm. Concentrations above 12000 ppm cause loss of consciousness.

Continue on next page

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Section 6. Health Hazard Data,*continued*

Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** Respiratory and central nervous systems, skin. **Primary Entry Routes:** Inhalation, skin and eye contact, ingestion. Liquid acetone is slowly absorbed through the skin. **Acute Effects:** Human systemic effects by inhalation include eye, nose and throat irritation; nausea and vomiting; changes in EEG (electroencephalogram) and carbohydrate metabolism; muscle weakness; drunken behavior; mental confusion and visual disturbance. In extreme cases, breathing high concentrations may produce coma. Human systemic effects by ingestion include gastrointestinal irritation, kidney damage (often indicated by albumin and red and white blood cells in the urine), liver damage (indicated by high levels of urobilin and early appearance of bilirubin), coma, metabolic changes, and systemic effects described for inhalation. Direct eye contact by liquid acetone may produce painful burning and stinging; watering of eyes; conjuctival inflammation; and corneal injury. Skin contact produces a cold feeling, dryness, and mild irritation.
Chronic Effects: Cases of chronic poisoning resulting from prolonged exposure to low concentrations of acetone are rare. Workers exposed to 1000 ppm, 3 hrs per day for 7-15 yrs, complained of dizziness, asthenia (lack or loss of strength), and chronic inflammation of the airways, stomach, and duodenum. Prolonged or repeated skin contact with liquid acetone may defat the skin and cause eczematoid dermatitis.
FIRST AID
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing because it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air, monitor for respiratory distress, and administer 100% humidified supplemental oxygen as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. **After first aid, get appropriate in-plant, paramedic, or community medical support.**
Note to Physicians: In symptomatic patients, monitor serum and urine acetone, fluid intake, blood glucose, and arterial pH. Because of the prolonged elimination half-life of acetone, the symptomatic patient may need medical supervision for many hours (up to 30 hrs). Patients may develop hyperglycemia and ketosis mimicking acute diabetic coma. The hyperglycemia may persist for several days following acute exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against inhalation and skin or eye contact. If feasible and without risk, stop leak. Use water spray to reduce vapor, but it may not prevent ignition in closed spaces. For small spills, take up with sand or other noncombustible absorbent material and using nonsparking tools, place into containers for later disposal. For large spills, dike far ahead of liquid spill for later disposal. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Toxicity:** LC_{50} *Salmo gairdneri* (rainbow trout): 5540 mg/L/ 96 hr at 54 °F (12 °C). LC_{50} (oral) Ring-necked pheasant: >40,000 ppm. **Environmental Degradation:** Acetone biodegrades when released into the environment. The biological oxygen demand for 5 days (BOD5) is 46-55%. **Soil Absorption/Mobility:** Acetone volatilizes, leaches, and biodegrades if released on soil. **Disposal:** Acetone is a good candidate for fluidized bed, rotary kiln incineration, or catalytic oxidation. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): Hazardous Waste No. U002 (Ignitability), (40 CFR 261.31): F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per Clean Water Act, Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For concentrations < 1000 ppm, wear any chemical cartridge respirator with organic vapor cartridge(s) and wear eye protection to avoid irritation or damage. For concentrations <6250 ppm, wear any supplied-air respirator operated in a continuous-flow mode. For concentrations < 12,500 ppm, wear any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. For concentrations < 20,000 ppm, wear any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyethylene/ethylene vinyl alcohol, Teflon, or butyl rubber with breakthrough times > 8 hr is recommended for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry well-ventilated area away from heat, sparks, flames, and other incompatibles. Keep large stocks away from inhabited buildings. Use non-sparking tools to open containers. Keep dry chemical or CO_2 extinguishers on hand in case of fire. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all containers and equipment during fluid transfer. For bulk storage rooms, install electrical equipment, Class I, Group D. **Administrative Controls:** Consider preplacement and periodic medical examinations with emphasis on the skin and respiratory tract. Also consider liver and kidney function tests and urinalysis.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Acetone	**Packaging Authorizations**	**Quantity Limitations**	**Vessel Storage Requirements**
DOT Hazard Class: 3	**a) Exceptions:** 173.150	**a) Passenger, Aircraft, or Railcar:** 5L	**Vessel Stowage:** B
ID No.: UN1090	**b) Non-bulk Packaging:** 173.202	**b) Cargo Aircraft Only:** 60L	**Other:** --
DOT Packaging Group: II	**c) Bulk Packaging:** 173.242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T8			

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 176, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:

Sheet No. 316
Benzene

Issued: 11/78 Revision: E, 8/90

Section 1. Material Identification 32

Benzene (C_6H_6) Description: Derived by fractional distillation of coal tar, hydrodealkylation of toluene or pyrolysis of gasoline, catalytic reforming of petroleum, and transalkylation of toluene by disproportionation reaction. Used as a fuel; a chemical reagent; a solvent for a large number of materials such as paints, plastics, rubber, inks, oils, and fats; in manufacturing phenol, ethylbenzene (for styrene monomer), nitrobenzene (for aniline), dodecylbenzene (for detergents), cyclohexane (for nylon), chlorobenzene, diphenyl, benzene hexachloride, maleic anhydride, benzene-sulfonic acid, artificial leather, linoleum, oil cloth, varnishes, and lacquers; for printing and lithography; in dry cleaning; in adhesives and coatings; for extraction and rectification; as a degreasing agent; in the tire industry; and in shoe factories. Benzene has been banned as an ingredient in products intended for household use and is no longer used in pesticides.
Other Designations: CAS No. 0071-43-2, benzol, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, nitration benzene, phene, phenyl hydride, pyrobenzol.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 4
S 2*
K 4
*Skin absorption

NFPA
3
2 0
-

HMIS
H 3
F 3
R 0
PPG†
† Sec. 8

Cautions: Benzene is a confirmed *human carcinogen* by the IARC. *Chronic low-level exposure may cause cancer (leukemia) and bone marrow damage, with injury to blood-forming tissue.* It is also a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzene, ca 100%*

1989 OSHA PELs
(29 CFR 1910.1000, Table Z-1-A)
8-hr TWA: 1 ppm, 3 mg/m³
15-min STEL: 5 ppm, 15 mg/m³

(29 CFR 1910.1000, Table Z-2)
8-hr TWA: 10 ppm
Acceptable Ceiling Concentration: 25 ppm
Acceptable Maximum Peak: 50 ppm (10 min)†

1989-90 ACGIH
TLV-TWA: 10 ppm, 32 mg/m³

1988 NIOSH RELs
TWA: 0.1 ppm, 0.3 mg/m³
Ceiling: 1 ppm, 3 mg/m³

1985-86 Toxicity Data‡
Man, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted
Man, inhalation, TC_{Lo}: 150 ppm inhaled intermittently over 1 yr in a number of discrete, separate doses affects the blood (other changes) and nutritional and gross metabolism (body temperature increase)
Rabbit, eye: 2 mg administered over 24 hr produces severe irritation

* OSHA 29 CFR 1910.1000, Subpart Z, states that the final benzene standard in 29 CFR 1910.1028 applies to all occupational exposures to benzene except in some subsegments of industry where exposures are consistently under the action level (i.e., distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures); for the excepted subsegments, the benzene limits in Table Z-2 apply.
† Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift.
‡ See NIOSH, *RTECS* (CY1400000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: 42 °F (5.5 °C)
Vapor Pressure: 100 mm Hg at 79 °F (26.1 °C)
Vapor Density (Air = 1): 2.7
Evaporation Rate (Ether = 1): 2.8

Molecular Weight: 78.11
Specific Gravity (15 °C/4 °C): 0.8787
Water Solubility: Slightly (0.180 g/100 g of H_2O at 25 °C)
% Volatile by Volume: 100
Viscosity: 0.6468 mPa at 20 °C

Appearance and Odor: A colorless liquid with a characteristic sweet, aromatic odor. The odor recognition threshold (100% of panel) is approximately 5 ppm (unfatigued) in air. Odor *is not* an adequate warning of hazard.

Section 4. Fire and Explosion Data

Flash Point: 12 °F (-11.1 °C), CC	Autoignition Temperature: 928 °F (498 °C)	LEL: 1.3% v/v	UEL: 7.1% v/v

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to extinguish benzene fires. Water may be ineffective as an extinguishing agent since it can scatter and spread the fire. Use water spray to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.
Unusual Fire or Explosion Hazards: Benzene is a Class 1B flammable liquid. A concentration exceeding 3250 ppm is considered a potential fire explosion hazard. Benzene vapor is heavier than air and can collect in low lying areas or travel to an ignition source and flash back. Explosive and flammable benzene vapor-air mixtures can easily form at room temperature. Eliminate all ignition sources where benzene is used, handled, or stored.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Structural firefighter's protective clothing provides limited protection. Stay out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Runoff to sewer can create pollution, fire, and explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Benzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Benzene explodes on contact with diborane, permanganic acid, bromine pentafluoride, peroxodisulfuric acid, and peroxomonosulfuric acid. It ignites on contact with dioxygen difluoride, dioxygenyl tetrafluoroborate, iodine heptafluoride, and sodium peroxide + water. Benzene forms sensitive, explosive mixture with iodine pentafluoride, ozone, liquid oxygen, silver perchlorate, nitryl perchlorate, nitric acid, and arsenic pentafluoride + potassium methoxide (explodes above 30 °C). A vigorous or incandescent reaction occurs with bromine trifluoride, uranium hexafluoride, and hydrogen + Raney nickel [above 410 °F (210 °C)]. Benzene is incompatible with oxidizing materials.
Conditions to Avoid: Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition of benzene can produce toxic gases and vapors such as carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, OSHA, and IARC list benzene as, respectively, a supected human carcinogen, a cancer hazard, and, based on sufficient human and animal evidence, a human carcinogen (Group 1).
Summary of Risks: Prolonged skin contact or excessive inhalation of benzene vapor may cause headache, weakness, appetite loss, and fatigue. The most important health hazards are cancer (leukemia) and bone marrow damage with injury to blood-forming tissue from chronic low-level exposure. Higher level exposures may irritate the respiratory tract and cause central nervous system (CNS) depression.
Medical Conditions Aggravated by Long-Term Exposure: Exposure may worsen ailments of the heart, lungs, liver, kidneys, blood, and CNS.
Target Organs: Blood, central nervous system, bone marrow, eyes, upper respiratory tract, and skin.
Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Symptoms of acute overexposure include irritation of the eyes, nose, and respiratory tract, breathlessness, euphoria, nausea, drowsiness, headache, dizziness, and intoxication. Severe exposure may lead to convulsions and unconsciousness. Skin contact may cause a drying rash (dermatitis).
Chronic Effects: Long-term chronic exposure may result in many blood disorders ranging from aplastic anemia (an inability to form blood cells) to leukemia.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Immediately rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air. Emergency personnel should protect against inhalation exposure. Provide CPR to support breathing or circulation as necessary. Keep awake and transport to a medical facility.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* since aspiration may be fatal. Call a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Evaluate chronic exposure with a CBC, peripheral smear, and reticulocyte count for signs of myelotoxicity. Follow up any early indicators of leukemia with a bone marrow biopsy. Urinary phenol conjugates may be used for biological monitoring of recent exposure. Acute management is primarily supportive for CNS depression.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a benzene spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation, eye contact, and skin absorption. Absorb as much benzene as possible with an inert, noncombustible material. For large spills, dike far ahead of spill and contain liquid. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of confined spaces such as sewers, watersheds, and waterways because of explosion danger. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U019
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307 (a), 311 (b)(4), 112; and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations at least below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and incompatible materials. *Caution! Benzene vapor may form explosive mixtures in air.* To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. When opening or closing benzene containers, use nonsparking tools. Keep fire extinguishers readily available.
Engineering Controls: Because OSHA specifically regulates benzene (29 CFR 1910.1028), educate workers about its potential hazards and dangers. Minimize all possible exposures to carcinogens. If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if absolutely essential. Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Designate regulated areas of benzene use (see legend in the box below) and label benzene containers with "DANGER, CONTAINS BENZENE, CANCER HAZARD."
Other Precautions: Provide preplacement and periodic medical examinations with emphasis on a history of blood disease or previous exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Benzene (*benzol*)	**IMO Shipping Name:** Benzene
DOT Hazard Class: Flammable liquid	**IMO Hazard Class:** 3.2
ID No.: UN1114	**ID No.:** UN1114
DOT Label: Flammable liquid	**IMO Label:** Flammable liquid
DOT Packaging Exceptions: 173.118	**IMDG Packaging Group:** II
DOT Packaging Requirements: 173.119	

DANGER
BENZENE
CANCER HAZARD
FLAMMABLE–NO SMOKING
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

MSDS Collection **References:** 1, 2, 12, 26, 73, 84-94, 100, 101, 103, 109, 124, 126, 127, 132, 134, 136, 138, 139, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Sheet No. 366
Chlorobenzene

Issued: 11/82 Revision: B, 11/90

Section 1. Material Identification

33

Chlorobenzene (C_6H_5Cl) Description: Produced by chlorinating benzene in the presence of a catalyst. Used in dry cleaning; as a solvent in manufacturing paints, adhesives, polishes, waxes, diisocyanates, natural rubber, and pharmaceuticals; a chemical intermediate for phenol, *o*-, and *p*-chloronitrobenzene, DDT, and aniline; and an intermediate in manufacturing dyestuffs.

Other Designations: CAS No. 0108-90-7, benzene chloride; chlorobenzol; MCB; monochlorobenzene; phenyl chloride.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

Cautions: Chlorobenzene is a skin and mucous membrane irritant, a fairly strong narcotic, and a central nervous system (CNS) depressant. Chronic inhalation may cause *lung, liver, and kidney damage*. This material is a dangerous fire hazard when exposed to heat or flame.

NFPA
R 1
I 3
S 2
K 3

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Chlorobenzene, ca 100%

1989 OSHA PEL
8-hr TWA: 75 ppm, 350 mg/m³

1990-91 ACGIH TLV*
TWA: 75 ppm, 345 mg/m³

1988 NIOSH REL
None established

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 2910 mg/kg; toxic effects not yet reviewed
Rat, inhalation, TC_{Lo}: 210 ppm administered for 6 hr to a 6- to 15-day pregnant female produces specific developmental abnormalities

1987 IDLH Level
2400 ppm

* In its "Notice of Intended Changes (for 1990-91)," the ACGIH lists a proposed lower level TWA for chlorobenzene: 10 ppm, 46 mg/m³.[154]
†See NIOSH, *RTECS* (CZ0175000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 270 °F (132 °C) at 760 mm Hg
Melting Point: -50.1 °F (-45.6 °C)
Vapor Pressure: 11.8 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 3.88
Viscosity: 0.790 centipoise at 70 °F (21 °C)
Molecular Weight: 112.56
Specific Gravity (20 °C/4 °C): 1.1058
Water Solubility: Insoluble

Appearance and Odor: A clear, colorless, volatile liquid with a faint, almond-like odor. Threshold odor concentration: 100% recognition, 0.21 ppm.

Section 4. Fire and Explosion Data

Flash Point: 85 °F (29.5 °C), CC	Autoignition Temperature: 1180 °F (638 °C)	LEL: 1.8% v/v	UEL: 9.6% v/v

Extinguishing Media: Use carbon dioxide, dry chemical, halon, water spray, or standard foam to extinguish fires involving chlorobenzene. Use water in flooding quantities as fog since solid streams of water may spread fire. Apply water spray from as far as possible to cool fire-exposed containers.

Unusual Fire or Explosion Hazards: Chlorobenzene is dangerous when exposed to heat or flame. Vapor may travel to an ignition source and flash back.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Do not extinguish fire unless flow can be stopped. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Chlorobenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Chlorobenzene is incompatible with strong oxidizers; contact may cause fires and explosions. It reacts violently with dimethyl sulfoxide. Silver perchlorate forms a solvated, shock-sensitive salt with chlorobenzene (explosion). Chlorobenzene is potentially explosive with powdered sodium or phosphorus trichloride + sodium.

Conditions to Avoid: Avoid all heat and ignition sources and incompatible materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition products of chlorobenzene can include soot, hydrogen chloride, phosgene, and carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list chlorobenzene as a carcinogen.
Summary of Risks: Chlorobenzene is a fairly strong narcotic and can cause central nervous system (CNS) depression. Overexposure is irritating to the eyes, nasal passages, and upper respiratory tract. It is moderately toxic by inhalation or ingestion and can be absorbed slowly through the skin. Short exposures to liquid may cause skin irritation and defatting, while prolonged or repeated skin contact may result in dermatitis or skin burns. Following absorption of toxic doses, liver and kidney degeneration are also observed. Chlorobenzene may also cause hemolysis.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with skin, liver, kidney, or chronic respiratory disease may be at increased risk from exposure.
Target Organs: Respiratory system, eyes, skin, central nervous system, and liver.
Primary Entry Routes: Inhalation, ingestion, eye and skin contact.
Acute Effects: Symptoms to be expected from acute exposure are headache, eye and upper respiratory tract irritation, dizziness, drowsiness, cyanosis, spastic contractions of extremities, and loss of consciousness, depending on the exposure's concentration and duration. Symptoms of ingestion include pallor, cyanosis, and coma, followed by complete recovery.
Chronic Effects: Frequently repeated contact with chlorobenzene may result in skin burns, eye and upper respiratory tract irritation, headaches, dizziness, somnolence, and dyspeptic disorders (indigestion). Chronic inhalation may result in lung, liver, and kidney damage.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water. Consult a physician immediately. If vomiting occurs, administer more water.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: In a *conscious* patient, attempt to induce vomiting with Syrup of Ipecac. Consider activated charcoal cathartic. Administer charcoal slurry with saline, water, or sorbitol. In an *unconscious* patient, do gastric lavage with suction.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a chlorobenzene spill control and counter measure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and contact with liquid. Take up spilled material with a noncombustible absorbent material and place into containers for disposal. For large spills, dike far ahead of spill to contain. Do not release runoff to sewers or waterways since chlorobenzene is harmful to aquatic life in very low concentrations. Aquatic toxicity: A 20-ppm concentration of chlorobenzene administered to bluegill in fresh water during a 96-hr test period is the median tolerance limit (TLm) at which 50% of the aquatic organisms survive. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U037
CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Use an organic vapor-acid gas respirator where appropriate. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets (polyvinyl alcohol is recommended) to prevent prolonged or repeated skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a well-ventilated, fire-resistant area away from heat and ignition sources and oxidizing agents. Outside or detached storage is preferred. Storage and handling must be suitable for an OSHA Class IC flammable liquid. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and contact with liquid. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide a preplacement questionnaire that emphasizes detecting a history of skin, liver, kidney, or chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Chlorobenzene	**IMO Shipping Name:** Chlorobenzene
DOT Hazard Class: Flammable liquid	**IMO Hazard Class:** 3.3
ID No.: UN1134	**ID No.:** UN1134
DOT Label: Flammable liquid	**IMO Label:** Flammable liquid
DOT Packaging Exceptions: 173.118	**IMDG Packaging Group:** II
DOT Packaging Requirements: 173.119	

MSDS Collection **References:** 38, 73, 84, 85, 89, 100, 101, 103, 124, 126, 131, 132, 133, 136, 138, 139, 140, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

1,2-Dichloroethylene Description: An industrial solvent composed of 60% cis- and 40% trans-isomers. Both isomers, cis and trans, are made by partial chlorination of acetylene. Used as a general solvent for organic materials, lacquers, dye extraction, thermoplastics, organic synthesis, and perfumes. The trans-isomer is more widely used in industry than either the cis-isomer or the mixture. Toxicity also varies between the two isomers.
Other Designations: CAS No. 0540-59-0; $C_2H_2Cl_2$; acetylene dichloride; *cis*-1,2-dichloroethylene; *sym*-dichloroethylene; *trans*-1,2-dichloroethylene, dioform.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 2
S 2
K 1

NFPA

HMIS
H 2
F 3
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dichloroethylene, ca 100%

OSHA PEL
8-hr TWA: 790 mg/m³, 200 ppm

ACGIH TLV, 1989-90
TLV-TWA: 790 mg/m³, 200 ppm

NIOSH REL, 1987
790 mg/m³, 200 ppm

Toxicity Data*
Rat, oral, LD_{50}: 770 mg/kg; toxic effects not yet reviewed
Frog, inhalation, TC_{Lo}: 117 mg/m³ inhaled for 1 hr affects the peripheral nerve and sensation (flaccid paralysis without anesthesia); behavior (excitement); lungs, thorax, or respiration (respiratory depression)

* See NIOSH, *RTECS* (KV9360000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 119 °F/48 °C
Melting Point: -56 to -115 °F/-49 to -82 °C/
Vapor Pressure: 180 to 264 torr at 68 °F/20 °C
Vapor Density (Air = 1): 3.4

Molecular Weight: 96.95 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.27 at 77 °F/25 °C
Water Solubility: Insoluble

Appearance and Odor: A colorless, low-boiling liquid with a pleasant odor.

Section 4. Fire and Explosion Data

Flash Point: 37 °F/2.8 °C, CC	Autoignition Temperature: 860 °F/460 °C	LEL: 5.6% v/v	UEL: 12.8% v/v

Extinguishing Media: Use dry chemical, CO_2, halon, water spray, or standard foam. Water may be ineffective unless used to blanket the fire.
Unusual Fire or Explosion Hazards: This material's vapors are a dangerous fire hazard and moderate explosion hazard when exposed to any heat or ignition source or oxidizer.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Vapors may travel to heat or ignition sources and flash back. Stay upwind and out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: This material is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material is incompatible with alkalies, nitrogen tetraoxide, difluoromethylene, strong oxidizers, and dihypofluorite. When in contact with copper or copper alloys or by reaction with potassium hydroxide, explosive chloroacetylene may be released.
Conditions to Avoid: Addition of hot liquid to cold 1,2-dichloroethylene may cause sudden emission of vapor that could flash back to an ignition source.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,2-dichloroethylene can produce highly toxic fumes of chlorine (Cl^-).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 1,2-dichloroethylene as a carcinogen.
Summary of Risks: 1,2-Dichloroethylene's most important effect is its irritation of the central nervous system (CNS) and narcosis. This material is toxic by inhalation, ingestion, and skin contact. It is also irritating to the eyes. The trans-isomer at 2200 ppm causes nausea, vertigo, and burning of the eyes. The trans-isomer is twice as potent as the cis-isomer. If renal effects occur, they are transient.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Central nervous system, eyes, respiratory system.
Primary Entry Routes: Inhalation, ingestion, skin and eye contact.
Acute Effects: Inhalation of 1,2-dichloroethylene causes narcosis, respiratory tract irritation, nausea, vomiting, tremor, weakness, central nervous depression, and epigastric (the abdomen's upper midregion) cramps. Contact with the liquid causes eye and skin (on prolonged contact) irritation. Ingestion causes slight depression to deep narcosis.
Chronic Effects: None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed. Have trained personnel administer 100% oxygen, preferably with humidification.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Intravenous injections of calcium gluconate may relieve cramps and vomiting. Treat central nervous system effects symptomatically.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a 1,2-dichloroethylene spill control and countermeasure plan (SCCP).* Notify safety personnel, remove all heat and ignition sources, evacuate hazard area, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Absorb small spills on paper towels. After evaporating the 1,2-dichloroethylene from these paper towels in a fume hood, burn the paper in a suitable location away from combustible material. Collect and atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001, per Clean Water Act, Sec. 307(a)]†
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)
† Listed as 1,2-*trans*-dichloroethylene.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. 1,2-dichloroethylene attacks some forms of plastics, rubber, and coatings.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and oxidizing materials. Outside or detached storage is preferred. If stored inside, place containers in a standard flammable liquids storage cabinet or room. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. 1,2-dichloroethylene is a dangerous fire hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement questionnaires which emphasize detecting a history of chronic respiratory disease.
Transportation Data (49 CFR 172.101, .102): Not listed

***MSDS Collection* References:** 7, 26, 38, 73, 84, 85, 87, 88, 100, 101, 103, 109, 126, 127, 136, 137
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD F7

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Section 1. Material Identification

Ethylbenzene ($C_6H_5C_2H_5$) Description: Derived by heating benzene and ethylene in presence of aluminum chloride with subsequent distillation, by fractionation directly from the mixed xylene stream in petroleum refining, or dehydrogenation of naphthenes. Used as a solvent, an antiknock agent in gasoline; and as an intermediate in production of synthetic rubber, styrene, cellulose acetate, diethylbenzene, acetophenone, ethyl anthraquinone, propyl oxide, and α-methylbenzol alcohol.
Other Designations: CAS No. 100-41-4, ethylbenzol, EB, phenylethane, NCI-C56393.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 4
* Skin absorption

NFPA

HMIS
H 2†
F 3
R 0
PPE - Sec. 8
† Chronic effects

Cautions: Ethylbenzene is a skin and mucous membrane irritant considered the most irritating of the benzene series. Inhalation causes acute and chronic central nervous system (CNS) effects. It is highly flammable and forms explosive mixtures with air.

Section 2. Ingredients and Occupational Exposure Limits

Ethylbenzene, ca >99.0%. Impurities include ~ 0.1% *meta & para* xylene, ~ 0.1% cumene, and ~ 0.1% toluene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 125 ppm (545 mg/m^3)
Action Level: 50 ppm (217 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH REL
TWA: 100 ppm (435 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category 1: local irritants
Peak Exposure Limit: 200 ppm, 5 min momentary value, max of 8/shift
Danger of cutaneous absorption

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 100 ppm/8 hr caused eye effects, sleep, and respiratory changes.
Human, lymphocyte: 1 mmol/L induced sister chromatid exchange.
Rat, oral, LD_{50}: 3500 mg/kg; toxic effects not yet reviewed
Rat (female), inhalation, TC_{Lo}: 1000 ppm/7 hr/day, 5 days/wk, for 3 wk prior to mating and daily for 19 days of gestation produced pups with high incidence of extra ribs.[179]

* See NIOSH, *RTECS* (DA0700000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 277 °F (136 °C)
Melting Point: -139 °F (-95 °C)
Surface Tension: 31.5 dyne/cm
Ionization Potential: 8.76 eV
Viscosity: 0.64 cP at 77 °F (25 °C)
Refraction Index: 1.4959 at 68 °F (20 °C)
Relative Evaporation Rate (ether = 1): 0.0106
Bulk Density: 7.21 lb/Gal at 77 °F (25 °C)
Critical Temperature: 651 °F (343.9 °C)
Critical Pressure: 35.6 atm

Molecular Weight: 106.16
Density: 0.863 at 77 °F (25 °C)
Water Solubility: Slightly, 14 mg/100 mL at 59 °F (15 °C)
Other Solubilities: Miscible in alcohol, ether; soluble in carbon tetrachloride, benzene, sulfur dioxide, and many organic solvents; insoluble in ammonia
Odor Threshold: 2.3 ppm
Vapor Pressure: 7.1 mm Hg at 68 °F (20 °C); 10 mmHg at 78.62 °F (25.9 °C); 100 mm Hg 165.38 °F (74.1 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0768 lb/ft^3 or 1.2298 kg/m^3

Appearance and Odor: Colorless, flammable liquid with a pungent odor.

Section 4. Fire and Explosion Data

Flash Point: 64 °F (18 °C) CC	Autoignition Temperature: 810 °F (432 °C)	LEL: 1.0% v/v	UEL: 6.7% v/v

Extinguishing Media: Class 1B Flammable liquid. For small fires, use dry chemical, carbon dioxide, or 'alcohol-resistant' foam. For large fires, us fog or 'alcohol-resistant' foam. Use water only if other agents are unavailable; EB floats on water and may travel to an ignition source and spread fire. **Unusual Fire or Explosion Hazards:** Burning rate = 5.8 mm/min. Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. EB poses a vapor explosion hazard indoors, outdoors, and in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demanc or positive-pressure mode. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw immediately if you hear rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ethylbenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardou polymerization cannot occur.
Chemical Incompatibilities: Reacts vigorously with oxidizers.
Conditions to Avoid: Exposure to heat and oxidizers.
Hazardous Products of Decomposition: Thermal oxidative decomposition of EB can produce acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list EB as a carcinogen. **Summary of Risks:** Occupational exposure to EB alone is rare since it is usually present together with other solvents. EB is irritating to the eyes, skin, and respiratory tract. Vapor inhalation produces varying degrees of CNS effects depending on concentration. The liquid is absorbed through the skin but vapors are not. 56 to 64% of inhaled ethylbenzene is retained and metabolized. Urinary metabolites following exposure to 23 to 85 ppm for 8 hr are mandelic acid (64%), phenylglyoxylic acid (25%), and methylphenylcarbinol/1-phenyl ethanol (5%). Concurrent exposure to xylene and ethylbenzene causes slower excretion of EB metabolites. Based on the rat LD_{50}, one manufacturer gives 3 to 4 oz. as the lethal dose for a 100 lb person.

Continue on next page

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Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Skin and CNS diseases and impaired pulmonary function (especially obstructive airway disease). **Target Organs:** Eyes, respiratory system, skin, CNS, blood. **Primary Entry Routes:** Inhalation, skin and eye contact. **Acute Effects:** Vapor inhalation of 200 ppm caused transient eye irritation; 1000 ppm caused eye irritation with profuse watering (tolerance developed rapidly); 2000 ppm caused severe and immediate eye irritation and watering, nasal irritation, chest constriction, and vertigo; 5000 ppm was intolerable and caused eye and nose irritation. Inhalation of high concentrations may cause narcosis, cramps, and death due to respiratory paralysis. Skin exposed to pure ethylbenzene for 10 to 15 min absorbed 22 to 33 mg/cm^2/hr. Immersion of hand in solutions of 112 & 156 mg/L for 1 hr absorbed 118 & 215.7 µg/cm^2/hr, respectively. **Chronic Effects:** Repeated skin contact may cause dryness, scaling, and fissuring. Workers chronically exposed to > 100 ppm complained of fatigue, sleepiness, headache, and mild irritation of the eyes and respiratory tract. Repeated vapor inhalation may result in blood disorders, particularly leukopenia (abnormally low level of white blood cells) and lymphocytosis.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting! Aspiration of even a small amount of EB in vomitus can cause severe damage since its low viscosity and surface tension will cause it to spread over a large area of the lung tissue.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: BEI = mandelic acid in urine (1.5 g/g of creatinine), sample at end of shift at workweeks end. Since this test is not specific, test for EB in expired air for confirmation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate and ventilate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container. Dike far ahead of large spill for later reclamation or disposal. Report any release >1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, EB partially evaporates into the atmosphere, with a half-life of hrs to wks, and some leaches into groundwater, especially in soil with low organic carbon content. Biodegradation occurs with a half-life of 2 days. Some EB may absorb to sediment or bioconcentrate in fish. Evidence points to slow biodegradation in groundwater. In air, it reacts with photochemically produced hydroxyl radicals with a half-life of hrs to 2 days. Additional amounts may be removed by rain. **Ecotoxicity Values:** Shrimp (*Mysidopsis bahia*), LC_{50} = 87.6 mg/L/96 hr; sheepshead minnow (*Cyprinodon variegatus*) LC_{50} = 275 mg/L/96 hr; fathead minnow (*Pimephales promelas*) LC_{50} = 42.3 mg/L/96 hr in hard water & 48.5 mg/L/96 hr in softwater. **Disposal:** A candidate for rotary kiln incineration at 1508 to 2912°F (820 to 1600°C), liquid injection incineration at 1202 to 2912°F (650 to 1600°C), and fluidized bed incineration at 842 to 1796°F (450 to 980°C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4) & CWA, Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use a powered air-purifying respirator with an appropriate organic vapor cartridge, a supplied-air respirator (SAR), SCBA, or chemical cartridge respirator with appropriate organic vapor cartridge. For < 2000 ppm, use a SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or polyvinylchloride to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from ignition sources and oxidizers. Outside or detatched storage is preferred. If inside, store in a standard flammable liquids cabinet. Containers should have flame-arrester or pressure-vacuum venting. To prevent static sparks, electrically ground and bond all equipment used with ethylbenzene. Install Class 1, Group D electrical equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain levels as low as possible. Purge and ventilate reaction vessels before workers are allowed to enter for maintenance or cleanup. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, skin, blood, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Ethylbenzene
DOT Hazard Class: 3
ID No.: UN1175
DOT Packing Group: II
DOT Label: Flammable liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60 L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: —

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 153, 159, 162, 163, 164, 167, 168, 171, 176, 179
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Methylene Chloride
Chemical Formula: CH_2Cl_2
CAS No.: 75-09-2
Synonyms: DCM, dichloromethane, Freon 30, methylene bichloride, methylene dichloride, NCI-C50102, Solmethine
Derivation: Produced by chlorination of methane.
General Use: Used as a solvent for cellulose acetate, adhesives, food processing, and pharmaceuticals; in degreasing and cleaning fluids, paint and varnish removers, decaffeination of coffee, in propellant mixtures for aerosols; as a blowing agent in foams, dewaxing agent, component of fire extinguishing compound, chemical intermediate, low temperature heat-transfer medium, and as a fumigant. Formerly used as an anesthetic.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Methylene chloride, ca < 100 % vol
Trace Impurities: Stabilizers may be added such as: amines, 4-cresol, hydroquinone, methanol, 2-methyl-2-ene, 1-naphthol, nitromethane + 1,4-dioxane, phenol, resorcinol, and thymol.

OSHA PELs
8-hr TWA: ~~500~~ ppm*
Ceiling: 1000 ppm (2000 ppm 5 min. peak in any 2 hr period)

ACGIH TLV
TWA: 50 ppm (174 mg/m^3)

NIOSH REL
Carcinogen; lowest feasible concentration.

IDLH Level
Ca [5000 ppm]

DFG (Germany) MAK
TWA: 100 ppm (360 mg/m^3)
Category II: Substances with systemic effects
Onset of Effect: < 2 hr
Half-life: 2 hr to shift length

Peak Exposure Limit:
500 ppm, 30 min. average value, 2/shift

*~~Proposed~~ changed to: 25 ppm (TWA); 125 ppm (STEL)

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Methylene chloride is a colorless, volatile liquid with a sweet odor. It is irritating to the eyes, skin, and respiratory tract. At high concentrations it can cause narcosis (unconsciousness). Methylene chloride is metabolized to carbon monoxide in the body which contributes to much of its toxicity. It can form flammable mixtures with air (forming toxic phosgene when burned) and becomes explosive when mixed with oxygen.

Wilson Risk Scale
R 1
I 3
S 2*
K 1
*Skin absorption

HMIS
H 2*
F 1
R 0
*Chronic Effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin and eye contact.
Target Organs: Eyes, skin, central nervous system (CNS), cardiovascular system (CVS), blood.
Acute Effects
Inhalation: Symptoms include headache, giddiness, irritability, nausea, stupor, numbness and tingling of limbs, fatigue, anemia and polymorphonuclear leukocytosis, digestive disturbances, and neurasthenic disorders (emotional and psychic disorders characterized by easy fatigue, lack of motivation, feelings of inadequacy, and psychosomatic symptoms). Many symptoms are attributed to the metabolism of methylene chloride to carbon monoxide in the body. The carbon monoxide forms carboxyhemoglobin in the blood, which unlike hemoglobin, does not have the ability to carry oxygen. This lack of oxygen leads to CNS and CVS problems. However, CNS effects *have* been seen in persons without a significantly elevated blood carbon monoxide level.
Eye: Exposure to vapors produces irritation, tearing, and conjunctivitis. Direct contact with the liquid causes severe pain, but permanent damage does not occur.
Skin: Contact is irritating and can be painful (burns) if confined to skin (i.e. trapped under gloves or clothing). Methylene chloride can be absorbed through the skin to cause systemic effects.
Ingestion: Expected to cause gastrointestinal irritation, nausea, vomiting, and systemic effects (see inhalation).
Carcinogenicity: IARC (Class 2B, possibly carcinogenic to humans with limited human and sufficient animal evidence), NTP (Class 2, reasonably anticipated to be a carcinogen with limited human and sufficient animal evidence), ACGIH (TLV-A2, suspected human carcinogen as agent is carcinogenic in animals at dose levels considered relevant to worker exposure but insufficient epidemiological studies are available to confirm an increased cancer risk), NIOSH (Class X, carcinogen defined without further categorization), EPA (Class B2, sufficient evidence from animal studies and inadequate or no data from epidemiologic studies), and DFG (MAK B, justifiably suspected of having carcinogenic potential).
Medical Conditions Aggravated by Long-Term Exposure: Skin and cardiovascular disorders.

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Chronic Effects: Repeated skin contact can cause dermatitis. Liver disease has been reported. *Case Reports*: 1 yr exposure caused toxic encephalopathy (toxicity of the brain) with audio and visual delusions and hallucinations; 3 yr exposure to 300 to 1000 ppm caused memory loss, intellectual impairment, and balance disturbances.

Other: Methylene chloride will cross the placenta. The estimated lethal dose is 0.5 to 5 mL/kg. Although methylene chloride has a distinct sweetish odor, it is not recognized at levels low enough to protect from overexposure.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, administer 100% humidified, supplemental oxygen and support breathing.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult an ophthalmologist if pain or irritation persist.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with Ipecac syrup. If vomiting does not occur, the decision to perform gastric lavage should be made.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Lethal blood level = 280 mg/L. Biological monitoring: carbon monoxide in expired air (nonsmokers only). Recently, methylene chloride concentrations in urine have been found to correlate well to concentrations in air.

Section 5 - Fire-Fighting Measures

NFPA

Flash Point: Methylene chloride does not have a flash point by standard tests. However, it does form flammable mixtures with air.

Autoignition Temperature: 1033 °F (556 °C)

LFL: 12% v/v

UFL: 19% v/v

LEL: 15.5% (in oxygen)

UEL: 66.4% (in oxygen)

Extinguishing Media: For small fires, use dry chemical or carbon dioxide. For large fires, use water spray, fog, or regular foam.

Unusual Fire or Explosion Hazards: Creates an explosion hazard if allowed to enter a confined space. Container may explode in heat of fire.

Hazardous Combustion Products: Hydrogen chloride, carbon monoxide and phosgene.

Fire-Fighting Instructions: Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel need to protect against inhalation and skin/eye contact.

Small Spills: Take up with earth, sand, vermiculite, or other absorbent, noncombustible material.

Large Spills

Containment: Dike far ahead of spill for later reclamation or disposal. Do not release into sewers or waterways.

Cleanup: Damp mop any residue.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Do not use near ignition sources. Wear appropriate PPE. Do not use plastic or rubber hose for unloading trucks or tank cars unless the materials have been tested and approved for methylene chloride service.

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 10). To minimize decomposition, all storage containers should be galvanized or lined with a phenolic coating. Indoor storage tanks should have vents piped outdoors to prevent vapors from escaping into work areas. Prevent moisture from entering tanks.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Do not use closed circuit rebreathing systems employing soda lime or other carbon dioxide absorber because of formation of toxic compounds capable of producing cranial nerve paralysis. To prevent static sparks, electrically ground and bond all equipment used with and around methylene chloride.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne levels below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, liver, CNS, CVS, and blood. A complete blood count should be performed and carboxyhemoglobin levels should be determined

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periodically. Any level above 5% should prompt investigation of employee and workplace to determine the cause (smokers will already have an increased level of carboxyhemoglobin and are at increased risk). Use less hazardous solvents where possible.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use any SCBA or supplied-air respirator (with auxiliary SCBA) with a full facepiece and operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyvinyl alcohol and Viton laminated with Neoprene are suitable materials for PPE. Natural rubber, synthetic rubbers, and polyvinyl chloride *do not* provide protection against methylene chloride. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove methylene chloride from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using methylene chloride, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance and Odor: Colorless; volatile with a sweet odor.
Odor Threshold: 205 to 307 ppm
Vapor Pressure: 350 mm Hg at 68 °F (20 °C); 440 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3, 0.075 lb/ft^3): 2.256 kg/m^3 or 0.141 lb/ft^3
Formula Weight: 84.9
Specific Gravity (H_2O=1, at 4 °C): 1.33 at 15 °C
Water Solubility: 2%
Octanol/Water Partition Coefficient: log Kow = 1.25
Other Solubilities: Soluble in alcohol, acetone, chloroform, carbon tetrachloride, ether, and dimethylformamide.
Boiling Point: 104 °F (40 °C)
Freezing Point: -142 °F (-97 °C)
Viscosity: 0.430 cP at 68 °F (20 °C)
Refractive Index: 1.4244 at 68 °F (20 °C/D)
Surface Tension: 0.5 to 2.3 g/L (*in oxygen*)
Bulk Density: 11.07 lb/gal at 68 °F (20 °C)
Ionization Potential: 11.32 eV
Critical Temperature: 473 °F (245 °C)
Critical Pressure: 60.9 atm

Section 10 - Stability and Reactivity

Stability: Methylene chloride is stable at room temperature in closed containers under normal storage and handling conditions. Tends to carbonize when vapor contacts steel or metal chlorides at high temperatures 572 to 842 °F (300 to 450 °C).

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Include aluminum, lithium, sodium, aluminum bromide, azides, dimethyl sulfoxide + perchloric acid, N-methyl-N-nitrosourea + potassium hydroxide, sodium-potassium alloy, potassium *t*-butoxide, dinitrogen pentoxide, dinitrogen tetraoxide, nitric acid, and oxidizers. Methylene chloride will attack some forms of plastic, rubber, and coatings. Corrodes iron, some stainless steel, copper, and nickel.

Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.

Hazardous Decomposition Products: Hydrogen chloride, carbon monoxide and phosgene.

Section 11- Toxicological Information

Toxicity Data:*

Eye Effects:
Rabbit, eye: 162 mg caused moderate irritation.
Skin Effects:
Rabbit, skin: 810 mg/24 hr caused severe irritation.
Carcinogenicity:
Rat, inhalation: 3500 ppm/2 yr (intermittently) caused endocrine tumors.
Mutagenicity:
Rat, oral: 1275 mg/kg caused DNA damage.
Human, fibroblast: 5000 ppm/1 hr (continuously) caused DNA inhibition.

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: 500 ppm/1 yr (intermittently) caused altered sleep time, somnolence, and change in heart rate.
Human, inhalation, TC_{Lo}: 500 ppm/8 hr caused euphoria.
Acute Oral Effects:
Human, oral, LD_{Lo}: 357 mg/kg caused somnolence, paresthesia, and convulsions or effect on seizure threshold.
Rat, oral, LD_{50}: 1600 mg/kg
Multiple Dose Toxicity Data:
Rat, inhalation: 8400 ppm/6 hr/13 weeks (intermittently) caused changes in liver weight.

* See NIOSH, *RTECS* (PA8050000), for additional toxicity data.

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Section 12 - Ecological Information

Ecotoxicity: *Pimephales promelas* (fathead minnow), LC_{50} = 193 mg/L/96 hr; *Lepomis macrochirus* (bluegill), LC_{50} = 230 mg/L/24 hr; *Poecilia reticulata* (guppies), LC_{50} = 294 ppm/14 days. Cytotoxic to plants.

Environmental Degradation: In air, methylene chloride degrades by reaction with photochemically-produced hydroxyl radicals (half-life = a few months) but does not undergo *direct* photolysis. Degradation products include carbon monoxide, carbon dioxide, and phosgene. In water, it is removed primarily by evaporation (est. half-life = 3 to 5.6 hr under moderate mixing conditions). Some may biodegrade but it is not expected to adsorb to sediment or bioconcentrate. If released to soil most methylene chloride will rapidly evaporate. Some may leach through soil. Methylene chloride will adsorb to peat moss but not to sand.

Section 13 - Disposal Considerations

Disposal: Pour on sand or earth at a safe distance/location from occupied areas and allow to evaporate (most is transformed to carbon monoxide). A good candidate for liquid injection, rotary kiln, or fluidized bed incineration. Investigate biodegradation: methylene chloride is reported to completely biodegrade under aerobic conditions with sewage seed or activated sludge between 6 hrs. and 7 days. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Dichloromethane
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN1593
Packing Group: III
Label: Keep away from food
Special Provisions (172.102): N36, T13

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: –

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste Number (40 CFR 261.33): U080
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001 and CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 1000 lb (454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 1, 8, 73, 103, 124, 132, 136, 148, 149, 153, 159, 187, 190, 192, 194, 195

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... S Gilson, CIH
Medical Review ..... J Brent, MD, PhD

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Section 1. Material Identification

Perchloroethylene (C_2Cl_4) Description: By chlorination of hydrocarbons and pyrolysis of the carbon tetrachloride that is formed, or by catalytic oxidation of 1,1,2,2-tetrachloroethane. Used in dry cleaning and textile processing, metal degreasing, insulating fluid and cooling gas in electrical transformers, production of adhesives, aerosols, paints, and coatings; as a chemical intermediate, a solvent for various applications, extractant for pharmaceuticals, a pesticide intermediate, and an antihelminthic (parasitic worm removal) agent in veterinary medicine.
Other Designations: CAS No. 127-18-4, Ankilostin, carbon dichloride, Didakene, ethylene tetrachloride, Perchlor, Perclene, Perk, Tetracap, tetrachloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA
0
2 0
-

HMIS
H 2†
F 0
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Cautions: Perchloroethylene is a central nervous system depressant, causes liver and kidney damage (from acute or chronic exposures), and is considered an IARC Class 2B carcinogen (animal sufficient evidence, human inadequate data).

Section 2. Ingredients and Occupational Exposure Limits

Perchloroethylene, < 99%. Impurities include a small amount of amine or phenolic stabilizers.

1991 OSHA PEL
8-hr TWA: 25 ppm (170 mg/m^3)

1990 IDLH Level
500 ppm

1990 NIOSH REL
NIOSH-X Carcinogen
Limit of Quantitation: 0.4 ppm

1992-93 ACGIH TLVs
TWA: 50 ppm (339 mg/m^3)
STEL: 200 ppm (1357 mg/m^3)

1990 DFG (Germany) MAK
TWA: 50 ppm (345 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Man, inhalation, TC_{Lo}: 280 ppm/2 hr caused conjunctival irritation and anesthesia.
Human, lung: 100 mg/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 3005 mg/kg; caused somnolence, tremor, and ataxia.
Rat, inhalation, TC_{Lo}: 200 ppm/6 hr given intermittently over 2 years produced leukemia and testicular tumors.
Rabbit, eye: 162 mg caused mild irritation.
Rabbit, skin: 810 mg/24 hr caused severe irritation.

* See NIOSH, *RTECS* (KX3850000), for additional irritation, mutation, reproductive, tumorigenic, & toxicity data.

Section 3. Physical Data

Boiling Point: 250 °F (121.2 °C)
Freezing Point: -8 °F (-23.35 °C)
Vapor Pressure: 13 mm Hg at 68 °F (20 °C)
Surface Tension: 31.74 dyne/cm at 68 °F (20 °C)
Viscosity: 0.84 cP at 77 °F (25 °C)
Refraction Index: 1.50534 at 68 °F (20 °C)
Molecular Weight: 165.82
Density: 1.6311 at 59 °F (15/4 °C)
Water Solubility: 0.02% at 77 °F (25 °C)
Other Solubilities: Miscible with alcohol, ether, benzene, chloroform, and oils.
Odor Threshold: 47 to 71 ppm (poor warning properties since olfactory fatigue is probable)
Evaporation Rate: 0.15 gal/ft^2/day at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.081 lb/ft^3 or 1.296 kg/m^3
Appearance and Odor: Colorless liquid with an ether-like odor.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	Autoignition Temperature: Nonflammable	LEL: None reported	UEL: None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2). For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and collect in low-lying areas.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Perchloroethylene is stable up to 932 °F (500 °C) in the absence of catalysts, moisture, and oxygen but deteriorates rapidly in warm, moist climates. It is slowly decomposed by light. Amine or phenolic stabilizers are usually added. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Slowly (faster in presence of water) corrodes aluminum, iron, and zinc. It is incompatible with chemically active metals (i.e., barium, beryllium, and lithium (explodes with lithium shavings), strong oxidizers, sodium hydroxide, caustic soda, potash, and nitric acid. Perchloroethylene forms an explosive mixture with dinitrogen tetraoxide and reacts with activated charcoal at 392 °F (200 °C) to yield hexachloroethane and hexachlorobenzene. **Conditions to Avoid:** Contact with moisture and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of perchloroethylene can produce carbon dioxide and toxic chlorine, hydrogen chloride, and phosgene gas (also produced by contact with UV light).

Section 6. Health Hazard Data

Carcinogenicity: Perchloroethylene is listed as a carcinogen by The IARC (Group 2B, animal sufficient evidence, human inadequate data),[164] NTP (Class 2, reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence),[169] NIOSH (Class-X, carcinogen defined with no further explanation),[164] and DFG (MAK-B, justifiably suspected of having carcinogenic potential)[164]. There is some controversy regarding human carcinogenicity because even though there is an increased number of cancers of the skin, colon, lung, urogenital tract, and lympho-sarcomas; the dry cleaning workers studied were also exposed to other chemicals. **Summary of Risks:** Perchloroethylene is stored in the fatty tissue and slowly metabolized with the loss of chlorine. The half-life of its urinary metabolite (trichloroacetic acid) is 144 hours. Perchloroethylene exerts the majority of its toxicity on the central nervous system causing symptoms ranging from light-headedness and slight 'inebriation' to unconsciousness. Liver damage is possible after severe acute or minor long-term exposure. It has a synergistic effect with toluene.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Nervous, liver, kidney, or skin disorders. **Target Organs:** Liver, kidney, eyes, upper respiratory tract, skin, and central nervous system. **Primary Entry Routes:** Inhalation and skin and eye contact. **Acute Effects:** Exposure to high levels can cause liver damage which may take several weeks to develop. Vapor exposure can cause slight smarting of the eyes and throat (in high concentrations). In human studies, exposure to 2000 ppm/5 min caused mild CNS depression; 600 ppm/10 min caused numbness around the mouth, dizziness, and incoordination; 100 ppm/7 hr caused mild eye, nose, and throat irritation, flushing of the face and neck, headache, somnolence, and slurred speech. Skin contact may produce dermatitis because of perchloroethylene's defatting action (more common after repeated exposure). Direct eye contact causes tearing and burning but no permanent damage. Ingestion is rare but can cause irritation of the lips, mouth and gastrointestinal tract, irregular heartbeat, nausea & vomiting, diarrhea (possibly blood stained), drowsiness, unconsciousness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Prolonged exposure can cause impaired memory, extremity (hands, feet) weakness, peripheral neuropathies, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine) and kidney damage (oliguric uremia, conjestion and granular swelling).

FIRST AID ***Rescuers must not enter areas with potentially high perchloroethylene levels without a self-contained breathing apparatus.***
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. *Never administer adrenalin!* **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Be sure victim's head is positioned to avoid aspiration of vomitus into the lungs. **Note to Physicians:** Monitor level of consciousness, EEG (abnormalaties may indicate chronic toxicity), blood enzyme levels (for 2 to 3 wk after exposure), EKG, adequacy of respirations & oxygenation, and liver and kidney function. *BEIs:* C_2Cl_4 in expired air (10 ppm), sample prior to last shift of work week; C_2Cl_4 in blood (1 mg/L), sample prior to last shift of work week; trichloroacetic acid in urine (7 mg/L), sample at end of workweek.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources (although noncombustible, it forms toxic vapors from thermal decomposition). For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of spill and await reclamation or disposal. Report any release in excess of 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, perchloroethylene evaporates and some leaches to groundwater. It may absorb slightly to soils with heavy organic matter. Biodegradation may be important in anaerobic soils. In water, it is subject to rapid volatilization with an estimated half-life from <1 day to several weeks. In air, it exists mainly in the vapor-phase and is subject to photooxidation with a half-life of 30 minutes to 2 months. **Ecotoxicity Values:** Guppy (*Poecilia reticulata*), LC_{50} = 18 ppm/7 days; fathead minnow (*Pimephales promelas*), LC_{50} = 18.4 mg/L/96 hr, flow through bioassay. **Disposal:** Consider recovery by distillation. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) or fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U210
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per CWA Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear a faceshield (8 inch minimum) per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a supplied-air respirator or SCBA with a full facepiece operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, Neoprene, or Viton to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from sunlight, and incompatibles. Do not store sludge from vapor degreasers in tightly-sealed containers and keep outside until disposal is arranged. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Check stabilizer levels frequently and ventilation equipment (air velocity, static pressure, air valve) at least every 3 months. Install an air dryer in ventlines to storage tanks to prevent moisture from rusting and weakening the tank and contaminating or discoloring its contents. Purge all tanks before entering for repairs or cleanup. Build a dike around storage tanks capable of containing all the liquid. Ground tanks to prevent static electricity. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver, kidney, and nervous system function, and the skin. Alcoholism may be a predisposing factor.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrachloroethylene
DOT Hazard Class: 6.1
ID No.: UN1897
DOT Packing Group: III
DOT Label: Keep away from food
Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheet

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1,1,2,2-TETRACHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

Material Name: 1,1,2,2-TETRACHLOROETHANE

Description (Origin/Uses): Used as a solvent primarily for cleaning and extraction procedures and as a chemical intermediate in the manufacture of trichloroethylene and tetrachloroethylene; and as an analytic reagent by textile manufacturers in polymer characterization tests.

Other Designations: Acetylene Tetrachloride; *sym*-Tetrachloroethane; $CHCl_2CHCl_2$; CAS No. 0079-34-5

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

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H	2	R	1
F	0	I	4
R	0	S	--
PPG*		K	--

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
1,1,2,2-Tetrachloroethane, CAS No. 0079-34-5	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 1 ppm, 7 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 1 ppm, 7 mg/m³ **Toxicity Data**** Human, Oral, TD_{Lo}: 30 mg/kg Human, Inhalation, TC_{Lo}: 1000 mg/m³ (30 Mins) Rat, Oral, LD_{50}: 800 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS* (KI8575000), for additional data with references to reproductive, tumorigenic, and irritative effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 295 F (146 C)
Melting Point: -47 F (-44 C)
% Volatile by Volume: Ca 100
Vapor Pressure: 6 Torrs at 77 F (25 C)*
Molecular Weight: 168 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.58658 at 77 F (25 C)

Appearance and Odor: A colorless, nonflammable, heavy, mobile liquid; sweetish, suffocating, characteristic chloroform odor. The odor recognition threshold is reported to be less than 3 ppm.

*At 77 F (25 C) the concentration of 1,1,2,2-tetrachloroethane in saturated air is approximately 7900 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2,2-Tetrachloroethane does not burn. Use extinguishing agents that will put out the surrounding fire. **Unusual Fire or Explosion Hazards:** None reported. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the effects of the nearby fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2,2-Tetrachloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Hazardous reactions between 1,1,2,2-tetrachloroethane and 2,4-dinitrophenyl disulfide, nitrogen tetroxide, chemically active metals such as potassium; and strong caustics such as potassium hydroxide, sodium, sodium-potassium alloy, hot iron, aluminum, and zinc in the presence of steam are reported. **Conditions to Avoid:** Prevent exposure to the incompatible chemicals listed above. Contact with water causes appreciable hydrolysis that will degrade and decompose this liquid. **Hazardous Products of Decomposition:** Thermal-oxidative degradation of 1,1,2,2-tetrachloroethane can produce highly toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: NIOSH lists 1,1,2,2-tetrachloroethane as a carcinogen.
Summary of Risks: 1,1,2,2-Tetrachloroethane is absorbed through intact skin in significant amounts; one human fatality has been attributed to this route of exposure. This liquid is considered to be one of the most toxic of the common chlorinated hydrocarbons, particularly with respect to the liver. Severely acute exposure causes depression of the central nervous system (CNS), which can cause death within 12 hours. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, gastrointestinal system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** The initial symptoms of exposure are lacrimation, salivation, and irritation of the nose and throat; continued exposure can lead to nausea, vomiting, and narcosis. Also, low blood pressure and cardiac rhythm abnormalities; respiratory depression; nausea, vomiting, burns of the esophagus, and diarrhea; and anesthesia with dizziness leading to loss of consciousness and coma; plus possible transient liver and kidney changes. **Chronic Effects:** The two sets of manifestations are (1) malaise, drowsiness, decreased appetite, then nausea and retching, a bad taste in the throat, constipation, headache, pale stools, jaundice, and dark urine, as well as mental confusion, stupor, and coma; and (2) hand

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SECTION 6. HEALTH HAZARD INFORMATION, cont.

tremors, sensation of deafness, numbness in hands and feet, a decrease in reflexes, headache, and nausea. FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. Skin. Rinse the affected areas with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. Should this type of exposure occur, give the exposed person 3 glasses of water to drink and induce vomiting, then repeat this procedure. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Workers exposed to this liquid should be evaluated with a full battery of tests for the liver, kidneys, and CNS systems, as well as the blood.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel must be properly clothed and equipped to protect the skin and eyes against any contact with the liquid as well as inhalation of its vapor (see sect. 8). Vacuum the spilled 1,1,2,2-tetrachloroethane and pump it into suitable containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Waste, No. U209
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of this liquid is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with this liquid. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale 1,1,2,2-tetrachloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2,2-tetrachloroethane in closed, airtight containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Provide storage areas with adequate ventilation to prevent concentrations of the vapor from building up beyond the occupational exposure limits cited in section 2.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Tetrachloroethane
DOT Hazard Class: ORM-A
ID No. UN1702
DOT Packaging Requirements: 49 CFR 173.620
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: 1,1,2,2-Tetrachloroethane
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

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Section 1. Material Identification

Toluene ($C_6H_5CH_3$) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.
Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, toluol, Tolu-sol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high centrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA: 3 / 2 / 0 / -

HMIS
H 2- Chronic effects
F 3
R 0
PPE-Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs
8-hr TWA: 100 ppm (375 mg/m^3)
15-min STEL: 150 ppm (560 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH RELs
TWA: 100 ppm (375 mg/m^3)
STEL: 150 ppm (560 mg/m^3)

1992-93 ACGIH TLV (Skin)
TWA: 50 ppm (188 mg/m^3)

1990 DFG (Germany) MAK*
TWA: 100 ppm (380 mg/m^3)
Half-life: 2 hr to end of shift
Category II: Substances with systemic effects
Peak Exposure Limit: 500 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.
Human, oral, LD_{Lo}: 50 mg/kg; toxic effects not yet reviewed
Human, eye: 300 ppm caused irritation.
Rat, oral, LD_{50}: 5000 mg/kg
Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.
†See NIOSH, *RTECS* (XS5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)
Melting Point: -139 °F (-95 °C)
Molecular Weight: 92.15
Density: 0.866 at 68 °F (20/4 °C)
Surface Tension: 29 dyne/cm at 68 °F (20 °C)
Viscosity: 0.59 cP at 68 °F (20 °C)
Refraction Index: 1.4967 at 20 °C/D

Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.
Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0797 lb/ft^3 or 1.2755 kg/m^3
Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC	Autoignition Temperature: 896 °F (480 °C)	LEL: 1.27% v/v	UEL: 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluenes' burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm^2/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to it lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia wit biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contami nants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebra fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluen causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

Continue on next pa

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Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesis, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, transient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and symptoms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend.
FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC_{50} = 17 mg/L/24 hr; shrimp (*Crangonfracis coron*), LC_{50} = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals.
Disposal: Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
[* per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]
Listed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 2000 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class 1, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Toluene
DOT Hazard Class: 3
ID No.: UN1294
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 150
b) Non-bulk Packaging: 202
c) Bulk Packaging: 242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
Vessel Stowage: B
Other: –

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, CIH, MPH; **Medical Review:** AC Darlington, MD, MPH

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 679

1,1,2-TRICHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION 27

Material Name: 1,1,2-TRICHLOROETHANE

Description (Origin/Uses): Prepared by the catalytic chlorination of ethane or ethylene. Used as a solvent for fats, waxes, natural resins, and alkaloids.

Other Designations: ß-Trichloroethane; Ethane Trichloride; Vinyl Trichloride; $CH_2ClCHCl_2$; CAS No. 0079-00-5

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

Genium

HMIS			
H	1	R	1
F	0	I	4
R	0	S	2
PPG*		K	0

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
1,1,2-Trichloroethane, CAS No. 0079-00-5	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 10 ppm, 45 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 10 ppm, 45 mg/m³ **NIOSH REL** Lowest Feasible Level **Toxicity Data**** Rat, Oral, LD_{50}: 580 mg/kg Rat, Inhalation, LC_{Lo}: 500 ppm (8 Hrs)

*This material can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS* (KJ3150000), for additional data with references to irritative, tumorigenic, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 237°F (114°C)
Melting Point: -33°F (-36°C)
% Volatile by Volume: 100
Vapor Pressure: 19 Torrs at 68°F (20°C)

Molecular Weight: 133 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.4416 at 68°F (20°C)

Appearance and Odor: A colorless, nonflammable liquid; sweet, pleasant odor resembling chloroform.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2-Trichloroethane does not burn. Use an extinguishing agent such as "alcohol" foam, water spray, carbon dioxide, or dry chemical to put out the surrounding fire.

Unusual Fire or Explosion Hazards: None reported.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the harmful effects of the surrounding fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2-Trichloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur.

Chemical Incompatibilities: 1,1,2-Trichloroethane can react dangerously with strong caustics such as sodium hydroxide and chemically active metals such as sodium, potassium, powdered magnesium, aluminum, and sodium-potassium alloys.

Conditions to Avoid: Prevent exposure to these incompatible materials.

Hazardous Products of Decomposition: Thermal-oxidative degradation of this liquid can produce toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

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SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: 1,1,2-Trichloroethane is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Inhaling 1,1,2-trichloroethane vapor or absorbing the liquid through the skin depresses the central nervous system (CNS), which can progress to narcosis. Administration of this liquid to experimental animals has produced liver damage (fatty degeneration) and has induced cancer of the liver in mice. 1,1,2-Trichloroethane is 10 to 20 times more toxic than the trichloroethylene congener. **Medical Conditions Aggravated by Long-Term Exposure:** Persons with a history of chronic respiratory, liver, or kidney disease may be at increased risk from exposure to this liquid. Preplacement questionnaires are recommended. **Target Organs:** Skin, eyes, CNS, respiratory system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Irritation of skin, eyes, nose, throat, and mucous membranes; and anesthesia manifested by CNS effects such as headache, dizziness, drowsiness, and incoordination. **Chronic Effects:** Liver and kidney damage and eventually coma and death may occur. Removal from exposure will reverse this progression.
FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel should wear protective clothing and equipment (see sect. 8). Soak up the spilled 1,1,2-trichloroethane onto a suitable absorbent such as vermiculite or sawdust and place it into containers suitable for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).

EPA Designations (40 CFR 302.4)

RCRA Waste, No. U227

CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent skin contact with 1,1,2-trichloroethane. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale 1,1,2-trichloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2-trichloroethane in closed containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Storage facilities must have adequate ventilation because this volatile liquid can evaporate and build up hazardous concentrations in these areas.

Transportation Data (49 CFR 172.101-2): Not Listed

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

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Section 1. Material Identification

Trichloroethylene (C_2HCl_3) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).
Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 2
S 2*
K 3
* Skin absorption

NFPA
2 2 0 -

HMIS
H 2†
F 2
R 0
PPE‡
† Chronic Effects
‡ Sec. 8

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m^3)
15-min STEL: 200 ppm (1080 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
10-hr TWA: 25 ppm (~135 mg/m^3)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m^3)
STEL: 200 ppm (1070 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min average value; 2 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD_{Lo}: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, *RTECS* (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (*not an effective warning*)

Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft^3; 1.2 kg/m^3): 0.0956 lbs/ft^3; 1.53 kg/m^3
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC	Autoignition Temperature: 788 °F (420 °C)	LEL: 8% (25 °C); 12.5% (100 °C)	UEL: 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetraoxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2',3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. **Conditions to Avoid:** Exposure to light, moisture, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO_2) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). **Summary of Risks:** TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

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Section 6. Health Hazard Data, *Continued*

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may inhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be triphasic with half lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 μg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, *sample at end of workweek.* BEI = 4 mg/L (trichloroethanol) in blood, *sample at end of shift at end of the workweek.* These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, LC_{50} = 44,700 μg/L/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 40.7 mg/L/96 hr. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a Log K_{oc} of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (*spent solvent*)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles (cup-type or rubber framed, equipped with impact-resistant glass), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. At any detectable concentration, wear a SCBA with a full facepiece operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made from Viton or Neoprene to prevent skin contact. *Do not* use natural rubber or polyvinyl chloride (PVC). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber) colored glass bottles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene
DOT Hazard Class: 6.1
No.: UN1710
DOT Packing Group: III
DOT Label: Keep Away From Food
DOT Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60L
b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MD

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Section 1. Material Identification

Vinyl Chloride (C_2H_3Cl) Description: Derived from ethylene dichloride and alcoholic potassium, by reaction of acetylene and hydrogen chloride (as gas or liquids), or by oxychlorination where ethylene reacts with hydrochloric acid and oxygen. Inhibitors such as butyl catechol, hydroquinone, or phenol are added to prevent polymerization. Used in the plastics industry for the production of polyvinyl chloride resins, in organic synthesis and formerly as a refrigerant, extraction solvent, and propellant (banned in 1974 because of its carcinogenic activity).

Other Designations: CAS No. 75-01-4, chloroethylene, chloroethene, ethylene monochloride, Trovidur, VC, VCM.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Vinyl chloride is a confirmed human carcinogen. Vapor inhalation leads to central nervous system (CNS) depression. The liquid can cause frostbite. It is a flammable gas at room temperature and polymerizes on exposure to air or sunlight. Avoid exposure to VC through engineering controls and wearing PPE

R	2	NFPA
I	4	
S	4	
K	4	

HMIS
H 3*
F 4
R 2
PPE - Sec. 8
* Chronic effects

Section 2. Ingredients and Occupational Exposure Limits

Vinyl Chloride, ca 98 to 99%. Impurities include water, acetaldehyde, hydrogen chloride, hydrogen peroxide, methyl chloride, butane, 1,3-butadiene, chlorophene, diacetylene, vinyl acetylene, and propine.

1991 OSHA PELs
8-hr TWA: 1 ppm
Ceiling: 5 ppm; OSHA-X

1990 NIOSH REL
NIOSH-X

1992-93 ACGIH TLV
TWA: 5 ppm (13 mg/m^3)
TLV-A1

1990 DFG (Germany) TRK*
Existing Installations: 3 ppm
MAK-A1

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: Intermittent exposure to 200 ppm for 14 yr caused liver tumors.
Man, inhalation, TC_{Lo}: 30 mg/m^3/5 yr caused spermatogenesis.
Human, inhalation, TC: Continuous exposure to 300 mg/m^3 for an undetermined number of weeks caused blood tumors.
Rat, oral, LD_{50}: 500 mg/kg; toxic effects not yet reviewed

* TRK (technical exposure limit) is used in place of MAK when a material is a carcinogen. Unlike an MAK below which no adverse effects are expected, the TRK is a limit set below which adverse effects may still occur. This is based on the theory that 1 molecule of a carcinogenic substance may still produce a tumor. The TRK is set to allow for an acceptable risk (for example, 1 tumor in 1 million persons may be an acceptable risk).
† See NIOSH, *RTECS* (KU9625000), for additional mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 7 °F (-13.9 °C)
Freezing Point: -245 °F (-159.7 °C)
Molecular Weight: 62.5
Specific Gravity: 0.9106 at 68 °F (20 °C)
Ionization Potential: 9.99 eV
Refraction Index: 1.370 at 20 °C/D
Surface Tension: 23.1 dyne/cm at -4 °F (-20 °C)
Odor Threshold: 2000 to 5000 ppm*
Vapor Density (Air = 1): 2.155

Water Solubility: Slightly soluble, 0.1% at 77 °F (25 °C)
Other Solubilities: alcohol, benzene, carbon tetrachloride, ether, hydrocarbon and oils.
Vapor Pressure: 2530 mm Hg at 68 °F (20 °C), 400 mm Hg at -18.4 °F (-28 °C)
Critical Temperature: 304.7 °F (151.5 °C)
Critical Pressure: 56.8 atm
Viscosity: 0.01072 cP at 68 °F (20 °C), *gas*; 0.28 cP at -4 °F (-20 °C), *liquid*
Appearance and Odor: A gas at room temperature. Usually found as a compressed/cooled liquid. The colorless liquid forms a vapor with a pleasant ethereal odor.

*The actual vapor concentration that can be detected by humans has not been adequately determined and varies from one individual to another, from impurities, and probably from exposure duration. The odor threshold is not an accurate warning of exposure.

Section 4. Fire and Explosion Data

Flash Point: -108.4 °F (-78 °C) OC	Autoignition Temperature: 882 °F (472 °C)	LEL: 3.6% v/v	UEL: 33% v/v

Extinguishing Media: For small fires, use dry chemical or carbon dioxide. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Large fires can be practically inextinguishable. Vapors may travel to an ignition source and flash back. VC may polymerize in cylinders or tank cars and explode in heat of fire. Vapors pose an explosion hazard indoors, outdoors, and in sewers. VC decomposes in fire to hydrogen chloride, carbon monoxide, carbon dioxide, and phosgene. Burning rate = 4.3 mm/min. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Stop gas leak if possible. Let tank, tank car, or tank truck burn unless leak can be stopped. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. *Do not* release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Long term exposure to air may result in formation of peroxides which initiates explosive polymerization of the chloride. VC can polymerize on exposure to light or in presence of a catalyst. **Chemical Incompatibilities:** VC can explode on contact with oxide of nitrogen, may liberate hydrogen chloride on exposure to strong alkalies, and is incompatible with copper, oxidizers, aluminum, and peroxides. In the presence of moisture, VC attacks iron and steel. **Conditions to Avoid:** Exposure to sunlight, air, heat, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of vinyl chloride can produce carbon oxides, and chloride gas.

Section 6. Health Hazard Data

Carcinogenicity: Vinyl chloride is listed as a carcinogen by the IARC (Class 1, *sufficient human evidence*),[164] NTP (Class 1, *sufficient human evidence*),[169] NIOSH (Class X, *carcinogen defined without further categorization*),[163] ACGIH (TLV-A1, *confirmed human carcinogen*),[163] DFG (MAK-A1, *capable of inducing malignant tumors in humans*),[163] and OSHA (Class X, *carcinogen defined without further categorization*).[164] Liver tumors (angiosarcomas) are confirmed from VC exposure. Other tumors of the CNS, respiratory system, blood, and lymphatic system have occurred from exposure to the polyvinyl chloride manufacture process but VC itself may not be the causative agent. **Summary of Risks:** Vapor inhalation causes varying degrees of CNS depression with noticeable anesthetic effects at levels of 1% (10,000 ppm). Studies have shown loss of libido and sperm in men exposed to VC and in Russian studies, 77% of exposed women experienced ovarian dysfunction, benign uterine growths, and prolapsed genital organs. However, no teratogenic effects have been seen in offspring of exposed workers.

Continue on next pag

Section 6. Health Hazard Data, *continued*

It appears that metabolism is necessary before many of VC's toxic effects occur. Some vinyl chloride is exhaled unchanged but most is metabolized to chloroacetaldehyde. Skin absorption may occur if liquid is confined on skin but absorbed amount would be small. It is possible that the phenol inhibitor may be absorbed as well. The compressed liquid can cause frostbite. Vapors are severely irritating to the eyes. Chronic exposure can cause cancer and a triad of syndromes known as *vinyl chloride disease*. **Medical Conditions Aggravated by Long-Term Exposure:** Liver, cardiac, pulmonary, and connective tissue disorders. **Target Organs:** Liver, CNS, respiratory and lymphatic systems, bone, and connective tissue of the skin. **Primary Entry Routes:** Inhalation, skin/eye contact. **Acute Effects:** CNS effects include fatigue, headache, vertigo, ataxia, euphoria, visual disturbances, dulling of auditory cues, numbness and tingling in the extremities, narcosis, unconsciousness, and death due to respiratory failure. Respiratory problems include dyspnea, asthma, and pneumonoconiosis. **Chronic Effects:** Repeated exposure has lead to liver cancer; confirmed because of the otherwise rarity of its type (angiosarcoma). Tumors in other organs have occurred in the polyvinyl chloride industry but agents other than VC may be responsible; authorities are still debating this issue. A triad of other effects are associated with VC exposure. Acro-osteolysis is associated with hand cleaning of polymerization vessels and characterized by dissolution of bone in the hands, especially when associated with resorption. Raynaud's Phenomenon is a vascular disorder marked by recurrent spasm of the capillaries and especially those of the fingers and toes on exposure to cold. This is usually accompanied by pain and in severe cases may progress to local gangrene. Sclerodermatous skin changes (affecting the dorsal hands and distal forearms) are seen and described as a slowly progressive disease marked by deposition of fibrous connective tissue in the skin. The skin becomes thickened and raised nodules appear. Arthralgias (pain in one or more joints) and blood changes with decreased platelet number and capillary abnormalities may also occur.
FIRST AID Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. For frostbite, immerse affected area in 107.6 °F (42 °C) water until completely rewarmed. *Do not* use dry heat. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Unlikely! VC is a gas above 7 °F (-14°C). **Note to Physicians:** Endotracheal intubation may be required if significant CNS or respiratory depression occur. Diagnostic test: thiodiglycolic acid in urine (normally < 2 mg/g creatinine).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. If possible without risk, stop gas flow. Shut off ignition sources. Report any release > 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** VC reacts with hydroxyl radicals in the trophosphere with a half-life of 1.2 days. The half-life = a few hr in photochemical smog. Reaction products in the air include chloroacetaldehyde, hydrogen chloride, chloroethylene, epoxide, formaldehyde, formyl chloride, formic acid, and carbon monoxide. In soil, VC rapidly volatilizes. What does not evaporate will be highly mobile and may leach into groundwater. In water, VC is not expected to hydrolyze, bioconcentrate, or absorb to sediment. It will rapidly volatilize with an estimated half-life of 0.805 hr for evaporation from a river 1 meter deep with a current of 3 meter/sec and a wind velocity of 3 meter/sec. In waters containing photosensitizers such as humic acid, photodegradation will be rapid. **Soil Absorption/Mobility:** From an estimated solubility of 2,700 ppm, a Koc of 56 is established for VC which indicates high soil mobility and potential to leach into groundwater. **Disposal:** Dilute any waste compressed liquid to a 1% solution and remove phenol inhibitor as sodium. Pour onto vermiculite, sodium bicarbonate, or a sand & soda ash mixture (90/10). Add slaked lime if fluoride is present. Mix in paper boxes, place in incinerator, cover with scrap wood and paper, and ignite with excelsior train. Another method is to dissolve waste in a flammable solvent and spray in incinerator firebox equipped with an afterburner and alkali scrubber. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U043
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 307 (a); CAA, Sec. 112, & RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. According to NIOSH[148], for any detectable concentration use a SCBA or supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode. See 29 CFR 1910.1017 for detailed OSHA respirator recommendations. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or chlorinated polyethylene to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL's (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate work clothes from street clothes, launder before reuse and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area in clearly labeled containers. Outside or detached storage is preferred. Large amounts should be stored in steel containers under pressure. Keep separate from incompatibles (Sec. 5). Venting, under pressure should be safety relief. At atm, venting should be pressure vacuum. Regularly monitor inhibitor levels. To avoid static sparks, electrically ground and bond all equipment used with VC. Avoid open flames, spark formation and electric discharges around VC. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Install Class 1, Group D electrical equipment. **Administrative Controls:** Inform VC exposed personnel of hazards associated with its use. Preplacement and periodic medical exams of workers exposed above the action level is mandatory under OSHA 29 CFR (1910.1017). Monitor for liver cancer, scleroderma, pneumonitis, clotting abnormalities, and acro-osteolysis.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Vinyl Chloride
DOT Hazard Class: 2.1
ID No.: UN1086
DOT Packing Group: --
DOT Label: Flammable Gas
Special Provisions (172.102): B44

Packaging Authorizations
a) Exceptions: 173.306
b) Non-bulk Packaging: 173.304
c) Bulk Packaging: 173.314 & 173.315

Quantity Limitations
a) Passenger Aircraft or Railcar: Forbidden
b) Cargo Aircraft Only: 150 kg

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171, 174, 175
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:

Sheet No. 318
Xylene *(Mixed Isomers)*

Issued: 11/80 Revision: E, 9/92

Section 1. Material Identification

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Xylene (Mixed Isomers) (C_8H_{10}) Description: The commercial product is a blend of the three isomers [*ortho*-(*o*-), *meta*-(*m*-), *para*-(*p*-)] with the largest proportion being *m*- xylene. Xylene is obtained from coal tar, toluene by transalkylation, and pseudocumene. Used in the manufacture of dyes, resins, paints, varnishes, and other organics; as a general solvent for adhesives, a cleaning agent in microscope technique; as a solvent for Canada balsam microscopy; as a fuel component; in aviation gasoline, protective coatings, sterilizing catgut, hydrogen peroxide, perfumes, insect repellants, pharmaceuticals, and the leather industry; in the production of phthalic anhydride, isophthalic, and terephthalic acids and their dimethyl esters which are used in the manufacture of polyester fibers; and as an indirect food additive as a component of adhesives. Around the home, xylene is found as vehicles in paints, paint removers, degreasing cleaners, lacquers, glues and cements and as solvent/vehicles for pesticides.

Other Designations: CAS No. 1330-20-7 [95-47-6; 108-38-3; 106-42-3 (*o*-, *m*-, *p*-isomers)], dimethylbenzene, methyltoluene, NCI-C55232, Violet 3, xylol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Xylene is an eye, skin, and mucous membrane irritant and may be narcotic in high concentrations. It is a dangerous fire hazard.

R	1
I	2
S	2
K	3

NFPA: 3 / 2 / 0 / –

HMIS
H 2†
F 3
R 0
PPE ‡
† Chronic Effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Xylene (mixed isomers): the commercial product generally contains ~ 40% *m*-xylene; 20% each of *o*-xylene, *p*-xylene, and ethylbenzene; and small quantities of toluene. Unpurified xylene may contain pseudocumene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 150 ppm (655 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH RELs
TWA: 100 ppm (435 mg/m^3)
STEL: 150 ppm (655 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 150 ppm (651 mg/m^3)
BEI (Biological Exposure Index): Methylhippuric acids in urine at end of shift: 1.5 g/g creatinine

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category II: Substances with systemic effects
Half-life: < 2 hr
Peak Exposure: 200 ppm, 30 min, average value, 4 peaks per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 200 ppm produced olfaction effects, conjunctiva irritation, and other changes involving the lungs, thorax, or respiration.
Man, inhalation, LC_{Lo}: 10000 ppm/6 hr; toxic effects not yet reviewed.
Human, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted.
Rat, oral, LD_{50}: 4300 mg/kg; toxic effect not yet reviewed.
Rat, inhalation, LC_{50}: 5000 ppm/4 hr; toxic effects not yet reviewed.

* See NIOSH, *RTECS* (XE2100000), for additional toxicity data.

Section 3. Physical Data

Boiling Point Range: 279 to 284 °F (137 to 140 °C)*
Boiling Point: *ortho:* 291 °F (144 °C); *meta:* 281.8 °F (138.8 °C); *para:* 281.3 °F (138.5 °C)
Freezing Point/Melting Point: *ortho:* -13 °F (-25 °C); *meta:* -53.3 °F (- 47.4 °C); *para:* 55 to 57 °F (13 to 14 °C)
Vapor Pressure: 6.72 mm Hg at 70 °F (21 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.23 kg/m^3, 0.077 lbs/ft^3

Appearance and Odor: Clear, sweet-smelling liquid.

Molecular Weight: 106.16
Specific Gravity: 0.864 at 20 °C/4 °C
Water Solubility: Practically insoluble
Other Solubilities: Miscible with absolute alcohol, ether, and many other organic liquids.
Octanol/Water Partition Coefficient: logKow = 3.12-3.20
Odor Threshold: 1 ppm
Viscosity: <32.6 SUS

* Materials with wider and narrower boiling ranges are commercially available.

Section 4. Fire and Explosion Data

Flash Point: 63 to 77 °F (17 to 25 °C) CC	Autoignition Temperature: 982 °F (527 °C) (*m*-)	LEL: 1.1 (*m*-, *p*-); 0.9 (*o*-)	UEL: 7.0 (*m*-, *p*-); 6.7 (*o*-)

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray or regular foam. For large fires, use water spray, fog or regular foam. Water may be ineffective. Use water spray to cool fire-exposed containers. **Unusual Fire or Explosion Hazards:** Xylene vapors or liquid (which floats on water) may travel to an ignition source and flash back. The heat of fire may cause containers to explode and/or produce irritating or poisonous decomposition products. Xylene may present a vapor explosion hazard indoors, outdoors, or in sewers. Accumulated static electricity may occur from vapor or liquid flow sufficient to cause ignition. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide limited protection. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Stay clear of tank ends. Use unmanned hose holder or monitor nozzles for massive cargo fires. If impossible, withdraw from area and let fire burn. Withdraw immediately in case of any tank discoloration or rising sound from venting safety device. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Xylene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Xylene is easily chlorinated, sulfonated, or nitrated. **Chemical Incompatibilities:** Incompatibilities include strong acids and oxidizers and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin). Xylene attacks some forms of plastics, rubber, and coatings. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of xylene can produce carbon dioxide, carbon monoxide, and various hydrocarbon products.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list xylene as a carcinogen. **Summary of Risks:** Xylene is an eye, mucous membrane, and respiratory tract irritant. Irritation starts at 200 ppm; severe breathing difficulties which may be delayed in onset can occur at high concentrations. It is a central nervous system (CNS) depressant and at high concentrations can cause coma. Kidney and liver damage can occur with xylene exposure. With prolonged or repeated cutaneous exposure, xylene produces a defatting dermatitis. Chronic toxicity is not well defined, but it is less toxic than benzene. Prior to the 1950s, benzene was often found as a contaminant of xylene and the effects attributed to xylene such as blood dyscrasias are questionable. Since the late 1950s, xylenes have been virtually benzene-free and blood dyscrasias have not been associated with xylenes. Chronic exposure to high concentrations of xylene in animal studies have demonstrated milk reversible decrease in red and white cell counts as well as increases in platelet counts.

Continue on next pag

Section 6. Health Hazard Data, *continued*

irregularity was reported in association with workplace exposure to xylene perhaps due to effects on liver metabolism. Xylene crosses the human placenta, but does not appear to be teratogenic under conditions tested to date. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, respiratory, eye, skin, gastrointestinal (GI), liver and kidney disorders. **Target Organs:** CNS, eyes, GI tract, liver, kidneys, and skin. **Primary Entry Routes:** Inhalation, skin absorption (slight), eye contact, ingestion. **Acute Effects:** Inhalation of high xylene concentrations may cause dizziness; nausea, vomiting, and abdominal pain; eye, nose, and throat irritation; respiratory tract irritation leading to pulmonary edema (fluid in lung); drowsiness; and unconsciousness. Direct eye contact can result in conjunctivitis and corneal burns. Ingestion may cause a burning sensation in the oropharynx and stomach and transient CNS depression. **Chronic Effects:** Repeated or prolonged skin contact may cause drying and defatting of the skin leading to dermatitis. Repeated eye exposure to high vapor concentrations may cause reversible eye damage, peripheral and central neuropathy, and liver damage. Other symptoms of chronic exposure include headache, fatigue, irritability, chronic bronchitis, and GI disturbances such as nausea, loss of appetite, and gas.

FIRST AID *Emergency personnel should protect against exposure.* **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing as it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Monitor exposed person for respiratory distress. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, *do not induce vomiting!* If spontaneous vomiting should occur, keep exposed person's head below the hips to prevent aspiration (breathing liquid xylene into the lungs). *Aspiration of a few millimeters of xylene can cause chemical pneumonitis, pulmonary edema, and hemorrhage.* **Note to Physicians:** Hippuric acid or the ether glucuronide of *ortho*-toluic acid may be useful in diagnosis of *meta-*, *para-* and *ortho*-xylene exposure, respectively. Consider gastric lavage if a large quantity of xylene was ingested. Proceed gastric lavage with protection of the airway from aspiration; consider endotracheal intubation with inflated cuff.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate spill area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without undue risk, stop leak. Use appropriate foam to blanket release and suppress vapors. Water spray may reduce vapor, but does not prevent ignition in closed spaces. For small spills, absorb on paper and evaporate in appropriate exhaust hood or absorb with sand or some non-combustible absorbent and place in containers for later disposal. For large spills dike far ahead of liquid to contain. Do not allow xylene to enter a confined space such as sewers or drains. On land, dike to contain or divert to impermeable holding area. Apply water spray to control flammable vapor and remove material with pumps or vacuum equipment. On water, contain material with natural barriers, booms, or weirs; apply universal gelling agent; and use suction hoses to remove spilled material. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** Little bioconcentration is expected. Biological oxygen demand 5 (after 5 days at 20 °C): 0.64 (no stated isomer). **Ecotoxicity values:** LD_{50}, Goldfish, 13 mg/L/24 hr, conditions of bioassay not specified, no specific isomer. **Environmental Degradation:** In the atmosphere, xylenes degrade by reacting with photochemically produced hydroxyl radicals with a half-life ranging from 1-1.7 hr. in the summer to 10-18 hr in winter or a typical loss of 67-86% per day. Xylenes are resistant to hydrolysis. **Soil Absorption/Mobility:** Xylenes have low to moderate adsorption to soil and when spilled on land, will volatilize and leach into groundwater. **Disposal:** As a hydrocarbon, xylene is a good candidate for controlled incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U239, F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4); per RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations >1000 ppm, use any chemical cartridge respirator with organic vapor cartridges; any powered, air-purifying respirator with organic vapor cartridges; any supplied-air respirator; or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.*Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. With breakthrough times > 8 hr, consider polyvinyl alcohol and fluorocarbon rubber (Viton) as materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, tightly closed, containers in a cool, well-ventilated place, away from strong oxidizing materials and heat and ignition sources. During transferring operations, electrically ground and bond metal containers. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use hermetically sealed equipment, transfer xylene in enclosed systems, avoid processes associated with open evaporating surfaces, and provide sources of gas release with enclosures and local exhaust ventilation. Use Class I, Group D electrical equipment. **Administrative Controls:** Establish air and biological monitoring programs and evaluate regularly. Consider preplacement and periodic medical examinations including a complete blood count, a routine urinalysis, and liver function tests. Consider hematologic studies if there is any significant contamination of the solvent with benzene. If feasible, consider the replacement of xylene by less toxic solvents such as petrol (motor fuel) or white spirit. Before carrying out maintenance and repair work, steam and flush all equipment to remove any xylene residues.

Transportation Data (49 CFR 172.101)

	Packaging Authorizations	Quantity Limitations	Vessel Stowage Requirements
DOT Shipping Name: Xylenes	a) Exceptions: 173.150	a) Passenger, Aircraft, or Railcar: 5L	a) Vessel Stowage: B
DOT Hazard Class: 3	b) Nonbulk Packaging : 173.202	b) Cargo Aircraft Only: 60L	b) Other: –
ID No.: UN1307	c) Bulk Packaging: 173.242		
DOT Packing Group: II			
DOT Label: Flammable Liquid			
Special Provisions (172.102): T1			

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 176, 180.
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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ATTACHMENT C
EMERGENCY PROCEDURES FOR EXPOSURE TO HAZARDOUS MATERIALS/WASTE

ATTACHMENT C

EMERGENCY PROCEDURES FOR EXPOSURE TO HAZARDOUS MATERIALS / WASTE

1. Call ambulance or transport individual to hospital/clinic immediately. Monitor airway, breathing, and circulation during trip to hospital or while waiting for the ambulance. Administer first aid or CPR, as necessary. Do not forget to take the HASP with you; it contains information on the contaminants expected to be found on site, and will assist the physician in his/her assessment of the exposure.

2. Fill in Potential Exposure Report, answering each of the questions to the best of your ability.

3. Contact our physician(s) at Continuum Healthcare as soon as possible. The procedure is as follows:

   a. **Call Continuum Healthcare at 1-800-229-3674!**

   b. Ask to speak with:

      Dr. David L. Barnes;
      Dr. Elaine Theriault; or
      Ms. T.J. Wolff, R.N.

   Note: During nonbusiness hours (after 6 p.m.) call 1-800-229-3674 and follow directions for paging the aforementioned individuals.

4. Once in contact with any of these individuals, explain what has happened (they will review the information on the form with you and may ask you to fax the form to them, if possible), and allow either of them to speak with the attending physician.

5. When asked about payment (and they will ask), inform the Hospital / Clinic / Physician that this is a "work related injury" and have them contact Louise Woods at (412) 269-2524. Have invoices sent to:

   Michael Baker Jr., Inc.
   Attn: Benefits Coordinator
   Airport Office Park, Building 3
   Coraopolis, PA 15108

6. Contact the Project Manager and the Project Health and Safety Officer as soon as it is feasible, but wait no longer than 24 hours.