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FINAL

WORK PLAN

REMEDIAL DESIGN HADNOT POINT INDUSTRIAL AREA SHALLOW AQUIFER

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0134

Prepared For:

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

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

JANUARY 7, 1993

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DECEMBER 2, 1992

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LIST OF ACRONYMS AND ABBREVIATIONS

A/W	Air to Water
ARAR	Applicable or Relevant and Appropriate Requirements
bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (1980), regulating cleanup of hazardous waste sites. Also known as "Superfund." Amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA)
CLEJ	Camp Lejeune
CLP	Contract Laboratory Program
COC	Chain of Custody
DEHNR	Department of Environmental, Health, and Natural Resources
1,2-DCE	1,2-dichloroethene
EIC	Engineer in Charge
EPA	United States Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
F	Fahrenheit
FS	Feasibility Study
ft/ft	foot per foot
gpm	gallons per minute
HASP	Health and Safety Plan
HPIA	Hadnot Point Industrial Area
IRA	Interim Remedial Action
LANTDIV	Naval Facilities Engineering Command Atlantic Division
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
µg/l	micrograms per liter
mg/l	milligram per liter

NEESA	Naval Energy and Environmental Support Activity
O&G	Oil and Grease
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plans
RCRA	Resource Conservation Recovery Act
RDWP	Remedial Design Work Plan
RFP	Request For Proposal
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SMP	Site Management Plan
STP	Sewage Treatment Plant
TCE	Trichloroethene
TS	Treatability Study
TSS	Total Suspended Solids
TSWP	Treatability Study Work Plan
VOC	Volatile Organic Compound

1.0 INTRODUCTION

The United States Navy, Naval Facilities Engineering Command, Atlantic Division, has directed Baker Environmental, Inc. (Baker) to conduct a treatability study and remedial design for an Interim Remedial Action (IRA) for the shallow aquifer at the Hadnot Point Industrial Area (HPIA) Operable Unit Site at Marine Corps Base Camp Lejeune (CLEJ) in Onslow County, North Carolina. This IRA has been documented in a Draft Final IRA Record of Decision (ROD) for the Site (Baker, August 11, 1992). The Navy/Marine Corps has obtained concurrence from the State of North Carolina and the United States Environmental Protection Agency (U. S. EPA) Region IV on this IRA.

The initial phase of this project requires Baker to develop the following project control documents:

- Remedial Design Work Plan/Treatability Study Work Plan
- Project Management Plan (PMP)
- Sampling and Analysis Plan (SAP)
- Quality Assurance Project Plans (QAPP)
- Health And Safety Plan (HASP)

This document presents the Remedial Design/Treatability Study Work Plan. The other work plans are contained in separate documents which are included in this binder. Each of these plans outline specific activities related to the interim remediation of the HPIA Site.

The intent of all of these documents is to present the scope of work necessary to execute a technically sound, cost effective treatability study and remedial design that satisfies the ROD issued by U.S. EPA.

The level of detail provided in these documents varies according to the current information available on which to base the activities associated with each element. As the project progresses and decisions are made regarding specific details of the remedial design, the work plan elements can be better defined.

The following discussion provides project background, the purpose and objectives of the work plans, and the organization of this document.

1.1 Objectives of the Remedial Design/Treatability Study Work Plan

The objectives of the Remedial Design Work Plan (RDWP) are:

1. Identify and describe the tasks to be performed in order to complete the remedial design for the HPIA site.

2. Identify any anticipated technical problems that may be encountered during the remedial design, and determine appropriate courses of action for these problems.

The project described here, and in the other project control documents, will conform with the requirements of the remedial action in the ROD, according to the appropriate and applicable guidance and regulations of CERCLA, RCRA and other relevant environmental programs, and in accordance with standard engineering practice.

The remedial alternative in the ROD is confined to an interim action designed to address only the shallow aquifer at Site 78 of the HPIA, and is designed to protect human health and the environment from exposure to benzene, trichloroethylene (TCE), 1,2-dichloroethene (1,2-DCE), and various metals in the shallow aquifer.

1.2 Remedial Design Work Plan Format

The RDWP presented in this document addresses the major components of the remedial design, and includes the following elements:

- Section 2: Background and Setting
- Section 3: Treatability Study Work Plan
- Section 4: Aquifer Pump Test
- Section 5: Sewer Line Capacity and Integrity Study
- Section 6: Collection and Treatment System Design

As noted previously, the Project Management Plan (PMP) for this project has been prepared as a separate plan, which is included in this document. The PMP identifies the project organization proposed for completing the tasks identified in the RDWP and the other project control documents.

2.0 BACKGROUND AND SETTING

The following sections provide site background information, nature and extent of contamination, and the type of studies to be conducted. Some of this information is based on that contained in the Interim Remedial Action Feasibility Study for the Shallow Aquifer at the Hadnot Point Industrial Area Operable Unit, Baker Environmental, Inc., April 1992.

2.1 Site Background Information

The information contained in the following sections contains the site location, site description, hydrology, and meteorology, for the HPIA, Marine Corps Base (MCB), Camp Lejeune, North Carolina.

2.1.1 Site Location

Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina (Figure 2-1). The base covers approximately 170 square miles and is bounded to the southeast by the Atlantic Ocean, to the northeast by State Road 24, and to the west by U.S. 17. The town of Jacksonville, North Carolina is north of the base.

The area for this Treatability Study is the shallow aquifer in the area of the HPIA. The HPIA is defined as Site 78 at MCB Camp Lejeune. Site 78, along with Site 21 (Transformer Storage Yard) and Site 24 (Industrial Area Fly Ash Dump), comprise the HPIA Operable Unit at MCB Camp Lejeune. The HPIA is bounded by Sneads Ferry Road to the north, Holcomb Boulevard to the west, Louis Road to the east, and Main Service Road to the south (Figure 2-2). Site 21 is also located within this boundary. Site 24 is located along Louis Road across from Site 78.

2.1.2 Site Description

The HPIA, constructed in the early 1940's was the first facility at MCB Camp Lejeune. It was comprised of approximately 75 buildings and facilities including: maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, storage yards, and a dry cleaning facility. A steam plant and training facility occupy the southwest portion of the HPIA. A transformer storage yard (Site 21) and an industrial area fly ash dump (Site 24) are part of the overall HPIA Operable Unit. These two areas are not included in the scope of this treatability study but will be considered at a later time.

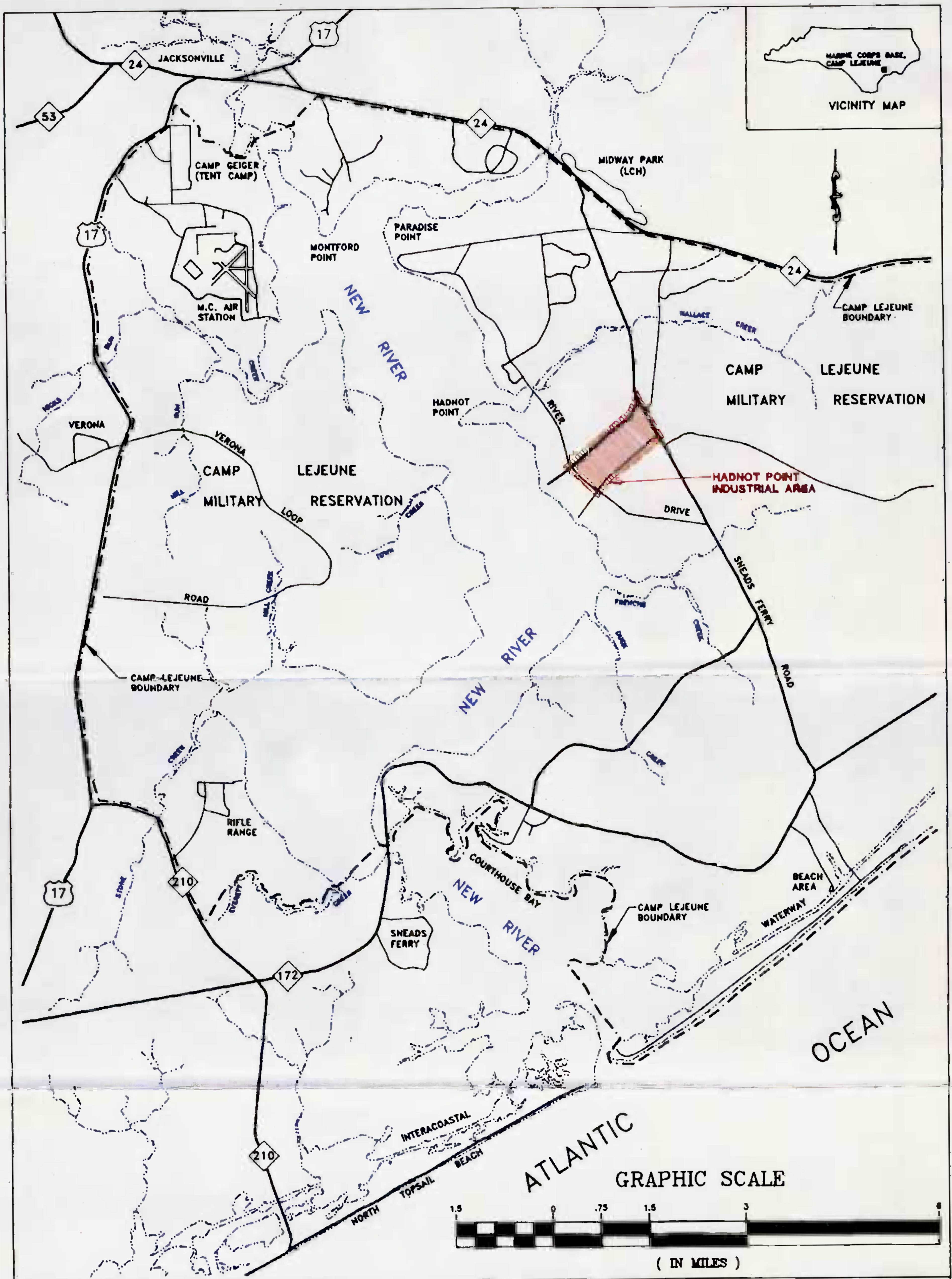
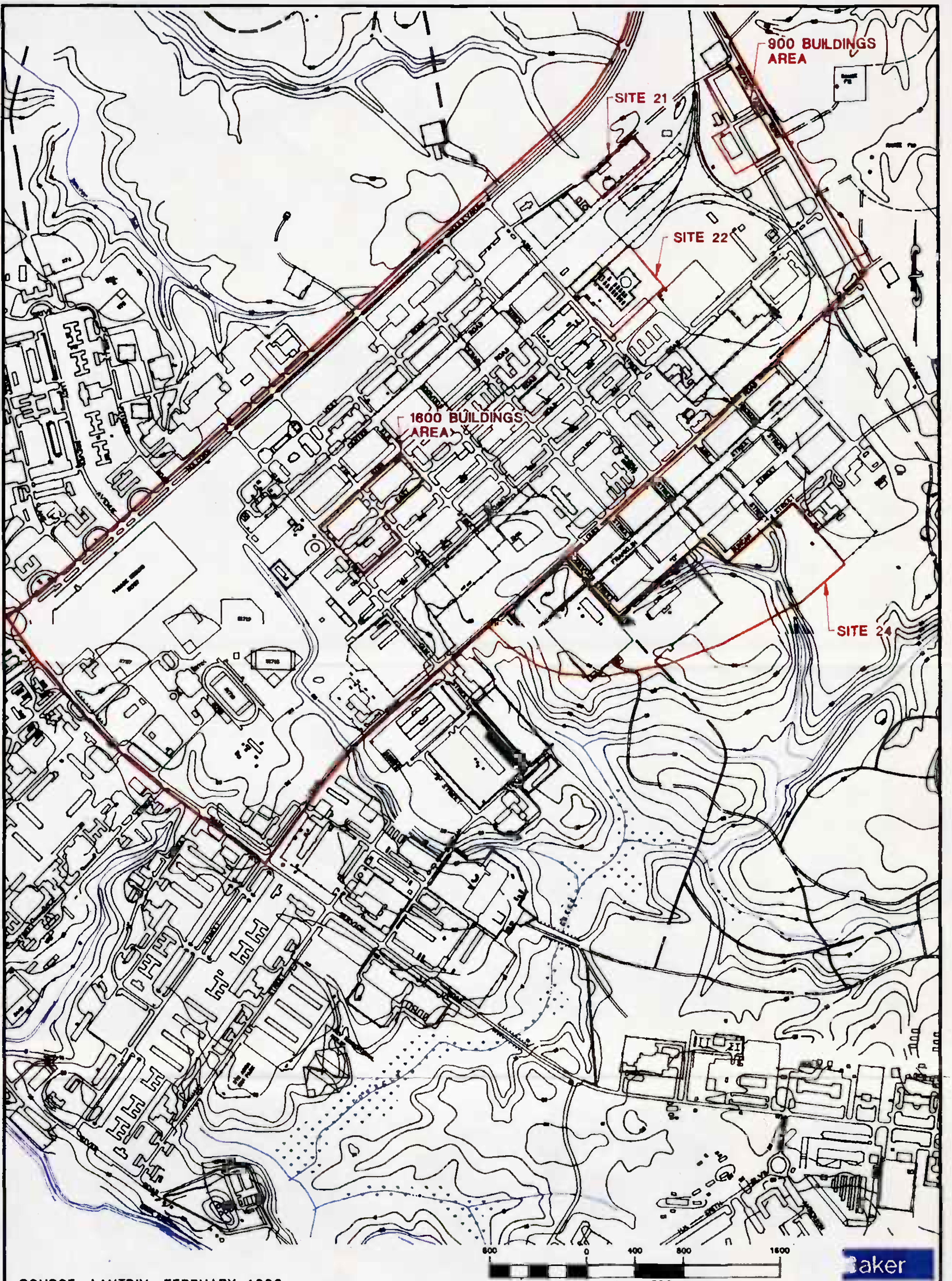


FIGURE 2-1
LOCATION MAP
MCB CAMP LEJEUNE, NORTH CAROLINA



SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-2
SITE MAP
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

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In addition to Sites 21 and 24, a fuel tank farm (Site 22) is located within the HPIA operable unit near the 1000 series buildings. The fuel farm is an underground storage tank site which is not being administered under CERCLA regulations. Therefore, Site 22 is not included as part of the HPIA Operable Unit. A fuel recovery/groundwater treatment option is currently being implemented at the tank farm.

Several areas at the HPIA have been investigated for potential soil and groundwater contamination due to Marine operations and activities resulting in the generation of potentially hazardous wastes. The investigations indicate that contamination has resulted at HPIA due to improper waste disposal, underground storage tank leakage, solvent spills, and sludge disposal.

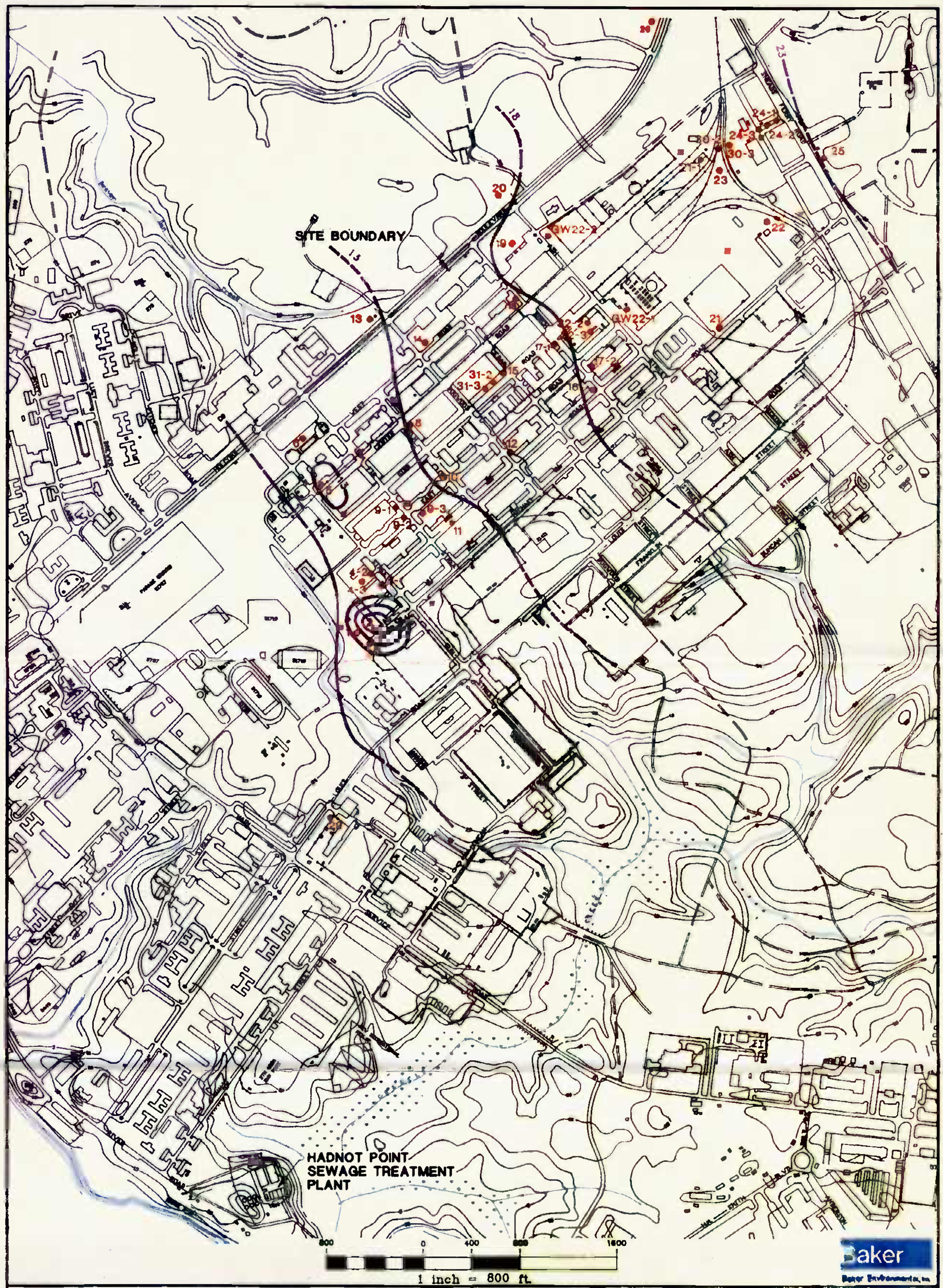
2.1.3 Hydrology

The hydrologic system at Camp Lejeune consists of an unconfined (water table) aquifer and underlying semiconfined aquifers. The unconfined aquifer extends from the water table to the first significant confining layer, approximately 25 feet below land surface (bls).

The water table within HPIA was at an elevation ranging between 8.48 and 25.56 mean sea level during January 1991. The depth to water table ranged from 6.67 to 23.18 feet bls. This variation in water table elevation is due to variations in water recharge throughout the area. This is caused by manmade features (parking lots, buildings, drainage ditches).

Groundwater flow in the shallow aquifer is predominantly to the southwest in the southern portion of HPIA and to the west-southwest in the northern and central portions of the site. There is some groundwater mounding in the southern corner of the site. Generally, the shallow groundwater flows toward the New River. Figure 2-3 presents a potentiometric surface map of the water table aquifer constructed from water level measurements taken in shallow monitoring wells on February 20, 1991 by Environmental Science and Engineering, Inc. (ESE). Water in the lower water bearing zones trends generally in the same direction (southwest) as that in the surficial.

As determined from February 1991 potentiometric surface maps, the horizontal hydraulic gradient in the shallow aquifer is approximately 0.003 feet per foot (ft/ft). The estimated



LEGEND

● EXISTING MONITORING WELL LOCATION

—8 GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INFERRED)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-3
SHALLOW GROUNDWATER ELEVATION
CONTOUR MAP (2-20-91)
HADNOT POINT INDUSTRIAL AREA

MCB CAMP LEJEUNE, NORTH CAROLINA

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gradient for the intermediate and deep zones are approximately 0.0015 ft/ft and 0.0021 ft/ft, respectively.

2.1.4 Meteorology

Camp Lejeune is influenced by mild winters and humid summers with elevated temperatures. Rainfall averages more than 50 inches per year. The winter and summer months are typically the wet seasons. Evapotranspiration varies from 34 to 36 inches of rainfall equivalent per year.

Typical temperatures in January range from 33 to 53 degrees Fahrenheit. Average temperatures in July range from 71 to 88 degrees Fahrenheit. The growing season for the area is approximately 230 days.

Winds are generally from the south-southwest during the warm seasons and from the north-northwest during the cooler seasons.

2.2 Nature and Extent of Contamination

Previous studies indicate that the shallow groundwater is contaminated primarily with fuel related compounds, benzene, 1,2-dichloroethene (1,2-DCE), trichloroethene (TCE), solvents, and metals, such as antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, and nickel. Several compounds were detected at concentrations exceeding the Federal and North Carolina drinking water standards for groundwater.

The most recent shallow groundwater data was collected in January 1991 by ESE. This data is similar to the results of the earlier studies with the exception that the compound concentrations from the January data were generally lower than the concentrations identified in the earlier studies. Based upon the results of the 1991 sampling, the following compounds were identified as potential contaminants of concern for the shallow aquifer at the HPIA: benzene, 1,2-DCE, TCE, antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, and nickel. Table 2-1 presents a summary of the 1991 shallow aquifer groundwater data with respect to the contaminants of concern. Oil & grease data is not included on Table 2-1 due to the fact that this analysis was not conducted on any of the 1991 samples. The maximum concentrations of benzene (7900 µg/l) were detected in a monitoring well immediately adjacent to the fuel tank farm (Site 22). Maximum concentrations of 1,2-DCE

TABLE 2-1

SUMMARY OF CONTAMINANTS OF CONCERN DETECTED IN THE SHALLOW GROUNDWATER AQUIFER, JANUARY 1991

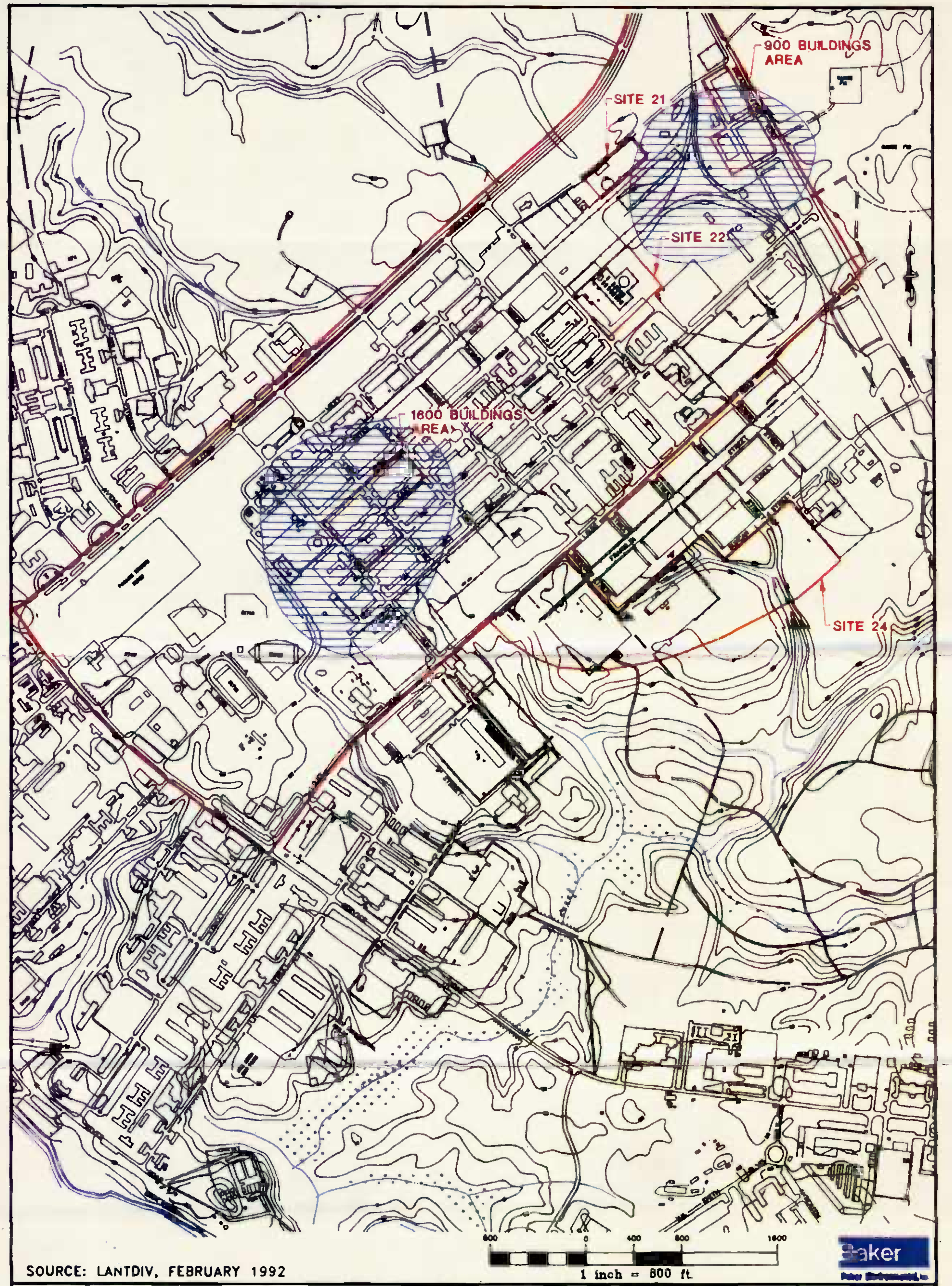
Potential Contaminants of Concern	HPGW1	HPGW2	HPGW3	HPGW4-1	HPGW5	HPGW6	HPGW7	HPGW8	HPGW9-1	HPGW10	HPGW11	HPGW12	HPGW13	HPGW14	HPGW15
VOCs (ug/l):															
Benzene	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <	5 <
1,2-Dichloroethene (1,2,-DCE)	73	10 <	10 <	5 <	5 <	5 <	5 <	5 <	1200	5 <	5 <	5 <	5 <	5 <	7
Trichloroethene (TCE)	91	5 <	5 <	0.9 J	5 <	5 <	5 <	2 J	14000	5 <	5 <	5 <	5 <	5 <	4 J
Inorganics (ug/l):															
Chromium	87	64.3	16.7	187	3.6 B	1590	313	91.8	66.4	310	140	25.5	48.9	127	21.4
Iron	64100	34800	10400	100000	3100	265000	65700	40900	19800	119000	31800	5600	33500	87200	4800
Lead	16.6	29.4	11.4	66.6	13.6	60.7	112	54.1	128	186	45.2	15.7	9	66.5	16.6
Manganese	168	77	53.9	425	162	487	136	46.5	45	255	103	18.3	30.3	80	18.3
Antimony	13.3 <	15.6 B	46.5 B	21.9 B	13.3 <	13.3 <	22 <	22	17.6 B	22 <	22 <	22 <	13.3 <	13.3 <	22 <
Arsenic	8 B	24.1	15.6	15.5	1.5 <	31.5	18.3	28.4	3 B	39.9	9.1 B	1.8 <	47	45.6	1.8 <
Beryllium	6	1.7 BG	1.2 B	6.7	0.86 B	20	4.8 B	2.1	0.79 B	5.6	2.1 <	2.1 <	0.59 B	2.7 B	2.1 <
Mercury	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	1.4	0.25	0.13	0.1 <	0.82	0.1 B	0.1 <	0.1 <	0.26	0.1 <
Nickel	31.3 B	16.9 B	12.1 B	57	5.2 <	161	50.7	25.2	15.1 B	92.2	23.6 B	11 <	21.2 B	41.6	11 <

Potential Contaminants of Concern	HPGW16	HPGW17-1	HPGW18	HPGW19	HPGW20	HPGW21	HPGW22	HPGW23	HPGW24-1	HPGW25	HPGW26	HPGW29	22GW1	22GW2
VOCs (ug/l):														
Benzene	5 <	5 <	N/A	5 <	5 <	5 <	5 <	24	3 J	5 <	5 <	5 <	7900	5 <
1,2-Dichloroethene (1,2,-DCE)	5 <	5 <	N/A	0.8 J	5 <	5 <	5 <	8900	42000 D	5 <	5 <	5 <	5 <	5 <
Trichloroethene (TCE)	5 <	5 <	N/A	2 J	5 <	3 J	5 <	3700	180	5 <	5 <	5 <	5 J	5 <
Inorganics (ug/l):														
Chromium	209	37	N/A	13.8	424	45	79.8	76.3	26.3	205	13	179	457	26.3
Iron	47200	10500	N/A	36200	2E+05	56600	24400	23300	19200	46600	19000	76200	1E+05	16200
Lead	100	23.7	N/A	31.7	20	49.4	39.4	45	21.4	71.6	9	29.1	307	16.2
Manganese	98.3	31.3	N/A	79	217	136	94.1	68.8	54.8	118	10.6 B	236	284	763
Antimony	22 <	22 <	N/A	13.3	21.9 B	13.3 <	24.6 B	24.6 <	22 <	13.3 <	13.3 <	13.3 <	20.9 B	13.3
Arsenic	17.3	1.8 <	N/A	5 B	49.4	12.1	7.2 B	6.6 B	4.2 B	13.2	1.5 <	25.6	50.3	11
Beryllium	5.3	2.1 <	N/A	2.3 B	9.5	3.7 B	0.6 B	1 B	2.1 <	2.8 B	0.5 <	8.7	5.8	0.5
Mercury	0.13 B	0.1 <	N/A	N/A	0.5	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.35	0.1
Nickel	41	11.9 B	N/A	7.3 B	168	30.8 B	23.2 B	33.2 B	14 <	39.2 B	5.2 <	93.5	186	17

Notes: N/A = Not Analyzed
< = Compound was analyzed, but not detected at the listed detection limit
J = Value is estimated
B = Reported value is < contract required detection limit, but > instrument detection limit (IDL)
D = Compound identified in an analysis at a secondary dilutuin factor

(42,000 µg/l) and TCE (14,000 µg/l) were detected in the northeast corner of the site (near the 1600 series buildings) and in the southwestern portion of the site (near the 900 series buildings), respectively. Metals concentrations were elevated throughout most of the site, especially near the fuel farm (lead).

Based on review of existing data, two major areas of contaminated groundwater (source areas) have been identified in the shallow aquifer at HPIA as shown on Figure 2-4. The first area or plume is located northeast of Cedar Street near the 900 series buildings. The other plume is located southwest of Cedar Street near the 1600 series buildings.



SOURCE: LANTDIV, FEBRUARY 1992

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▤ APPROXIMATE SOURCE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER

FIGURE 2-4
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER
HADNOT POINT INDUSTRIAL AREA

MCB CAMP LEJEUNE, NORTH CAROLINA

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3.0 TREATABILITY STUDY

This section presents the Treatability Study Work Plan (TSWP) for conducting bench and pilot-scale studies associated with metals removal, oil/water separation, air stripping, and carbon adsorption. The purpose of this TSWP is to provide performance data to support the design of the on-site treatment systems at the HPIA. The TSWP consists of the following subsections:

3.1 Project Description

Information on the objectives of this project and site characteristics are provided in Sections 1 and 2 of this RDWP. This subsection discusses the scope of planned bench-scale and pilot-scale tests.

Bench-scale testing will be performed to assess the effectiveness of oil/water separation and metals removal for the groundwater at the HPIA. These tests will be performed to verify the technologies' ability to meet expected clean-up goals on a contaminant-specific basis for the HPIA Operable Unit. The objective of the testing will be to estimate contaminant removal efficiencies at different throughput rates.

In addition, a pilot-scale test will be performed to verify the effectiveness of using an air stripper and a liquid phase carbon adsorption unit when compared with the clean-up goals on a contaminant-specific basis for the HPIA Operable Unit. These pilot-scale test results will be used in the design of the groundwater remediation units.

3.2 Remedial Technology Description

A description of the liquid treatment processes to be evaluated in the bench-scale and pilot-scale tests is presented in this subsection.

3.2.1 Bench-Scale

Bench-scale testing shall be designed to simulate the following processes:

- Oil/water separation will be used as pretreatment to remove free oil through gravity separation.
- Metals Removal will be used to remove inorganics from the groundwater. The metals removal processes may include flocculation, precipitation, and sedimentation:
    - Flocculation is the process by which very small, unsettleable particles suspended in a liquid medium collide and agglomerate into larger heavier particles or flocs and settle out.
    - Precipitation is the process in which materials in solution are transferred into a solid phase for removal.
    - Sedimentation is the process used to remove suspended solids from aqueous waste streams by gravity separation.

3.2.2 Pilot-Scale

Pilot-Scale testing will consist of the following processes:

- Air Stripping is a physical treatment process in which water and air are brought into contact with each other for the purpose of transferring volatile substances from solution in a liquid to solution in a gas.
- Carbon Adsorption is a physical process that binds organic molecules to the surface of the activated carbon particles. Activated carbon has an enormous surface area. One gram of commercially activated carbon is estimated to have a surface area of 1,000 to

1,400 square meters. The process involves contacting a waste stream with carbon, usually by flow through a series of packed-bed reactors.

3.3 Test Objectives

The Feasibility Study (FS) for the HPIA Operable Unit provided remedy screening of potential technologies for the treatment of the contaminants of concern. This treatability study will provide remedy selection testing to evaluate the remedial technologies' performance in meeting the site-specific clean-up goals for the HPIA Operable Unit. The cleanup goals include Federal and North Carolina Groundwater MCLs, as shown on Table 3-1. These goals have been defined by the USEPA Region IV and the North Carolina DEHNR. The treatability studies will provide data to support the design of pretreatment components (e.g., metals removal, oil separation) and the air stripping treatment unit. Additionally, the pilot study will provide data to evaluate whether other treatment components (i.e., carbon adsorption) are required as part of the treatment system in order to meet cleanup goals.

3.4 Bench-Scale Testing

This section describes the experiment design and procedures, and equipment and materials necessary for the bench-scale test. A representative sample of groundwater (approximately 70 liters) will be collected from the extraction well during the aquifer pump test for the sample characterization and bench-scale treatability testing. The sample will be split and preserved as required for the oil/water separation and metals removal bench-scale testing. Oil/water separation and metals removal via jar testing will be conducted and the results compared to the Federal Drinking Water Standard Maximum Contaminants Levels (MCLs) and NC Groundwater Criteria shown on Table 3-1.

3.4.1 Experiment Design and Procedures

This subsection describes the design and procedures for the sample characterization, oil and grease removal, and chemical treatment jar tests (metals removal).

TABLE 3-1

FEDERAL AND STATE CRITERIA FOR THE CONTAMINANTS OF CONCERN IDENTIFIED FOR THE SHALLOW AQUIFER

Contaminant of Concern	North Carolina* Water Quality Criteria for Groundwater (µg/l)	Federal Drinking Water MCLs (µg/l)	North Carolina* Water Criteria for Fresh Surface Water (µg/l) Class C Waters	North Carolina* Water Quality Criteria for Tidal Salt Waters (µg/l) Class SC Waters
TCE	2.8	5	92.4 (4)	92.4 (4)
1,2-DCE	--	70	--	--
Benzene	1	5	71.4 (4)	71.4 (4)
Antimony	--	6	--	--
Arsenic	50	50	50 (1)	50 (1)
Beryllium	--	4	.117 (4) 6.5 (1)	.117 (4)
Chromium	50	100	50 (1)	20 (1)
Iron	300	--	1000 (5)	--
Lead	50	15(3)	25 (1)	25 (1)
Manganese	50	--	--	--
Mercury	1.1	2	0.012 (1)	.025 (1)
Nickel	150	100	88 (1)	--

*From NC Administrative Code 15A NCAC 2B.0200
(1) Protection of Aquatic Life.
(2) -- = No standard established.
(3) MCL is action level for public water supply systems.
(4) Protection of Human Health through consumption of fish/shell fish.
(5) NC Action Level for discharge to fresh waters.

3.4.1.1 Sample Characterization

Characterization samples from the groundwater pumping well in the HPIA Operable Unit will be submitted to the laboratory for analytical testing using EPA methods and Level III reporting. For this contaminant plume, a raw unfiltered composite sample will be tested for Target Analyte List (TAL) metals, and selected engineering parameters as specified on Table 3-2. Analyses associated with these samples will provide information on the total organics and inorganics content of the sample.

In addition, a groundwater sample will be vacuum filtered through a 45-micron filter. This sample will be analyzed for only the TAL metals constituents listed in Table 3-2. This will provide information on the dissolved metals content of the sample and will indicate if simple sand filtration can be employed to reduce metals levels to below treatment objectives. Filtration also may be needed if the level (<10 ppm) of Total Suspended Solids (TSS) is such that solids could plug carbon adsorbers and increase changeout or backwash rates.

Treatability testing will be performed based on the results of the characterization analyses. A 48-hour turn around will be requested for these characterization analyses so that the necessary bench-scale tests can be defined and started no later than seven days after sample collection. Bench-scale testing of the following unit operations may be required:

- Oil /Water Separation
- Chemical Treatment Jar Tests (Metals Removal)

Each of these operations is discussed in more detail in the following subsections.

3.4.1.2 Oil/Water Separation

Typical oil and grease (O&G) limits for discharge to surface waters range from 10 to 20 parts per million (ppm). Oil/water separation treatability work will be performed if the level in the raw groundwater sample exceeds 10 ppm of O&G.

It is anticipated that one run will be performed for this study; three samples will be drawn per run for a total of three O&G samples. Five liters of the raw groundwater sample will be placed into a 1.5 gallon pyrex jar. The experiment is anticipated to be performed at room temperature (about 72°F). Three one-liter samples will be drawn, the first after 15 minutes,

Table 3-2

Groundwater Characterization and Bench-Scale Treatability Testing Analytical Requirements Summary Table

Parameter	Method	Practical Quantitation Limit (ug/l)	Maximum Contaminant Level (ug/l)	Anticipated Number of Samples	Sample Volume Requirement	Container Type	Sample Preservation	Holding Time
Target Analyte List Metals								
Aluminum	EPA 200.7	40	50	8	500 ml	Plastic	Cool to 4 C HNO3 to pH < 2	180 Days Except Mercury at 28 Days
Antimony	EPA 204.2	2	5					
Arsenic	EPA 206.2	5	50					
Barium	EPA 200.7	2	2000					
Beryllium	EPA 200.7	2	1					
Cadmium	EPA 213.2	1	5					
Calcium	EPA 200.7 EPA 215.1	5						
Chromium	EPA 218.2	5	10					
Cobalt	EPA 200.7	5						
Copper	EPA 200.7	7	1300					
Iron	EPA 200.7	6	300					
Lead	EPA 239.2	5	15					
Magnesium	EPA 200.7	100						
Manganese	EPA 200.7	1	50					
Mercury	EPA 245.1	0.2	2					
Nickel	EPA 200.7	20	10					
Potassium	EPA 200.7	200						
Selenium	EPA 270.2	2	50					
Silver	EPA 200.7	20	100					
Sodium	EPA 200.7	100						
Thallium	EPA 279.2	5	1					
Vanadium	EPA 200.7	7						
Zinc	EPA 200.7	50	5000					
Engineering Parameters								
Ammonia	EPA 350.2	100		1	500 ml	Plastic	Cool to 4 C H2SO4 to pH < 2	28 Days
Bicarbonate	SM 403/40	1000		1	500 ml	Plastic	None Required	14 Days
Carbonate	SM 403/40	1000		1	500 ml	Plastic	None Required	14 Days
Chloride	EPA 325.2	1000	250000	1	250 ml	Plastic	None Required	28 Days
Hardness	EPA 130.2	1000		1	150 ml	Plastic	HNO3 to pH < 2	180 Days
Nitrate/Nitrite	EPA 353.2	10		1	250 ml	Plastic	Cool to 4 C H2SO4 to pH < 2	28 Days
Oil and Grease	EPA 413.1	2000		4	1000 ml	Glass	Cool 4 C H2SO4 to pH < 2	28 Days
Total Dissolved Solids	EPA 160.1	1000	500000	1	250 ml	Plastic	Cool to 4 C	7 Days
Total Suspended Solids	EPA 160.2	1000		1	250 ml	Plastic	Cool to 4 C	7 Days

the second after 30 minutes and the third after one hour. Samples will be drawn from near the bottom of the jar to ensure that no floating O&G are included as part of the sample.

This experiment will give an indication of the optimal holding time for a pilot or full-scale oil/water separator. One duplicate O&G Quality Assurance/Quality Control (QA/QC) sample will be taken for each run for a total of three QA/QC samples.

3.4.1.3 Chemical Treatment Jar Tests (Metals Removal)

Chemical treatment jar tests for evaluating metals removal procedures will be required if the total metals analyses (generated as part of the sample characterization) show that the level of any particular metal contaminant exceeds its discharge criteria (assumed to be its drinking water Maximum Contaminant Level [MCL]), or NC Groundwater Criteria. In addition, jar tests may be required if levels of certain contaminants appear high enough to pose operational problems. For example, total iron and manganese levels above 5 milligrams per liter (mg/l) can cause frequent fouling of air stripper packing material. If levels of dissolved iron and manganese are above this, pretreatment for their removal could prove cost-effective.

Past investigations have indicated that total levels of antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury, and nickel potentially may be of concern in on-site groundwater. Lead, in particular, appears to be of greatest concern. Treatment for lead can be accomplished via reaction to form lead carbonate followed by precipitation. Lead carbonate is formed by the addition of soda ash; optimum pH range for lead carbonate precipitation is 7.5 to 9.0. The optimum carbonate level for precipitation has been reported at 200 mg/l as $CaCO_3$. Also, lead can be precipitated in the hydroxide form via reaction with lime or caustic; the optimum pH range for lead hydroxide precipitation may fall anywhere from 6.0 to 10.0, depending on the waste stream. However lead carbonate sludges typically have more desirable settling and dewatering characteristics than lead hydroxide sludges. Sludges will be vacuum dewatered and tested for resulting moisture content.

If total lead levels exceed MCLs, Baker will perform one-liter jar tests to investigate the applicability of precipitation of lead in both its carbonate and hydroxide forms. A sample test matrix is depicted in Table 3-3. Levels of contaminants of concern following treatment will be spot checked using a HACH chemical test kit. It is anticipated that up to six samples (plus two duplicates) will be submitted to the laboratory for analysis of the full set of TAL metals

TABLE 3-3
SAMPLE TEST MATRIX FOR METALS REMOVAL JAR TESTS

	EXPERIMENTAL				DUPLICATES
EXPERIMENTAL	Run No.: 1 pH to 7.5 w/ 1N NaOH Soda Ash to 200 mg/l CO3 Reaction Time: 5 min	Run No.: 2 pH to 8.0 w/ 1N NaOH Soda Ash to 200 mg/l CO3 Reaction Time: 5 min	Run No.: 3 pH to 8.5 w/ 1N NaOH Soda Ash to 200 mg/l CO3 Reaction Time: 5 min	Run No.: 4 pH to 9.0 w/ 1N NaOH Soda Ash to 200 mg/l CO3 Reaction Time: 5 min	Run No.: 5 Repeat best case run 1 to 4
	Run No.: 6 pH to best runs 1 to 4 Soda Ash to 100 mg/l CO3 Reaction Time: 5 min	Run No.: 7 pH to best runs 1 to 4 Soda Ash to 150 mg/l CO3 Reaction Time: 5 min	Run No.: 8 pH to best runs 1 to 4 Soda Ash to 250 mg/l CO3 Reaction Time: 5 min	Run No.: 9 pH to best runs 1 to 4 Soda Ash to 300 mg/l CO3 Reaction Time: 5 min	Run No.: 10 Repeat best case run 5 to 9
	Run No.: 11 pH to 6.5 w/ 1N NaOH Lime to 0.5 g/l Reaction Time: 5 min	Run No.: 12 pH to 7.5 w/ 1N NaOH Lime to 0.5 g/l Reaction Time: 5 min	Run No.: 13 pH to 8.5 w/ 1N NaOH Lime to 0.5 g/l Reaction Time: 5 min	Run No.: 14 pH to 9.5 w/ 1N NaOH Lime to 0.5 g/l Reaction Time: 5 min	Run No.: 15 Repeat best case run 11 to 14
	Run No.: 16 pH to best runs 11 to 14 Lime to 0.1 g/l Reaction Time: 5 min	Run No.: 17 pH to best runs 11 to 14 Lime to 0.25 g/l Reaction Time: 5 min	Run No.: 18 pH to best runs 11 to 14 Lime to 1.0 g/l Reaction Time: 5 min	Run No.: 19 pH to best runs 11 to 14 Lime to 1.5 g/l Reaction Time: 5 min	Run No.: 20 Repeat best case run 15 to 19
	Run No.: 21 Best runs 1 to 20 Reaction Time: 1 min	Run No.: 22 Best runs 1 to 20 Reaction Time: 2.5 min	Run No.: 23 Best runs 1 to 20 Reaction Time: 10 min	Run No.: 24 Best runs 1 to 20 Reaction Time: 15 min	Run No.: 25 Repeat best case run 21 to 24

(Table 3-2). Should precipitation not produce acceptable levels of lead in the treated groundwater, coagulation with alum, ferrous sulfate and/or ferric sulfate will be investigated.

Because addition of reagents such as lime and soda ash is a common treatment technique for numerous metals contaminants, jar test samples will be analyzed for the complete set of TAL metals listed on Table 3-2. If other metals remain at levels above treatment objectives (MCLs) following treatment or if a different metals contaminant is of concern, then other treatment techniques will be researched and bench-scale tests developed to ensure that treatment objectives can be met. The volume of groundwater required for the characterization samples and bench-scale tests described above are shown in Table 3-4.

TABLE 3-4

GROUNDWATER QUANTITIES REQUIRED FOR CHARACTERIZATION AND BENCH-SCALE TREATABILITY TESTING

	Bench-Scale Testing	TAL Metals	Engineering Parameters
Characterization Analyses		2 liters	4 liters
Characterization Dissolved Metals Analyses		2 liters	
Oil and Grease Removal	10 liters		
Metals Removal	50 liters		
Totals	60 liters	4 liters	4 liters

3.4.2 Equipment and Materials

This subsection presents a description of the test equipment to be used in the bench-scale testing.

3.4.2.1 Oil/Water Separation

The following equipment will be used for the oil/water separation bench-scale test.

- One 1.5 gallon pyrex jar w/valved spout
- One laboratory thermometer
- Sample bottles with the appropriate preservative (H_2SO_4 to pH <2)

The test apparatus to be used for oil/water separation is depicted on Figure 3-1.

3.4.2.2 Metals Removal

Groundwater samples for metals removal testing will be placed in one-liter pyrex jars. A pH meter will be used to monitor pH during testing. Sodium hydroxide (1 N) will be used to adjust pH to the desired level. Chemical doses will be weighed on an analytical balance. Jars will be placed on a gang stirrer and allowed to mix at a selected speed while the appropriate chemical dosages are introduced. Bench-scale testing equipment for the jar tests is shown on Figure 3-2. A vacuum pump, Erlenmeyer flask, Buchner funnel, and Whatman Number 2 filter paper will be used to dewater the resulting sludges.

3.4.3 Sampling and Analysis

Bench-scale tests are subject to change based on chemical characteristics of the groundwater sample; additional analytics could be required for these tests. Appropriate analytical methods, bottle requirements, and preservation and storage details have been presented previously on Table 3-2.

3.4.4 Data Analysis and Interpretation

The Treatability Study Report will summarize bench-scale testing activities, provide analytical support, and provide information for the design of the remediation unit. Raw data will be provided as an appendix to the report. The body of the report will discuss and present data as described in the following paragraphs.

3.4.4.1 Sample Characterization

Sample characterization data (including total and dissolved metals) will be presented in the treatability study report in tabular form and the appropriate discharge criteria will be included for comparison purposes. Conclusions can then be drawn on the applicability of filtration and/or chemical precipitation as an appropriate metals removal pretreatment step.

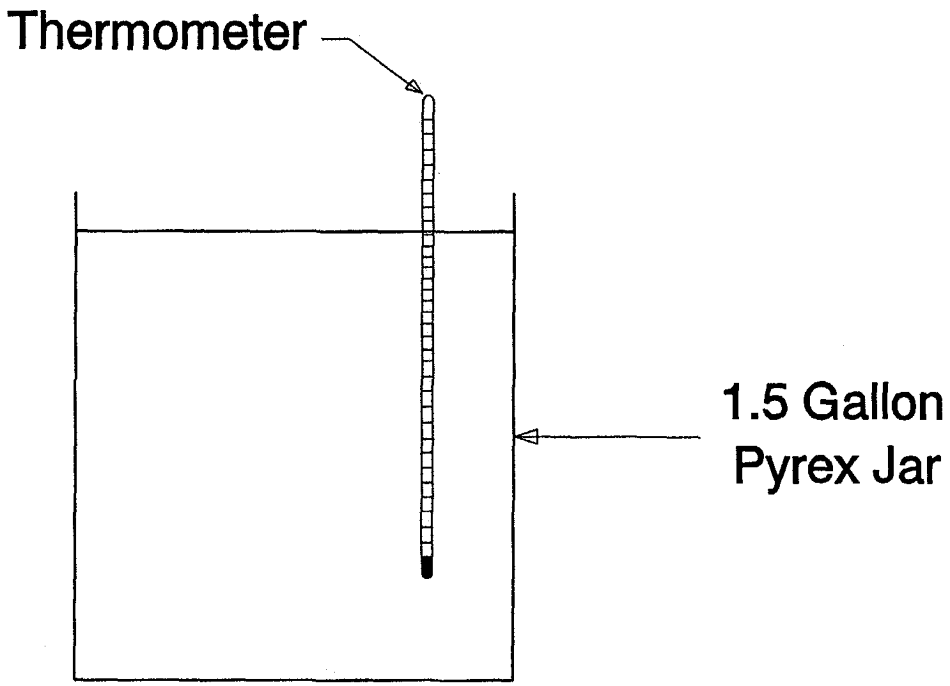


Figure 3-1
Oil and Grease Removal Equipment

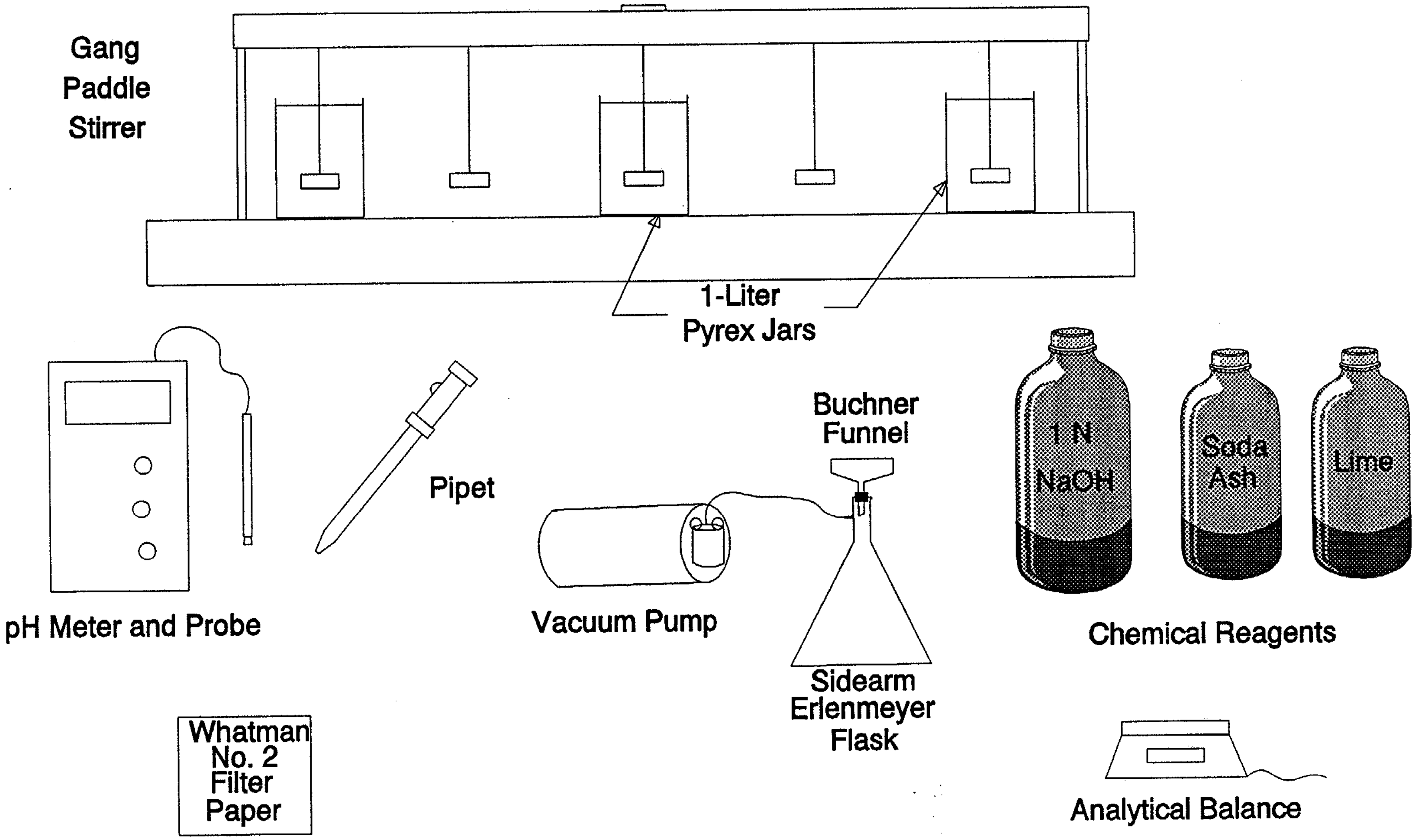


Figure 3-2
Metals Removal Apparatus

3.4.4.2 Oil/Water Separation

Oil and grease values at the various time intervals will be presented in tabular and graphic form (percent removal vs. time at two temperatures). This will be a convenient form to present information on the rate of removal of O&G.

3.4.4.3 Metals Removal

A detailed discussion of the metals removal test runs will be presented in the treatability study report. As numerous tests will be run and only six samples are anticipated to actually be analyzed by a laboratory, justification will be provided for why each sample was or was not submitted for analysis. A table showing details of each test run will be developed. In addition, analytical data generated from runs deemed most applicable will be presented. A recommendation will be made concerning chemical addition based on the metals removal results of the various treatment options evaluated.

3.5 Pilot-Scale Testing

In order to determine the effectiveness and implementability of using an air stripper and liquid phase carbon adsorption unit to treat groundwater, pilot scale testing of this equipment will be performed. This task will consist of extracting the groundwater through a submersible pump and discharging it through an air stripper and a carbon adsorption unit.

3.5.1 Experiment Design and Procedures

This subsection describes the design and procedures for conducting the pilot-scale test.

3.5.1.1 Groundwater Pumping

This phase will involve the installation of a groundwater pumping well, which will be located in the contamination plume around the 900 series buildings, near HPGW 24-1, as shown on Figure 2-4. The flow rates and pump specifications are described in Section 4 of this Work Plan as the pilot test will be performed during the 72 hour aquifer test.

3.5.1.2 Pilot Scale Testing

The pilot scale testing will consist of the following tasks:

- Mobilizing and setting up a pilot-scale treatment system near the groundwater pumping well. The pilot system will consist of an oil/water separator, air stripper and carbon adsorption unit as shown on Figure 3-3. Potable water will be used to determine the optimum liquid/air ratios and to stabilize the system.

- Conducting the 72 hour aquifer pump test as described in Section 4 of this Work Plan, with the groundwater being pumped through the pilot system. The treated groundwater will be discharged to the sanitary sewer system.

- Collecting samples every twelve hours during the pump test. These samples will be taken at influent to the air stripper, effluent from the air stripper, and effluent from the carbon adsorption unit. This will equate to 21 samples.

- Collecting QA/QC samples required under United States Environmental Protection Agency (EPA) and Naval Energy and Environmental Support Activity (NEESA) protocols. This will primarily be a daily trip blank (volatile analysis only), one preservation blank, one field blank, and two duplicate samples.

- Analysis of all samples for the following parameters: volatile organics (EPA method 601/602) and inorganics. Samples will be collected during the first and last sampling events at the influent and effluent of the oil/water separator, and will be analyzed for O&G. Additional influent samples will be collected during the first and last sampling events and will be analyzed for the following parameters: ammonia; bicarbonate; carbonate; chlorides; total dissolved solids; total suspended solids; hardness; nitrate/nitrite; and pH. One of the seven rounds of samples at the influent and effluent to the carbon adsorption unit will also be analyzed for multi-concentration acute toxicity tests. All of the constituents to be analyzed are shown on Table 3-5. Baker will analyze these samples using CLP protocol, Level III data quality. Detailed information about the samples and sampling can be found in the Sampling and Analysis Plan which is included in this document.

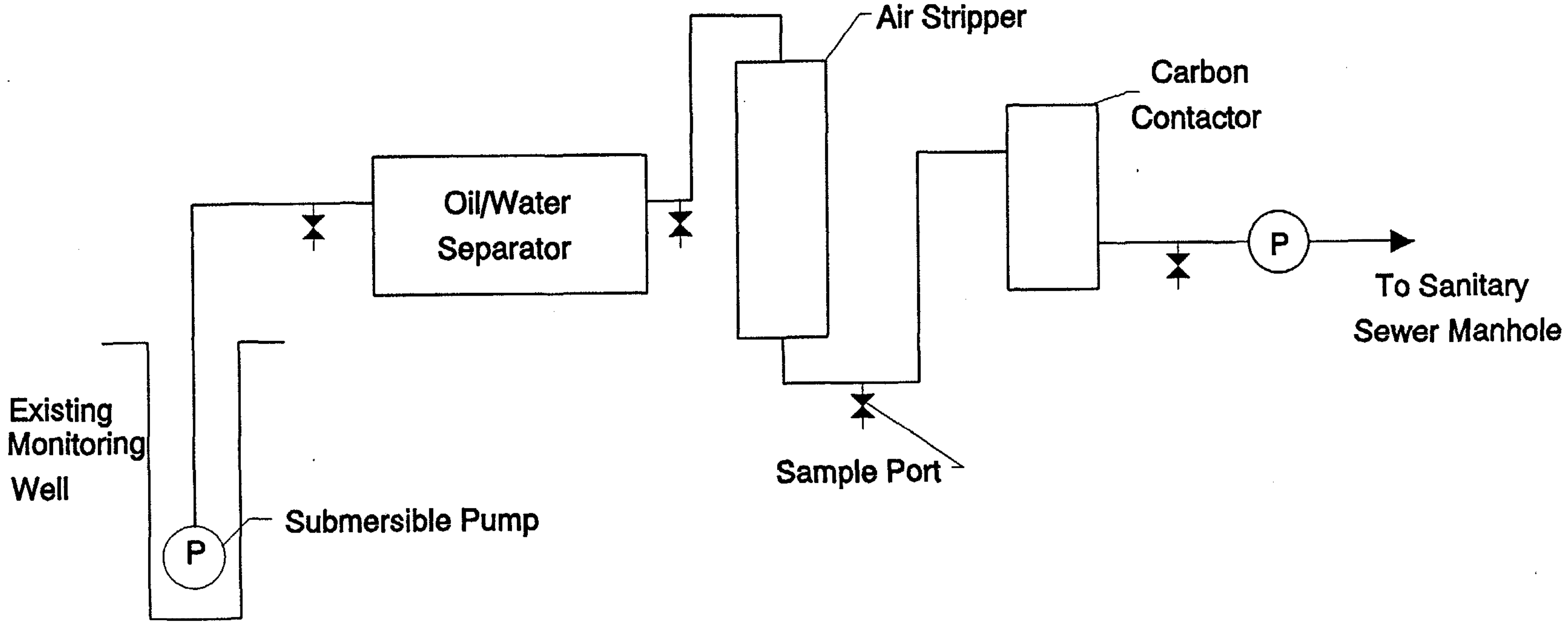


Figure 3 - 3

Pilot Scale Treatment System Schematic

Table 3-5
Pilot-Scale Treatability Testing Analytical Requirements Summary Table

Parameter	Method	Practical Quantitation Limit (ug/l)	Maximum Contaminant Level (ug/l)	Anticipated Number of Samples	Sample Volume Requirement	Container Type	Sample Preservation	Holding Time
Purgeable Halocarbons								
Bromodichloromethane	EPA 601	2		21	3 x 40 ml	Glass; Teflon Lined Septum	Cool to 4 C	14 Days
Bromoform		5						
Bromomethane		2						
Carbon Tetrachloride		2	5					
Chlorobenzene		2	100					
Chloroethane		2						
2-Chloroethylvinyl ether		2						
Chloroform		2						
Chloromethane		2						
Dibromochloromethane		2						
1,2-Dichlorobenzene		5	600					
1,3-Dichlorobenzene		5						
1,4-Dichlorobenzene		5	75					
Dichlorodifluoromethane		2						
1,1-Dichloroethane		2						
-Dichloroethane		2	5					
1,1-Dichloroethene		2	7					
trans-1,2-Dichloroethene		2	100					
1,2-Dichloropropane		2	5					
cis-1,3-Dichloropropene		2						
trans-1,3-Dichloropropene		2						
Methylene chloride		5						
1,1,2,2-Tetrachloroethane		2						
Tetrachloroethene		2	5					
1,1,1-Trichloroethane		2	200					
1,1,2-Trichloroethane		2						
Trichloroethene		2	5					
Trichlorofluoromethane		2						
Vinyl chloride		5	2					
Purgeable Aromatics								
Benzene	EPA 602	2	5	21	3 x 40 ml	Glass; Teflon Lined Septum	Cool to 4 C HCl to pH < 2	14 Days
Chlorobenzene		2	100					
1,2-Dichlorobenzene		5	600					
1,3-Dichlorobenzene		5						
1,4-Dichlorobenzene		5	75					
Ethylbenzene		2	700					
Toluene		2	1000					

Table 3-5 (continued)
Pilot-Scale Treatability Testing Analytical Requirements Summary Table

Parameter	Method	Practical Quantitation Limit (ug/l)	Maximum Contaminant Level (ug/l)	Anticipated Number of Samples	Sample Volume Requirement	Container Type	Sample Preservation	Holding Time
Target Analyte List Metals								
Aluminum	EPA 200.7	40	50	21	500 ml	Plastic	Cool to 4 C HNO3 to pH < 2	180 Days Except Mercury at 28 Days
Antimony	EPA 204.2	2	5					
Arsenic	EPA 206.2	5	50					
Barium	EPA 200.7	2	2000					
Beryllium	EPA 200.7	2	1					
Cadmium	EPA 213.2	1	5					
Calcium	EPA 200.7 EPA 215.1	5						
Chromium	EPA 218.2	5	10					
Cobalt	EPA 200.7	5						
Copper	EPA 200.7	7	1300					
Iron	EPA 200.7	6	300					
Lead	EPA 239.2	5	15					
Magnesium	EPA 200.7	100						
anganese	EPA 200.7	1	50					
rcury	EPA 245.1	0.2	2					
Nickel	EPA 200.7	20	10					
Potassium	EPA 200.7	200						
Selenium	EPA 270.2	2	50					
Silver	EPA 200.7	20	100					
Sodium	EPA 200.7	100						
Thallium	EPA 279.2	5	1					
Vanadium	EPA 200.7	7						
Zinc	EPA 200.7	50	5000					
Engineering Parameters								
Ammonia	EPA 350.2	100		2	500 ml	Plastic	Cool to 4 C H2SO4 to pH < 2	28 Days
Bicarbonate	SM 403/406	1000		2	500 ml	Plastic	None Required	14 Days
Carbonate	SM 403/406	1000		2	500 ml	Plastic	None Required	14 Days
Chloride	EPA 325.2	1000	250000	2	250 ml	Plastic	None Required	28 Days
Hardness	EPA 130.2	1000		2	150 ml	Plastic	HNO3 to pH < 2	180 Days
Nitrate/Nitrite	EPA 353.2	10		2	250 ml	Plastic	Cool to 4 C H2SO4 to pH < 2	28 Days
Oil and Grease	EPA 413.1	2000		4	1000 ml	Glass	Cool 4 C H2SO4 to pH < 2	28 Days
Total Dissolved Solids	EPA 160.1	1000	500000	2	250 ml	Plastic	Cool to 4 C	7 Days
Total Suspended Solids	EPA 160.2	1000		2	250 ml	Plastic	Cool to 4 C	7 Days
uatic Toxicity Bioassays								
Multi-Concentration Acute Toxicity	EPA/600/ 4-90-027	NA	NA	2	2000 ml	Plastic	Cool to 4 C	36 Hours

All sampling conducted during the pilot test will be the responsibility of a Baker Sampling Technician.

3.5.2 Equipment and Materials

The pilot testing will take place at near the pumping well which will be located near HPGW 24-1, at the HPIA Operable Unit as shown on Figure 2-4. The pilot test system will consist of an oil/water separator, air stripper, and liquid phase carbon adsorption unit.

The groundwater will be extracted from the shallow unconfined aquifer via a submersible pump. The groundwater will then travel through an oil/water separator before reaching the air stripper.

An air stripper with a flow capacity of 0 - 10 gpm will follow the oil/water separator. After the air stripper a liquid phase carbon adsorption unit will be utilized before the treated groundwater is discharged to the HPIA sanitary sewer system approximately 12,000 feet from the HPIA STP. The HPIA STP is a biological treatment system consisting of an aerated equalization lagoon, primary clarifiers, trickling filters, secondary clarifiers, and a chlorine contact tank.

3.5.3 Data Analysis and Interpretation

The following information will be included in the Treatability Study Report:

- Pilot-scale testing procedures, results and conclusions.
- Analytical data generated during testing (including QA/QC).
- Recommendations for the design of an oil/water separation component.
- Recommendations for the design of a metals removal pretreatment component.
- Recommendations for the design of an air stripping treatment unit.
- Recommendations on whether carbon adsorption is required to met the cleanup goals.

- Information on the capacity of the sanitary sewer system, which will be used to transport treated water to the HPIA sewage treatment plant.

- Information on the design and placement of extraction wells.

The report will discuss the analytical data generated during the pilot test and present it in a tabular form. Raw data will be provided as an appendix to the report.

In addition to the analytical dated generated during the pilot test, up to 30 days of operational data will be collected during start-up of the full size treatment system. This data will be used to confirm that the system is operating at a treatment level necessary to meet the federal MCLs and NC groundwater criteria. If this operating data demonstrates that the treatment system is not meeting design requirements, the system will be shut down, and the necessary modification or corrections would be made. The sampling to be conducted during the startup of the treatment systems will be detailed in the Remedial Action Work Plans which Baker will prepare during the remedial design.

3.6 Sampling and Analysis Plan

The Sampling and Analysis Plan (SAP) addresses field sampling, waste characterization, and the sampling and analysis during treatability testing. The SAP helps to ensure that the samples are representative and that the quality of the analytical data generated is generally known. The Sampling and Analysis Plan for this project has been prepared as a separate plan, which is included in these work plans.

3.7 Data Management

Due to the quantity of data to be collected during the treatability study, the way the data is documented plays a vital role. The following information provides guidance in the documentation of samples and general observations.

Five types of documentation will be used in tracking and shipping analytical samples:

- Field logbook;
- Sample labels;
- Chain-of-Custody Records;

- Custody Seals; and
- Commercial carrier air bills.

At a minimum, the label for each sample bottle shall contain the following information:

- Site Name;
- Sample number;
- Monitoring Well I.D. number;
- Date and time of collection;
- Sample type (grab or composite);
- Preservatives;
- Sample Matrix; and,
- Samplers initials.

The sample information, as well as the analysis to be performed on the sample will be entered into the field logbook for sampling location. Additionally, the following items also will be entered:

- Date and time;
- Name of field personnel on site;
- Names of visitors on site;
- Field conditions;
- Description of Activities;
- Sampling remarks and observations;
- QA/QC samples collected; and,
- Sketch of sample location and 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. A sample is considered to be in an individual's possession if:

- It is in the sampler's possession or view after being in their possession;
- It was in the sampler's possession and then locked or sealed to prevent tampering; or
- It is in a secure area.

The sample custody will be documented using Chain-of-Custody (COC) records. Field personnel will complete a COC record in waterproof ink to accompany each cooler forwarded from the site to the laboratory. Any errors in the COC record 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, placed in the appropriate cooler, and secured to the cooler's 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 air 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 air bill.

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 their designee, will sign the COC record upon receipt of the samples. 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. Specific laboratory COC procedures are discussed in the Laboratory Quality Assurance Project Plan.

3.8 Health and Safety Plan

The Health and Safety Plan for field activities associated with this project is presented as a separate plan in these project control documents.

3.9 Residuals Management

This section describes the management of the treatability study residuals for the bench-scale test. The expected residuals from the bench-scale test will be drummed and disposed of through a disposal contractor. It is estimated that there will be 20 gallons of liquids developed during the bench-scale test.

Sludges generated will be tested for moisture content by placing in a drying oven. This project will drive off volatile organics and, therefore, sludges are not anticipated to be hazardous. The dried sludge cakes will be submitted to the laboratory for TCLP analysis. Method of disposal (conventional or hazardous) will be determined after the analytical results are returned from the laboratory.

3.10 Community Relations

A public meeting was held on May 14, 1992 to present the Proposed Remedial Action Plan (PRAP) and answer any questions which may be a concern to the public. The turnout was very low, probably because the remedial action will take place at the HPIA, away from most base housing. The DoN has been keeping members of the Technical Review Committee aware of ongoing process applicable to this remedial action. In accordance with Section 300.435 (40 CFR) a Fact Sheet will be prepared detailing the results of the treatability study and remedial design. In addition, the Community Relations Plan for MCB Camp Lejeune is being updated at present. The CRP will summarize all CRP activities that are anticipated for active CERCLA sites throughout MCB Camp Lejeune, in addition to this remedial design.

3.11 Reports

A Treatability Study (TS) Report will be generated which documents the results of the bench scale and pilot scale treatability studies. The report will describe the technical approach, and provide an evaluation of the test results. Any modifications to the design of the interim remedial action alternative that may be necessary to implement the alternative, based on the results of the testing, will be identified. Results of the Aquifer Tests also will be included.

All laboratory results, validation results, chain-of-custody forms, and any other back-up information will be appended. In addition, the Sewer Line Capacity and Integrity Study, and the Aquifer Pump Test Report will be appended. The TS Report will be distributed in accordance with the Request for Proposal (RFP).

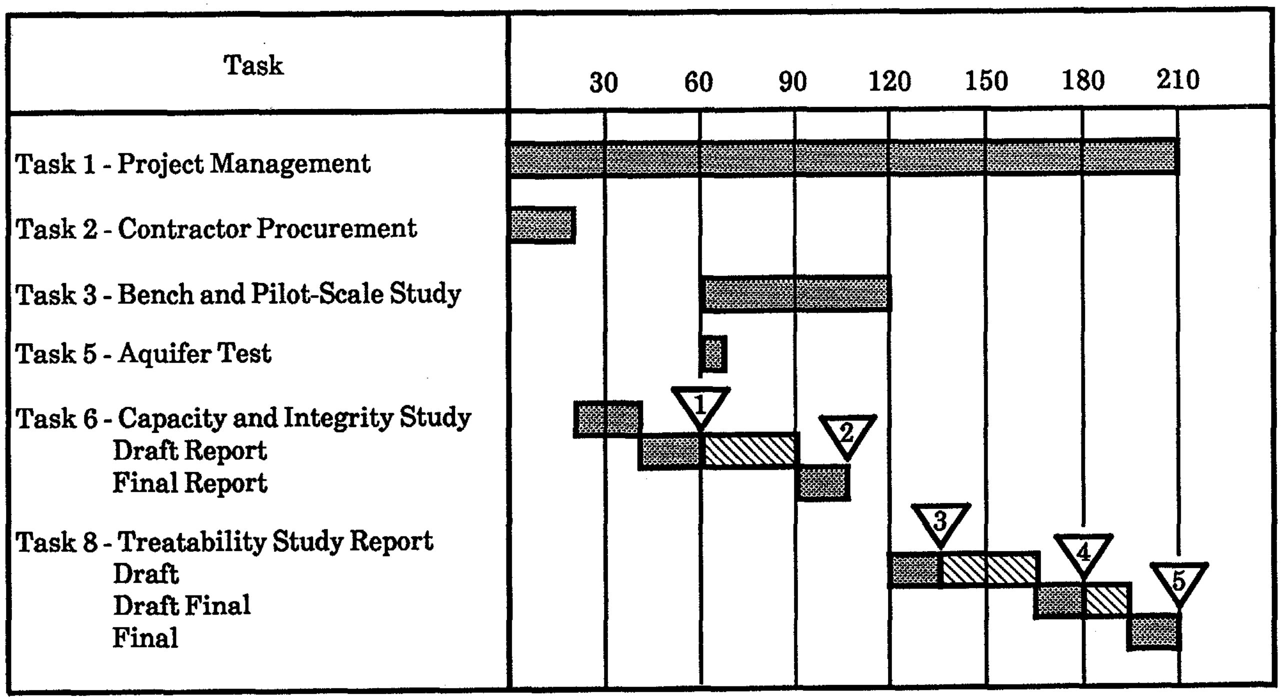
3.12 Schedule

This treatability study and pilot study will be performed in accordance with the schedule identified in Figure 3-4.

Factors that may effect this schedule causing an increase (or decrease) in the schedule include Government review periods, site access, weather conditions, or other unforeseen factors beyond Baker's control.

FIGURE 3-4

PROJECT SCHEDULE



▨ Government review

▒ Contractor Activity

▽1 Draft Capacity Report (60 days following notice to proceed)

▽2 Final Capacity Report (14 days following receipt of government comments)

▽3 Draft Treatability Study Report (135 days following notice to proceed)

▽4 Draft Final Treatability Study Report (14 days following receipt of gov't comments)

▽5 Final Treatability Study Report (14 days following receipt of government comments)

3.13 Management and Staffing

The Baker Project Team for the Treatability Study will be managed by Mr. Steven J. Kretschman, P.E. Mr. Kretschman will be responsible for monitoring the technical performance of the project, project costs and schedule, reporting, and maintaining close communication with the LANTDIV Engineer in Charge (EIC), Mr. Byron Brant, P.E. As shown on Figure 3-5, Mr. Kretschman will report to Mr. William D. Trimbath, P.E. Mr. John W. Mentz will be responsible for overall QA/QC. Mr. Raymond P. Wattras, MCB Camp Lejeune Activity Coordinator, will provide additional administrative and/or technical support and coordination as needed.

In terms of assigning project personnel, Baker tentatively has identified the following team members and their primary responsibilities.

- Project Engineer - Ms. Tammi A. Halapin: Bench-Scale Treatability Studies
- Project Geologist - Mr. Don Shields: Aquifer Testing
- Assistant Engineer II - Mr. Delbert J. Brown, P.E.: Sewer Line Capacity and Integrity Study

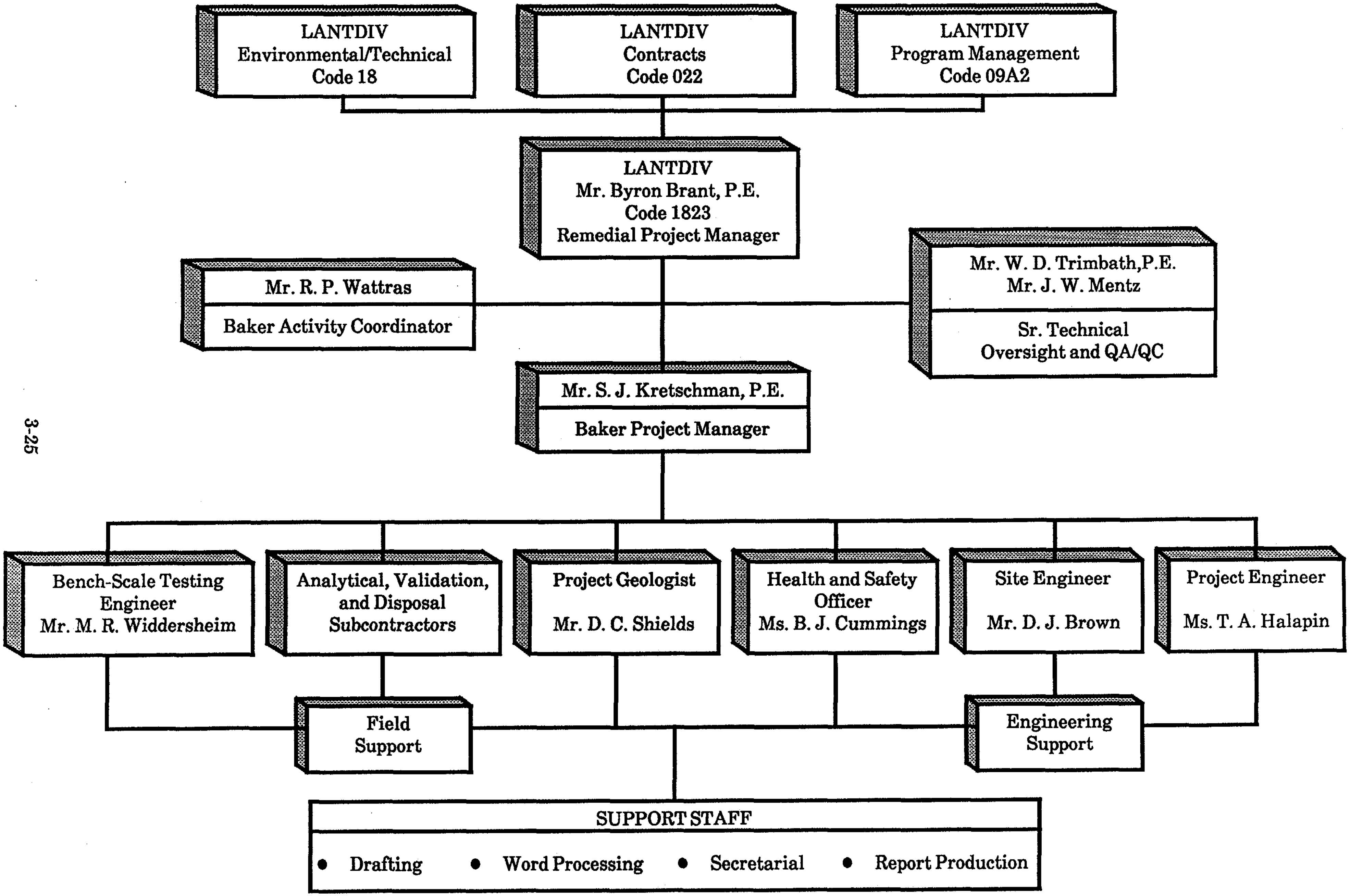
Other project support and resources are illustrated in Figure 3-5.

3.14 Budget

Estimated project budget costs for conducting the Treatability Study were presented in Baker's Draft Implementation Plan and Fee Proposal for a modification to Contract Task Order 0017, dated November 6, 1992. The estimated project cost is $109,524. This estimated cost may change based on the scope of services presented in the final version of these Work Plans.

FIGURE 3-5

PROJECT ORGANIZATION



4.0 AQUIFER PUMP TESTS

A shallow aquifer pump test will be conducted in the 900 buildings area within HPIA. The purpose of the aquifer pump test is to evaluate aquifer characteristics (hydraulic conductivity, transmissivity) and to determine optimum flow rates and zones of influence in the area. The results of the aquifer pump test will be used in the design of a groundwater extraction remedial system for the shallow aquifer at HPIA.

Activities associated with the aquifer pump tests will include the following:

- Installation and development of the pumping well
- Installation of observation piezometers
- Pump installation
- Step drawdown test
- 72-hour aquifer pumping test
- Groundwater Sampling
- Recovery test
- Extracted groundwater treatment

4.1 Installation and Development of the Pumping Well

A pumping well will be installed in order to conduct the aquifer test. The pumping well will be located in the 900 buildings area, near HPGW 24-1. This location was selected on the basis of its location (near the center of a contaminant plume) and the results of previous sampling activities.

The pumping well will be installed in accordance with the following procedures.

- A drilling rig will be used to adhere 8-inch (minimum) inside diameter hollow stem augers to the selected depth (25 feet).

- A minimum 4-inch diameter stainless steel well with 10 feet of 20-slot wire wrap screen will be installed inside the hollow stem augers.

- The augers will be removed in small increments as the well construction materials (gravel pack, bentonite) are installed.

- A coarse gravel pack will be installed around the screen to a minimum of 2 feet above the top of the screen.
- The remaining borehole internal (from the top of the filter pack to surface) will be filled with a bentonite seal.

In order to ensure proper hydraulic communication between the aquifer and the pumping well, the well will be developed by surging and pumping techniques. Temperature, pH, specific conductivity, and turbidity of the pumped water will be monitored. Development will continue until these parameters have stabilized. All development water will be treated in accordance with procedures outlined in Section 4.8.

4.2 Installation of Observation Piezometers

Observation piezometers will be installed to monitor water table drawdown during the aquifer pump test. Two observation piezometers will be installed in the vicinity of the pumping well. The observation piezometers will be located approximately 30 and 40 feet from the pumping well (in a nonlinear fashion).

The observation piezometers will be installed in accordance with the following procedures:

- A drilling rig will be used to advance 2-inch (minimum) inside diameter hollow stem augers to the same depth that the pump will be set in the pumping well during the aquifer pump test (estimated 24 feet).
- One-inch diameter PVC pipe (with a 6-inch hand-slotted screen interval at the base) will be installed inside the hollow stem augers. The pipe will be open at the base (i.e., no bottom cap).
- A coarse sand or pea-gravel filter pack will be installed around the screen to a minimum of 2 feet above the top of the screen.
- The remaining borehole interval (from the top of the filter pack to surface) will be filled with a bentonite pellet seal.

- Observation piezometers will not be developed.

- At the end of aquifer pump test activities, the observation piezometers will be abandoned. A drilling rig will be used to overdrill the piezometer and the resulting borehole will be filled with a cement/bentonite grout.

4.3 Pump Installation

An electric submersible pump will be temporarily installed in the pumping well. Upon installation the pump will be suspended 6 inches to 1 foot above the bottom of the pumping well using either a nylon rope or a steel cable.

Either a solid PVC pipe or a flexible hose may be used as the discharge line from the pump to the top of the well. As the pump is lowered into the monitoring well, the electric cable, discharge line, and the suspension cable will be taped together at periodic intervals to allow maximum clearance within the recovery well.

Upon reaching the top of the well, the discharge line will be attached to a flow meter with a totalizing meter of appropriate accuracy and capacity. A sampling port (outlet) will be attached to the up-flow side of the flow meter. The discharge line will then proceed through a valve. The valve will be used to regulate the discharge rates of the pump. After the valve, the discharge line will be extended to a container that is suitable for fluid storage.

4.4 Step-Drawdown Test

After the pump and associated equipment is installed, fluid level measurements will be obtained from the pumping well, the newly installed piezometers and nearby existing monitoring wells located in the area of concern. The Insitu, Inc. Model No. SE-2000 data logger and one pressure transducer will be installed to operate within the pumping well for the step-drawdown test.

The SE-2000 will be set to obtain fluid level data on a logarithmic scale. Fluid levels for each step of the test will be recorded by the hydrologic monitor from the pressure transducer according to the schedule shown below.

Elapsed Time	Recording Interval
0-5 seconds	0.5 seconds
5-20 seconds	1 second
20-120 seconds	5 second
2-10 minutes	0.5 minutes
10-100 minutes	2 minutes
100 minutes to end of test	10 minutes

If a significant amount of free product is present (0.05 feet or greater) the fluid level measurements will be obtained using an interface probe. These manually obtained measurements will also be obtained on a logarithmic scale utilizing a schedule similar to that shown below.

Elapsed Time	Recording Interval
0-2 minutes	15 seconds
2-10 minutes	30 seconds
10-20 minutes	1 minute
20-30 minutes	2 minutes
30 minutes to end of STEP	5 minutes

Based upon previous investigations at the site, it is estimated that the maximum sustained discharge capacity of a recovery well will be five gallons per minute (gpm). The proposed initial discharge rates for the step-drawdown test will be three gpm (i.e., 60 percent), four gpm (i.e., 80 percent), five gpm (i.e., 100 percent), and six gpm (i.e., 120 percent). Drawdown of water levels in the pumping well will be measured. Decisions as to when the flow rates should be increased to the next step will be based on the drawdown observed in the recovery well. The discharge rate will be increased incrementally until the maximum sustainable pumping rate is exceeded.

After each step is completed, fluid level measurements from observation piezometers and the nearest monitoring wells (including HPGW 24-1) will also be recorded. If drawdown influences are observed in these monitoring wells, additional measurements will be obtained from monitoring wells further away from the recovery well. This procedure is intended to determine what influences, if any, may be observed in the monitoring wells during the 72-hour aquifer test.

Once the various steps have been completed for the step-drawdown test, the flow rate of the pump will be adjusted with the gate valve to the discharge rate which will be used for the 72-hour aquifer tests. The pump will then be shut down by terminating the power supplied to the pump, and the gate valve will be closed before the meter to prevent water from flowing back into the well. The recovery of the water levels inside the recovery well will be measured on a logarithmic scale, similar to the scale used for the drawdown phase of the test. Fluid levels within the recovery well and the monitoring wells will be allowed to return to static before starting the 72-hour aquifer test. Groundwater extracted during the step-drawdown tests will be treated in accordance with the procedures outlined in Section 4.8.

4.5 72-Hour Aquifer Pump Tests

The 72-Hour Aquifer Pump Test will maintain a constant discharge rate during the extraction of the groundwater from the pumping well. The selected discharge rate will be the estimated maximum sustainable discharge rate as determined from the step-drawdown test. The observation piezometers and as many as four additional monitoring wells will be monitored continuously with data loggers to assist in the evaluation of the hydraulic conditions in the shallow aquifer. Prior to starting the test, fluid level measurements will be obtained from all the wells and piezometers. The time intervals used by the SE-2000 to record the fluid levels will be the same as those used during the step-drawdown test.

Flow rates will be recorded periodically. Site personnel will record flow rates frequently during the initial portion of the test. If flow rates fluctuate more than 0.25 gpm from the desired flow rate, the gate valve will be used to adjust the flow rate accordingly. Data obtained from the flow meter will be used to determine the total volume of fluids discharged and the average flow rate for the test. Groundwater extracted during the aquifer pump tests will be treated in accordance with the procedures outlined in Section 4.8.

4.6 Groundwater Sample Collection During 72-Hour Aquifer Pump Tests

Samples of the groundwater extracted during the 72-hour Aquifer Pump Tests will be collected. Samples will be collected for the following:

- The influent to the pilot plant;
- The effluent from the air stripper; and,
- The effluent from the liquid phase carbon adsorption limit.

Samples will be collected at the initiation of the test and at 12-hour intervals thereafter.

All samples will be submitted to the laboratory for analysis. Analytical parameters are outlined in Section 3.5.1. Samples collected for VOC analysis will not be composited.

4.7 Recovery Test

At the conclusion of the drawdown phase of the aquifer test, the pump will be shut down and the fluid levels permitted to recover. The frequency for obtaining fluid levels during the recovery test with the SE-2000 will be the same as those used for the drawdown test. Only those monitoring wells that had a measurable drawdown will be monitored during the recovery test.

The recovery test will be terminated after the fluid levels in the pumping well and observation piezometers have returned to 90 percent of the original level. The pump and other downhole equipment will not be removed from the pumping wells until the recovery test is concluded.

4.8 Extracted Groundwater Treatment

All extracted groundwater will be pumped through the pilot-scale treatment system before being released into the HPIA sanitary system. Therefore no disposal of the extracted groundwater will be necessary as the water will be treated from the pilot-scale treatment system. However, provisions will need to be made to temporarily hold the extracted groundwater, prior to treatment, if the results of the step-drawdown test indicate that the maximum sustainable discharge rate is greater than 20 gpm. A description of the pilot-scale treatment system is included in Section 3.5.

5.0 SEWER LINE CAPACITY WORK PLAN

This section of the Work Plan presents the Sewer Line Capacity Work Plan for the Interim Remedial Action of the Shallow Aquifer at the Hadnot Point Industrial Area, Marine Corps Base, Camp Lejeune, North Carolina. The purpose of this testing is to determine whether or not the existing sanitary sewer system would be capable of accepting the additional flow necessary for the remediation of the shallow aquifer without reaching or exceeding the systems maximum capacity.

5.1 Sewer Line Capacity Study

The following sections describe the purpose and description of the sewer line capacity testing to be performed on the specified section of the HPIA sanitary sewer system.

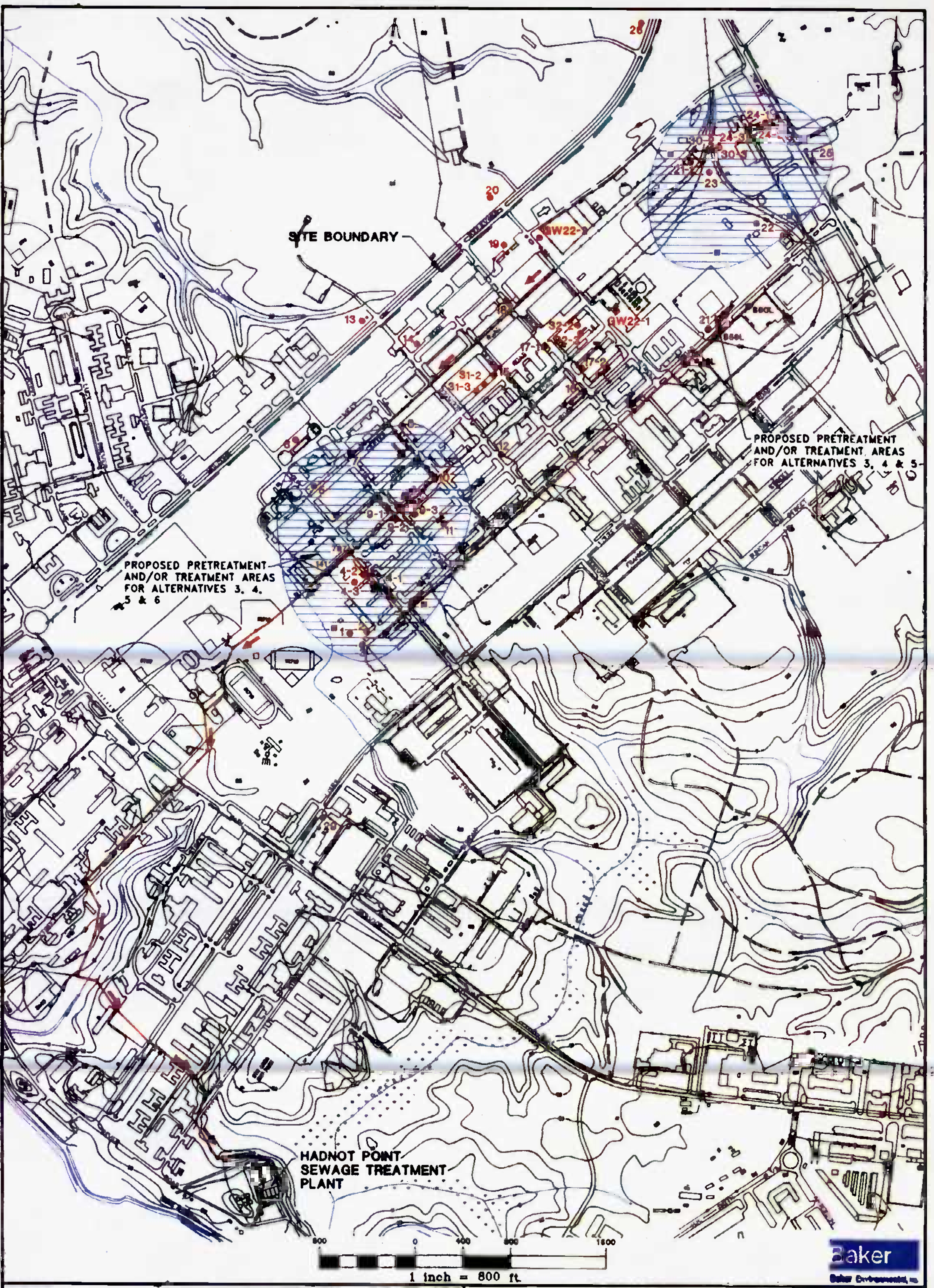
5.1.1 Purpose of Study

The objective of this wastewater study is to collect and evaluate information to determine the capacity of the sewer lines proposed for transporting groundwater to the HPIA STP as shown on Figure 5-1. To date, the wastewater flow has been assumed at 70 percent of the capacity of the sewer lines. The sewer lines range in size from 10-inches in diameter, with a capacity of approximately 490 gpm, to 36-inches with a capacity of approximately 6,000 gpm. This study will provide more accurate sewage flow rates in order to evaluate whether the sewer lines can handle an additional loading ranging from 40 gpm to 160 gpm. Based on a present flow of 70 percent of capacity, the sewer lines can handle this additional flow.

5.1.2 Description of Study

Three flow meters ("Marsh-McBirney Flo-Tote" or equal) will be installed at three locations to monitor flow conditions for a three-week period. The flow meters will be leased but installed by Baker. Flow levels will be compiled at 15 minute intervals during an appropriate three-week period. Following this period, the meters will be removed and the data interpreted.

Prior to the installation of the three flow meters the condition of the following manhole elements will be recorded on inspection logs:



LEGEND

29	EXISTING MONITORING WELL LOCATION
▤	APPROXIMATE SOURCE AREA OF GROUNDWATER CONTAMINATION IN THE SHALLOW AQUIFER
■	PROPOSED EXTRACTION WELL LOCATION
•	MANHOLES
—	PROPOSED SEWER LINES TO BE USED

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 5-1
LOCATION OF INITIAL PHASE EXTRACTION WELLS, ON-SITE TREATMENT SYSTEMS AND PROPOSED SANITARY SEWER LINES
HADNOT POINT INDUSTRIAL AREA
MCB CAMP LEJEUNE, NORTH CAROLINA

01502P05Y

- Frame
- Cover
- Walls
- Fixed ladder rungs
- Bench
- Diameter and material of pipe connections
- Flow channels
- Rim elevation
- Depth from cover rim to flow channel invert of each pipe connection
- Evidence of infiltration/inflow

Only those manholes chosen for the placement of the metering equipment will be inspected.

One rainfall gauge will be provided to record precipitation during the flow monitoring period. The rain gauges will be monitored weekly.

5.2 Sewer Line Integrity Study

The following subsections describe the purpose and the description of the sewer line integrity study which may be performed on the sanitary sewer system at the HPIA. The integrity study will be performed if the results of the pilot-scale study indicate that the treated effluent may exceed North Carolina groundwater standards (See Table 3-1).

5.2.1 Purpose of Study

The purpose of this study will be to assess the condition and integrity of that portion of the existing sanitary sewer lines where the combined concentration of sewage and treated groundwater exceeds North Carolina groundwater standards, and evaluate methods of repairing or relining the sewer. This study will involve a records search, manhole inspections, light sewer cleaning, and closed circuit television (CCTV) inspection. The CCTV inspection will be subcontracted; however, Baker will be present as the monitoring is being performed in order to evaluate the integrity of the sewer line.

5.2.2 Description of Study

The records search will consist of efforts to gather additional information in order to update the sanitary sewer line system. This information may include: sanitary sewer mapping; horizontal and vertical ground control datum; water/sewage flow records; rainfall records; tidal records; previous rehabilitation work records; construction/design drawings; utility location records; and interviews with Public Works personnel.

A maximum of 48 manholes will be inspected by the subcontractor and Baker's on-site engineer. The inspection will verify all manhole locations along the length of proposed pipe and will note the conditions of the structure. Manholes with significant leaks due to poor conditions will be noted. The manhole inspection will focus only on those manholes that are visible from the ground surface (i.e., the inspection will not include manholes that are covered over or otherwise inaccessible).

The condition of the following manhole elements will be recorded on inspection logs:

- Frame
- Cover
- Walls
- Fixed ladder rungs
- Bench
- Diameter and material of pipe connections
- Flow channels
- Depth from cover rim to flow channel invert of each pipe connection
- Evidence of infiltration/inflow

Manholes will be inspected to the greatest extent possible following rainy periods so that infiltration can be observed.

The CCTV inspection will be performed on a maximum of 12,100 feet of sanitary sewer line. An estimated breakdown, by sewer line pipe diameter, is given below.

12-inch diameter line:	1500 feet
15-inch diameter line:	7600 feet
36-inch diameter line:	3000 feet

Prior to the CCTV inspection, the sewer line will be cleaned to remove debris such as sludge, dirt, sand, grease, or other material that could hamper the CCTV inspection and hide defects in the pipe. It is assumed that this cleaning will be "light cleaning", which is defined as one-third or less of pipe diameter filled with debris when measured vertically at the invert of the downstream manhole of the pipe section. Cleaning will be performed using rodding, bucket and high water velocity water machines and hydraulically propelled devices to remove roots and minor obstructions. The source of water for cleaning is assumed to be fire hydrants. The use of these lines along with access to the sewer lines will be coordinated with the Public Works Department and the Environmental Management Department. Waste and debris that is removed from the sewer lines will be hauled to an environmentally acceptable location in compliance with Federal and State regulations. The subcontractor will be responsible for disposing of this debris.

CCTV inspections will be performed following cleaning. When a storm event or detrimental discharge in the system in the system occurs after cleaning of a line segment but before CCTV inspection has begun, the line segment will be recleaned by the subcontractor at no cost. Approximately 12,100 feet of sanitary line is estimated to be inspected by CCTV. Inspections will be recorded in color on a video cassette and audio description. The format will be suitable for playback with a standard VHS system. A footage counter and real time and date identification will be provided in one corner of the screen.

The camera/recording quality will be sufficient to clearly identify existing deficiencies, defects and physical conditions. The audio recording shall be synchronized with the video and will place special emphasis on observed conditions, defects, and deficiencies. Existing landmarks (manholes, laterals, etc.) will be identified for orientation.

Inspection logs will contain at least the following:

- Date and time of inspection
- Weather conditions
- Manhole number and set up location
- Entrance and exit points of camera
- Distance from reference manhole to defect
- Building number serviced by lateral
- Direction of flow

- Pipe material
- Diameter of pipe tested
- Length of pipe reach between manholes
- Location and compass orientation of each lateral
- Tape counter number corresponding to start of inspection for corresponding pipe run

Air testing of sewer line joints will be performed at selected locations to assist in determining the integrity of the sewer lines to be considered.

6.0 COLLECTION AND TREATMENT SYSTEM DESIGN

Following approval of the final RDWP Baker will initiate tasks associated with the design of the groundwater collection and pretreatment system. This section presents a description of the proposed treatment system, a discussion of the design activities that will be performed and design or implementation precautions that have been identified.

6.1 Description of Proposed Treatment System

The proposed treatment system selected by the Feasibility Study for remediation of the shallow aquifer at the HPIA site includes: groundwater extraction, treatment, and discharge to the Hadnot Point STP. There will be two on-site treatment systems, each capable of treating up to 80 gpm of groundwater from a maximum of 16 extraction wells. Additional details of the system components are provided in the following subsections.

6.1.1 Groundwater Extraction system

Initially, the system will be designed to extract groundwater from four extraction wells installed into each of the two contaminant plumes. Each of the extraction wells will be 4-inches in diameter and will be designed to withdraw groundwater up to approximately 25 feet below the ground surface, at an assumed rate of approximately 5 gpm. The design will include provisions for installing additional extraction wells based on the results of monitoring conducted after the system is operating.

6.1.2 Groundwater Treatment System

Once extracted, the contaminated groundwater will be pumped to an on-site treatment system. A treatment system will be located within the area of each plume, as shown on Figure 5-1. Each treatment system will be designed for an ultimate flow capacity of 80 gpm, assuming a maximum of 16 extraction wells (at 5 gpm per well). The first step in the treatment system will consist of a gravity oil/water separation process for the removal of floating oils and/or oily wastes that are heavier than water. The oil/water gravity separation system will include a holding tank for retention of the extracted free oil product. Collected free product will be either sold to a waste oil recycler or incinerated in a RCRA permitted facility.

The aqueous effluent from the gravity separation system will be transferred to an inorganic chemical treatment system for the removal of the inorganic contaminants of concern (e.g., chromium, lead, manganese, iron, etc.). The inorganic system will include but not be limited to the following technologies: chemical precipitation, chemical reduction, and filtration and/or sedimentation. Residuals generated from the treatment system will be disposed of in a RCRA permitted facility.

Following inorganic chemical treatment the groundwater will be sent to an air stripper for removal of volatile organic contaminants. Depending on the results of the bench scale studies, the groundwater may require additional organic contaminant removal with a granular activated carbon column.

6.1.3 Discharge to Hadnot Point STP

The treated groundwater will be pumped to the closest sanitary sewer manhole for discharge to the existing biological treatment system at the Hadnot Point STP. A brief description of the STP is provided in Section 3.5.2.

6.2 Description of Remedial Design Process

The remedial design activities for this project will be performed in accordance with LANTDIV's Guide for Architect/Engineer Firms Performing Services for the Atlantic Division (A & E Guide), U.S. EPA's OSWER Directive 9355.0-4A, and with standard engineering practices. The design will take place in three phases, 1) Preliminary (30 percent) Design, 2) Pre-Final (90 percent) Design, and Final (100 percent) Design. Baker will prepare design submittal packages for each of these three phases, which will be submitted to LANTDIV for review and approval. The requirements of each of these three design steps are discussed in the following subsections.

6.2.1 Preliminary Design

In the Preliminary Design phase Baker will initiate the layout and design of the groundwater collection and treatment system. Baker will prepare the following preliminary design deliverables: a basis of design report, preliminary (30 percent) design drawings, an outline of the technical specifications, supporting calculations, a construction schedule and a construction cost estimate. A more detailed description of the activities to be completed by Baker are as follows:

- Reviewing background and site-specific information provided by the Activity on the HPIA site.
- Preparing a Basis of Design Report which presents a summary of the engineering considerations incorporated into the remedial design. The Basis of Design Report will be organized in accordance with LANTDIV's A & E Guide.
- Preparing preliminary (30 percent) engineering drawings. This submittal will include preparing preliminary site plans and flow diagrams using available mapping that will show some of the considerations to be included in the final design drawings.
- Preparing a preliminary outline for Technical Specifications based on NACFAC guide specifications and prepared in the SPECSINTACT system format. The specifications will present the minimum requirements necessary for implementing the proposed treatment.
- Preparing a preliminary construction schedule in a time-scaled logic diagram format.
- Preparing a preliminary construction cost estimate spreadsheet for the project that follows the Cost Engineering Systems (CES) format.

It should be noted that the preliminary design process is scheduled to begin prior to or concurrently with the planned treatability study, which is being conducted under a separate contract task order.

6.2.2 Pre-Final Design

Upon receiving comments on the preliminary project design submittal and completion of the treatability study, Baker will continue the design activities for the Pre-Final Design stage. The deliverables that Baker will prepare for the Pre-Final submittal include the following:

- Revising the Basis of Design Report incorporating the comments from the preliminary design submittal and more detailed design information.

- Developing the Technical Specifications to include more detailed descriptions of the items in the preliminary design submittal, including incorporation of comments from Government review of the preliminary design submittal.

- Preparing detailed engineering design drawings as outlined in the preliminary design submittal. These drawings will also incorporate any changes due to comments on the preliminary design submittal.

- Revising the preliminary construction schedule incorporating information developed during the Pre-Final design process and comments received from the preliminary design submittal.

- Revising the preliminary construction cost estimate. The cost estimate for this submittal will be in CES format. A computer disk containing the complete estimate will be included in the submittal.

At this point the project design will be complete, with the Pre-Final project design submittal being made to ensure compliance with EPA, DoD and LANTDIV requirements and to review the design to ensure constructability.

6.2.3 Final Design

The Final Design submittal will finalize the design drawings and technical specifications to prepare these documents for contractor procurement. Comments received on the Pre-Final design review by LANTDIV and other governing agencies will be incorporated into the final design. The deliverables that Baker will prepare for the Pre-Final submittal include the following:

- Revising and completing the final Basis of Design Report.

- Completing the Technical Specifications incorporating comments from the Pre-Final design review.

- Preparing final engineering drawings, incorporating comments from the Pre-Final design review. Submitting thirty four (34) sets of D size drawings, one (1) set of mylar reproducibles, and one (1) set of drawings on floppy disk in a format compatible with AutoCAD Version 11 software.

- Preparing the final construction schedule incorporating comments from the Pre-Final design review.

- Preparing the final construction cost estimate by incorporating comments from the Pre-Final design review. The final construction cost estimate will be in CES format. A floppy disk containing the complete estimate will be included in the submittal.

6.3 Design/Implementation Precautions

During the design stages of the groundwater treatment system Baker will be cognizant of items that may pose special technical or implementation problems with the project. Items to be considered include:

- Availability of site access for construction and operation of groundwater extraction wells, piping, treatment, and discharge systems.

- Availability of the required electrical power for the treatment systems.

- Any easements or special access that may be required for the extraction wells, piping, and treatment system.

- The need for any formal community relation activities associated with the project.

- The impact of the groundwater extraction wells on the local hydrogeology, including any areas where ground subsidence may pose a potential problem.

Should Baker determine that one or more of these items may pose a problem to the design or implementation of the project, Baker would notify LANTDIV in order to discuss available solutions or alternatives to minimize or eliminate the problem.

FINAL

PROJECT MANAGEMENT PLAN

REMEDIAL DESIGN
HADNOT POINT INDUSTRIAL AREA
SHALLOW AQUIFER

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0134

Prepared For:

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

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

JANUARY 7, 1993

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FIGURE

1.0 INTRODUCTION

The United States Navy, Naval Facilities Engineering Command, Atlantic Division, has directed Baker Environmental, Inc. (Baker) to conduct a treatability study and remedial design for an Interim Remedial Action (IRA) for the shallow aquifer at the Hadnot Point Industrial Area (HPIA) Operable Unit at Marine Corps Base (MCB) Camp Lejeune (CLEJ) in Onslow County, North Carolina. This IRA has been documented in a Draft Final IRA Record of Decision (ROD) for the site (Baker, August 11, 1992). The Navy/Marine Corps has obtained concurrence from the State of North Carolina and the United States Environmental Protection Agency (USEPA) Region IV on this IRA.

The initial phase of this project requires Baker to develop the following project control documents:

- Remedial Design Work Plan/Treatability Study Work Plan
- Project Management Plan (PMP)
- Sampling and Analysis Plan (SAP)
- Quality Assurance Project Plans (QAPP)
- Health and Safety Plan (HASP)

This document presents the Project Management Plan (PMP). The remaining plans are contained in separate documents. Each of these plans outline specific activities related to the interim remediation of the HPIA site.

The intent of all of these documents is to present the scope of work necessary to execute a technically sound, cost effective treatability study and remedial design that satisfies the ROD issued by the USEPA.

The level of detail provided in these documents varies according to the current information available on which to base the activities associated with each element. As the project progresses and decisions are made regarding specific details of the remedial design, the work plan elements can be better defined.

This Project Management Plan is to be included as part of the Remedial Design Work Plan. The PMP identifies the organization of the project, the specific responsibilities of the field team, the design team, and the reporting lines of authority for the project personnel.

1.1 Project Organization and Responsibilities

Personnel responsible for the technical performance of this remedial design and for quality assurance throughout the duration of this project are the Project Manager and the Senior Engineer. Baker will utilize subcontractors to perform laboratory analyses, data validation, and other services that may be needed (drilling and monitoring well installation, surveying). A project organization chart is shown on Figure 1-1. This figure displays the project organization, the lines of authority and the support personnel/organizations.

The responsibilities of some key personnel are presented below:

1. The Program manager, Mr. William D. Trimbath, P.E., has final responsibility and authority for all work performed under the project. He will manage the daily operations of the entire contract and the Navy CLEAN Program management Office. He will provide overall program direction, client contact and quality assurance. From a quality perspective, the Program manager is responsible for:

    - Ensuring, through an effective quality assurance program, that program and project direction is implemented and accomplished

    - Approving and funding the quality assurance program

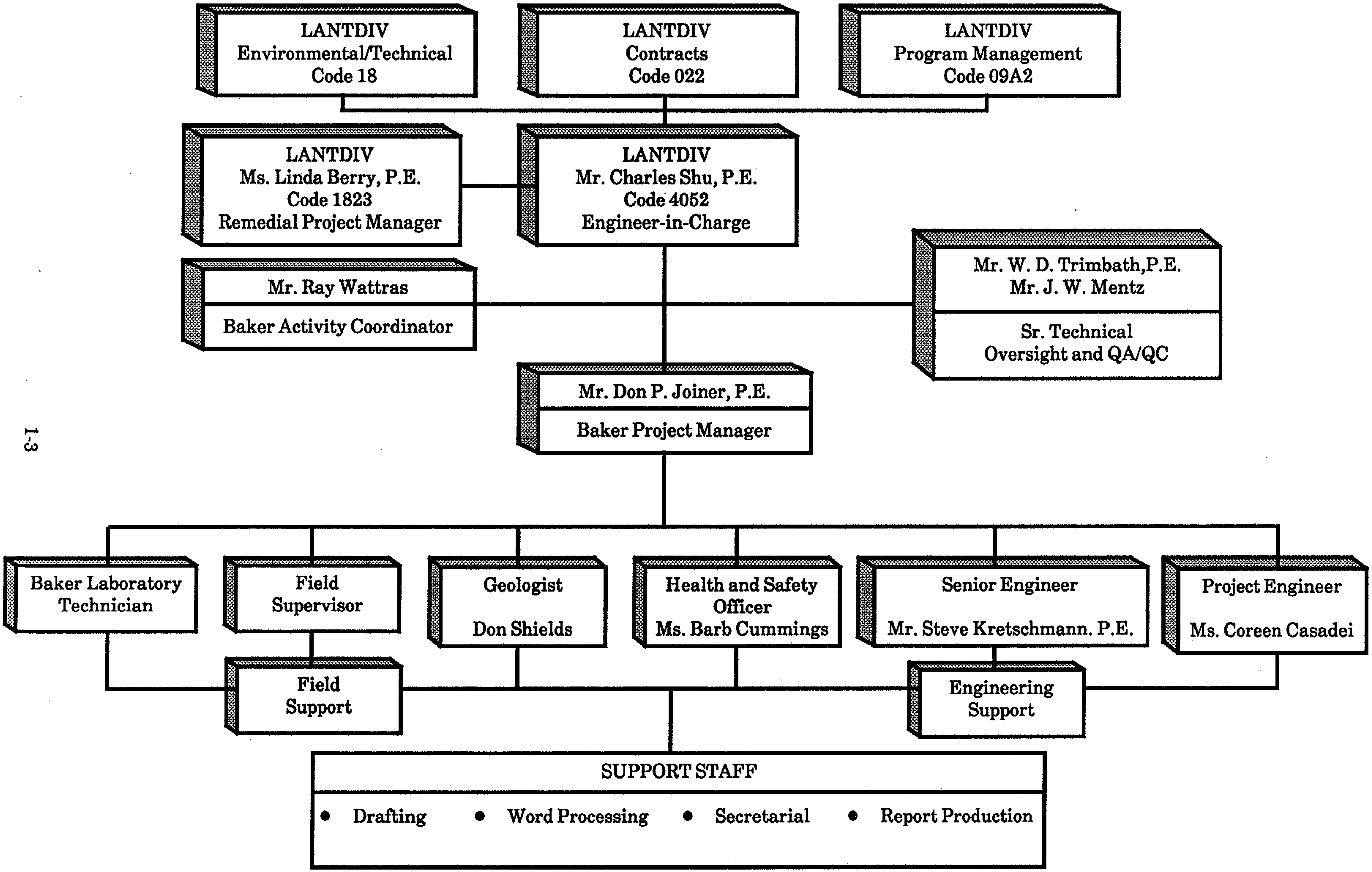
    - Participating actively in the quality assurance program

    - Assisting the Quality Assurance Officers, as necessary

2. The Deputy Program Manager, Mr. John Mentz, will serve as the primary technical contact with subcontractors, with responsibilities for budget and schedule control, project management, and health and safety issues. From a quality perspective, the Deputy Program manager has responsibilities similar to those outlined above for the Program Manager.

3. The Baker Activity Coordinator, Mr. Ray Wattras, is the liaison between Baker and LANTDIV for all MCB Camp Lejeune projects. He is to serve as the single point of

FIGURE 1-1
PROJECT ORGANIZATION



contact for both the Activity and LANTDIV personnel regarding all CLEAN work being conducted at the activity. He will serve as the communication focal point.

4. The Project Manager, Mr. Don Joiner, P.E., is responsible for managing all work for this CTO, from initiation to final closeout. He is responsible for maintaining budget, schedule, and technical performance as well as quality performance for the CTO. The Project Manager shall receive support from all project management staff and use the capabilities of the technical staff. The Project Manager is responsible for Design Work Plan for this CTO. Some specific responsibilities of the project manager are to prepare and review all invoices, provide project specific resources planning, and coordinate with LANTDIV, the Activity and the subcontractors.

5. The Senior Engineer, Mr. Steve Kretschman, P.E., is responsible for technical review of all Work Plans, Sampling and Analysis Plans, Quality Assurance Project Plans, Project Management Plans, Engineering Design Reports and Design Drawings.

6. Baker Laboratory Technician: It is the responsibility of Baker's laboratory technician to prepare and conduct the bench-scale treatability study tests as instructed in the Treatability Study Work Plan and in compliance with all applicable state and Federal regulations. The laboratory technician is also responsible for conducting bench-scale testing, effluent sampling and shipping the samples to a subcontracted laboratory for analyses. The Baker laboratory technician shall report any problems encountered or additional testing necessary to the project manager.

7. Engineering Support is responsible for preparing the project design, the design calculations, the design drawings and the engineering report. Engineering support personnel are also responsible for instructing drafting, word processing and report production personnel.

8. The geologist, Mr. Don Shields, will be responsible for interpreting aquifer test data and preparing the geological section of engineering reports. He will also be responsible for assisting in the design of pumping systems and other geological aspects of the remediation design. He will also provide assistance to the field supervisor, should it be required.

9. A Field Supervisor will be assigned to manage all field activities. The Field Supervisor will ensure that all field activities are conducted in accordance with the project plans (the Work Plan, this Field Sampling and Analysis Plan, the Quality Assurance Project Plan, and the Health and Safety Plan).

   The Field Supervisor 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 telefax. The Field Supervisor 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

10. Field Support: The field portion of this project will consist of a field team assigned to perform the pump test and conduct sampling activities for the HPIA operable unit. All field activities will be coordinated by the Field Supervisor.

    The Field Support Team will conduct all additional sampling activities as directed by the Remedial Design Work Plan (RDWP) and the Sampling and Analysis Plan (SAP).

11. The Health and Safety Officer, Ms. Barb Cummings, is responsible for preparing the Health and Safety Plans for field activities and ensuring Baker's compliance with all Health and Safety Regulations.

1.2 Project Organization

The Project Organization is shown on Figure 1-1. This figure shows the reporting lines of authority for the design team as well as the organization of all personnel involved with the project.

FINAL

SAMPLING AND ANALYSIS PLAN

REMEDIAL DESIGN
HADNOT POINT INDUSTRIAL AREA
SHALLOW AQUIFER

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0134

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The intent of all of these documents is to present the scope of work necessary to execute a technically sound, cost effective treatability study and remedial design that satisfies the ROD issued by U.S. EPA.

The level of detail provided in these documents varies according to the current information available on which to base the activities associated with each element. As the project progresses and decisions are made regarding specific details of the remedial design, the work plan elements can be better defined.

The following discussion provides project background, the purpose and objectives and organization of the SAP.

1.1 Purpose of the Sampling and Analysis Plan

The purpose of the SAP is to provide guidance for the field activities presented in the Remedial Design Work Plan (RDWP) by describing in detail the sampling and data collection methods to be used to implement the RDWP for CTO-0134. The guidance also helps to insure that sampling and data collection activities are carried out in accordance with EPA Region IV and Naval Energy and Environmental Support Activity (NEESA) practices so that data obtained during the remedial design are of sufficient quantity and quality to evaluate the potential technologies for remediation of the contaminated groundwater.

The project described here, and in the other project control documents, is oriented to conform with the requirements of the remedial action recommended in the ROD, according to the appropriate and applicable guidance and regulations of CERCLA, RCRA and other relevant environmental programs, and in accordance with standard engineering practice.

The remedial alternative recommended in the ROD is confined to an interim action designed to address only the shallow aquifer at the HPIA Operable Unit, and is designed to protect human health and the environment from exposure to benzene, trichloroethylene (TCE), 1,2-dichloroethene (1,2-DCE), and various metals in the shallow aquifer.

1.2 Sampling and Analysis Plan Format

The remaining portion of this section presents the background and setting of the HPIA. Section 2.0 (Data Quality Objectives) identifies the Data Quality Objective (DQOs) for the field sampling program described in the Treatability Study Work Plan. The media, number and types of samples, and the frequency of sampling are discussed in Section 3.0 (Sampling Locations and Frequency). Section 4.0 (Sample Designation) describes the sample numbering scheme to be followed for identifying and tracking the samples. The investigative procedures for collecting the groundwater and surface water samples are presented in Section 5.0 (Investigative Procedures). Sample handling and analysis is described in Section 6.0 (Sample Handling and Analysis). Project management activities are presented in the Project Management Plan, which is presented in a separate document.

1.3 Background and Setting

Information on MCB Camp Lejeune, and on the HPIA in particular, is presented in detail in Section 2.0 of the RDWP.

2.0 DATA QUALITY OBJECTIVES

Data quality objectives are described in detail in Section 5.0 of the Quality Assurance Project Plan.

3.0 SAMPLING LOCATIONS AND FREQUENCY

This section of the SAP identifies the groundwater and wastewater sampling matrices to be collected and the constituents to be analyzed for the bench-scale testing and the pilot-scale/pump testing.

3.1 Groundwater Sample Collection During 72-Hour Aquifer Pump Test

Samples of the groundwater extracted during the 72-hour aquifer pump test will be collected. The samples will be collected from the sampling ports at the influent to the air stripper, effluent from the air stripper, and effluent from the carbon adsorption unit.

These groundwater characterization samples will be collected from the 4-inch extraction well during the pump test. Samples will be collected every 12 hours during the pump test. These samples will be submitted to the laboratory for analyses of purgeable halocarbons (EPA Method 601), purgeable aromatic (EPA Method 602), TAL metals, and engineering parameters.

3.2 Bench-Scale Sampling

In order to determine the effectiveness of the proposed groundwater treatment system, the bench-scale testing water will be sampled and analyzed. The bench-scale testing consists of three different testing procedures: sample characterization, oil and grease removal, and chemical treatment jar tests. Sampling and analytical testing will be conducted with each bench-scale testing procedure. The bench-scale testing procedures and sampling requirements are discussed in the following sections.

3.2.1 Sample Characterization

One characterization sample (unfiltered raw composite) will be submitted to a laboratory for analytical testing for TAL metals and selected engineering parameters. The second characterization sample will be a raw composite sample that will be vacuum filtered through a 45 micron filter. After filtration, the sample will be analyzed for TAL metals.

3.2.2 Oil and Grease Removal

Three oil and grease samples will be drawn from the bottom of their testing jars. These three samples will be analyzed for oil and grease by EPA Method 413.1. Three duplicate oil and grease quality assurance/quality control (QA/QC) samples will be taken for these tests.

3.2.3 Chemical Treatment Jar Tests (Metals Removal)

Should the characterization sample show metals contamination above MCLs, one-liter jar tests will be performed to investigate the applicability of precipitation of lead, the primary inorganic contaminant of concern, in its carbonate and hydroxide forms. A sample test matrix has been established (Section 3.5, RDWP) with a total of six samples to be analyzed for TAL metals.

3.3 QA/QC Samples

QA/QC requirements for this investigation are presented in the Quality Assurance Project Plan (QAPP). Field QA/QC samples will be collected during field sampling activities. Field QA/QC samples include:

- Trip Blanks

  Trip blanks are defined as samples which originate from organic-free deionized water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic analysis (VOA) samples. One trip blank should accompany each cooler containing VOAs, should be stored at the laboratory with the samples, and analyzed by the laboratory. Trip blanks are only analyzed for VOAs.

- Equipment Rinsates

  Equipment rinsates are the final organic-free deionized water rinse from equipment cleaning collected daily during a sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples must be analyzed. The results from the blanks will be used to flag or assess the levels of analytes in the samples. This comparison is made during data validation. The rinsates are analyzed for the same parameters as the related samples.

One equipment rinsate will be collected per day of field sampling.

- Field Blanks

  Field blanks consist of the source water used in decontamination and steam cleaning. At a minimum, one field blank from each event and each source of water must be collected and analyzed for the same parameters as the related samples.

  One field blank per source per event will be collected.

- Field Duplicates/Split Samples

  Field duplicates (or split samples) for soil samples are collected, homogenized, and split. All samples except VOAs are homogenized and split. Volatiles are not mixed, but select segments of soil are taken from the length of the core and placed in 4-ounce glass jars. The duplicates for water samples should be collected simultaneously. The water samples will not be composited.

  Field duplicates will be collected at a frequency of 10 percent.

- Preservative Blanks

  Preservative blanks are prepared by putting organic-free deionized water in the containers and then preserving the samples with the appropriate preservatives. These samples are submitted to the laboratory for full TCL or TAL analysis. One round of preservative blanks will be collected during this investigation.

4.0 SAMPLE DESIGNATION

All samples collected during the bench-scale test and pilot-scale test, including QA/QC samples, will be designated a unique number. The number will serve to identify the investigation, the site, the sample media, sampling location, the round of sample, and QA/QC qualifiers.

The sample designation format is as follows:

Site # - Media - Location - Round(QA/QC)

An explanation of each of these identifiers is given below.

Site #:	The HPIA
Media:	GW = Groundwater SW = Surface Water
Location:	The location numbers identify the sampling location. This will include the monitoring well number.
Round QA/QC:	(FB) = Field Blank (D) = Duplicate Sample (TB) = Trip Blank (ER) = Equipment Rinsate (PB) = Preservative Blank

Under this sample designation format the sample number 78-GW-20-1-D refers to:

78-GW-20-1-D	Site 78
78-GW-20-1-D	Groundwater Sample
78-GW-20-1-D	Monitoring Well No. 20
78-GW-20-1-D	Round 1
78-GW-20-1-D	Duplicate (QA/QC) Sample

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

5.0 INVESTIGATIVE PROCEDURES

This section presents the sampling procedures to be followed during this project for collecting groundwater samples.

5.1 Groundwater Samples Collected for the Treatability Study

Groundwater samples will be collected from Monitoring Well HPGW 24-1 and the pumping well during the bench-scale test and the pilot-scale tests in accordance with the following procedures.

5.1.1 Bench-Scale Groundwater Sample Collection

The collection of an initial groundwater sample prior to the start of the bench-scale test includes the following steps:

1. First open the well cap on Monitoring Well HPGW 24-1 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. If volatile organic detection equipment measurements in the work area are greater than 5 ppm for five continuous minutes, or if an instantaneous reading is greater than 500 ppm, work will stop and the Project Health and Safety Officer will be notified.

2. If volatile organic measurements are acceptable, sound the well for total depth and water level (decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well.

3. Lower purging equipment (submersible pump) into the well to a short distance below the water level and begin water removal. Pump the purged water into 55-gallon drums.

4. Measure the rate of discharge using a bucket and stopwatch.

5. 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.

6. Record measurements of specific conductance, temperature, and pH during purging to ensure the groundwater stabilizes. These measurements will be made after each well volume.

7. Lower the teflon bailer into the well, submerge into the groundwater, and retrieve. Pour groundwater from the bailer into the laboratory-supplied sample bottles. Clean nonpowdered latex or vinyl gloves will be worn by sampling personnel.

8. Samples collected for TAL inorganics will be analyzed for both total and dissolved constituents. Samples collected for analysis of dissolved TAL inorganics will be passed through a 45 micron filter.

Sample preservation handling procedures are outlined in Section 6.

5.1.2 Groundwater Sample Collection During Pilot-Scale and Pump Testing

During the pilot test groundwater samples from the pumping well will be collected every 12 hours. During these sampling events, samples will be collected from the sampling ports located at the influent to the air stripper, effluent from the air stripper, and effluent from the carbon adsorption unit. Sample collection and handling procedures outlined in Section 5.1.1 will be utilized.

The samples will be collected by pouring the effluent directly to the laboratory-supplied sample bottles. Clean nonpowdered latex or vinyl gloves will be worn by sampling personnel at each sampling station.

Care will be taken when collecting samples for analysis of volatile organics compounds (VOCs) to avoid excessive agitation that could result in loss of VOCs. VOC samples will be collected prior to the collection of the samples for analysis of the other parameters. Sample bottles will be filled in the same order at all sampling stations.

Temperature, pH, specific conductance, and dissolved oxygen of the water will be measured at each sampling location, prior to sample collection.

Sample preservation and handling procedures are outlined in Section 6.

5.2 Decontamination Procedures

Equipment and materials utilized during this investigation that will require decontamination fall into two broad categories:

- Field measurement and sampling equipment: water level meters, bailers, compositing bottles, hand covers, etc.
- Large machinery and equipment: tanker trucks

The following decontamination procedures are taken from USEPA IV Standard Operating Procedures (1991).

5.2.1 Field Measurement Sampling Equipment

5.2.1.1 Cleaning Procedures for Teflon® or Glass Field Sampling Equipment used for the Collection of Samples for Trace Organic Compounds and/or Metals Analyses

1. Equipment will be washed thoroughly with laboratory detergent and hot water using a brush to remove any particulate matter or surface film.

2. The equipment will be rinsed thoroughly with hot tap water.

3. Rinse equipment with at least a 10 percent nitric acid solution.

4. Rinse equipment thoroughly with hot tap water.

5. Rinse equipment thoroughly with deionized water.

6. Rinse equipment twice with solvent and allow to air dry for at least 24 hours.

7. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and date.

8. Rinse the Teflon® or glass sampling equipment thoroughly with tap water in the field as soon as possible after use.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone or hexane to remove the materials before proceeding with Step 1. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the field equipment cannot be cleaned utilizing these procedures, it should be discarded.

Small and awkward equipment such as vacuum bottle inserts and well bailers may be soaked in the nitric acid solution instead of being rinsed with it. Fresh nitric acid solution should be prepared for each cleaning session.

5.2.1.2 Cleaning Procedures for Stainless Steel or Metal Sampling Equipment used for the Collection of Samples for Trace Organic Compounds and/or Metals Analyses

1. Wash equipment thoroughly with laboratory detergent and hot water using a brush to remove any particulate matter or surface film.
2. Rinse equipment thoroughly with hot tap water.
3. Rinse equipment thoroughly with deionized water.
4. Rinse equipment twice with solvent and allow to air dry for at least 24 hours.
5. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and date.
6. Rinse the stainless steel or metal sampling equipment thoroughly with tap water in the field as soon as possible after use.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone or hexane to remove the materials before proceeding with Step 1. In extreme cases, when equipment is painted, badly rusted, or coated with materials that are difficult to remove, it may be necessary to steam clean, wire brush, or sandblast equipment before proceeding with Step 1. Any metal sampling equipment that cannot be cleaned using these procedures should be discarded.

5.2.1.3 Reusable Glass Composite Sample Containers

1. Wash containers thoroughly with hot tap water and laboratory detergent, using a bottle brush to remove particulate matter and surface film.
2. Rinse containers thoroughly with hot tap water.
3. Rinse containers with at least 10 percent nitric acid.
4. Rinse containers thoroughly with tap water.
5. Rinse containers thoroughly with deionized water.
6. Rinse twice with solvent and allow to air dry for at least 24 hours.
7. Cap with aluminum foil or Teflon® film.
8. After using, rinse with tap water in the field, seal with aluminum foil to keep the interior of the container wet, and return to the laboratory.

When these containers are used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the container several times with pesticide-grade acetone before proceeding with Step 1. If these materials cannot be removed with acetone, the container should be discarded. Glass reusable composite containers used to collect samples at pesticide, herbicide, or other chemical manufacturing facilities that produce toxic or noxious compounds shall be properly disposed of (preferably at the facility) at the conclusion of sampling activities and shall not be returned for cleaning. Also, glass composite containers used to collect in-process wastewater samples at industrial facilities shall be discarded after sampling. Any bottles that have a visible film, scale, or discoloration remaining after this cleaning procedure shall also be discarded.

5.2.1.4 Plastic Reusable Composite Sample Containers

1. Proceed with the cleaning procedures as outlined in Section 5.2.1.3 but omit the solvent rinse.

Plastic reusable sample containers used to collect samples from facilities that produce toxic or noxious compounds or are used to collect in-process waste stream samples at industrial facilities will be properly disposed of (preferably at the facility) at the conclusion of the sampling activities and will not be returned for cleaning. Any plastic composite sample containers that have a visible film, scale, or other discoloration remaining after this cleaning procedure will be discarded.

5.2.1.5 Well Sounders or Tapes Used to Measure Ground Water Levels

1. Wash with laboratory detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Allow to air dry overnight.
5. Wrap equipment in aluminum foil (with tab for easy removal), seal in plastic, and date.

5.2.1.6 Submersible Pumps and Hoses Used to Purge Ground Water Wells

1. Using a brush, scrub the exterior of the contaminated hose and pump with soapy water.
2. Rinse the soap from the outside of pump and hose with tap water.
3. Rinse the tap water residue from the outside of pump and hose with deionized water.
4. Place hose in clean bucket filled with deionized water and pump deionized water through the hose.

5. Equipment should be placed in a polyethylene bag or wrapped with polyethylene film to prevent contamination during storage or transit.

5.2.2 Large Machinery and Equipment

All drilling rigs, drilling and sampling equipment, backhoes, and all other associated equipment involved in the drilling and sampling activities shall be cleaned and decontaminated before entering the designated drill site. All equipment should be inspected before entering the site to ensure that there are no fluids leaking and that all gaskets and seals are intact. All drilling and associated equipment entering a site shall be clean of any contaminants that may have been transported from another hazardous waste site, thereby minimizing the potential for cross-contamination. Before site drilling activities are initiated, all drilling equipment shall be thoroughly cleaned and decontaminated at the designated cleaning/decontamination area. The following requirements and procedures are to be strictly adhered to on all drilling activities.

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) shall be steam cleaned before being brought on the site to remove all rust, soil and other material which may have come from other hazardous waste sites. The drill rig and/or other equipment associated with the drilling and sampling activities shall be inspected to insure that all oil, grease, hydraulic fluid, etc., have been removed, and all seals and gaskets are intact and there are no fluid leaks. No oils or grease shall be used to lubricate drill stem threads or any other drilling equipment being used over the borehole or in the borehole without EPA approval. If drill stems have a tendency to tighten during drilling, Teflon® string can be used on the drill stem threads. The drill rig(s) shall be steam cleaned prior to drilling each borehole. In addition, all downhole sampling equipment that will come into contact with the downhole equipment and sample medium shall be cleaned and decontaminated by the following procedures.

1. Clean with tap water and laboratory grade, phosphate-free detergent, using a brush, if necessary, to remove particulate matter and surface films. Steam cleaning and/or high pressure hot water washing may be necessary to remove matter that is difficult to remove with the brush. Hollow-stem augers, drill rods, shelby tubes, etc., that are hollow or have holes that transmit water or drilling fluids, shall be cleaned on the inside and outside. The steam cleaner and/or high pressure hot water washer shall be

capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam (200°F plus).

2. Rinse thoroughly with tap water (potable).

   NOTE: Tap water (potable) may be applied with a pump sprayer. All other decontamination liquids (D.I. water, organic-free water, and solvents), however, must be applied with noninterfering containers. These containers shall be made of glass, Teflon®, or stainless steel. This aspect of the decontamination procedures used by the driller will be inspected by the site geologist and/or other responsible person prior to beginning of operations.

3. Rinse thoroughly with deionized water.

4. Rinse twice with solvent (pesticide grade isopropanol).

5. Rinse thoroughly with organic-free water and allow to air dry. Do not rinse with deionized or distilled water.

   Organic-free water can be processed on site by purchasing or leasing a mobile deionization-organic filtration system.

   In some cases when no organic-free water is available, it is permissible (with approval) to leave off the organic-free water rinse and allow the equipment air dry before use.

6. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported. Clean plastic can be used to wrap augers, drill stems, casings, etc., if they have been air dried.

7. All downhole augering, drilling and sampling equipment shall be sandblasted before Step #1 if painted, and/or if there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam and/or high pressure cleaning. All sandblasting shall be performed prior to arrival on site.

8. All well casing, tremie tubing, etc., that arrive on site with printing and/or writing on them shall be removed before Step #1. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can supply materials without the printing and/or writing if specified when materials are ordered.

9. Well casing, tremie tubing, etc., that are made of plastic (PVC) shall not be solvent rinsed during the cleaning and decontamination process. Used plastic materials that cannot be cleaned are not acceptable and shall be discarded.

Cleaning and decontamination of all equipment shall occur at a designated area on the site, downgradient, and downwind from the clean equipment drying and storage area. All cleaning of drill rods, auger flights, well screen and casing, etc., will be conducted above the plastic sheeting using saw horses or other appropriate means. At the completion of the drilling activities, the pit shall be backfilled with the appropriate material designated by the Site Manager, but only after the pit has been sampled, and the waste/rinse water has been pumped into 55-gallon drums. No solvent rinsates will be placed in the pit unless prior approval is granted. All solvent rinsates shall be collected in separate containers for proper disposal.

6.0 SAMPLE HANDLING AND ANALYSIS

6.1 Sample Program Operations

Field activities will be conducted according to the guidance of USEPA Region IV Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (February 1, 1991).

The number of samples (including QA/QC samples), analytical method, data quality level and laboratory turnaround times are included in Table 6-1. Preservation requirements, bottle requirements and holding times are included in the Quality Assurance Project Plan. Collection procedures for field QA/QC samples are outlined in Section 3.3.

6.2 Chain-of-Custody

Chain-of-custody procedures will be followed to ensure a documented, traceable link between measurement results and the sample/parameter that they represent. These procedures are intended to provide a legally acceptable record of sample preparation, storage and analysis.

To track sample custody transfers before ultimate disposition, sample custody will be documented using the chain-of-custody form shown in Figure 6-1. A chain-of-custody seal is shown in Figure 6-2. A sample label is shown in Figure 6-3. In addition, a master logbook will be used as a centralized mechanism for documenting project activities.

A chain-of-custody form will be completed for each container in which the samples are shipped. The shipping containers will usually be coolers. After the samples are properly packaged, the coolers will be sealed and prepared for shipment. Custody seals will be placed on the outside of the coolers to ensure that the samples are not disturbed prior to reaching the laboratory.

A field notebook, containing a master sample log, will be maintained for the site.

6.3 Logbooks and Field Forms

Field notebooks and a master sample log will be used to record sampling activities and information. Field notebooks will be bound, field survey books with numbered pages.

TABLE 6-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAMS AT THE HPIA OPERABLE UNIT MCB CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline No. of Samples(1)	Analysis	Data Quality Level	Analytical Method	Laboratory Turnaround Time	Field QA/QC Samples(3)	
							Field Duplicates	Field Blanks
HPIA Operable Unit Characterization Samples	Groundwater	1 Raw Unfiltered Sample	TAL Metals	III	EPA 200.7 EPA 204.2 EPA 206.2 EPA 213.2 EPA 215.1 EPA 218.2 EPA 239.2 EPA 245.1 EPA 270.2 EPA 279.2	48 hours	1	1
			Engineering Parameters:					
			Ammonia	III	EPA 350.2			
			Bicarbonate	III	SM 403/40			
			Carbonate	III	SM 403/40			
			Chloride	III	EPA 325.2			
			Hardness	III	EPA 130.2			
			Nitrate/Nitrite	III	EPA 353.2			
			Oil & Grease	III	EPA 413.1			
			TDS	III	EPA 160.1			
			TSS	III	EPA 160.2			
		1 Filtered Sample	TAL Metals	III	See Above	48 hours	1	1
Bench-Scale Treatability Studies	Groundwater	1 Run x 3 Samples per Run = 3 Total	Oil and Grease	III	EPA 413.1	Routine(2)	3	1
		6 (Metals Removal)	TAL Metals	III	See Above	Routine	1	1

TSS = Total Suspended Solids
TDS = Total Dissolved Solids
(1) Baseline number of samples do not include field QA/QC samples.
(2) *Routine analytical turnaround is between 28 to 40 days following receipt of sample.*
(3) Other Field QA/QC samples are:
Trip Blank - 1 per cooler (VOCs only)
Equipment Rinsate - 1 per day for each parameter sampled
Matrix Spike/Matrix Spike Duplicate - 1 per 20 samples

TABLE 6-1 (Continued)

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAMS AT THE HPIA OPERABLE UNIT
MCB CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline No. of Samples(1)	Analysis	Data Quality Level	Analytical Method	Laboratory Turnaround Time	Field QA/QC Samples(3)	
							Field Duplicates	Field Blanks
Pilot-Scale Treatability Studies	Groundwater	7 Runs x 3 Samplers per Run = 21	Purgeable Halocarbons	III	EPA 601	Routine	7	7
			Purgeable Aromatics	III	EPA 602			
			TAL Metals	III	EPA 200.7 EPA 204.2 EPA 206.2 EPA 213.2 EPA 215.1 EPA 218.2 EPA 239.2 EPA 245.1 EPA 270.2 EPA 279.2			
			Engineering Parameters:					
			Ammonia	III	EPA 350.2			
			Bicarbonate	III	SM 403/40			
			Carbonate	III	SM 403/40			
			Chloride	III	EPA 325.2			
			Hardness	III	EPA 130.2			
			Nitrate/Nitrite	III	EPA 353.2			
			Oil & Grease	III	EPA 413.1			
			TDS	III	EPA 160.1			
			TSS	III	EPA 160.2			
		2 Influent and 2 Effluent = 4	Oil and Grease	III	EPA 413.1	Routine	1	1
		1 Influent and 1 Effluent = 2	Multi-Concentration Acute Toxicity	III	EPA/600/4-90-027	Routine		

TSS = Total Suspended Solids
TDS = Total Dissolved Solids
(1) Baseline number of samples do not include field QA/QC samples.
(2) Routine analytical turnaround is between 28 to 40 days following receipt of sample.
(3) Other Field QA/QC samples are:
Trip Blank - 1 per cooler (VOCs only)
Equipment Rinsate - 1 per day for each parameter sampled
Matrix Spike/Matrix Spike Duplicate - 1 per 20 samples

FIGURE 6-1

CHAIN-OF-CUSTODY RECORD

oject Name:

S. O. Number:

Sampler: (Print)

Signature:

Sheet ____ of ____

BAKER ENVIRONMENTAL, INC.
Airport Office Park - Bldg No. 3
420 Rouser Road
Coraopolis, PA 15108
(412) 269-6000

				Sample Storage and Preservation Details*									
		Sampled		Cooling		HNO$_3$		H$_2$SO$_4$ Cooling		Other		Other	
Baker Sample I.D. No.	Sample Type	Date	Time	No. of Contnr.	Type/ Volume Contnr.	No. of Contnr.	Type/ Volume Contnr.	No. of Contnr.	Type/ Volume Contnr.	No. of Contnr.	Type/ Volume Contnr.	No. of Contnr.	Type/ Volume Contnr.

General Remarks:

*NOTES: Record type of container used with abbreviation P (plastic) or G (glass)
Record volume of containers in leters

Relinguished By (Sign):
Date: Time:
Remarks:

Received By (Sign):
Date: Time:
Remarks:

Shipment/Transportation Details:

Relinguished By (Sign):
Date: Time:
Remarks:

Received By (Sign):
Date: Time:
Remarks:

Shipment/Transportation Details:

Relinguished By (Sign):
Date: Time:
Remarks:

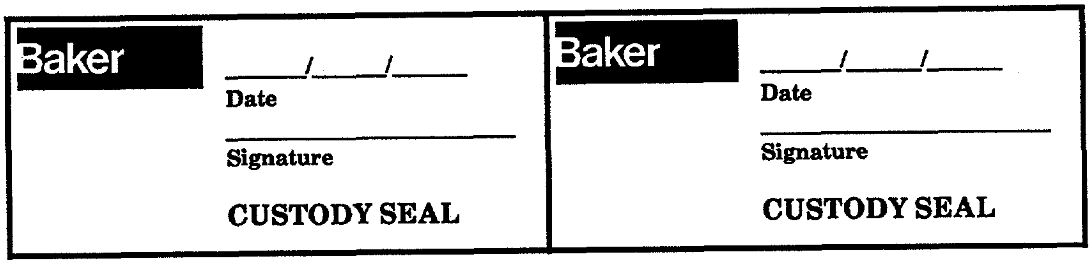
Received By (Sign):
Date: Time:
Remarks:

Shipment/Transportation Details:

Distribution:
- Original - Sent with samples to lab (return with lab results to Project Manager for filing)
- Copy - Retained by sampling personnel for filing

FIGURE 6-2

EXAMPLE CUSTODY SEAL



Baker

_____/_____/_____

Date

____

Signature

CUSTODY SEAL

Baker

_____/_____/_____

Date

____

Signature

CUSTODY SEAL

FIGURE 6-3

EXAMPLE SAMPLE LABEL

Baker

Baker Environmental Inc.
Airport Office Park, Bldg. 3
420 Rouser Road
Coraopolis, PA 15108

Project: ____________________ **CTO No.:** ____________

Sample Description: ______________________________

Date: ____/____/____ **Sampler:** ________________

Time: ____________

Analysis: ______________ **Preservation:** __________

Project Sample No.: ______________________________

Notebooks will be copied and submitted to the field sampling task leader, for filing upon completion of the assignment. The cover of each logbook will contain:

- The name of the person to whom the book is assigned
- The book number
- The project name
- Entry start date
- Entry completion date

Entries will include general sampling information so that site activities may be reconstructed. The beginning of each entry will include the date, sampling site, start time, weather conditions, field personnel present and level of personal protection. Other possible entries would be names and purpose of any visitors to the vicinity during sampling, unusual conditions which might impact the interpretation of the subsequent sampling data, or problems with the sampling equipment. All entries will be in ink with no erasures. Incorrect entries will be crossed out with a single strike and initialed.

A master sample log will be maintained on site for all samples taken. A full description of the sample, its origin and its condition will be included in the master log entry.

6.4 Sample Logbook

The sample logbook is a three-ring binder which contains sample log sheets for each sample collected. A sample log sheet (Figure 6-4) is filled out for each and every sample collected. This form records vital information concerning the sample source, sampling methods, sample conditions and field measurements, and is used for sample validation and report preparation. The sample log sheets are numbered in order when placed in the sample logbook, and the sample number and log sheet page number are recorded on the sample logbook table of contents sheets (which is placed at the front of the sample logbook) for easy reference and access.

FIGURE 6-4

FIELD TEST BORING RECORD

Baker
Baker Environmental, Inc

PROJECT: ____________________
CTO NO.: ____________________ BORING NO.: ____________________
COORDINATES: EAST: ____________________ NORTH: ____________________
ELEVATION: SURFACE: ____________________ TOP OF STEEL CASING: ____________________

RIG:									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)									
LENGTH									
TYPE									
HAMMER WT.									
FALL									
STICK UP									

REMARKS: ____________________

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL	Sample ID	Samp. Rec.	SPT Blows Per 0.5'	Lab. Class	Lab. M.C. %	Classification (Grain Size, Principal Constituents, Etc.)	Color	Consist. or Density	Moisture Content, Organic Content, Plasticity, and Other Observations	SOIL	ELEVATION
	ROCK	Type - No. (N = No Samp.)	(Ft. & %)	*RQD (Ft. & %)*	*Pen. Rate*		*Classification (Name, Grain Size, Principal Constituents, Etc.)*	*Color*	*Hardness*	*Weathering, Bedding, Fracturing, and Other Observations*	*ROCK*	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

DRILLING CO.: ____________________ BAKER REP.: ____________________
DRILLER: ____________________ BORING NO.: ____________________ SHEET ____ OF ____

FIGURE 6-4 (CONTINUED)

Baker

Baker Environmental, Inc

FIELD TEST BORING RECORD

PROJECT: ______________________________

CTO NO.: ____________________ BORING NO.: ____________

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL	Sample ID -----	Samp. Rec.	SPT Blows Per 0.5'	Lab. Class	Lab. M.C. %	Classification (Grain Size, Principal Constituents, Etc.)	Color	Consist. or Density	Moisture Content, Organic Content, Plasticity, and Other Observations	SOIL	ELEVATION
	ROCK	Type - No. (N = No Samp.)	(Ft. & %)	*RQD (Ft. & %)*	*Pen. Rate*		***Classification (Name, Grain Size, Principal Constituents, Etc.)***	***Color***	***Hardness***	***Weathering, Bedding, Fracturing, and Other Observations***	*ROCK*	
1												
2												
3												
4												
5												
6												
7												
8												
9												
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
0												

DRILLING CO.: ______________________ BAKER REP.: ______________________

DRILLER: ______________________ BORING NO.: ______________ SHEET ____ OF ____

FINAL

QUALITY ASSURANCE PROJECT PLAN

REMEDIAL DESIGN
HADNOT POINT INDUSTRIAL AREA
SHALLOW AQUIFER

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0134

Prepared For:

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

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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JANUARY 7, 1993

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1.0 INTRODUCTION

The United States Navy, Naval Facilities Engineering Command, Atlantic Division, has directed Baker Environmental, Inc. (Baker) to conduct a treatability study and remedial design for an Interim Remedial Action (IRA) for the shallow aquifer at the Hadnot Point Industrial Area (HPIA) Operable Unit at Marine Corps Base (MCB) Camp Lejeune (CLEJ) in Onslow County, North Carolina. This IRA has been documented in a Draft Final IRA Record of Decision (ROD) for the site (Baker, August 11, 1992). The Navy/Marine Corps has obtained concurrence from the State of North Carolina and the United States Environmental Protection Agency (USEPA) Region IV on this IRA.

The initial phase of this project requires Baker to develop the following project control documents:

- Remedial Design Work Plan/Treatability Study Work Plan
- Project Management Plan (PMP)
- Sampling and Analysis Plan (SAP)
- Quality Assurance Project Plans (QAPP)
- Health and Safety Plan (HASP)

This document presents the Quality Assurance Project Plan. The remaining plans are contained in separate documents. Each of these plans outline specific activities related to the interim remediation of the HPIA site.

The intent of all of these documents is to present the scope of work necessary to execute a technically sound, cost effective treatability study and remedial design that satisfies the ROD issued by the USEPA.

The level of detail provided in these documents varies according to the current information available on which to base the activities associated with each element. As the project progresses and decisions are made regarding specific details of the remedial design, the work plan elements can be better defined.

The preparation of this QAPP, and other related project plans, is being performed under the Navy CLEAN Contract Task Order 0134. This QAPP addresses the quality assurance and quality control steps and procedures that will be administered for the sample collection and analysis for this interim remedial action. 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 Sampling and Analysis Plan (SAP).

2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) addresses sample collection and analysis to be conducted for the Interim Remedial Action at the Hadnot Point Operable Unit of Camp Lejeune, North Carolina. The QAPP has been developed for the Department of Navy (DoN) in accordance with U. S. Environmental Protection Agency (USEPA) guidelines. Contractors will follow 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 interim action will require:

1. Use of a NEESA-certified analytical laboratory;

2. Use of accepted analytical methods for the samples outlined in the Sampling and Analysis Plan (SAP). Analysis of samples for hazardous constituents parameters will be performed using the following documents:

   - "Statement of Work for Inorganic Analysis," USEPA, ILM02.0, March 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

3. Field audit(s) during initial sampling activities to verify that sampling is being performed according to the Plan.

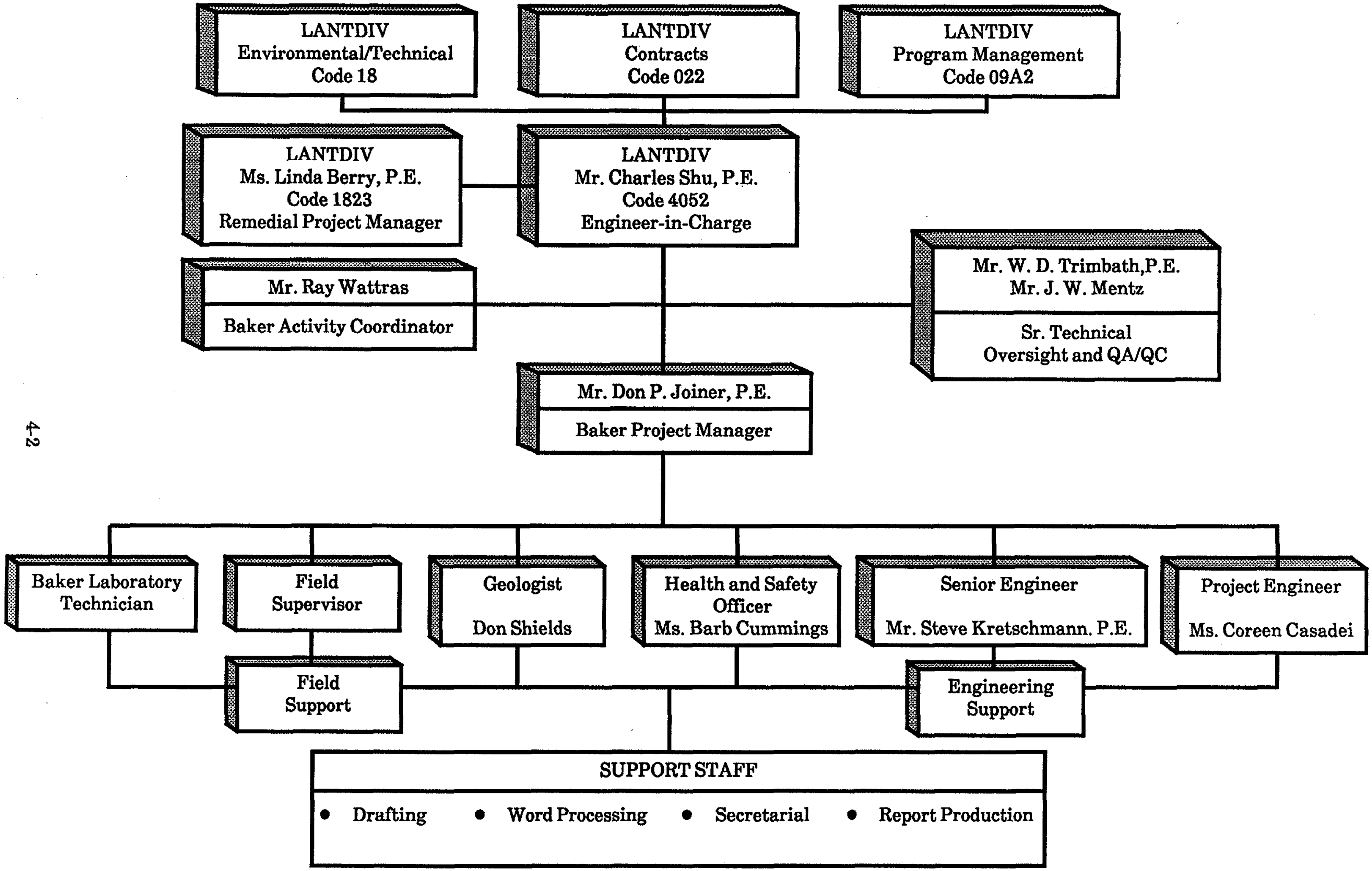
3.0 PROJECT DESCRIPTION

An introduction to the planned IRA at the Hadnot Point Operable Unit describing the project objectives and scope are given in the IRA Work Plan. This work plan discusses the objectives of the IRA, and the various field sampling and analytical programs. A detailed description of the field investigations, including sample location and designation, sampling procedures and frequency, and sample handling and analysis is presented in Sections 3.0, 4.0, 5.0, and 6.0 of the SAP.

4.0 PROJECT ORGANIZATION

Technical performance of the IRA at the Hadnot Point Operable Unit at MCB Camp Lejeune and key personnel responsible for quality assurance throughout its duration are described in the Project Management Plan. The contractor will utilize subcontractors to perform laboratory analysis and data validation. Specific subcontractors have not yet been identified. Figure 4-1 shows the project organization, lines of authority, and support personnel/organizations.

FIGURE 4-1
PROJECT ORGANIZATION



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

Project QA objectives are:

- Scientific data will be of a quality sufficient to meet scientific and legal scrutiny;
- Data will be gathered/developed in accordance with procedures appropriate for the intended use of the data; and
- Data will be 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:

- 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; and
- 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 quality control (QC) procedures to be followed by the laboratory during the course of the project.

This QAPP 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 U.S. EPA 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 Inorganic Analysis," USEPA , ILM02.0, March 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
- "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 are given in Table 5-1.

The Project Manager, in conjunction with the Navy Engineer-in-Charge (EIC), is responsible for defining the DQOs. 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

TABLE 5-1

DEFINITIONS OF DATA QUALITY INDICATORS

PRECISION - A measure of mutual agreement among individual measurements of the same 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 likelihood of all types of errors associated with a particular decision.

limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The data collected during the course of the IRA will be used:

- To characterize the wastes to be contained and/or managed; and,

- To assess the effectiveness of remedial technologies being considered for the shallow aquifer of the Hadnot Point Operable Unit.

All samples for evaluating remedial alternatives via a treatability study will be analyzed and reported by the laboratory as Level III data. Samples collected to evaluate process options (e.g., TDS, TSS, etc.) will be analyzed and reported by the laboratory as Level III data quality. Field parameters including temperature (aqueous only), pH, and specific conductance will be Level I data quality.

6.0 SAMPLING PROCEDURES

Descriptions of the procedures to be used for sampling the groundwater at the site are provided in Section 5.0 of the SAP. The number of samples, sampling locations, and sampling rationale by media also are presented in the SAP.

7.0 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 SAP. 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: (1) ensure complete analysis of the requested parameters within the required turnaround times; and (2) document the sample from the point of collection to the final data report.

7.1 Sampling Handling

New polyethylene or glass bottles containing the proper preservatives will be provided by the laboratory 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 (see Table 7-1 for summaries of containers, preservation, and holding times for water).

7.2 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; or
- It is in a secure area.

TABLE 7-1

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR WATER SAMPLES

Parameter	Container	Preservation	Holding Time
TCL Volatiles	Two 40-ml vials with teflon septum caps	Cool to 4°C HCl pH <2	14 days (7 days if unpreserved)
TCL Semivolatiles	1-liter amber glass bottle with teflon caps	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis
TAL Metals	1-liter polyethylene bottle	HNO_3 pH <2	6 months; Mercury 28 days
TSS	1-liter polyethylene bottle	Cool to 4°C	7 days
TDS	1-liter polyethylene bottle	Cool to 4°C	7 days
Ammonia	500 ml plastic	Cool to 4°C H_2SO_4 to pH <2	28 days
Bicarbonate	500 ml plastic	None Required	14 days
Carbonate	500 ml plastic	None Required	14 days
Chloride	250 ml plastic	None Required	28 days
Hardness	150 ml plastic	HNO_3 pH <2	180 days
Nitrate/Nitrite	250 ml plastic	Cool to 4°C H_2SO_4 to pH <2	28 days
Oil and Grease	1 liter glass	Cool to 4°C H_2SO_4 to pH <2	28 days
Multi-Concentration Acute Toxicity	2 liter plastic	Cool to 4°C	36 hours

TCL - Target Compound List
TAL - Target Analyte List
TSS - Total Suspended Solids
TDS - Total Dissolved Solids

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; and
- 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; and
- Sampler's initials.

The sample information, as well as the analysis to be performed on the sample, will be entered in the field log book 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; and
- 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 Chain-of-Custody (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's 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 log books and records that provide a custody record during sample preparation and analysis.

Laboratory Chain-of-Custody Procedures

Upon sample receipt the steps below are performed.

- Samples are received and unpacked in the laboratory where the staff checks for bottle integrity (loose caps, broken bottles, etc.).

- Samples are verified with incoming paperwork (packing slip, etc.) by type of bottle and stabilizer. The paperwork is either signed or initialed.

- Information concerning the sample (from the sampling record, Chain-of-Custody, and observation) is recorded along with parameters to be analyzed, date of sampling, and date the sample is received in the laboratory.

- Samples are placed in an appropriate secured storage area, e.g. refrigeration, until analysis.

- When analysis is complete, samples are stored for a 30-day period unless otherwise specified.

If collected samples arrive without Chain-of-Custody or incorrect Chain-of-Custody records, the following steps are taken:

- The laboratory prepares a nonconformance form stating the problem;
- The site supervisor and Project Manager are notified; and
- If the missing information cannot be reconstructed by the Project Manager or field staff, the samples affected are removed from the sampling program.

Primary considerations for sample storage are:

- Secured storage;
- Maintain prescribed temperature, if required, which is typically four degrees Celsius; and
- Analyze samples within the prescribed holding time for the parameters of interest.

7.3 Document Custody Procedures

Project records are necessary to support the validity of the work, to allow it to be recreated if necessary, 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 are established to assure that all documents attesting to the validity of work are 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 are 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, are to 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 are to be submitted to the proper file. In addition, records transmitted are adequately protected from damage and loss during transfer (e.g, by hand carrying or by making copies prior to shipment).

The following documents will be transferred to the proper files during the course of this project: calculations and checkprints; reports and other data transmittals; copies of proposals, purchase orders for project services, and contracts; correspondence including incoming and outgoing letters, memoranda, and telephone records; and reference material.

All individuals on the project staff are responsible for reporting obsolete or superseded project-related information to the Project Manager. In turn, the Project Manager notifies 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 are to 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 for, and date of voiding clearly indicated.

Documents are to 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.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 Field Instruments

One field instrument will be used for health and safety monitoring: the HNu System portable photoionizer. This instrument will be calibrated on site daily according to the manufacturer's instructions in addition to the factory calibration it will receive prior to the start of site sampling. The calibration standards will be recorded in the field log book. Specific procedures for the calibration of water quality instruments are given in Appendix A of this document.

A pH meter and a conductivity meter will be used to analyze groundwater samples. Procedures from "Test Methods for Evaluating Solid Waste," USEPA, SW-846, November 1986, 3rd Edition will be used to calibrate these meters. Specific procedures for the calibration of water quality instruments are given in Appendix A of this document.

8.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures are to be in accordance with the protocols presented in the following documents:

- "Statement of Work for Inorganic Analysis," USEPA, ILM02.0, March 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

Formal calibration procedures are established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures apply to all instruments and equipment. All calibrations are performed by laboratory personnel or external agencies using standard reference materials.

All calibrations are recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data are 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 are used. Equipment and instrumentation not meeting the specified calibration criteria are to be segregated from active equipment whenever possible. Such equipment is repaired and recalibrated before reuse.

All equipment should 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) are to be used for calibration whenever available.

8.2.1 Method Calibration

Method calibration is performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves are prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves are prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

8.2.2 System Calibration Procedure for GC Purgable Halocarbons and Aromatics

The system must be calibrated daily by external calibration. A minimum of three concentration levels, of each parameter, is used to prepare a calibration curve. The working calibration curve must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than plus or minus ten percent, the test must be repeated using a fresh calibration standard.

The laboratory must spike and analyze a minimum of ten percent of all samples to monitor continuing laboratory performance.

Prior to analysis, the system must be demonstrated to be free from contamination, under the conditions of the analysis, by running a laboratory reagent blank.

The retention time window used to make the identification should be based upon measurements of actual retention time variations of standards over the course of the day.

If the response peak exceeds the working range of the system, prepare a dilution of the sample with reagent water and reanalyze.

8.2.3 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 are performed in support of these requirements:

- Documentation of standard response; and
- Correlation coefficient monitoring.

The AA system utilized for direct aspiration technique analysis is initially calibrated with a calibration blank and five calibration standards. The standard concentrations are determined as follows. One standard is at a concentration near, but above, the MDL. The other concentrations correspond to the expected range of concentrations found in the actual samples. This five-point calibration is performed daily.

The AA system utilized for graphite furnace technique analysis is initially calibrated with a calibration blank and three calibration standards. The standard concentrations are determined as follows. One standard is at a concentration at the Contract Required Detection Limit (CRDL). The other concentrations correspond to the expected range of concentrations found in the actual samples. This three-point calibration is performed daily.

For AA systems, the calibration standards are 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 is calibrated initially with a calibration blank and one calibration standard. This calibration is 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 are 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 is >0.995 for AA analyses and >0.995 for ICP analysis.

Calibration Verification

The initial calibration curve is verified on each working day by the measurement of one mid-range calibration standard. The calibration verification acceptance criterion is as follows:

- ICEP/GFAA - 90 to 110 percent of true value; and
- Cold Vapor AA - 80 to 120 percent of true value.

When measurements exceed the control limits, the analysis is terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

8.2.4 System Calibration Procedure for Inorganic Analyses

This section outlines the requirements that are used for calibration of colorimetric systems for analyses of inorganic parameters. The following are performed in support of these requirements:

- Documentation of standard response; and
- Correlation coefficient monitoring.

The system is initially calibrated with a blank and five calibration standards. Standard concentrations are one standard 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 are utilized to calculate slope, intercept, and correlation coefficient of a best fit line. An acceptable correlation coefficient is achieved before sample analysis may begin. An acceptable correlation coefficient is >0.995 for all systems.

Calibration Verification

The initial calibration curve is verified on each working day by the measurement of two calibration standards. One standard is at a concentration near the low end of the calibration curve and one standard is at the high end of the curve. The acceptance criteria for recovery of verification standards is within 15 percent of the expected recovery for cyanide analyses and 10 percent of the expected recovery for other inorganic analyses. When measurements exceed control limits, analysis is terminated, the problem is corrected, the instrument is recalibrated, and calibration is reverified.

8.2.5 Periodic Calibration

Periodic calibration is 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 is recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration is performed.

- Balances are calibrated weekly with class S weights.

- The pH Meter meter is calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.

- The temperatures of the refrigerators are recorded daily.

- All liquid in glass thermometers are calibrated annually with the N.B.S. certified thermometer. Dial thermometers are calibrated quarterly.

- The N.B.S. Certified Thermometer is 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; and
- Water Bath, Mercury - within 2 degrees of 95 degrees Celsius.

9.0 ANALYTICAL PROCEDURES

9.1 Field Analysis

An HNu PI-101 will be used to analyze ambient air for health and safety monitoring. The HNu PI-101 detects total organic vapor. This instruments will be operated in accordance with the manufacturer's instructions.

The pH 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.

9.2 Laboratory Analysis

The samples that will be collected during the investigation will be analyzed for constituents listed in Table 9-1. Parameters will be analyzed using EPA methods as noted in Table 9-1. Compounds and the corresponding method performance limits also are listed in Table 9-1.

TABLE 9-1

METHOD PERFORMANCE LIMITS

Compound	Water MDL(1) (µg/l)	Method
Purgable Halocarbons		EPA Method 601(3)
Chloromethane	0.08	
Bromomethane	1.18	
Dichlorodifluoromethane	1.81	
Vinyl chloride	0.18	
Chloroethane	0.52	
Methylene Chloride	0.25	
Trichlorofluoromethane	ND(2)	
1,1-Dichloroethene	0.13	
1,2-Dichloroethane	0.07	
trans-1,2-Dichloroethene	0.10	
Chloroform	0.05	
1,1-Dichloroethane	0.03	
1,1,1-Trichloroethane	0.03	
Carbon tetrachloride	0.12	
Bromodichloromethane	0.10	
1,2-Dichloropropane	0.04	
trans-1,3-Dichloropropene	0.34	
Trichloroethene	0.12	
Dibromochloromethane	0.09	
1,1,2-Trichloroethane	0.02	
cis-1,3-Dichloropropene	0.20	
2-Chloroethyl vinyl ether	0.13	
Bromoform	0.20	
1,1,2,2-Tetrachloroethane	0.03	
Tetrachloroethene	0.03	
Chlorobenzene	0.25	
1,3-Dichlorobenzene	0.32	
1,2-Dichlorobenzene	0.15	
1,4-Dichlorobenzene	0.24	

(1) Method Detection Limit.
(2) Not determined.
(3) EPA Methods 601/602 require second column confirmation.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS

Compound	Water MDL(1) (µg/l)	Method
Purgable Aromatics		EPA Method 602(3)
Benzene	0.2	
Toluene	0.2	
Ethylbenzene	0.2	
Chlorobenzene	0.2	
1,4-Dichlorobenzene	0.3	
1,3-Dichlorobenzene	0.4	
1,2-Dichlorobenzene	0.4	

(1) Method Detection Limit.
(2) Not determined.
(3) EPA Methods 601/602 require second column confirmation.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS

Analyte	Method Number(1)	CRQL(2) (µg/l)	Method Description
Aluminum	200.7	200	Inductively Coupled Plasma
Antimony	200.7 204.2	60	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Arsenic	200.7 206.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Barium	200.7	200	Inductively Coupled Plasma
Beryllium	200.7 210.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cadmium	200.7 213.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Calcium	200.7 215.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Chromium	200.7 218.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cobalt	200.7	50	Inductively Coupled Plasma
Copper	200.7	25	Inductively Coupled Plasma
Iron	200.7	100	Inductively Coupled Plasma
Lead	200.7 239.2	3	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Magnesium	200.7 242.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Manganese	200.7	15	Inductively Coupled Plasma

(1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM02.0, March 1990.

(2) Contract Required Quantitation Limit.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS

Analyte	Method Number(1)	CRQL(2) (µg/l)	Method Description
Mercury		0.2	
	245.1		Water by manual cold vapor technique
	245.2		Water by automated cold vapor technique
	245.5		Soil/sediment by manual cold vapor technique
Nickel		40	
	200.7		Inductively Coupled Plasma
Potassium		5000	
	200.7		Inductively Coupled Plasma
	258.1		Atomic Absorption, Direct Aspiration
Selenium		5	
	200.7		Inductively Coupled Plasma
	270.2		Atomic Absorption, Furnace Technique
Silver		10	
	200.7		Inductively Coupled Plasma
	272.2		Atomic Absorption, Furnace Technique
Sodium		5000	
	200.7		Inductively Coupled Plasma
	273.1		Atomic Absorption, Direct Aspiration
Thallium		10	
	200.7		Inductively Coupled Plasma
	279.2		Atomic Absorption, Furnace Technique
Vanadium		50	
	200.7		Inductively Coupled Plasma
Zinc		20	
	200.7		Inductively Coupled Plasma

(1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM02.0, March 1990.

(2) Contract Required Quantitation Limit.

TABLE 9-1 (Continued)

METHOD PERFORMANCE LIMITS

Parameter	Water Performance Limit	Method
Other Parameters		
Ammonia	N/A	EPA 350.2
Bicarbonate	N/A	SM 403/40
Carbonate	N/A	SM 403/40
Chloride	N/A	EPA 325.2
Hardness	N/A	EPA 130.2
Nitrate/Nitrite	N/A	EPA 353.2
Oil & Grease	N/A	EPA 413.1
Total Suspended Solids (TSS)	N/A	EPA 160.2
Total Dissolved Solids (TDS)	N/A	EPA 160.1

N/A - Not Applicable

10.0 DATA REDUCTION, VALIDATION AND REPORTING

10.1 Field Data Procedures

Data validation practices as described by "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses," USEPA, June 1988, and "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses - Draft," USEPA, June 1991 will be followed to insure that raw data are not altered and that an audit trail is developed for those data which require reduction. The documentation of sample collection will include the use of bound field log books 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 is 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 close-out; 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.

10.2 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, are documented and subjected to quality control review. Records of numerical analyses are legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator.

Laboratory Data Validation

Data validation begins with data reduction and continues through to the reporting of data.

Data processing is checked by an individual other than the analyst who performed the data processing. The checker reviews the data for the following:

- Utilization of the proper equations;
- Correctness of numerical input;
- Correctness of computations; and
- Correct interpretation of raw data (chromatographs, strip charts, etc.).

The checking process is thorough enough to verify the results.

All entries made in benchbooks, data sheets, computation sheets, input sheets, etc. are made in ink. No entry will be rendered unreadable.

Analytical Reports

The items listed below are required of analytical reports.

- Data is presented in a tabular format.

- Analytical reports are approved by appropriate laboratory personnel.

- The following information is 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 are numbered.

- The sample numbers and corresponding laboratory numbers are identified.

- The parameters analyzed, report units, and values are identified.

- Method, trip, and field blank results are reported.

- Matrix spike, matrix spike duplicate, and replicate recoveries are reported.

- Calibration summaries are reported.

- Surrogate recoveries are reported.

- Holding times and sample analysis dates are reported.

- The detection limit of the procedure is identified.

- Consistent significant figures are used.

- Referenced footnotes are used when applicable.

- A letter of transmittal accompanies the report if any anomalies are associated with the data. The letter specifies these anomalies.

11.0 INTERNAL QUALITY CONTROL CHECKS

11.1 Field Internal Quality Control Checks

Field internal quality control checks to be used during the this investigation include field duplicates, field blanks, and trip blanks. The results from the field quality control samples will be used by the data validator to determine the overall quality of the data.

11.2 Types of QC Samples

Documentation of the analyses of the following types of QC samples is maintained in the laboratory bench notebooks and/or the specific client or project files.

Trip Blank

Analysis of trip blanks is 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 is prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples are prepared by adding four drops of concentrated hydrochloric acid and then filling the container with deionized water (ASTM Type II). 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.

Method Blank

Analysis of method blanks is performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks are initiated by the analyst prior to the preparation and/or analysis of the sample set. A method blank consists of a volume of deionized water or organic-free water equal to the sample volume which is carried through the entire analytical procedure. A method blank is 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 is performed to demonstrate the precision of an analysis. An interlaboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure. The frequency of interlaboratory replicate analysis for each analyte is summarized in Table 11-1.

Spike Analysis

Spike analysis is 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 11-1.

TABLE 11-1

QC ANALYSIS FREQUENCY

Parameter	Replicate	Spike
Organic		
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%
General Chemistry		
Nitrate	5%	5%
Sulfide	5%	5%

Surrogate Standards

Surrogate standard analysis is performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC are fortified with a surrogate spiking solution prior to purging.

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.

11.3 Laboratory Control Limits

Control limits are established for QC checks (spikes, duplicates, blanks, etc.). Control limits for spikes, duplicates, and reference samples are determined internally through statistical analysis.

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions are 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 analyses, the criteria below are used for method blank analysis.

- A method blank for volatiles analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, and chloroform).

- 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 repurged and reanalyzed, when possible. If the affected samples cannot be 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.

Surrogate Standards

For method blank surrogate standard analysis, corrective action is 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.

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 is taken if any one of the following conditions exist:
    - Recovery of any one surrogate compounds in the volatile fraction is outside the 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 of the sample or extract if the above corrective action fails to solve the problem.
- Reanalysis of the sample if none of the above are a problem.

11.4 Quality Assurance Review of Reports, Plans, and Specifications

Prior to issuance of a final report, it is reviewed by senior-level program staff, the Project Manager, or a designated representative. This review addresses whether:

- The report satisfies the scope of work, client requirements, and pertinent regulatory requirements;
- Assumptions are clearly stated, justified, and documented;
- A reference is cited for any information utilized in report preparation that was originated outside the project;
- The report correctly and accurately presents the results obtained by the work;
- The tables and figures presented in the report are prepared, checked, and approved according to requirements;

- The report figures are signed and dated by the appropriate members of the project staff and project management; and

- The typed report has been proofread and punctuation, grammar, capitalization, and spelling are correct.

11.4.1 Laboratory Quality Assurance

Field Quality Assurance

Four types of field quality assurance/quality control samples will be submitted to the laboratory: trip blanks, equipment rinsates, field blanks, and field duplicates. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 11-2. A summary of the number of environmental and QA/QC samples to be submitted for analysis is given in the SAP.

TABLE 11-2

QA/QC SAMPLE FREQUENCY

Type of Sample	Metal	Organic
Trip Blank (for volatiles only)	NA(1)	One per cooler or one per shipping day
Field Blank	One per source per event(2)	
Field Duplicate(3)	10%	10%

1 - Not Applicable

2 - Source water includes water used in decontamination and steam cleaning.

4 - The duplicate must be taken from the same sample which will become the laboratory matrix spike/matrix spike duplicate for organics or for the sample used as a duplicate in inorganic analysis.

12.0 PERFORMANCE AND SYSTEM AUDITS

A field audit may be conducted during the field investigation to verify that sampling is being performed according to the plan. A report will be submitted within 30 calendar days of completion of the audit. Serious deficiencies will be reported within 24 hours of the time of discovery of the deficiency, including actions taken or to be taken to correct such deficiencies.

The following table (Table 12-1) is used for audits. At the appropriate time, the Project Manager or Program QA/QC designee will conduct field audits.

TABLE 12-1

SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS

Project No. ____________________

Date ____________________

Project Name &
Location ____________________

Name & Signature
of Auditor ____________________

Team Members ____________________

Name & Signature of
Field Team ____________________

Yes _____ No _____ 1. Is there a set of accountable field documents checked out to the Site Manager?
Comments: ____________________
____
____

Yes _____ No _____ 2. Is the transfer of field operations from the Site Manager to field participants documented in a log book?
Comments: ____________________
____
____

Yes _____ No _____ 3. Is there a written list of sampling locations and descriptions?
Comments: ____________________
____
____

Yes _____ No _____ 4. Are samples collected as stated in the project plan or as directed by the Site Manager?
Comments: ____________________
____
____

Yes _____ No _____ 5. Are samples collected in the type of container specified in the project plan or as directed by the Site Manager?
Comments: ____________________
____
____

Yes _____ No _____ 6. Are samples preserved as specified in the project plan or as directed by the Site Manager?
Comments: ____________________
____
____

TABLE 12-1
SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS
PAGE TWO

Yes _____ No _____ 7. Are the number, frequency and type of samples collected as specified in the project plan or as directed by the Site Manager?

Comments: ______________________________

____

____

Yes _____ No _____ 8. Are the number, frequency and type of measurements taken as specified in the project plan or as directed by the Site Manager?

Comments: ______________________________

____

____

Yes _____ No _____ 9. Are samples identified with sample labels?

Comments: ______________________________

____

____

Yes _____ No _____ 10. Are blank and duplicate samples properly identified?

Comments: ______________________________

____

____

Yes _____ No _____ 11. Are sample and serial numbers for samples split with other organizations recorded in a log book or on a chain-of-custody record?

Comments: ______________________________

____

____

Yes _____ No _____ 12. Are samples listed on a chain-of-custody record?

Comments: ______________________________

____

____

Yes _____ No _____ 13. Is chain-of-custody documented and maintained?

Comments: ______________________________

____

____

Yes _____ No _____ 14. Are quality assurance checks performed as directed?

Comments: ______________________________

____

____

TABLE 12-1
SYSTEM AUDIT CHECKLIST - FIELD OPERATIONS
PAGE THREE

Yes _____ No _____ 15. Are photographs documented in logbooks as required?
Comments: ________________________________
____
____

Yes _____ No _____ 16. Are all documents accounted for?
Comments: ________________________________
____
____

Yes _____ No _____ 17. Have any documents been voided or destroyed?
Comments: ________________________________
____
____

13.0 PREVENTIVE MAINTENANCE

13.1 Field Maintenance

The HNu PI-101 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 Appendix A, Field Water Quality Instruments.

13.2 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 addresses the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime; and

- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Trouble shooting, maintenance, and spare parts inventory are recorded in the logs. Instruments and equipment are 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 are 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 are placed on instrumentation when not in use.

- Instrument parts are cleaned as required (i.e., mirrors, probes, detector cells).

14.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

14.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives which are stated during the design phase of the investigation. 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.

14.2 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 Project Manager will perform field audit(s) during the investigation to document that the appropriate procedures are being followed with respect to sample (and blank) collection. These audits will include a thorough review of the field books used by the project personnel to insure that all tasks were performed as specified in the instructions. The field audits will necessarily enable the data quality to be assessed with regard to the field operations.

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.

14.3 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 are reviewed and evaluated to ensure acceptance criteria are met. These criteria are method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results are 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 are 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 are checked as possible sources of contamination.

- Standard Calibration Curve Verification - The calibration curve or midpoint calibration standard (check standard) is 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 is 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 are used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples are analyzed for this project, field, and interlaboratory. Duplicate results are used to calculate precision as defined by the RPD. If interlaboratory duplicate values exceeds the control limit, the sample set are reanalyzed for the parameter in question. Precision limits are updated periodically following review of data.

- Reference Sample Analyses - The results of reference sample analysis are compared with true values, and the percent recovery of the reference sample is calculated. If correction is required (excessive or inadequate percent recovery), the reference sample is reanalyzed to demonstrate that the corrective action has been successful.

- Matrix Spike Analyses - The observed recovery of spike versus theoretical spike recovery is 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 is 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, sample data that does not meet the established criteria will be recollected, reextracted, or reanalyzed.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis of samples 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.

14.4 Laboratory Data Validation

Review of analyses will be performed. A preliminary review will be performed by the project manager to verify all necessary paperwork (e.g., chain-of-custodies, traffic reports, analytical reports, and laboratory personnel signatures) and deliverables are present. A detailed quality assurance review will be performed by a data validation subcontractor to verify the qualitative and quantitative reliability of the data presented. This review will include a detailed review and interpretation of all data generated by the laboratory. The primary tools which will be used by experienced data validation personnel will be guidance documents, established criteria, and professional judgment.

A quality assurance report stating the qualitative and quantitative reliability of the analytical data will be prepared for NEESA. This report will consist of a general introduction section, followed by qualifying statements that should be taken into consideration for the analytical results to be best utilized. The report will reference NEESA 20.2-047B for applicable guidance, format, and standards.

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.

15.0 CORRECTIVE ACTION

Corrective action is taken whenever a nonconformance occurs. A nonconformance is defined as an event which 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 are responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses; and

- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities.

15.1 Corrective Action

Nonconformances are documented by the person originating or identifying it. Documentation includes the following:

- Identification of the individual(s) originating or identifying the nonconformance;
- Description of the nonconformance;
- Any required approval signatures (initials);
- Corrective action taken; and
- Corrective action completion date.

The NEESA contract representative (NCR), along with the contract project director will be notified of a nonconformance and the corrective action taken, if one of the following is true:

- A nonconformance causes a delay in work beyond the schedule completion date;
- A nonconformance affects information already reported; and
- A nonconformance affects the validity of the data.

15.2 Limits of Operation

The limits of operation that are used to identify nonconformances are established by the contents of the plan and by control limits produced by statistical analyses.

16.0 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 following: 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 Navy Engineer-in-Charge through informal, verbal reports during the project as well as through monthly progress reports.

APPENDIX A
FIELD WATER QUALITY INSTRUMENTS

APPENDIX A

FIELD WATER QUALITY INSTRUMENTS

A. Calibration and Preventive Maintenance

Activity Before Site Visit

Field meters to be used during sampling, specifically the pH and specific conductance/ thermistor meters will be checked against the contractor laboratory meters to insure proper calibration and precision response. Thermometers will be checked against a precision thermometer certified by the National Bureau of Standards. These activities will be performed by the contractor laboratory manager. In addition, buffer solutions and standard KCl solutions to be used to field calibrate the pH and conductivity meters will be laboratory tested to insure accuracy. The preparation date of standard solutions will be clearly marked on each of the containers to be taken into the field. A log which documents problems experienced with the instrument, corrective measures taken, battery replacement dates, when used and by whom for each meter and thermometer will be maintained by the contractor's laboratory manager. Appropriate new batteries will be purchased and kept with the meters to facilitate immediate replacement, when necessary in the field.

All equipment to be utilized during the field sampling will be examined to certify that it is in operating condition. This includes checking the manufacturer's operating manuals and the instructions with each instrument to ensure that all maintenance items are being observed. A spare electrode will be sent with each pH meter that is to be used for field measurements. Two thermometers will be sent to each field site where measurement of temperature is required, including those sites where a specific conductance/thermistor meter is required.

Activity at Site

The pH meter must be calibrated a minimum of twice each day using at least two different pH buffer solutions expected to bracket the pH range of field samples. Rinse the probe thoroughly between buffer measurements with distilled water and again after calibration is completed. Record in the field log book what buffer solutions were used. When the meter is moved, check pH reading by measuring the pH value of the buffer solution closest to the expected range of the sample. If the reading deviates from the known value by more than 0.1 standard units, recalibrate the instrument as described above. If unacceptable deviations still occur, consult the operating manual for remedial course of action.

The specific conductance/thermistor meter is less likely to exhibit random fluctuations and will only require daily checks against a known KCl solution, which should be chosen to be within the expected conductivity range. Note that specific conductance is temperature-dependent and, therefore, the meter readings must be adjusted to reflect the temperature of the standard solution. Thoroughly rinse the probe with distilled water after immersing in KCl standard solution. In addition to daily checks of the conductivity readings, the thermistor readings must also be checked daily. This is accomplished by taking a temperature reading of the KCl standard solution with both the conductivity probe and a mercury thermometer.

Before use, visually inspect the thermometer to assure there is no break in the mercury column. If there is a break, visually inspect the spare thermometer. If both thermometers have a break in the mercury, neither can be used until the break is corrected. This may be done by cooling the bulb until the mercury is all contained in the bulb.

B. Analytical Methods

All field measurements will be obtained in accordance with "Handbook for Sampling and Sample Preservation of Water and Wastewater," EPA-600/4-82-029, September 1982 or "Test Methods for Evaluating Solid Wastes," SW-846, November 1986. The quality assurance procedures for field analysis and equipment are detailed in these documents cited.

FINAL

HEALTH AND SAFETY PLAN

FOR THE REMEDIAL DESIGN OF THE SHALLOW AQUIFER AT THE HADNOT POINT INDUSTRIAL AREA

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0134

Prepared For:

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

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

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Coraopolis, Pennsylvania

JANUARY 7, 1993

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EXECUTIVE SUMMARY

There are several potential chemical and physical hazards associated with the tasks of this project. The chemical hazards include the potential for exposure to volatile compounds and metals. The physical hazards include heavy equipment, heat stress, uneven terrain, noise, and confined space entry (manholes). The Environmental Hazards include native flora and fauna. These hazards are described in Section 3.0.

Section 5.0 describes the air monitoring requirements which consist of using a PID or FID, and an oxygen/combustible gas/hydrogen sulfide/carbon monoxide meter to monitor air contaminant levels.

The level of personal protective equipment (PPE) used for work tasks and other operations is expected to be levels D or D+, with protection upgrades dependent on air monitoring results and the Site Health and Safety Officer's discretion.

1.0 INTRODUCTION

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 Health and Safety Plan (HASP). The HASP is written based on the anticipated hazards and expected work conditions and applies to activities performed by both Baker and Subcontractor personnel. The HASP may be modified/updated with the approval of the Project Health and Safety Officer (PHSO) and Project Manager. Proper notification will be given to the Navy Engineer-in-Charge (EIC) when such changes to the plan are implemented.

This HASP is based on an outline developed by the U.S. Coast Guard for responding to hazardous chemical releases (U.S.C.G. Pollution Response COMDTINST-ML6456-30) and by NIOSH, OSHA, USCG, and EPA's recommended health and safety procedures (Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities). This plan, at a minimum, meets the requirements under OSHA Standard 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response). This plan has been designed as a Site-Specific HASP for the Interim Remedial Action of the Shallow Aquifer at the Hadnot Point Industrial Area (HPIA), Marine Corps Base, Camp Lejeune, North Carolina.

1.2 References

The following publications have been referenced in the development and implementation of this HASP.

- National Institute for Occupational Safety and Health/Occupational Safety and Health Administration/U.S. Coast Guard/U.S. Environmental Protection Agency (NIOSH/OSHA/USCG/EPA), October 1985, Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.

- U.S. Department of Health and Human Services, June 1990, Public Health Service, Centers for Disease Control, NIOSH, NIOSH Pocket Guide to Chemical Hazards.

- American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 1991-1992.

- Lewis, Richard J., Sr., 1991, Hazardous Chemicals Risk Reference, 3rd Edition, Van Nostrand Reinhold, New York, New York.

- The Center for Labor Education and Research, Lori P. Andrews, P.E., Editor, 1990, Worker Protection During Hazardous Waste Remediation, Van Nostrand Reinhold, New York, New York.

- U.S. Coast Guard. Policy for Response to Hazardous Chemical Releases. USCG Pollution Response COMDTINST-M16465.30.

- U.S. Department of Health and Human Services, December 1979, Public Health Service, Centers for Disease Control, NIOSH, Criteria for a Recommended Standard ... Working in Confined Spaces.

1.3 Pre-Entry Requirements

During the initiation of site activities (site mobilization), the SHSO will perform a reconnaissance of the anticipated work areas as identified in the Work Plan, establish or confirm emergency points of contact and procedures, and review any other issues deemed necessary to address site safety and health. The SHSO will then call a meeting with site personnel (as identified in Section 2.0) to discuss site-specific safety and health hazards, data obtained from a previous site reconnaissance, provisions outlined in this HASP, and appropriate safety and health related procedures/protocols.

2.0 PROJECT PERSONNEL AND RESPONSIBILITIES

The following personnel are designated to carry out the stated job functions for both on- and off-site activities. (Note: One person may carry out more than one job function, and personnel identified are subject to change.). The responsibilities that correspond with each job function are outlined below.

PROJECT MANAGER: Donald Joiner

The project manager is responsible for assuring that all activities are conducted in accordance with the HASP. The Project Manager has the authority to suspend field activities if employees are in danger of injury or exposure to harmful agents. In addition, the Project Manager is responsible for:

- Assisting the Project Health and Safety Officer in site-specific HASP development for all phases of the project.
- Designating a Site Health and Safety Officer and other site personnel who will assure compliance with the HASP.
- Reviewing and approving the information presented in this HASP.

PROJECT HEALTH AND SAFETY OFFICER (PHSO): Barbara Cummings

The Project Health and Safety Officer is responsible for general development and monitoring of compliance with the HASP. The PHSO will be the primary contact for inquiries as to the contents of the HASP. The PHSO will be consulted before changes to the HASP can be approved or implemented. The PHSO will also:

- Develop new protocols or modify the HASP as appropriate and issue amendments to the HASP.
- Resolve issues that arise in the field with respect to interpretation or implementation of the HASP.

- Monitor the field program through a regular review of field health and safety records, on-site activity audits, or a combination of both.

- Determine that all on-site personnel have received the required training and medical surveillance prior to entry onto the site.

- Coordinate review, evaluation, and approval of the HASP.

- Approve changes in PPE.

SITE MANAGER: (to be determined)

The Site Manager is responsible for assuring that all day-to-day activities are conducted in accordance with the HASP. The Site Manager has the immediate authority to suspend field activities if employees are subjected to a situation that can be immediately dangerous to life or health. The Site Manager's responsibilities include:

- Assuring that the appropriate health and safety equipment and PPE has arrived on site and that it is properly maintained.

- Coordinating overall site access and security.

- Controlling visitor access to hazardous areas.

- Approving all on site activities.

- Coordinating site safety and health issues with the Site Health and Safety Officer.

- Assisting the SHSO in coordinating emergency procedures with the Naval Activity, emergency medical responders, etc., during site mobilization activities.

- Assuring compliance with site sanitation procedures and site precautions.

- Coordinating activities for Baker and Subcontractor Personnel.

SITE HEALTH AND SAFETY OFFICER: (to be determined)

The SHSO is responsible for the implementation of the HASP. The SHSO will also:

- Coordinate the pre-entry briefing and daily/weekly briefings.
- Assure that monitoring equipment is properly calibrated and properly used.
- Assure compliance with site sanitation procedures and site precautions.
- Manage health and safety equipment, including instruments, respirators, PPE, etc., that is used in field activities.
- Arrange emergency response provisions in cooperation with Naval Activity Requirements, emergency medical care, etc., during site mobilization activities.
- Monitor conditions during field activities to assure compliance with the HASP and evaluate if more stringent procedures or a higher level of PPE should be implemented, and informing the PHSO and Project Manager.
- Prepare a daily report (in the field log book) as necessary, which may include all relevant health and safety events; recordkeeping of all personnel and site monitoring information; accident investigation and reporting; safety inspections; maintain a record of site conditions, personnel involved in field activities, and any other relevant health and safety issues
- Oversee the arrangement and execution of personnel and equipment decontamination.
- Determine safe boundary procedures for activities requiring Level C or higher protection levels.
- Suspend field activities if the health and safety of personnel are endangered.

- Audit the subcontractor training and medical surveillance records to verify compliance.

- Act as the Emergency Coordinator.

FIELD TEAM LEADER: ______________ (to be determined) ______________

The Field Team Leader is responsible for:

- Safety issues relevant to the tasks under his/her direction.

- Determining safe boundary procedures for activities requiring Level D or D+ protection levels.

- Assuring that PPE is properly maintained.

FIELD TEAM MEMBERS:

______________ (to be determined) ______________

____

____

The Field Team Members are responsible for:

- Familiarity with the HASP.

- Attending training sessions to review the HASP, and remain informed of additional safety and health information.

- Being alert to identified and unidentified hazards.

- Reporting unidentified hazards to the SHSO and Site Manager.

- Offering suggestions, ideas, or recommendations that may improve or enhance site safety.

- Complying with the contents of the HASP.

- Conducting site activities in an orderly and appropriate manner.

Subcontractor personnel are responsible for:

- Complying with the conditions as outlined under Field Team Members.

- Obtaining the appropriate training and medical requirements under 29 CFR 1910.120 and providing documentation thereof.

- Complying with the training and medical surveillance requirements as outlined in Sections 9.0 and 10.0, respectively, and providing his/her own PPE that meets or exceeds the level of protection as outlined in this HASP.

SUBCONTRACTOR COMPANIES:

Hazardous Waste
Transportation and Disposal Firm: (to be determined)

Underground Utility Televising
and Inspection Firm: (to be determined)

NAVFACENGCOM REPRESENTATIVES:

Mr. Byron Brant, P.E., Remedial Project Manager	(804) 445-2931
Dr. C. C. Shu, P.E., Design E.I.C.	(804) 444-9937

ACTIVITY/BASE REPRESENTATIVES:

Mr. George Radford (CLEJ EMD),	(919) 451-5872

FEDERAL/STATE/LOCAL REPRESENTATIVES:

Ms. Michele Glenn (USEPA)	
Mr. E. Peter Burger (NCDEHNR)	(919) 733-2801

3.0 SITE CHARACTERIZATION

3.1 Site Background

Camp LeJeune is a training base for the Marine Corps and is located in Onslow County, North Carolina. The area of concern for this Interim Remedial Action Study is the shallow aquifer in the Hadnot Point Industrial Area (HPIA) which is defined as Site 78 at MCB Camp LeJeune.

Several areas at the HPIA have been investigated for potential soil and groundwater contamination due to Marine operations and activities resulting in the generation of potentially hazardous wastes. The investigations indicate that contamination at the HPIA is due to proper waste disposal, underground storage tank leakage, solvent spills, and sludge disposal. Baker has been tasked by the Navy to perform an Interim Remedial Action Study for the Shallow Aquifer at the HPIA.

The Interim Remedial Action Design field activities will be comprised of a Treatability Study, a Sewer Line Capacity Test, and an Aquifer Pump Test. The Treatability Study will consist of a bench-scale test which will be used to verify the technologies' ability to meet expected clean-up goals on a contaminant-specific basis for the HPIA. The Sewer Line Capacity Test and Aquifer Pump Test will be used to determine whether or not the existing sanitary sewer system would be capable of accepting the additional flow necessary for the remediation of the shallow aquifer without reaching or exceeding the systems maximum capacity.

The hazards associated with this Interim Remedial Action Design consist of: Groundwater Sampling during the Bench-Scale Test and Manhole Entry/Flow Controller Installation during the Sewer Line Capacity/Aquifer Pump Test. Task-specific hazards for each of these tasks are further discussed in Section 3.4.1.

3.2 Site Work Plans

The Work Plan, Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Site Management Plan are bound with Health and Safety Plan to form one complete Project Plan Document.

3.3 Site Description

S.O.# 19134-40-SRN

Location: Marine Corps Base, Camp Lejeune, North Carolina

Start-Up Date: (to be determined)

Investigation Duration: (to be determined)

Area affected:

- Shallow aquifer in the area of the HPIA Operable Unit. This site is comprised of maintenance facilities, warehouses, painting shops, printing shops, autobody shops, etc. It covers an area of over 400 acres.

Surrounding population and topography:

- The site is primarily a conglomerate of numerous industrial and support operations including maintenance facilities, warehouses, painting/printing shops, etc. Activity is high with military personnel, civilian personnel, and vehicular traffic. Topography is essentially flat.

Anticipated weather conditions:

(to be determined when site schedule is known)

Results of previous sampling:

- Results of previous studies indicate that the shallow groundwater is contaminated primarily with fuel related compounds (Benzene), 1,2-dichloroethene, trichloroethene, solvents, and metals (antimony, arsenic, beryllium, chromium, iron, lead, manganese, mercury and nickel).

3.4 Hazard Evaluation

3.4.1 Task-Specific Hazards

Hazards at the site may be associated with several job tasks as detailed in the site work plan.

Only operators trained, qualified, and authorized by the SHSO will be permitted to operate project equipment. The equipment will be adequately sized to the job at hand. Hand signal communication will be prearranged between operators and personnel working in and around equipment. Personnel nonessential to the operation of the equipment will maintain a safe working distance from the equipment. This distance will be determined by the SHSO during operations.

Employees must exercise caution to remain out of the paths of moving equipment and materials. Caution should also be exercised to avoid slips, trips, and falls.

Listed below are summaries for the hazards associated with each of the site tasks.

Task 1 Groundwater Sampling (from Tank Trucks)

Chemical

- Skin contact with contaminated water.
- Eye contact from splashing water.
- Ingestion of hazardous materials from hand to mouth contact.
- Inhalation of volatiles emitting from the well opening or valve from tank truck.

Physical/Environmental

- Skin irritation from contact with insects and vegetation.
- Slips/trips/falls - sloped, uneven terrain.
- Interaction with native and potentially hostile animal life.

Task 2 Manhole Entry/Flow Controller Installation

Chemical

- Potential for contaminated material to be splashed onto body or in eyes.
- Ingestion of contaminated material from hand to mouth contact.
- Inhalation of volatile constituents within sanitary waters.
- Exposure to toxic chemicals such as H_2S, CO, etc.

Physical/Environmental

- Slips/trips/falls from entering or working around manhole.
- Suffocation due to a low percent of 0_2 in sewer.
- Explosion due to ignition of trapped flammable gases.
- Interaction with native and potentially hostile animal life.

3.4.2 Chemical Hazards

Exposure to hazardous chemicals can occur through various pathways into the body. These pathways include:

- Inhalation of vapors and/or particulates.
- Ingestion of contaminated particulates from hand-to-mouth contact.
- Dermal and eye contact from direct, unprotected contact.
- Absorption through the eye from exposure to concentrations in the air.

The chemical exposure potential for personnel working at the HPIA is expected to result from the chemicals detected during preliminary sampling investigations.

Therefore, Tables 1 and 2 identify the chemical/physical properties and exposure symptoms/routes of entry, respectively, for the volatile chemicals detected during preliminary sampling investigations that present the greatest hazard.

The chemicals not identified in Tables 1 and 2 consist of low levels of various metals as identified below:

- Antimony
- Arsenic
- Beryllium
- Chromium
- Iron
- Lead
- Manganese
- Mercury
- Nickel

TABLE 1

CHEMICAL/PHYSICAL PROPERTIES OF CHEMICALS DETECTED DURING PRELIMINARY SAMPLING AT THE HPIA

Chemical	Source	Highest Concentration Detected	Exposure Limit (EL)(a)	Short-Term Exposure Limit (STEL)(b)	IDLH(c)	Vapor Pressure(d)	Specific Gravity(e)	Ionization Potential
Benzene	Groundwater	7900 µg/L	1 ppm	5 ppm	3,000 ppm (CA)	75	0.88	9.24 eV
1,2-dichloroethene (DCE)	Groundwater	42,000 µg/L	200 ppm	--	4,000 ppm	180-264	1.27 (at 77°F)	9.65 eV
Trichloroethene (TCE)	Groundwater	14,000 µg/L	50 ppm	200 ppm	1,000 ppm (CA)	58	1.46	9.45 eV

(a) EL - Exposure Limit = A time-weighted average concentration for a normal eight-hour work day and 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without expected adverse effect. The EL represents published Exposure Levels according to the following hierarchical order: (1) OSHA PELs; (2) NIOSH RELs; (3) ACGIH TLVs; and, (4) other recognized sources.

(b) STEL - is the 15 - minute time weighted average exposure not to be exceeded during a work day.

(c) IDLH - Immediately Dangerous to Life or Health.

(d) Vapor Pressure = Expressed as mm/Hg at 68°F (unless otherwise mentioned).

(e) Specific Gravity = At 68°F (unless otherwise mentioned).

CA - Suspected or Proven Carcinogen
ppm - parts per million (in air)
Skin - Potential for dermal absorption
NA - Not Available
µg/l - micrograms per liter
eV - electron Volt

TABLE 2

CHEMICAL EXPOSURE INFORMATION

A summary of exposure symptoms/routes of entry for chemicals detected during preliminary sampling at the HPIA is provided in the table below.

Substance	Routes of Entry	Exposure Symptoms
Benzene	Inhalation, Absorption, Ingestion, Skin/Eye Contact	Eye, nose and respiratory irritation; nausea and staggered walk; dermatitis; bone marrow depressant; (carcinogen)
1,2-Dichloroethene (DCE)	Inhalation, Ingestion, Skin/Eye Contact	Eye and Respiratory Irritant; CNS depression
Trichloroethene (TCE)	Inhalation, Ingestion, Skin/Eye Contact	Headache, vertigo, visual disturbance, tremors, nausea, vomiting, eye irritation, dermatitis (carcinogen)

By eliminating the potential routes of exposure through the use of engineering controls (safe sampling techniques) and personal protective equipment (chemical protective clothing) the risk of exposure can be effectively eliminated for the aforementioned constituents and reduced for those chemicals identified in Table 1.

Material Safety Data Sheets for those materials listed above have been compiled, and are included as Attachment B.

3.4.3 Physical Hazards

3.4.3.1 Confined Space Entry

A confined space entry procedure will be required during the Sewer Line Capacity Test at the HPIA, when these activities require entrance in to sanitary sewers through existing (accessible) manholes.

OSHA defines a "permit required confined space" as having the following characteristics:

- Contains or has a known potential to contain a hazardous atmosphere.
- Has limited or restricted means of entry.
- Is large enough that an employee can bodily enter and perform work.
- Is not designed for continuous employee occupancy.
- Contains a material with potential for engulfment.
- Contains any other recognized serious safety or health hazard.

Equipment to be used will include a tripod, winch, rescue harness and safety line, ventilator, 5-minute escape pack, SCBA, and monitoring equipment as specified in Section 5. Before any operation is to be performed in a confined space, the PHSO must be contacted. Procedures for entering a confined space are outlined in Attachment A - Baker Safety SOPs.

3.4.3.2 Thermal Stress

Provisions for monitoring of heat stress and/or cold stress are outlined in Attachment A - Baker Safety SOPs.

3.4.3.3 Explosion and Fire

In general, the following items present potential physical hazards and will be monitored closely:

- Explosion and fire resulting from:
  - heavy equipment malfunction.
  - ignition of trapped flammable vapors (as in sewer lines).
  - vehicular accidents

Provisions for monitoring for potential fire/explosive conditions will include the use of a combustible gas meter (as indicated in Section 5.2). As additional concerns are identified, provisions for making changes to the HASP will be presented by the SHSO, as needed.

3.4.3.4 Noise

Excessive noise levels are not anticipated during site operations. Hearing protection in the form of ear protective devices will be available on site and distributed upon request.

3.4.4 Radiation Hazards

The presence of radiological wastes or radioisotopes at the HPIA is not anticipated, therefore, a radiation survey meter will not be used during these activities

3.4.5 Environmental Hazards

Hazardous Flora

Incidence of contact by individuals to poisonous/thorny plants is a real threat. 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 near vegetation. Personnel should avoid contact with known poisonous flora (i.e., poison ivy/oak). Care should also be taken when walking as uneven terrain may present a tripping hazard. All rashes and other injuries will be reported to the SHSO as soon as they are known.

Hazardous Fauna

Rodents such as rats pose a threat to personnel entering sewers; therefore, caution will be exercised while entering and walking in sewers.

Mosquitoes and gnats pose a nuisance and physical hazard to field personnel. As a nuisance, they distract workers, leading to accidents. Mosquitoes also pose a physical threat by injecting live microorganisms into their victim. Perfumes and scented deodorants should be avoided.

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.* All personnel should perform "checks" on each other periodically and at the end of the work shift. All insect bites must be reported to the SHSO.

Poisonous snakes such as the rattlesnake, copperhead, and cottonmouth (water moccasin), all known as pit vipers, are common to the United States. Snakes, as a general rule, are timid creatures. They typically do not attack people but will bite when provoked, angered, or accidentally injured (as when stepped on). When encountering a snake(s), avoid quick/jerky motions, loud noises, and retreat slowly; do not provoke the snake(s). Cover bare skin as much as practical (i.e., long pants and shirt, steel toe boots, leather gloves, safety glasses and head protection). If bitten, follow procedures outlined in Section 8.6, Emergency Medical Treatment.

Prior to initiating site activities, each individual shall be questioned as to any known sensitivities to the previously mentioned organisms or agents.

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* *Site personnel have been provided with a copy of Baker's policy (per our medical consultant) regarding the signs and symptoms of exposure for Lyme Disease.*

3.4.6 Additional Hazards

Provisions for the monitoring of hazards particular to the specific site activities (such as slippery ground, uneven terrain, overhead equipment, electrical lines, etc.,) shall be addressed at the pre-entry briefing by the SHSO or qualified designee. All personnel are expected to adhere to all applicable safety regulations in OSHA standards 29 CFR 1910 and 1926 and follow good safety practice as described in this HASP.

4.0 SITE CONTROL

4.1 Site Access

- The Site Manager is designated to coordinate overall access and security on site. Perimeters for activities to be conducted at the HPIA will be established according to the site boundary procedures identified in Section 4.3, Local Conditions, and Navy Activity requirements.

- Personnel will not be permitted within the Work (Exclusion) Zone without proper authorization from the SHSO.

- All personnel arriving or departing the site will be documented in the field sign-in log.

- All activities on site must be cleared through the Site Manager.

- Figure 1 identifies the location of the site(s) under investigation.

4.2 Site Conditions

- The prevailing wind conditions are (to be determined).

- The on-site Command Post has been established at (to be determined).
  This location will be in the Support Zone and oriented upwind from the Exclusion Zone (Work Zone).

4.3 Work Zones

Level C and B Activities

Activities requiring Levels C or B protection will not be conducted.

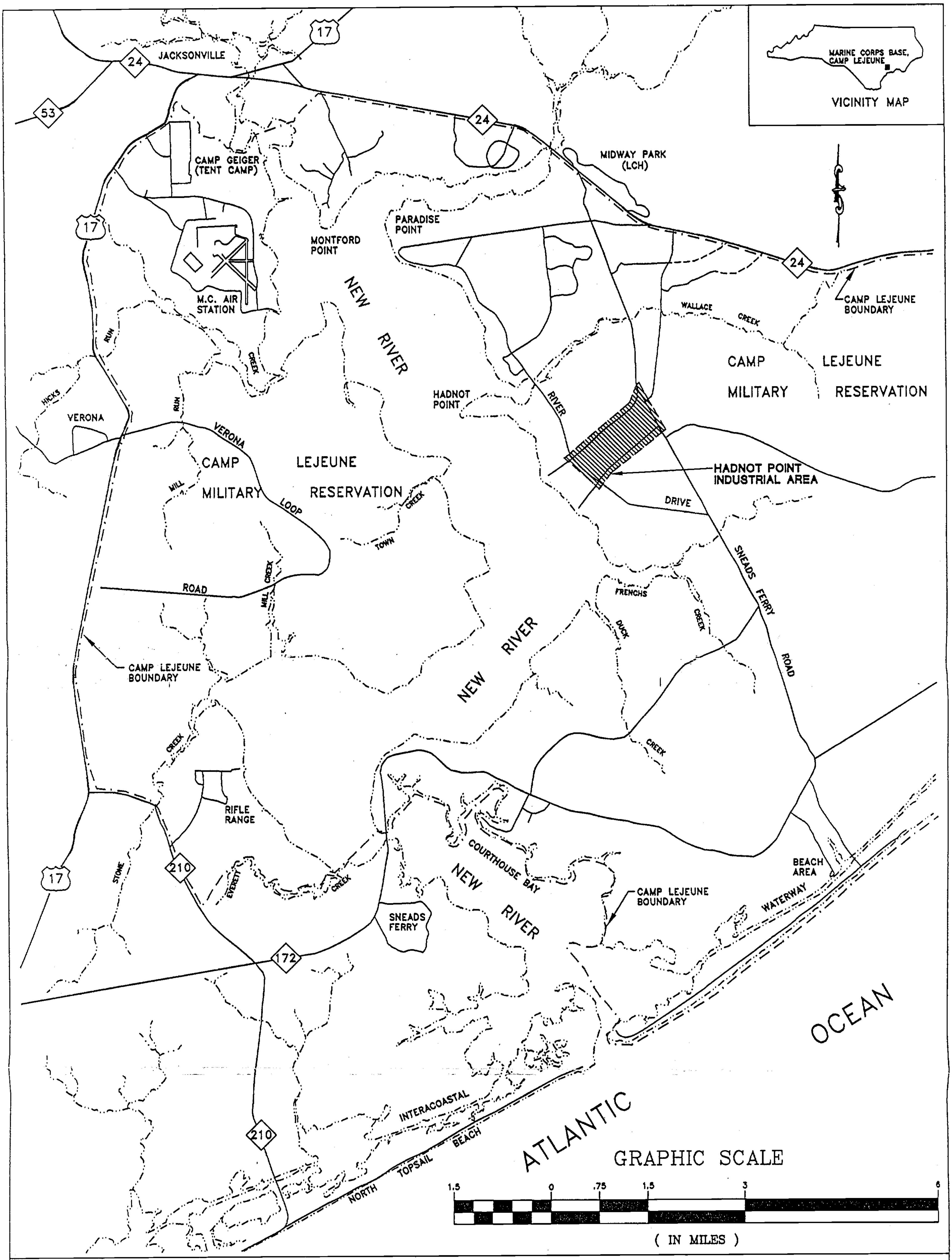


FIGURE 1
SITE LOCATION MAP FOR
THE INTERIM REMEDIAL ACTION OF THE
SHALLOW AQUIFER AT THE HPIA
MCB CAMP LEJEUNE, NORTH CAROLINA
CTO-0134

Level D and D+ Activities

Work Zones for activities conducted under Level D or D+ protection levels shall be established in such a manner as to preclude unauthorized personnel from entering the investigative area. A boundary will be established around the Work Zone to separate it from the Clean Zone using available materials. Such materials may include the Baker Field Vehicle, natural boundaries (wooded/vegetative areas, buildings, structures, fences), or signs/placards, boundary tape, cones, barricades, etc. for activities conducted in populated areas. In unpopulated or secluded areas, the aforementioned materials may not be used due to the exclusive nature of the site, the short duration of the activity, and the low risk to outside populations. The SHSO and/or Field Team Leader is responsible for making this determination.

4.4 "Buddy System"

All site activities that involve entry into the exclusion zone will be performed by a work team of no fewer than two people (Buddy System).

4.5 Safe Work Practices

Routine safe work practices may consist of:

- Setting up barriers to exclude personnel from contaminated areas
- Minimizing the number of personnel and equipment at the site (s)
- Establishing work zones within the site
- Establishing control points with regular access to and egress from work zones
- Conducting operations in a manner to reduce exposure of personnel and equipment
- Implementing appropriate decontamination procedures
- Conducting sampling activities from an upwind location

4.6 Sanitation/Site Precautions

Provisions for sanitation procedures and site precautions to be followed on site can be found in Attachment A - Baker Safety SOPs.

5.0 AIR MONITORING

5.1 Point Source Monitoring

Point source monitoring is defined by this HASP as monitoring performed at the source of the sampling/investigative activity. Instrumentation to be used will include a PID/FID, and an Oxygen/Combustible Gas/Hydrogen Sulfide/Carbon Monoxide meter as outlined in Section 5.4.

5.2 Personal Monitoring

The following personal monitoring will be in effect on site:

Personal monitoring will be accomplished using real time air monitoring instrumentation directed at the breathing zone of work party personnel and should be sufficient according to the work activities and hazards presented. Refer to the guidelines below for protection levels required according to the concentration measured.

*PID/FID

- Background to 5 ppm = Level D
- > 5 ppm for greater than 5 continuous minutes = stop work and consult SHSO
- Instantaneous peak concentrations > 70 ppm = Stop Work and consult SHSO

*PID with 10.2 eV ultraviolet lamp.

Oxygen/Combustible Gas/H_2S/CO Meter

Oxygen
- 19.5% to 22% = continue working
- <19.5% or >22% = Stop Work immediately and consult SHSO

Combustible Gas
- <10% of the Lower Explosive Limit (LEL) = continue working
- >10% of the LEL = Stop Work immediately and consult SHSO

Carbon Monoxide (EL = 35 ppm)
- Below limits of detection (BLD) to one half of the EL (Exposure Level) - Level D
- One half the EL to the EL = Stop Work and consult SHSO
- > the EL = Stop Work

Hydrogen Sulfide (EL = 10 ppm)

- Below limits of detection (BLD) to one half of the EL (Exposure Level) - Level D
- One half the EL to the EL = Stop Work and consult SHSO
- > the EL = Stop Work

As work progresses, the scope of monitoring may be extended based on monitoring results, odor detection, changing work conditions, and signs or symptoms of exposure. Any or all of these conditions will be immediately investigated and acted upon by the SHSO.

5.3 Perimeter Monitoring

Perimeter monitoring is defined as monitoring performed at borders beyond the Clean Zone and often at the "fence line." Releases occurring during these types of investigative activities are expected to be minimal. Therefore, it is anticipated that the type and frequency of monitoring required will be as follows:

- The PID/FID will be used periodically to scan the perimeter as a means of documenting any volatile releases that may extend past the work zone, if volatile concentrations exceeding 70 ppm are detected at the breathing zone.

5.4 Site-Specific Air Monitoring Equipment and Frequency

Air monitoring equipment and frequency for each site can be found in Table 3. Action levels that govern changes in levels of protection, can be found in Section 5.2.

5.5 Equipment Maintenance and Calibration

Baker's procedures for the return of equipment to inventory and for maintenance of the equipment shall be followed in order to assure that the optimum level of operation is maintained for the item. Equipment calibration under the direction of the SHSO will be completed daily and calibration information entered into the equipment calibration log sheet. The log sheets will be maintained on site for the duration of the project with copies to be given to the Equipment Manager once the equipment has been returned to the office. Procedures for equipment maintenance and calibration can be found in the operating manual provided by the manufacturer (included with each piece of equipment), or, in Baker's Standard Operating Procedures for Administrative, Field, and Technical Activities Manual.

TABLE 3

MONITORING EQUIPMENT AND FREQUENCY FOR EACH TASK CONDUCTED AT THE HPIA

Job Task	PID/FID(1)	Oxygen/Combustible Gas/H_2S/CO Meter
Groundwater Sampling	I&P	▨
Manhole Entry/Flow Meter Installation	I&C	I&C

I = Initially - At start of job task to confirm designated protection level.
P = Periodically - When site condition or set-up changes, or when a new area is entered.
C = Continuously - Monitor levels continuously.
D = At the discretion of the SHSO.
PID = Photoionization Detector
FID = Flame Ionization Detector

Note: As air concentrations are measured, they should be documented. In the case of continuous monitoring, every 15 to 30 minutes.

(1) A flame ionization detector will be used during all intrusive activities where methane gas is anticipated (i.e., landfills).

5.6 Monitoring Documentation

As environmental monitoring is performed, documentation of the results will be entered into the Field Log Book of the SHSO or other personnel performing the monitoring. At the end of each day (or at most each week), these values will be entered onto an air monitoring log sheet. The log sheets will be placed in a binder and remain on site till the end of the field activities, whereby the log sheets will become part of the permanent file.

6.0 PERSONAL PROTECTIVE EQUIPMENT

6.1 Levels of Protection

The required personal protective equipment for each level of protection is listed below. Specific information regarding respiratory protection is detailed in Section 6.3.

Personal Protective Equipment	Level of Protection				
	B	C	D+	D	Other
Chemical-Resistant Clothing (Polyethylene-coated Tyvek® or Saranex®)					
Uncoated Tyvek® Coveralls			X		
Normal Work Clothes or Coveralls				X	
Air-Line Respirator (ALR) with 5-minute escape pack					
Self-Contained Breathing Apparatus (SCBA) for rescue					
Full-Face Cartridge Respirator					
Half-Face Cartridge Respirator					
Full-face or Half-face Cartridge Respirator (on standby)					
Chemical-Resistant Gloves (Nitrile inner)			X	X	
Chemical-Resistant Gloves (Rubber/Neoprene outer)					
Chemical-Resistant Gloves (Latex inner)					
Chemical-Resistant Gloves (Nitrile outer)			X		
Work Gloves (outer)				X	
Chemical-Resistant Overboots (with steel toe and shank)			X		
Steel Toe Boots				X	
Chemical-Resistant Overboots (w/o steel toe)					
Safety Glasses/Goggles			X	X	
Face Shield					
Hard Hat			X	X(1)	
Hearing Protection			X(2)	X(2)	
5-Minute Escape Pack			X		

(1) At the discretion of the SHSO.
(2) Available upon request.

Changes to the type of PPE required under each level of protection may be instituted by the SHSO with the approval of the PHSO.

6.2 Site-Specific Levels of Protection

Based on an evaluation of potential hazards the levels of personal protection have been designated for the following tasks. Upgrading or downgrading the level of protection is not expected. Changes in level of protection will be the responsibility of the PHSO. Note: No single combination of protective equipment and clothing is capable of protection against all hazards. PPE should be used in conjunction with safe work practices, decontamination, and good personal hygiene.

Location	Job Task	Level of Protection				
		B	C	D+	D	Other
HPIA	Groundwater Sampling				X	
HPIA	Manhole Entry/Flow Meter Installation			X		

EXCEPT IN EMERGENCY SITUATIONS, CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL ONLY BE MADE WITH THE APPROVAL OF THE SITE HEALTH AND SAFETY OFFICER AND THE SITE MANAGER, IN CONSULTATION WITH THE PROJECT HEALTH AND SAFETY OFFICER AND PROJECT MANAGER.

6.3 Respiratory Protection

Standby emergency respiratory protection, listed below for Level D+, have been determined by qualified Baker personnel in compliance with OSHA Standard 29 CFR 1910.134.

Level D+

A NIOSH certified North brand 5-minute escape pack will be worn by entry personnel. A NIOSH certified North brand 30-minute SCBA will be made readily available to the rescue and entry person(s).

6.4 Care and Cleaning of Personnel Protective Equipment

Provisions for the care and cleaning of personal protective equipment used on site can be found in Attachment A - Baker Safety SOPs. Responsibility for compliance with these provisions lies with the Site Manager and/or Field Team Leader.

7.0 DECONTAMINATION PROCEDURES

7.1 Personnel Decontamination

Personnel leaving the Work Zone will be thoroughly decontaminated. The following protocol will be used for the decontamination stations according to levels of protection:

Level D	Level D+
1. Equipment drop	1. Equipment drop
2. Waterproof boot and glove gross contamination removal*	2. Outer boot and glove wash
3. Waterproof boot and glove wash*	3. Outer boot and glove rinse
4. Waterproof boot and glove rinse*	4. Tape Removal
5. Tape Removal*	5. Outer boot and glove removal
6. Waterproof boot and glove removal*	6. Coverall removal/ disposal
7. Coverall removal*	7. Inner glove removal/disposal
8. Hand/Face wash	8. Hand/face wash
9. Equipment wipe down	9. Equipment cleaning

*Optional - depends on degree of contamination and type of PPE used.

The following decontamination equipment is recommended for Levels D and D+ protection:

- Two small tubs (one set of wash and rinse water)
- Scrub brush
- Towels
- Disposable wipes
- Contaminated clothing disposal bag or drum
- Contaminated liquids disposal drum
- Liquinox and water as the decontamination solution

The decontamination liquids and clothing will be contained and disposed according to policy defined in the Sampling and Analysis Plan (SAP).

7.2 Equipment Decontamination

Provisions for the decontamination of equipment will be based on the size and type of equipment used. Specific decontamination procedures for the HPIA can be found in the SAP.

7.3 Waste Handling Procedures

The protocols outlined in the SAP for the handling, packaging, storing, and disposing of contaminated materials must 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 Generated Wastes," located in the Standard Operating Procedures for Administrative, Field, and Technical Activities Manual.

8.0 EMERGENCY PROCEDURES

8.1 Pre-Emergency Planning

All Navy/local emergency response contacts (On-Scene Coordinator, Fire Department, Security, Ambulance, Hospital, etc.) at the HPIA will be contacted 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 to be used on site.
- Expected length of time on site.
- Specific requirements the emergency response facilities may require.
- Confirmation of emergency phone numbers.

Specific points of contact, where applicable, will be established and added to the HASP. If requested, Material Safety Data Sheets will be provided at this time.

8.2 Emergency Coordinator

The SHSO acting as the Emergency Coordinator is responsible for field implementation of the Emergency Plan. 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 a backup/alternate Emergency Coordinator.

- Controlling activities of subcontractors and contacting the Navy On-Scene Coordinator and other base response groups.

- Anticipating, identifying, assessing, and controlling fires, explosions, chemical releases, and other emergency situations to the best of his/her abilities.

- Familiarity with site personnel trained in emergency first aid and CPR.

All on-site personnel, whether involved in emergency response or not, will be notified of their responsibilities by the Emergency Coordinator in an emergency. They will be familiar with the emergency procedures and the Emergency Coordinator's authority.

8.3 Communications

Internal communications will rely on direct communication (via verbal or two-way radios) between site personnel. External communications will employ a telephone located at the Command Post and various telephones located throughout the HPIA.

Personnel in the Work Zone should remain in constant communication or within sight of the Site Manager, SHSO, or Field Team Leader. Any failure of communication requires an evaluation of whether personnel should leave the Work Zone.

Air horns will be used for communication during emergency evacuation of site personnel. One long (3 second) air horn blast is the emergency signal to indicate that all personnel should evacuate the Work Zone. Air horns will also be used by Field Team members in the event of an emergency to gain the attention of other site personnel.

Hand signals will be used in case of failure of radio communications or when radio communications are not available:

Hand gripping throat .... - Out of air, 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 .... - No, negative

Telephone communication at the Command Post should be established as soon as practicable. The telephone number at the command post is (to be determined).

Coordination between Baker and Contractor Personnel is the responsibility of the Site Manager. The best means for securing the lines of communication will be determined prior to start-up by on-site project personnel.

Emergency telephone numbers will be place at strategic locations throughout the site. The list of emergency phone numbers is presented below.

Facility	Phone Number On-Base Phone	Phone Number Off-Base Phone**	Contact*
Security	911	(919) 451-4555 or 911	
Fire	911	911	Emergency Services Operator
Naval Ambulance Service	911	911	
Public Ambulance Service	455-9119	(919) 455-9119 or 911	Emergency Services Operator
Naval Hospital (Emergency Room)	911	911	Emergency Room Attendant
Onslow County Memorial Hospital (Emergency Room)	577-2240	911	Emergency Room Attendant
Hazardous Materials Team	911	911	Emergency Services Operator
Emergency (One Call)	911	911	Emergency Services Operator
Public Works Dept. (underground utilities via EMD contact)	5872	(919) 451-5872	George Radford
On-Scene Coordinator	911	911	Fire Chief
Agency for Toxic Substances and Disease Registry	1-404-639-0615	1-404-639-0615	Response Operator
Poison Control Center	1-800-672-1697	1-800-672-1697	Response Operator
NRC	1-800-424-8802	1-800-424-8802	Response Operator
CHEMTREC	1-800-424-9300	1-800-424-9300	Response Operator

*Remaining points of contact will be identified prior to the start of activities.

** Note: When calling 911 on a non-base phone to reach a base facility, ask Emergency Services Operator to transfer call to Base 911 system and report emergency.

8.4 Assembly Area

In the event of an emergency personnel will be instructed to meet at the Baker Site Trailer. If possible, personnel will exit the work area through the decontamination zone. If the trailer is inappropriate an alternate assembly area will be designated by the Emergency Coordinator in an upwind location from the site before the start of operations. At this location, emergency needs will be provided, such as:

- Assembly for evacuated personnel
- First aid for injured personnel
- Decontamination material
- Communications.

8.5 Emergency Hospital Route

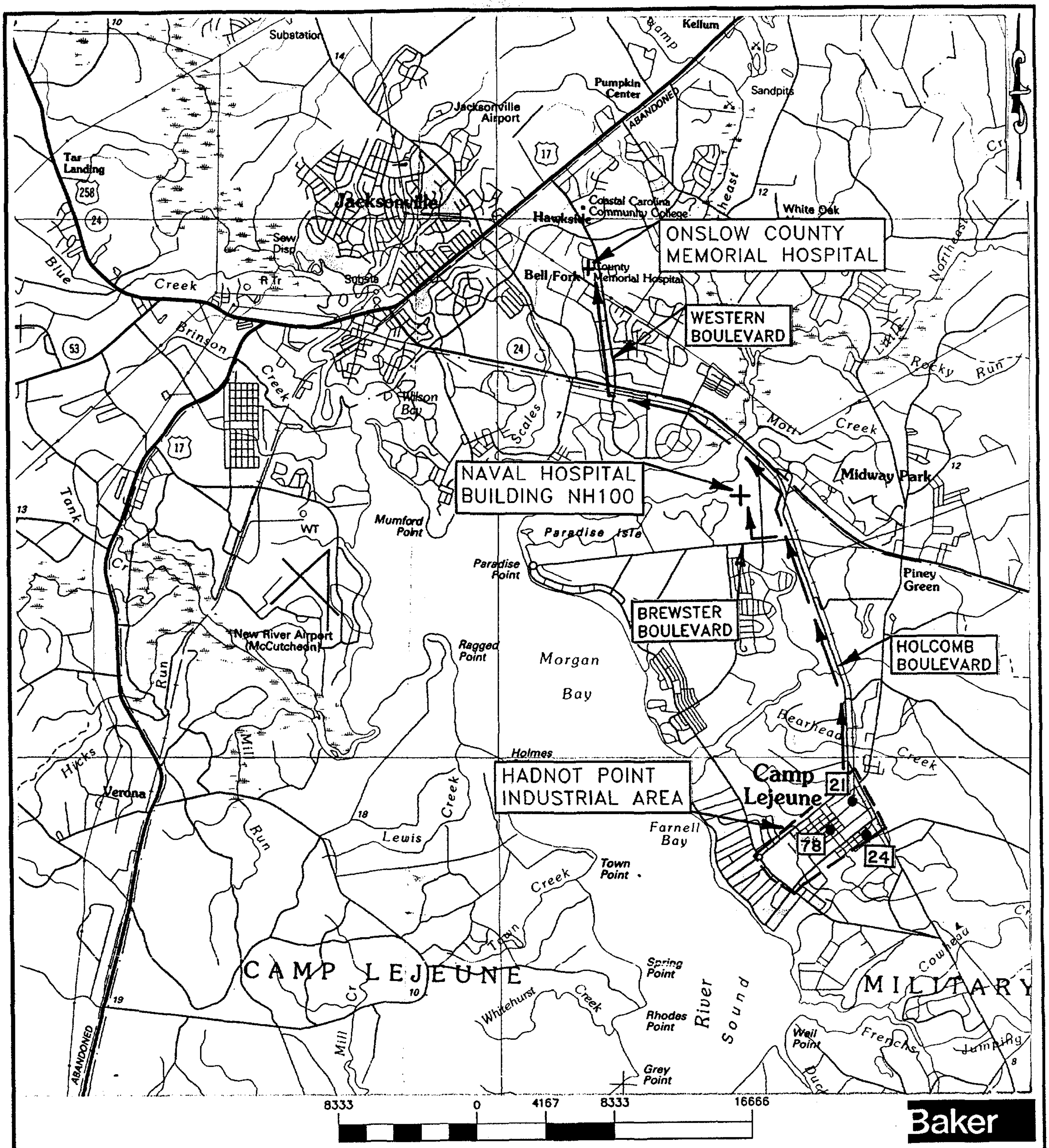
An emergency hospital route map showing the location of the local hospital will be posted at the Baker Command Post and Baker Field Vehicles. Personnel will be informed of the location of the map and the directions to the hospital.

Directions to the Base Naval Hospital (Building NH100) (Refer to Figure 2):

1. Proceed north on Holcomb Boulevard (towards Route 24).
2. Turn left onto Brewster Boulevard (heading west).
3. Continue on Brewster Boulevard until intersection with driveway to Naval Hospital, on right.
4. Turn onto driveway and continue until intersecting with the Naval Hospital.

Directions to Onslow County Memorial Hospital (317 Western Boulevard) (Refer to Figure 2):

1. From Holcomb Boulevard, leave base through main gate.
2. Take Highway 24 west to Western Boulevard and turn right (headed north).
3. Continue on Western Boulevard and hospital will appear on the left.



SOURCE: U.S.G.S. TOPOGRAPHIC MAP

1 inch = 8333 ft.

Baker
Baker Environmental, Inc.

FIGURE 2
EMERGENCY HOSPITAL ROUTE FOR
THE INTERIM REMEDIAL ACTION OF THE
SHALLOW AQUIFER AT THE HPIA
MCB CAMP LEJEUNE, NORTH CAROLINA

CTO-0134

Site Command Post Address: (to be determined)

Site Telephone Number: (to be determined)

8.6 Emergency Medical Treatment

Emergency Services

The nearest public hospital is Onslow County Memorial Hospital located at 317 Western Boulevard, Jacksonville, NC, phone no.: 577-2240 (on base) and (919) 577-2240 (off base).

Note: In emergencies, personnel may be transported to Building NH100 (Naval Hospital) for initial treatment.

Local ambulance service is available from the Base Ambulance Service at 911 and the City of Jacksonville at (919) 455-9119. Contact should be made with emergency personnel prior to the start of activities (See Section 8.1).

There will be a minimum of 2 person(s) on each site that will be trained in emergency first aid and CPR.

Physical Injury

If an employee working in a contaminated area is physically injured, first-aid procedures are to be followed. Depending on the severity of the injury, emergency medical response from base personnel may be sought to stabilize victim for transport to public hospitals. 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 8.7). Then, if circumstances permit, administered emergency first aid, and transported to an awaiting ambulance or to a local emergency medical facility.

Chemical Injury

If the injury to a worker is chemical in nature (e.g., overexposure), 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 emergency eyewash station using large amounts of water and lifting the lower and upper lids occasionally. A portable eyewash unit will be located in the CRZ decontamination area during exclusion zone work. Obtain medical attention immediately. Contact lenses will not be worn when working.

- 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 the poison control center. Do not make an unconscious person vomit. If signs of overexposure develop contact the North Carolina Duke Regional Poison Control Center at 1-800-672-1697.

- Breathing - If a person has difficulty breathing, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Obtain medical attention as soon as possible.

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. Systematic signs (which may or may not occur) including weakness, sweating, faintness, and signs of shock.

Provide treatment as follows:

1. Calm the victim and keep affected area still.

2. Contact ambulance if victim needs 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. Transport victim to the nearest medical facility.

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.

Inform the SHSO immediately if a snakebite has occurred. The SHSO will in turn, inform the PHSO, as soon as possible.

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 and chemicals involved.

Decontamination

If on-site decontamination of injured employee(s) is not possible, the Emergency Coordinator will provide polyethylene sheeting for a stretcher, and ambulance. If necessary, a site employee equipped with appropriate protective equipment and clothing will accompany the injured employee and will perform decontamination under the supervision of emergency medical personnel.

Instances requiring treatment beyond "first aid" will be handled at appropriate facilities and reported to the Project Manager and PHSO within 24 hours.

8.7 Emergency Decontamination Procedures

In the event of a medical emergency, patients are to be adequately decontaminated before transfer, if possible. This is 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	Level D+
Equipment drop, tape, boot, and glove removal, and coverall removal.	Equipment drop, tape, outer boot, and glove removal, coverall removal/disposal. and inner glove removal/ 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 and 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.

8.8 Personal Protection and First-Aid Equipment

PPE available for emergency response will include the following:

- Polyvinyl chloride boots
- Tyvek® suits, polyethylene coated and uncoated
- Nitrile gloves (inner and outer)
- Nitrile Gloves (outer)
- Face shields and goggles
- SCBA

PPE, first-aid equipment and the first-aid kits will be available in the support zone (i.e., Baker Field Vehicle or Baker Site Trailer).

Emergency and first aid equipment can be found at the following locations:

Fire Extinguisher:	"Baker Site Trailer" and Contractor Field Vehicle
First aid kit:	Baker Site Trailer and Baker Field Vehicle
Emergency eye wash bottle:	Baker Site Trailer and Baker Field Vehicle
Air Horn:	With Personnel
Portable Emergency Eye Wash Station:	Near Area With Greatest Potential for Chemical Splash/Exposure

8.9 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, he/she will report their findings to the Fire Chief (Navy On-Scene Coordinator) and the Environmental Management Department (EMD). The notification report will be made from the Baker Field Trailer site office, or other base locations and 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.
- The extent of injuries, and number of casualties.
- The possible hazards to human health or the environment and cleanup procedures.
- Assistance that is requested.

8.10 Hazard Assessment

The Emergency Coordinator will assess possible hazards to human health or the environment that may result from a chemical release, fire, explosion, or severe weather conditions to the best of his/her abilities, incorporating the following steps, as appropriate.

- Assess the immediate need to protect human health and safety.

- Identify the materials involved in the incident.

- Identify exposure and/or release pathways and the quantities of materials involved.

- Determine the potential effects of the exposure/release and appropriate safety precautions.

- Determine if release of materials meets EPA requirements for reportable quantities for spills under the RCRA or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

- Inform appropriate personnel as identified in Section 8.9.

This assessment will 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 generated or the effects of any hazardous surface water runoff from water or chemical agents used to control fire and heat-induced explosions).

8.11 Security

During activation of the Emergency Plan, the Emergency Coordinator or his/her designated representative will control access to the site and maintain an incident log until the Navy On-Scene Coordinator arrives. The incident log will include:

- Time of entry.
- Expected exit time.
- Use of team or "buddy" system.
- Task being performed.
- Location of task.
- Rescue and response equipment used.
- Protective equipment being used.

8.12 Emergency Alerting

Personnel Injury in the Exclusion Zone: Upon notification of an injury in the Exclusion Zone, verbal warning or one long airhorn blast shall be sounded, and all site personnel shall assemble at the decontamination control line (for Level D/D+). The rescue team will enter the Exclusion Zone (if required) to remove the injured person to the hotline. The SHSO and/or Site Manager will evaluate the nature of the injury, and assure that the affected person is decontaminated according to Section 8.7. If required, contact will be made with an ambulance, and/or with the designated medical facility. No persons shall reenter the Exclusion Zone until an accident investigation is performed by the SHSO and/or the Site Manager.

Personnel Injury in the Support Zone: Upon notification of any 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, verbal warning or one long airhorn blast shall be sounded and all remaining site personnel will move to the support zone for further instructions. Activities on site will stop until the added risk is mitigated.

Fire/Explosion: Upon notification of a fire or explosion on site, verbal warning or one long airhorn blast shall be sounded and all site personnel will assemble at the contamination control line (for Level D/D+) or the CRZ (for Level C or higher). The fire and security departments will be alerted and all personnel will move to a safe distance from the involved area for 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 Exclusion 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 Site Manager and/or the Field Team Leader and SHSO shall be notified to determine the effect of this failure on continuing operations on site. If the failure affects the safety of site personnel, work with the equipment will cease until the situation is evaluated and appropriate actions taken.

Accident/injury reports will be completed for any accidents no matter how minor the injury. All injuries resulting in treatment other than first aid will be reported to the Project Manager and PHSO within 24 hours. Records on equipment failure will also be completed.

In all situations, when an on-site emergency results in evacuation of the Exclusion 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.

8.13 Training

Site personnel will be informed of the details in the Emergency Plan during initial HASP training. The Emergency Plan will be reviewed/rehearsed by site personnel at least monthly or when elements of the plan change.

8.14 Spill Containment Procedures

In the event that a spill of hazardous substances (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. In the event of a spill, measures will be taken to contain the spill and clean it up. For the purpose of this HASP, a spill is defined as a release of a hazardous substance to soils or surface waters. Any release to soils or surface waters equaling or exceeding the reportable quantities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (40 CFR 304) or the EPA Clean Water Act (40 CFR 116 and 177) will be reported to the Environmental Management Department (EMD) who will contact the appropriate state agency within 24 hours.

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 will include:

- Absorbent towels
- Sheets of polyethylene
- Vermiculite

9.0 TRAINING REQUIREMENTS

9.1 General

All Baker employees or other personnel entering the site will need to have received training in compliance with the Occupational Safety and Health Administration (OSHA) Standard 29CFR 1910.120. Baker employees engaged in field activities which potentially expose workers to hazardous substances receive a minimum of 40 hours of instruction off site, and a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor. These are generally 5-day (40-hour) courses. Key points of the 40-hour training include field demonstrations, respiratory fit testing and training, risk assessment, toxicology, chemical reactivity, use of monitoring equipment, downrange work procedures, site safety procedures, levels of protection, protective clothing, decontamination, and practical field exercises (which include donning, doffing, and working in personal protective ensembles for personal protection Levels A, B, and C).

In addition to the initial 40-hour training program, Baker requires site employees to receive an annual 8-hour refresher training course on the items specified by the 1910.120 standard. The general purpose of the 8-hour refresher is to ensure that personnel retain the knowledge necessary to be adequately protected, and stay current with proper site health and safety procedures.

Baker also requires that personnel involved with on-site employee supervision receive (in addition to 40 hours initial training and three days of supervised field experience) at least eight additional hours of specialized training at the time of job assignment. Training topics include, but are not limited to, the employer's safety and health program and the associated employee training program, personal protective equipment program, spill containment program, and health hazard monitoring procedures and techniques. The 8-hour supervisory training is required to ensure that supervisors have the knowledge necessary to understand and use the various Health and Safety Programs and to implement the elements of the HASP. Table 4 provides the appropriate OSHA Training History for Baker Project Personnel.

9.2 Site-Specific Training

Site-specific training, as discussed in Section 1.3, will consist of an initial health and safety briefing on the following information:

TABLE 4

OSHA TRAINING HISTORY OF BAKER PROJECT PERSONNEL*

Personnel	Anticipated Site Activities	Training Status
Donald Joiner	• Project Manager	• 40-hr. training completed: 03/92 • Supervisory training: 03/92 • 8-hr. refresher completed: NA • First Aid Training: NA • CPR Training: NA • Medical surveillance: Yes
Barbara Cummings	• Project Health and Safety Officer	• 40-hr. training completed: 10/91 • Supervisory training: 09/91 • 8-hr. refresher completed: 08/92 • First Aid Training: 11/91 • CPR Training: 11/91 • Medical surveillance: Yes
(To be Determined)	• Site Manager	• 40-hr. training completed: • Supervisory training: • 8-hr. refresher completed: • First Aid Training: • CPR Training: • Medical surveillance:
(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 4 (Continued)

OSHA TRAINING HISTORY OF BAKER PROJECT PERSONNEL*

Personnel	Anticipated Site Activities	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)	● Environmental Scientist	● 40-hr. training completed: ● Supervisory training: ● 8-hr. refresher completed: ● First Aid Training: ● CPR Training: ● Medical surveillance:

* Training history for contractor personnel will be attached.

NA - Not Applicable

- Names of individuals responsible for site health and safety and methods of communicating safety and health concerns.
- Site-specific health and safety hazards.
- Use of PPE.
- Work practices by which employees can minimize risk.
- Safe use of equipment on site.
- Recognition of symptoms and signs of exposure to hazardous materials.
- Site control measures.
- Decontamination procedures.
- Emergency response procedures.

The SHSO will conduct the initial site-specific training prior to the initiation of field activities.

10.0 MEDICAL SURVEILLANCE REQUIREMENTS

This Site-Specific HASP will require that project personnel, who may be exposed to materials having potentially adverse and deleterious health effects, have obtained medical clearance from Baker's Board Certified Occupational Health Physician in accordance with 29 CFR 1910.120(f) prior to entry onto the 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, Occupational Safety and Health Administration (OSHA), Hazardous Waste Operations and Emergency Response Standard, 29 CFR 1910.120. Additionally, the program is intended to determine the individual's capability for performing on-site work, including wearing respiratory protective equipment.

All Baker employees that will be engaged in site activities covered by the 1910.120 standard receive a Group III physical examination by a licensed physician who is provided information on the individuals site activities, and exposure or anticipated exposure levels. This exam is received initially, then once every 12 months thereafter. More frequent medical examinations, consultations, and/or laboratory testing will be provided if the examining 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, pulmonary function test, urinalysis, and blood tests. Table 5 describes the medical surveillance testing parameters performed annually on Baker employees.

Prior to entry onto the site, all personnel, including subcontractors, will be required to provide medical clearance information from their company physician stating that they are physically capable of performing the activities required.

TABLE 5

MEDICAL SURVEILLANCE BASELINE TESTING PARAMETERS*

Group I - Individuals Rarely in the Field (<10 days/year)

- Medical History and Physical
- Eye Exam
- EKG (baseline and for individuals over 40 yrs.)
- CBC with differential

Group II - Individuals Occasionally in the Field (10-30 days/year)

- Medical History and Physical
- Eye Exam
- EKG (baseline and for individuals over 40 yrs.)
- 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 and Physical
- Eye Exam
- EKG (baseline and for individuals over 40 years)
- 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 and also associated with asbestos

- Group III testing with the Asbestos Medical Questionnaire

Group IV - Individuals associated with Asbestos

- Medical history and physical
- Eye Exam
- Chest X-ray (baseline then every 5 years)
- Pulmonary Function Test ($FVC_{1.0}$ and $FEV_{1.0}$)
- Urinalysis
- Audiometry
- Asbestos Medical Questionnaire

* The attending physician has the right to reduce or expand the medical monitoring on an annual basis as he/she deems necessary.

** Rare and expensive - to be performed only for individuals identified by the attending physician as being chronically exposed to organic compounds.

11.0 HEALTH AND SAFETY PLAN APPROVAL

This HASP has been reviewed by the following personnel prior to submission to LANTDIV.

Don P. Joiner	Project Manager	Don P. Joiner
Name (print)	Title (print)	Signature
Barbara J Cummings	Project Health and Safety Officer	Barbara J. Cummings
Name (print)	Title (print)	Signature

12.0 DECLARATION OF HASP REVIEW

All site personnel indicated below, have reviewed and are familiar with this Health and Safety Plan. Site personnel were briefed on the contents of this HASP on ________ at ________ a.m./p.m.

1.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)
2.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)
3.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)
4.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)
5.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)
6.	________________________ (Name-Print)	________________________ (Company)
	________________________ (Name-Sign)	________________________ (Date)

Declaration of Health and Safety Plan Review (Continued)

7. ______________________	______________________
(Name-Print)	(Company)
______________________	______________________
(Name-Sign)	(Date)
8. ______________________	______________________
(Name-Print)	(Company)
______________________	______________________
(Name-Sign)	(Date)
9. ______________________	______________________
(Name-Print)	(Company)
______________________	______________________
(Name-Sign)	(Date)
10. ______________________	______________________
(Name-Print)	(Company)
______________________	______________________
(Name-Sign)	(Date)

Attachment A
Baker Environmental, Inc.
Safety Standard Operating Procedures

ATTACHMENT A

BAKER ENVIRONMENTAL, INC.
SAFETY STANDARD OPERATING PROCEDURES

TABLE OF CONTENTS

1.0 - CONFINED SPACE ENTRY PROGRAM

1.1 INTRODUCTION

All confined space entries shall be performed in accordance with the following program based on the "Criteria Document for a Recommended Standard for Working in Confined Spaces," issued by NIOSH.

A confined space refers to a space, which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants; and which is not intended for continuous employee occupancy.

Confined spaces include, but are not limited to, storage tanks, compartments of ships, process vessels, pits, silos, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines. If there is a question as to whether or not an area should be considered as a confined space, appropriate safety personnel should be consulted prior to entry.

1.2 HAZARD IDENTIFICATION

Identify and evaluate each hazard of the permit spaces. Hazardous substances should be identified through the use of direct reading instruments such as an HNu or OVA meter, in addition to monitoring oxygen and explosive levels using a Combustible Gas/Oxygen (LEL/O_2) meter. In addition, a hydrogen sulfide and carbon monoxide meter will also be used to monitor for common contaminants.

IF TESTS OR CONDITIONS INDICATE THAT HAZARDS ARE PRESENT <u>DO NOT</u> ENTER THE CONFINED SPACE WITHOUT THE PROPER EQUIPMENT AND AUTHORIZATION FROM THE PROJECT HEALTH AND SAFETY OFFICER.

1.3 HAZARD CONTROL

Establish and implement the means, procedures, and practices by which the permit spaces can be entered safely. Ventilation and area cleaning should be performed in addition to the use of personal protective equipment. Occupation of the confined space should be kept to the minimum time period necessary. Continuous air monitoring must be performed to ensure the safety of entry personnel.

1.4 PERMIT SYSTEM

The Site Health and Safety Officer (SHSO) will complete the confined space entry permit identified in this SOP. This permit must be posted at the point of entry and is valid for up to four consecutive hours at each respective entry point. After four hours, or sooner if there is reason to believe that conditions may have changed, and a new permit must be completed. Completed and expired permits must be returned to the SHSO to be placed in the project file.

1.5 EMPLOYEE INFORMATION

Signs shall be posted near permit confined spaces to notify employees as to hazards that may be present, and, that only authorized personnel may enter. For personnel in the manhole inspection program, viewing of the video entitled "Safety Training for Sanitary Sewer Workers" is required before initiating work activities.

1.6 EMPLOYEE TRAINING

All employees entering or directly involved in the confined space activities must have completed a 40-hour and subsequent 8-hour refresher health and safety training course in accordance with 29 CFR 1910.120. Additionally, site-specific training must be conducted regarding the hazards associated with each confined space, and confined space entry procedures, that cover the following subjects:

- Oxygen Deficiency
- Explosivity
- Toxics
- Ventilation
- Respiratory Protection
- Initial Entry and Monitoring
- Emergency Procedures and Egress
- Personal Protective Equipment/Procedures

1.7 EQUIPMENT

All equipment must be inspected and maintained to ensure that the equipment does not present a hazard to personnel. Respirators and emergency equipment, lanyard, harness, tripod, etc. must be thoroughly inspected prior to the confined space entry. Records of the inspection shall be kept in the project file. The equipment shall be adequately decontaminated following each entry.

1.8 RESCUE

Ensure that procedures and equipment(1) necessary to rescue entrants from permit spaces are implemented and provided. The "buddy system" will be used for all entries. A qualified individual located outside of the confined space will keep in constant communication with the person(s) inside the confined space. At a minimum, there will be one person outside the confined space for every person inside.

The attached table provides a list of requirements with respect to each entry classification. The following items describe the three confined space entry classifications.

I CLASS A

- Immediate Danger to Life and Health (IDLH) condition exists
- Should only be entered under emergency conditions (Level B protection ensembles)
- Efforts should be made to reduce IDLH levels such as ventilation, cleaning, etc.
- IDLH conditions may include:
  - Oxygen levels below 19.5% or greater than 22%
  - LEL levels 20% or greater
  - Contaminant Concentration >PEL

II CLASS B

- Dangerous, but not IDLH conditions
- Levels of protection can range from C to B
- Range of conditions:
  - Oxygen from to 19.5% to 22%
  - LEL levels from 10% to 19%
  - Contaminant Concentration ≥ the PEL

(1) Equipment, at minimum, shall consist of:

- Tripod Assembly
- Winch
- Rescue harness and safety line
- Ventilator
- 5-minute escape packs
- SCBA
- Monitoring Equipment

III CLASS C

- Low Hazard Potential
- Requires no modification of work procedures but constant monitoring
- Range of conditions:
    - Oxygen levels from 19.5% to 22%
    - LEL levels less than or equal to 10%
    - Contaminant Concentrations < the PEL

CONFINED SPACE ENTRY

ITEM	CLASS A	CLASS B	CLASS C
1. Permit	X	X	X
2. Atmospheric Testing	X	X	X
3. Monitoring	X	X	X
4. Medical Surveillance	X	O	O
5. Training of Personnel	X	X	X
6. Labeling and Posting	X	X	X
7. <u>Preparation</u>			
Isolate/Lockout/Tag	X	X	X
Purge and Ventilate	X	X	O
Cleaning Procedures	X	O	O
Requirements for Special Equipment/Tools	X	X	O
8. <u>Procedures</u>			
Initial Plan	X	X	X
Standby	X	X	O
Communication/Observation	X	X	X
Rescue	X	X	X
Work	X	X	X
9. <u>Safety Requirement and Clothing</u>			
Head Protection	X	X	X
Hearing Protection	O	O	O
Hand Protection	X	X	O
Foot Protection	X	X	X
Body Protection	X	O	O
Respiratory Protection	X	X	O
Safety Belts	X	X	X
Life Lines, Harness	X	X	X
10. Rescue Equipment	X	X	X
11. Recordkeeping/Exposure	X	X	X

X - Indicates requirements
O - Indicates determination by the qualified individual

Baker

Baker Environmental, Inc

☐ CONFINED SPACE ENTRY PERMIT
☐ HAZARDOUS AREA ENTRY PERMIT

LOCATION and DESCRIPTION of Confined Space ____________________ Date ____________

PURPOSE of Entry ____________________ Time ____________ a.m./p.m.

JOB/SITE ____________________ Expiration ____________ a.m./p.m.

PERSON in Charge of Work ____________________

SAFETY REQUIREMENTS	Yes	No		Yes	No
Lock Out - De-Energize			Escape Harness		
Lines Broken - Capped or Blanked			Tripod Emergency Escape Unit		
Purge - Flush and Vent			Lifelines		
Ventilation			Fire Extinguishers		
Secure Area			Lighting		
Breathing Apparatus			Protective Clothing		
Resuscitator - Inhalator			Respirator		

TEST(S) TO BE TAKEN Valid for One 4-Hour Entry	Yes	No	CONCENTRATION	INSTRUMENT USED AND DATE CALIBRATED
% of Oxygen				
% of L.E.L.*				
Carbon Monoxide				
Aromatic Hydrocarbon				
Hydrocyanic Acid				
Hydrogen Sulfide				
Sulfur Dioxide				
Ammonia				
Other:				
Other:				

*L.E.L. = Lower Explosion Level

Atmosphere Tester: ____________________ ____________________
Name (print) Signature

Note: Continuous/periodic tests shall be established before beginning job. Any questions pertaining to test requirements contact the Site Health and Safety Officer.

Safety Standby Person(s)	Title

Supervisor authorizing all above conditions specified ____________________

ALL COPIES OF PERMIT WILL REMAIN AT JOB SITE UNTIL JOB IS COMPLETED.

3.0 - CARE AND CLEANING OF PERSONAL PROTECTIVE EQUIPMENT

3.1 INTRODUCTION

The following procedures cover the care and cleaning of Levels D, C, and B personal protective equipment. Note: These are general procedures that apply to most situations and are not all inclusive. Procedures are subject to change at the direction of the Site Health and Safety Officer (SHSO).

3.2 EQUIPMENT CARE

3.2.1 Chemical Resistant Suit (Levels C and B)

- Before donning, inspect suit for holes or tears; check to see that zippers are operable; and look for signs of suit degradation.

- When wearing, avoid contact with contaminated material where possible; be aware of sharp objects that can tear suit; periodically look over suit to check for major rips or tears.

- While decontaminating, remove gross excess of material from suit; remove suit so that material does not contact inner suit; place clothing in properly labeled disposal containers.

3.2.2 Inner/Outer Gloves (Levels D through B)

- Look for rips, tears, or degradation of material. Replace as necessary or at the direction of the SHSO.

3.2.3 Chemically Resistant Boots (Levels C and B)

- Nondisposable boots are to be examined on a daily basis before and after use. Disposable boots should be examined prior to donning and while in use. Dispose of according to site procedures.

3.2.4 Safety Shoes/Boots (Levels D through B)

- Examine daily for gauges, open seams, etc., anything that would lessen the integrity of the boot. Replace as shoe/boot becomes worn.

3.2.5 Hard Hats (Levels D through B)

- Should be visually inspected before donning for fit, cracks, and overall condition.

3.2.6 Safety Glasses/Goggles (Levels D and C)

- Should be visually inspected before donning for cracks, deteriorated parts, and overall condition. Replace as necessary.

3.2.7 Respirators (Levels C and B)

- Procedures for care of respiratory protective equipment are covered in Attachment D - Baker SOPs.

3.2.8 Hearing Protection (Levels D through B)

- Disposable - Replace daily, or as material becomes worn or dirty.
- Reusable - Inspect before use, clean regularly, replace parts as necessary.

3.3 EQUIPMENT CLEANING

General procedures for cleaning of equipment are listed below. Site-specific concerns will be addressed by the SHSO prior to and during site activities. Cleaning of respiratory equipment is covered under the "Respiratory Protection Program" SOP.

3.3.1 Gross Physical Removal

Large amounts of contaminated soil is scraped off with a tongue depressor, or wiped off using a disposable wipe.

3.3.2 Physical/Chemical Removal

The residual contamination will be scrubbed with a soft-bristled, long-handled brush using a nonphosphate detergent solution.

3.3.3 Rinsing/Dilution

The detergent solution and residual contaminants will be rinsed with tap water using a pressurized sprayer.

4.0 - SANITATION/SITE PRECAUTIONS

4.1 SANITATION

- 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 which is either chemical, recirculating, combustion, or flush, depending on local code requirements.
- A place for food handling meeting all applicable laws, otherwise, suitable alternatives to such facilities will be provided (i.e., nearby restaurants, food wagons, etc.).
- Clean wash water will be available in the decontamination zone and the Baker Site Trailer.

4.2 SITE PRECAUTIONS

- 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 any area designated as contaminated.
- Smoking will not be allowed in areas where flammable materials are present.
- Hands and face must be thoroughly washed upon leaving the work area.
- 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.

- No contaminated work garments are to be worn off site.
- Contact lenses are not permitted to be worn on site.
- No facial hair which interferes with a satisfactory fit of the mask-to-face seal, is allowed on personnel required to wear respirators.
- Contact with contaminated or potentially contaminated surfaces should be avoided. Wherever possible, do not walk through puddles, leachate, discolored surfaces, kneel on ground, lean, sit or place equipment on drums/containers.
- Medicine and alcohol can potentiate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel where the potential for absorption, inhalation, or ingestion of toxic substances exist unless specifically approved by a qualified physician. Alcoholic beverage intake should be minimized or avoided during after-hour operations.
- Alcoholic beverages are prohibited on site.
- Personal radios, TVs, and tape players are prohibited on site.
- Firearms are prohibited on site.
- All personnel will observe any posted sign, warning, fence, or barrier posted around contaminated areas.

5.0 HEAT STRESS

Monitoring

Provisions for monitoring for heat stress will be determined by the SHSO and performed as outlined below.

Heat stress monitoring is required for personnel wearing semipermeable or impermeable protective outerwear when there is an ambient air temperature greater than 70°F. One or more of the following procedures will be implemented when this condition exists:

1. Increased awareness of heat stress symptoms and buddy monitoring.
2. Fluid intake discipline.
3. Self monitoring of urine output quantities to prevent dehydration.
4. Work-rest intervals.
5. Calculate the Heat Exposure Threshold Limit Value (TLV) for work-rest intervals using the following steps:
   a. Calculate the WBGT (Wet Bulb Globe Temperature) Index using the Quest® Heat Stress Monitor
   b. Estimate the work load using the following guidelines:
      (1) Light work = sitting or standing to control machines, performing light hand or arm work.
      (2) Moderate work = walking about with moderated lifting and pushing.
      (3) Heavy work = pick and shovel work.
   c. Evaluate the calculations against the following Heat Exposure TLVs in °C or °F.

Work - Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous work	30.0 (86)	26.7 (80)	25.0 (77)
75% work - 25% rest, each hour	30.6 (87)	28.0 (82)	25.9 (78)
50% work - 50% rest, each hour	31.4 (89)	29.4 (85)	27.9 (82)
25% work - 75% rest, each hour	32.2 (90)	31.1 (88)	30.0 (86)

* For unacclimatized workers, the permissible heat exposure TLV should be reduced by 2.5°C.

Special Considerations

- Clothing - Subtract 2 from the TLV to compensate for the use of semipermeable clothing.
- Acclimatization - After approximately a week, workers should have acclimated themselves 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.

Causes and Symptoms

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 Level B and C protective ensembles will be difficult.

1. *Heat rash* results from continuous exposure to heat or humid air.
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; and dizziness.

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. Excessive cooling can cause hypothermia and should be avoided.

Prevention

Fluid intake should be increased during rest schedules to prevent dehydration. Drinking cool water is best; however, diluted electrolyte solutions (i.e., Gatorade or equivalent) can be substituted for water. Each individual should monitor their urine output and adjust their fluid intake to ensure that urine output and urine color are close to normal. Additional means for preventing heat-induced illnesses may include providing shelter or cooling devices, such as vests and showers.

6.0 COLD STRESS

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 and exposure symptoms for both hypothermia and frostbite are as follows:

1. *Hypothermia* - 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 hypothermic. 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; (3) unconsciousness; (4) freezing; and (5) death.

2. *Frostbite* - 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, 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.

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.

To prevent conditions from occurring have personnel:

- Dress in a minimum of three layers (a skin layer to absorb moisture and keep skin dry, an insulating layer, and an outer chemical-protective layer).

- Avoid touching cold surfaces (especially metal) with bare skin, minimize exposed skin surfaces.
- Keep active, use shelter areas during rest cycles.
- Maintain body fluids.
- Use wind breaks whenever possible.

Attachment B
Material Safety Data Sheets

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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

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.

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*)
DOT Hazard Class: Flammable liquid
ID No.: UN1114
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Benzene
IMO Hazard Class: 3.2
ID No.: UN1114
IMO Label: Flammable liquid
IMDG Packaging Group: II

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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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

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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^-).

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

Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 312
TRICHLOROETHYLENE
(Revision E)

Issued: July 1979
Revised: August 1987

SECTION 1. MATERIAL IDENTIFICATION

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MATERIAL NAME: TRICHLOROETHYLENE

DESCRIPTION (Origin/Uses): Prepared from *sym*-tetrachloroethane by way of eliminating HCl by boiling with lime. Used to manufacture organic chemicals, pharmaceuticals; in degreasing and dry cleaning; and as a solvent for fats, waxes, rubbers, oils, paints, varnishes, ethers, and cellulose esters.

OTHER DESIGNATIONS: Ethylene Trichloride; TCE; Trichloroethene; 1,1,2-Trichloroethylene; C_2HCl_3; NIOSH *RTECS* #KX4550000; CAS #0079-01-6

MANUFACTURER/SUPPLIER: Available from several suppliers, including:
Dow Chemical USA, 2020 Dow Center, Midland, MI 48640;
Telephone: *(517) 636-1000; (800) 258-CHEM*

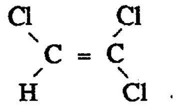
COMMENTS: Trichloroethylene is a toxic solvent and a suspected occupational carcinogen.

HMIS
H 2
F 1
R 1
PPE*
* See sect. 8

R 1
I 3
S 1
K 0

SECTION 2. INGREDIENTS AND HAZARDS

	%
Trichloroethylene, CAS #0079-01-6; NIOSH *RTECS* #KX4550000	100



* The TLV-TWA *is set to control subjective complaints such as headache,* fatigue, and irritability.

** The TLV-STEL is set to prevent incoordination and other beginning anesthetic effects from TCE. These levels should provide a wide margin of safety in preventing liver injury.

*** The OSHA PEL is 300 ppm for 5 minutes in any 2 hours.

HAZARD DATA

ACGIH Values 1987-88
TLV-TWA*: 50 ppm, 270 mg/m^3
TLV-STEL**: 200 ppm, 1080 mg/m^3
OSHA PEL 1986***
8-Hr TWA: 100 ppm
Ceiling: 200 ppm
NIOSH REL 1986
10-Hr TWA: 25 ppm
TOXICITY DATA
Human, Oral, LD_{Lo}: 7 g/kg
Human, Inhalation, TC_{Lo}: 6900 mg/m^3 (10 Min)
Human, Inhalation, TC_{Lo}: 160 ppm/83 Min
Human, Inhalation, TD_{Lo}: 812 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point ... 188.6°F (87°C)
Vapor Pressure ... 58 Torr at 68°F (20°C)
Water Solubility ... Insoluble
Vapor Density (Air = 1) ... 4.53
Evaporation Rate ... Not Listed
Specific Gravity ... 1.4649 at 68°F (20°C)
Melting Point ... -120.64°F (-84.8°C)
Molecular Weight ... 131.40 Grams/Mole

Appearance and odor: Colorless, nonflammable mobile liquid; sweetish odor like chloroform.

COMMENTS: TCE is highly soluble in lipids. A high vapor pressure at room temperature provides the potential for TCE vapors to contaminate use areas.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
			-	
Not Listed	770°F (410°C)	% by Volume	8%	10.5%

EXTINGUISHING MEDIA: TCE has no flash point in a conventional closed tester at room temperature, but it is moderately flammable at higher temperatures. Use dry chemical, carbon dioxide, alcohol foam, or other extinguishing agents suitable for the surrounding fire.

OSHA Flammability Class (29 CFR 1910.106): Not Regulated

UNUSUAL FIRE/EXPLOSION HAZARDS: During fire conditions TCE emits highly toxic and irritating fumes, including hydrochloric acid and phosgene. SPECIAL FIRE-FIGHTING PROCEDURES: Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or another positive-pressure mode. At TCE vapor levels of 300-1000 ppm, fire fighters who lack the proper respiratory equipment may experience incoordination and impaired judgment.

DOT Flammability Class (49 CFR 173.115): Not Regulated

SECTION 5. REACTIVITY DATA

Trichloroethylene is stable. Hazardous polymerization can occur under certain circumstances (see Conditions to Avoid and Comments, below).

CHEMICAL INCOMPATIBILITIES include magnesium or aluminum powder, NaOH, KOH, or other strong alkaline materials. Reactions with alkaline materials may lead to the formation of dangerous explosive mixtures of chloroacetylenes.

CONDITIONS TO AVOID: When TCE is heated (as in the case with vapor degreasers) or exposed to sunlight, it requires extra stabilization against oxidation, degradation, and polymerization. It is slowly decomposed by light when moist.

PRODUCTS OF HAZARDOUS DECOMPOSITION include hydrochloric acid and phosgene under certain conditions at elevated temperatures.

COMMENTS: TCE is stable under normal handling and storage conditions, and hazardous polymerization is not expected to occur. However, failure of the stabilizer at elevated temperatures or other extreme conditions may allow polymerization to take place..

SECTION 6. HEALTH HAZARD INFORMATION

Trichloroethylene is listed as a carcinogen by the NTP, IARC, and OSHA. NIOSH recommends that trichloroethylene be treated as an occupational carcinogen. IARC carcinogenic results are animal suspect, animal positive, and human indefinite. SUMMARY OF RISKS: Moderate exposures to TCE cause symptoms similar to those of alcohol inebriation. Higher concentrations cause narcotic effects. Ventricular fibrillation has been cited as the cause of death following heavy exposures. TCE-induced hepato cellular carcinomas have been detected in mice during tests conducted by the National Cancer Institute (*Chem & Eng News* 54 [April 5, 1976]:4). Organ systems affected by overexposure to TCE are the central nervous system (euphoria, analgesia, anesthesia), degeneration of the liver and kidneys, the lungs (tachypnea), heart (arrhythmia) and skin (irritation, vesication, and paralysis of fingers when immersed in liquid TCE). Contact with the liquid defats the skin, causing topical dermatitis. Certain people appear to experience synergistic effects from TCE exposure concomitant with exposure to caffeine, alcohol, and other drugs. When combined with alcohol intake, toxic effects are increased and may cause a red, blotchy facial and upper body rash commonly called "degreaser's flush." Other reported symptoms of TCE exposure include abnormal fatigue, headache, irritability, gastric disturbances, and intolerance to alcohol. Toxic effects from testing of TCE on humans include hallucination, distorted perception, somnolence (general depressed activity), and jaundice. TARGET ORGANS: Respiratory system, central nervous system, heart, liver, kidneys, and skin. PRIMARY ENTRY: Ingestion, inhalation, skin contact. ACUTE EFFECTS: Headache, vertigo, visual disturbance, tremors, nausea, vomiting, dermatitis, dizziness, drowsiness, and irritation to the eyes, nose, and throat. CHRONIC EFFECTS: None Reported. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: Diseases of the liver, kidneys, lungs, and central nervous system. FIRST AID: EYE CONTACT: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.* SKIN CONTACT: Wash thoroughly with soap and water. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment. Get medical help.* INHALATION: Remove victim to fresh air; restore and/or support his breathing as needed. Do not give adrenalin to the victim. Get medical help.* INGESTION: Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. A professional decision regarding whether or not to induce vomiting is required. Do not give adrenalin to the victim. Get medical help.*

*GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Get prompt medical assistance for further treatment, observation, and support after first aid.

COMMENTS: Workers' responses to TCE vary significantly because of many factors, including age, health status, nutrition, and intake of alcohol, caffeine, and medicines. Do not use these substances before, during, or after exposure to TCE. If a worker displays any of the symptoms of exposure to TCE, thoroughly investigate all the possible contributing factors to determine, if possible, how much the work environment levels of TCE are responsible.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Inform safety personnel of any trichloroethylene spill or leak and evacuate the area for large spills. Cleanup personnel must use respiratory and liquid contact protection. Adequate ventilation must be provided. Confine the spilled TCE to as small an area as possible. Do not allow it to run off to sewers or open waterways. Pick up spilled TCE with a vacuum cleaner or an absorbent such as vermiculite.

DISPOSAL: Consider reclamation, recycling, or destruction rather than disposal in a landfill.

Trichloroethylene is designated as a hazardous substance by the EPA (40 CFR 116.4).

Trichloroethylene is reported in the 1983 EPA TSCA Inventory.

EPA Hazardous Waste Number (40 CFR 261.33): U228

EPA Reportable Quantity (40 CFR 117.3): 1000 lbs (454 kgs)

Aquatic Toxicity Rating, TLm 96: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Always wear protective eyeglasses or chemical safety goggles. Follow the eye and face protection guidelines of 29 CFR 1910.133. GLOVES: Wear impervious gloves. RESPIRATOR: Use a NIOSH-approved respirator per the *NIOSH Guide to Chemical Hazards* (Genium ref. 88) for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. Any detectable concentration of TCE requires an SCBA, full facepiece, and pressure-demand/positive-pressure modes. WARNING: Air-purifying respirators will not protect workers from oxygen-deficient atmospheres. OTHER EQUIPMENT: Wear rubber boots, aprons, and other suitable body protection appropriate to the existing work environment. VENTILATION: Install and operate general and local exhaust ventilation systems of sufficient power to maintain airborne concentrations of TCE below the OSHA PEL standards cited in section 2. SAFETY STATIONS: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. OTHER SPECIAL MODIFICATIONS IN THE WORKPLACE: Because of the unresolved controversy about the carcinogenic status of TCE, all existing personal protective equipment and engineering technology should be used to prevent any possibility of worker contact with this material.

COMMENTS: Practice good personal hygiene. Keep material off of your clothes and equipment. Avoid transfer of material from hands to mouth while eating, drinking, or smoking. Adhere to the sanitation requirements of 29 CFR 1910.141 and 29 CFR 1910.142.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Prevent TCE from coming into contact with strong caustics such as NaOH; KOH; chemically active metal like Ba, Li, Na, Mg, Ti; and powdered aluminum or magnesium in acidic solutions. SPECIAL HANDLING/STORAGE: Store this material in a cool, dry, well-ventilated area. Avoid elevated temperatures because products of toxic and corrosive decomposition from TCE may form. Monitor the level of any stabilizer component that may be added to the TCE. (Consult the technical data from the supplier to determine the specifics of any added stabilizer.) If applicable, follow the supplier's recommendation concerning proper rotation of stock, shelf-life requirements, and levels of stabilizers.

ENGINEERING CONTROLS IN THE WORKPLACE: Avoid collecting aluminum fines (very small particles) or chips in a TCE vapor degreaser. Monitor TCE stabilizer levels regularly. Only trained personnel should operate vapor degreasers.

TRANSPORTATION DATA (per 49 CFR 172.101-2):

DOT Hazard Class: ORM-A
DOT ID No. UN1710
IMO Class: 6.1
IMO Label: St. Andrew's Cross (X)*
DOT Shipping Name: Trichloroethylene
DOT Label: None

* Harmful - Stow away from foodstuffs (IMO Label, Materials of Class 6.1 Packaging Group III).

References: 1-9, 12, 14, 21, 73, 87-94. PI

Approvals JPAccRocco

Indust. Hygiene/Safety DJW

Medical Review MJHarrison

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Material Safety Data Sheets Collection:

Sheet No. 70
Antimony Metal/Powder

Issued: 9/80 **Revision: A, 11/89**

Section 1. Material Identification 30

Antimony Metal/Powder Description: A naturally occurring ore found in sulfides, oxides, complex lead, silver, copper, and mercury sulfides. Prepared in the laboratory by reducing Sb_2O_5 with KCN. Used in manufacturing bullets, bearing metal, hard lead, blackening iron, coating metals, white metal, thermoelectric piles, storage batteries, cable sheaths, type metal, and alloys (Britannia or Babbitt metal). Pure antimony compounds are used as catalysts in organic synthesis, abrasives, plasticizers, pigment, and flameproofing compounds; also used in manufacturing paints, enamels, matches, glass, pharmaceuticals, explosives, and tartar emetic.
Other Designations: Stibium; antimony regulus; Sb; CAS No. 7440-36-0.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R	1
I	3
S	3
K	1

Genium

HMIS

H	3
F	1
R	1
PPG*	

* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Antimony, ca 99%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987*	Toxicity Data†
8-hr TWA: 0.5 mg/m³ (as Sb)	TLV-TWA: 0.5 mg/m³ (as Sb)	10-hr TWA: 0.5 mg/m³	Rat, intraperitoneal, LD_{50}: 100 mg/kg Rat, oral, LD_{50}: 100 mg/kg

* NIOSH has proposed a 10-hr TWA of 0.5 mg/m³ with an action level at 0.25 mg/m³. The TLV was established at a level to prevent irritation and systemic effects.
† See NIOSH, *RTECS* (CC4025000), for additional data with references to toxic effects.

Section 3. Physical Data

Boiling Point: 2975 °F (1635 °C)
Melting Point: 1166.9 °F (630.5 °C)
Vapor Pressure: 1 mm Hg at 1627 °F (886 °C)
Molecular Weight: 121.76 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 6.68 at 77 °F (25 °C)
Water Solubility: Insoluble
Mohs Hardness: 3.0 to 3.5

Appearance and Odor: A brittle, flaky, crystalline solid with a lustrous blue-white color; however, a noncrystalline form is also known. The powder form is dark gray, lustrous.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** Cloud,* 788 °F (420 °C); dust layer,* 626 °F (330 °C)	**LEL:** Dust cloud explosion, 0.42 oz/ft³	**UEL:** None reported

Extinguishing Media: Dry chemical powder.
Unusual Fire or Explosion Hazards: Antimony bulk metal is combustible in air at *high temperature*. When ignited it burns with a brilliant flame, giving off dense, white antimony trioxide (Sb_2O_3) fumes. When exposed to heat or ignition sources, powdered antimony is a moderate fire and explosion hazard. Particle size and dispersion in air determine reactivity.
Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Personal protective clothing and eye protection are essential.

* Ninety-one percent of dust goes through a 74-µm sieve. A 1.92-J spark can ignite an antimony dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Antimony metal (bulk) is stable in dry air at room temperature in closed containers. It slowly tarnishes in moist air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Antimony is not very reactive with cold, dilute acids, but it reacts readily with aqua regia and hot, concentrated sulfuric acid. Powdered antimony* also reacts with hot, concentrated hydrochloric acid (HCl). On contact with acid, it emits toxic antimony trihydride (SbH_3) fumes; electrolysis of acid sulfides and stirred antimony halide yields explosive antimony. Antimony can react vigorously or violently with oxidizing agents such as nitrate salts, halogens, nitric acid, perchloric acids, chlorine trifluoride (ClF_3), potassium permanganate ($KMnO_4$), ammonium nitrate (NH_4NO_3), bromine trinitride (BrN_3), bromine trifluoride (BrF_3), chlorine monoxide (ClO), chlorine trifluoride (ClF_3), potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), and potassium oxide (K_2O_2).
Conditions to Avoid: Nascent hydrogen can react with Sb, or its alloys with Mg or Zn, to form antimony trihydride, a colorless, highly toxic gas (causing headache, nausea, vomiting, abdominal pain, hemolysis (separation of hemoglobin from red blood corpuscles), hematuria (blood in the urine), and death) with a disagreeable odor (0.1-ppm TLV).
Hazardous Products of Decomposition: Thermal oxidative decomposition of antimony can produce toxic SbH_3 fumes.

* Powdered antimony reacts more vigorously than the bulk material and forms dangerous mixtures with oxidizing agents. Heating further increases its reactivity.

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists antimony as a carcinogen. However, its ore is a suspected carcinogen in antimony trioxide production. Antimony trioxide is prepared in the laboratory by a volatilization process involving antimony trichloride ($SbCl_3$) and water.

Summary of Risks: An irritant to mucous membranes, eyes, and skin. Exposures to dust/powder can cause eye inflammation (conjunctivitis), nasal irritation (rhinitis - perforation of the nasal septum), chronic dermatitis ranging from mild rashes to blemishes resembling chicken pox, and muscle pain and weakness. Some sources refer to antimony as a human poison by an unspecified route. Exposure to antimony may result in "metal fume fever," a flu-like syndrome with fever, fatigue, cough, and muscle ache.

Medical Conditions Aggravated by Long-Term Exposure: Chronic inhalation of subtoxic doses of dust or fume above the TLV may result in chemical pneumonia, intraalveolar lipid deposits, liver and cardiac involvement, and possible kidney disease.

Target Organs: Skin, eyes, mucous membranes, respiratory system, and cardiovascular system.

Primary Entry: Inhalation (dust and fume), ingestion.

Acute Effects: Acute ingestion may cause violent vomiting, diarrhea, slow pulse and low blood pressure, shallow breathing, and death.

Chronic Effects: Chronic exposures lead to dizziness, dry throat, sleeplessness, anorexia, and nausea.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: *Contact physician!* Never give anything by mouth to an unconscious or convulsing person. Give 1 to 2 glasses of water to dilute, although vomiting may be spontaneous after ingestion.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Physician's Note: If indicated, intravenous gastric lavage chelation therapy with BAL (British Anti-Lewsite) for 10 days is recommended.

Spill/Leak: Notify safety personnel of powder spills. Small spills can be removed by vacuuming or wet sweeping to minimize airborne dust. Cleanup personnel should use protective equipment.

Disposal: Return scrap metal to your supplier. Unsalvageable waste may be buried in an approved secure landfill. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* 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)

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: Wear a NIOSH-approved respirator if necessary. Follow OSHA respirator regulations (29 CFR 1910.134). Respirators should be available for nonroutine or emergency use for concentrations above the TLV: high-efficiency dust respirators for concentrations below 5 mg/m^3 and self-contained or air-supplied respirators with full facepiece for concentrations above 5 mg/m^3.

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.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standard (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 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. Launder contaminated clothing before wearing. Remove this material from your shoes and 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 a dry, well-ventilated, low fire-risk area. Avoid heat and direct sunlight.

Engineering Controls: Avoid breathing dust or fumes. Practice good housekeeping and cleaning techniques to prevent dust accumulation and to minimize airborne particulates. Minimize skin contact by using barrier creams, rubber gloves and aprons, and good personal hygiene. Keep antimony dust off clothing. Provide preplacement and periodic medical examinations for those workers exposed regularly to antimony, with emphasis on the skin, mucous membranes, and the pulmonary, cardiac, and reproductive systems. Provide suitable training to those working with antimony. Monitor the workplace. Keep records.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Antimony compounds, inorganic, n.o.s.

IMO Hazard Class: 6.1

IMO Label: Poison/St. Andrews Cross (Stow away from foodstuffs)

IMDG Packaging Group: I, II, III

MSDS Collection References: 1, 2-12, 24, 26, 27, 31, 37, 38, 41, 81, 84, 87, 89, 90, 91, 100, 109

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 296
Arsenic and Compounds

Issued: 4/90

Section 1. Material Identification

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Arsenic Description: Obtained from flue dust of copper and lead smelters as white arsenic (arsenic trioxide). Reduction with charcoal and sublimation in an N_2 current yields pure arsenic. Metallic arsenic is used for hardening copper, lead, and alloys; as a doping agent in germanium and silicon solid-state products, special solders, and medicine; and to make gallium arsenide for dipoles and other electronic devices. Arsenic compounds are used in manufacturing certain types of glass; in textile printing, tanning, taxidermy, pharmaceuticals, insecticides and fungicides, pigment production, and antifouling paints; and to control sludge formation in lubricating oils. Arsenic trioxide is the source for 97% of all arsenic products.

Other Designations: CAS No. 7440-38-2; arsen; arsenic black; As; gray arsenic; metallic arsenic.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
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S 2
K 0

Genium
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3 2
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HMIS
H 3
F 2
R 2
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Arsenic and soluble compounds, as As

OSHA PEL
8-hr TWA: 0.5 mg/m^3,* 0.01 mg/m^3†

ACGIH TLV, 1989-90
TLV-TWA: 0.2 mg/m^3

NIOSH REL, 1987
Ceiling: 0.002 mg/m^3

Toxicity Data‡
Man, oral, TD_{Lo}: 76 mg/kg administered intermittently over a 12-year period affects the liver (tumors) and blood (hemorrhage)
Man, oral: 7857 mg/kg administered over 55 years produces gastrointestinal (in the structure or function of the esophagus), blood (hemorrhage), and skin and appendage (dermatitis) changes
Rat, oral, TC_{Lo}: 605 µg/kg administered to a 35-week pregnant rat affects fertility (pre- and post-implantation mortality)

* Organic compounds.
† Inorganic compounds.
‡ See NIOSH, *RTECS* (CG0525000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data*

Boiling Point: sublimes at 1134 °F/612 °C
Melting Point: 1497 °F/814 °C
Vapor Pressure: 1 mm at 702 °F/372 °C (sublimes)

Atomic Weight: 74.92
Density: 5.724 at 57 °F/14 °C
Water Solubility: Insoluble†

Appearance and Odor: A brittle, crystalline, silvery to black metalloid. Odorless.

* This data pertains to arsenic only.
† Arsenic is soluble in nitric acid (HNO_3).

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Use dry chemical, CO_2, water spray, or foam to fight fires.
Unusual Fire or Explosion Hazards: Flammable and slightly explosive in the form of dust when exposed to heat or flame.
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. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Arsenic is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Arsenic can react vigorously on contact with powerful oxidizers such as bromates, peroxides, chlorates, iodates, lithium, silver nitrate, potassium nitrate, potassium permanganate, and chromium (VI) oxide. This material is also incompatible with halogens, bromine azide, palladium, dirubidium acetylide, zinc, and platinum.
Hazardous Products of Decomposition: Thermal oxidative decomposition of arsenic and its compounds produces irritating or poisonous gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC, NTP, and OSHA list arsenic as a human carcinogen (Group 1). This evaluation applies to arsenic and arsenic compounds as a whole, and not necessarily to all individual chemicals within the group. Studies report that both the trivalent and pentavalent compounds are strongly implicated as causes of skin, lung, and lymphatic cancers. Experimental studies have shown that arsenic has tumorigenic and teratogenic effects in laboratory animals.
Summary of Risks: Arsenic compounds are irritants of the skin, mucous membranes, and eyes. The moist mucous membranes are most sensitive to irritation. Prolonged contact results in local hyperemia (blood congestion) and later vesicular or pustular eruption. Epidermal carcinoma is a reported risk of exposure. Peripheral neuropathy (degenerative state of the nervous system) is common after acute or chronic arsenic poisoning. Symptoms include decreased sensation to touch, pinprick, and temperature; loss of vibration sense; and profound muscle weakness and wasting. Other complications of acute and chronic arsenic poisoning are encephalopathy (alterations of brain structure) and toxic delirium.
Medical Conditions Aggravated by Long-Term Exposure: Damage to the liver, nervous, and hematopoietic (responsible for the formation of blood or blood cells in the body) system may be permanent. Pulmonary and lymphatic cancer may also occur.
Target Organs: Liver, kidneys, skin, lungs, lymphatic system.
Primary Entry Routes: Inhalation, ingestion of dust and fumes, via skin absorption.
Acute Effects: Acute industrial intoxication is more likely to arise from inhalation of arsine. However, with corrosive arsenical vapors, conjunctivitis, eyelid edema, and even corneal erosion may result. Inhalation may result in nasal irritation with perforation of the septum, cough, chest pain, hoarseness, pharyngitis, and inflammation of the mouth. If ingested, metallic or garlic taste, intense thirst, nausea, vomiting, abdominal pain, diarrhea, and cardiovascular arrhythmias (heartbeat irregularities) may occur. Symptoms generally occur within 30 minutes, but may be delayed for several hours if ingested with food. Acute poisoning may result in acute hemolysis (breakdown of red blood cells).
Chronic Effects: Chronic symptoms include weight loss, hair loss, nausea, and diarrhea alternating with constipation, palmar and plantar hyperkeratoses (thickening of the corneous layer of skin on palms and soles of feet), and skin eruptions, and peripheral neuritis (inflammation of the nerves). Leukemia, bone marrow depression, or aplastic anemia (dysfunctioning of blood-forming organs) may occur after chronic exposure.
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.
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: If emesis is unsuccessful after two doses of Ipecac, consider gastric lavage. Monitor urine arsenic level. Alkalinization of urine may help prevent disposition of red cell breakdown products in renal tubular cells. If acute exposure is significant, maintain high urine output and monitor volume status, preferably with central venous pressure line. Abdominal X-rays should be done routinely for all ingestions. Chelation therapy with BAL, followed by n-penicillamine is recommended, but specific dosing guidelines are not clearly established.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against dust inhalation and contact with skin and eyes. Use nonsparking tools. With a clean shovel, scoop material into a clean, dry container and cover. Absorb liquid material with sand or noncombustible inert material and place in disposal containers. Do not release to sewers, drains, or waterways. 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*
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance† (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [† per Clean Water Act, Sec. 307(a); per Clean Air Act, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations‡
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

* Designations for arsenic only.
‡ Listed as arsenic organic compounds (as As).

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 skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PELs, ACGIH TLVs, and NIOSH REL (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 closed, properly labeled, containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and heat and ignition sources. Protect containers from physical damage.

Engineering Controls: Avoid inhalation or ingestion of dust and fumes, and skin or eye contact. Practice good personal hygiene and housekeeping procedures. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program with training, maintenance, inspection, and evaluation. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement and annual physical examination with emphasis on the skin, respiratory system, and blood.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Arsenic, solid
DOT Hazard Class: Poison B
ID No.: UN1558
DOT Label: Poison
DOT Packaging Requirements: 173.366
DOT Packaging Exceptions: 173.364

IMO Shipping Name: Arsenic, metallic
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II
ID No.: UN1558

MSDS Collection References: 7, 26, 38, 53, 73, 85, 87, 88, 89, 100, 103, 109, 123, 124, 126, 127, 130, 136, 138

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 59
Beryllium Metal/Powder

Issued: 4/80 Revision: A, 11/89

Section 1. Material Identification 30

Beryllium Metal/Powder Description: A naturally occurring ore found in chrysoberyl (Be_2SiO_4) or produced industrially from beryl ($3Be.OAl_2O_3.6SiO_2$). The ore is converted to the oxide or hydroxide, then to the fluoride or chloride. The halide may be reduced in a furnace by magnesium metal or by electrolysis. An alternative purification process is a liquid-liquid extraction with an organophosphate chelating agent. Used in aerospace structures, radio tube parts, inertial guidance systems, computer parts, Be-Cu alloys, gyroscopes; used as an additive in solid propellant rocket fuels, as a neutron source when bombarded with alpha particles, and as a neutron moderator and reflector in nuclear reactors.

Other Designations: Glucinium; Be; CAS No. 7440-41-7.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 4
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K 1

Genium

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Section 2. Ingredients and Occupational Exposure Limits

Beryllium and compounds, ca 100%

OSHA PELs	**ACGIH TLV, 1989-90***	**Toxicity Data†**
8-hr TWA: 0.002 ppm	TLV-TWA: 0.002 mg/m^3	Human, inhalation, TC_{Lo}: 300 mg/m^3, pulmonary effects
30-min STEL: 0.005 ppm	**NIOSH REL, 1987***	Rabbit, intravenous, TD_{Lo}: 20 mg/kg, neoplastic effects
Ceiling level: 0.025 ppm	Not to exceed 0.5 µg/m^3	

* These values are for beryllium and its compounds.
† See NIOSH, *RTECS* (DS1750000), for additional data with references to mutagenic and tumorigenic effects.

Section 3. Physical Data

Boiling Point: 5378 °F (2970 °C)
Melting Point: 2332 °F (1278 °C)
Vapor Pressure: 7.6 mm Hg at 3470 °F (1910 °C)
Atomic Weight: 9.01 g/mol

Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 1.848 at 68 °F (20 °C)
Water Solubility, hot water: Slight
cold water: Insoluble

Appearance and Odor: A grayish-white metal with a hexagonal and aniostropic crystal structure (i.e., their index of refraction varies with incident light direction), and a powdered metal, no odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** Powder, ca 1200 °F (649 °C)	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: *Never* use water or CO_2. Instead, smother the fire with an approved dry-powder extinguisher. Sand, graphite powder, and sodium chloride are also recommended.

Unusual Fire or Explosion Hazards: Beryllium can be a moderate fire hazard if exposed to flame. The hazards increase as particulate size decreases. A beryllium dust cloud can be explosive (areas where dusting may occur require Class 2, Group E electrical services, 29 CFR 1910.309). This material's combustion products are *highly toxic.*

Special Fire-fighting Procedures: Fire fighters should use full protective clothing, eye protection, and a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. After exposure to a beryllium fire, they should clean equipment and bathe carefully.

Section 5. Reactivity Data

Stability/Polymerization: Beryllium is stable at room temperature in closed containers.* Hazardous polymerization cannot occur.

Chemical Incompatibilities: Acid and alkali soluble, it reacts with strong bases to evolve hydrogen.† Warm beryllium reacts incandescently with phosphorus, fluorine, or chlorine. Molten lithium metal at 356 °F (180 °C) severely attacks beryllium metal.

Conditions to Avoid: When heated in air or in mixed CO_2 and nitrogen, beryllium is ignitable. Mixtures of the powdered metal with CCl_4 or trichloroethylene flash on heavy impact.

Hazardous Products of Decomposition: Thermal oxidative decomposition of beryllium emits very toxic oxide of beryllium fumes.

* When moist, beryllium forms thin, acid-resistant oxide films on solid surfaces.
† A simple asphyxiant gas, hydrogen is extremely flammable.

Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and ACGIH list beryllium as a carcinogen. Animal studies also indicate that beryllium produces lung and bone tumors.

Summary of Risks: Beryllium is highly toxic by inhalation of fume or dust and exposure to this element and its salts may cause death. Inhaled beryllium is partially deposited in the lungs, the blood system, and finally the bones, thus affecting all organ systems. Since the human body does not quickly eliminate beryllium, trace amounts in urine are detectable as long as 10 years after exposure. Prolonged or repeated skin contact can cause skin irritation or dermatitis. Eye contact can produce conjuctivitis and eye ulcers. If introduced through the skin via cuts or punctures, nonhealing ulcers may develop.

Continue on next page

Section 6. Health Hazard Data, continued

Medical Conditions Aggravated by Long-Term Exposure: Increased risk of lung, liver, gall bladder, and bile duct cancers. **Target Organs:** Lungs, mucous membranes, eyes, skin. **Primary Entry:** Inhalation. **Acute Effects:** Symptoms may occur up to 72 hr after a massive exposure. Acute inhalation can produce pneumonitis with inflammation of the upper and lower respiratory tracts, nasal congestion, nonproductive coughing, and pulmonary edema. High dose exposures may cause acute respiratory distress, brain hemorrhaging, liver inflammation, and spleen hemorrhaging. **Chronic Effects:** Symptoms may be delayed up to 15 years. Chronic exposures result from long-term exposure to small (microgram) quantities and can produce berylliosis. Berylliosis is a progressive granuloma formation in the lungs which eventually causes increasing shortness of breath and, in some cases, death. Since it also circulates among other organs, beryllium causes eventual heart enlargement and failure, liver and spleen enlargement, kidney stones, various malignant tumors, and damaging cell death in any organ in which it accumulates.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: After rinsing affected area with flooding amounts of water, wash it 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, then induce repeated vomiting until vomit is clear. Present studies indicate that beryllium is so poorly absorbed through the intestinal tract, that ingestion is not an important hazard (*Industrial Toxicology*, 3rd Edition, Hamilton).
After first aid, get appropriate in-plant, paramedic, or community medical attention and support. Watch for signs of respiratory deterioration, and use oxygen as needed.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: If powdered metal is spilled, notify safety personnel. Evacuate area except for cleanup personnel with protective equipment against contact or inhalation hazards. Provide ventilation and remove heat and ignition sources. To prevent dusting conditions, vacuum or wet mop powder spills. Collect particulate scrap, absorb on paper, and transfer to a sealed recovery or disposal container. **Disposal:** Dissolve beryllium in a small amount of 6M-HCl, filter it, and add a slight excess of 6M-NH_4OH to the filtrate using litmus as an indicator (blue at pH 8.3). Heat and coagulate the precipitate. After 12 hr, filter and dry it. Handle beryllium waste unsuitable for recycling in accordance with Federal, state, and local regulations. Dispose of scrap or waste material by arranging its return to the supplier in a mutually acceptable form. Contact your supplier or a licensed contractor for detailed recommendations.

OSHA Designations
Listed as Air Contaminant (29 CFR 1910.1000, Table Z-2)

EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
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), 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

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:** Wear a NIOSH-approved respirator for emergency and nonroutine use in concentrations above the 8-hr, 2-$\mu g/m^3$ TWA. For any time period, a half-mask, air-purifying respirator with a high-efficiency filter is suitable for concentrations as high as 25-μg Be/m^3 (see NIOSH, *A Recommended Standard for Occupational Exposure to Beryllium*, Sec. 4). A powered, air-purifying respirator equipped with a "fume filter" is suitable for concentrations up to 40 μg Be/m^3. A full facepiece, air-purifying respirator with a high-efficiency filter is suitable for concentrations up to 100 μg Be/m^3. A powered, air-purifying respirator equipped with a high-efficiency filter, operating in the positive-pressure mode, is suitable for concentrations up to 1000 μg Be/m^3. An SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode is suitable for concentrations above 1000 μg Be/m^3. Follow OSHA respirator regulations (29 CFR 1910.134). **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. When exposure levels exceed the TLV, change into clean protective clothing and shower at the end of your shift. **Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standards (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 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. Launder contaminated clothing before wearing. Remove this material from your shoes and 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: Clearly label and store beryllium away from incompatible materials (Sec. 5) in a clean, dry, low fire-hazard area. Protect containers from physical damage. **Engineering Controls:** Provide adequate ventilation in areas where beryllium can become airborne. Monitor these areas with personal samplers to limit and control exposure levels. Teach workers about beryllium's potential hazards. Practice good housekeeping to prevent accumulation of beryllium-containing deposits. Give preplacement and annual medical exams (chest x-rays, baseline pulmonary function tests [FVC_1 (functional vital capacity) and FEV_1 (the amount of air exhaled in the first second after maximum inhalation)] and body weight measurements to workers possibly exposed to concentrations above the TLV. Prevent exposing those with pulmonary disease, chronic skin, liver, heart, or kidney conditions; abnormal chest x-ray or blood count; or vital capacity depression greater than 10%. Ensure all engineering systems (production, transportation) are of maximum explosion-proof design. To prevent static sparks, electrically ground and bond all containers and pipelines used in shipping, transferring, reacting, producing, and sampling operations.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Beryllium compound, n.o.s.
DOT Hazard Class: Poison B
DOT ID No.: UN1567

IMO Shipping Name: Beryllium, metal powder
IMO Hazard Class: 6.1
IMO Label: Poison, flammable solid

MSDS Collection References: 1-12, 18-20, 24-26, 81, 84, 85, 88-91, 100, 116, 117
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: Warren Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 83
Chromium Metal/Powder

Issued: 3/81 Revision: A, 11/89

Section 1. Material Identification 30

Chromium Metal/Powder Description: Obtained from chrome ore, chromite ($FeCr_2O_4$), by electrolysis of chromium solutions, by direct reduction (ferrochrome), and by reducing the oxide with finely divided carbon or aluminum. Used for chromeplating other metals; for greatly increasing metal resistance and durability; in manufacturing chrome-steel or chrome-nickel-steel alloys (stainless steel); as a constituent of inorganic pigments; as protective coating for automotive and equipment accessories; and in nuclear and high-temperature research.
Other Designations: Chrome; Cr; CAS No. 7440-47-3.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 4
S 1
K 1

Genium

HMIS
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Chromium metal/powder, ca 100%

OSHA PEL	ACGIH TLV, 1988-89*	NIOSH REL, 1987†	Toxicity Data‡
8-hr TWA: 1 mg/m³	TLV-TWA: 0.5 mg/m³	8-hr TWA (for chromium metal and insoluble salts): 1 mg Cr/m³	Rat, implant, TD_{Lo}: 1200 µg/kg body weight administered intermittently over six weeks

* This TLV is applicable to Cr^{+2} and Cr^{+3} compounds. For water soluble and water-insoluble Cr^{+6}, the 8-hr TWA is 0.05 mg Cr^{+6}/m^3. Certain water-insoluble Cr^{+6} compounds (zinc chromate, calcium chromate, lead chromate, barium chromate, strontium chromate, and sintered chromium trioxide) are designated as A1a (human carcinogen).

† The NIOSH REL (10-hr TWA) for carcinogen Cr^{+6} compounds is 1 µg/m³; for noncarcinogenic Cr^{+6} compounds (including chromic acid), the RELs (10-hr TWAs) are 25 µg/m³ and 50 µg/m³ (15-min ceiling). The noncarcinogenic compounds include mono- and dichromates of hydrogen, cesium, sodium, lithium, potassium, rubidium, ammonia, and Cr^{+6} (chromic acid anhydride). Any and all Cr^{+6} materials excluded from the noncarcinogenic group above are carcinogenic Cr^{+6} compounds.

‡ See NIOSH, *RTECS* (GB4200000), for additional data with references to tumorigenic effects.

Section 3. Physical Data

Boiling Point: 4788 °F (2642 °C)
Melting Point: 3452 °F (1900 °C)
Vapor Pressure: 1 mm Hg at 2941 °F (1616 °C)
Vapor Density (Air = 1): 1.79

Atomic Weight: 51.996 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 7.2 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: Steel-gray, lustrous metal; no odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** Cloud, 1076 °F (580 °C); dust layer, 752 °F (400 °C)	**LEL:** Dust cloud explosion, 0.230 oz/ft³	**UEL:** None reported

Extinguishing Media: Use dry chemical or sand.
Unusual Fire or Explosion Hazards: Particle size and dispersion in air determine reactivity. Chromium powder explodes spontaneously in air, while chromium dust suspended in CO_2 is ignitable and explosive when heated.
Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

*One hundred percent of dust goes through a 74-µm sieve. A 140-mJ spark can ignite a dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Chromium is stable when properly handled and stored. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Chromium reacts readily with dilute, not nitric, acids to form chromous salts. It is soluble in acids (not nitric) and strong alkalis. Its powder is incompatible with strong oxidizing agents, including high O_2 concentration. Evaporation of mercury (Hg) from Cr amalgam leaves pyrophoric chromium. Finely divided Cr attains incandescence with nitrogen oxide, potassium chlorate, and sulfur dioxide. Molten lithium at 18 °C severely attacks Cr. Fused ammonium nitrate below 200 °C reacts explosively and may ignite or react violently with bromine pentafluoride.
Hazardous Products of Decomposition: Thermal oxidative decomposition of Cr can produce toxic chromium oxide fumes.

Section 6. Health Hazard Data

Carcinogenicity: The NTP and OSHA list chromium as a human carcinogen.

mary of Risks: When ingested chromium is a human poison, with gastrointestinal (GI) effects. Chromium 3 (Cr^{+3}) compounds show little or oxicity. Less soluble chromium 6 (Cr^{+6}) compounds are suspected carcinogens and severe irritants of the larynx, nasopharynx, lungs, and skin (Sec. 2). Chromic acid or chromate salts cause irritation of the skin and respiratory passage. Ingestion leads to severe irritation of the gastrointestinal tract, renal damage, and circulatory shock. Chromium metal (when heated to high temperatures) and insoluble salts are said to be involved in histological fibrosis of the lungs, which may progress to clinically evident pneumoconiosis. Exposure to chromate dust and powder can cause skin (dermatitis) and eye irritation (conjunctivitis).

Medical Conditions Aggravated by Long-Term Exposure: An incresed incidence of bronchogenic carcinoma occurs in workers exposed to chromate dust.

Target Organs: Respiratory system.

Primary Entry: Inhalation, percutaneous absorption, and ingestion.

Acute Effects: Acute exposures to dust may cause headache, coughing, shortness of breath, pneumoconiosis, fever, weight loss, nasal irritation, inflammation of the conjunctiva, and dermatitis.

Chronic Effects: Asthmatic bronchitis.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: Brush off chromium dust. After rinsing affected area with flooding amounts of water, wash it 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 slowly drink 1 to 2 glasses of water to dilute. Do not induce vomoting. A physician should evaluate all ingestion cases.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Physician's Note: Acute toxicity causes a two-phase insult: 1) multisystem shock due to gastrointestinal corrosivity and 2) hepatic, renal, hematopoetic insult. Treatment should use ascorbic acid as a neutralizer with gastric lavage. If the ingestion is substantial, exchange transfusions and/or consider hemodialysis. Treat allergic dermatitis with local cortisone or 10% ascorbic acid to reduce Cr^{+6} to Cr^{+3}. Ten percent EDTA in a lanolin base applied every 24 hr helps heal skin ulcers.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of large spills. Cleanup personnel should wear protective clothing and approved respirators. Remove heat and ignition sources. Provide adequate ventilation. Keep airborne dust at a minimum. Remove spills quickly and place in appropriate containers for disposal or reuse.

posal: Reclaim salvageable metal. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, e, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* 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)

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: Wear a NIOSH-approved respirator if necessary. Wear an SCBA with a full facepiece when the particle concentration's upper limit is 50 mg/m^3.

Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.

Other: Wear impervious rubber gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA standard (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 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. Launder contaminated clothing before wearing. Remove this material from your shoes and 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 material in cool, dry, well-ventilated area separate from acids and oxidizing agents. Seal and protect containers from physical damage. Keep away from heat or ignition sources.

Engineering Controls: Avoid dust inhalation. Practice good housekeeping (vacuuming and wet sweeping) to minimize airborne particulates nd to prevent dust accumulation. Use nonsparking tools and ground electrical equipment and machinery.

ransportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection References: 1, 2, 26, 38, 80, 87, 88, 89, 100, 109, 124, 126

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

MB

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Material Safety Data Sheets Collection:

Sheet No. 758
Iron

Issued: 7/91

Section 1. Material Identification

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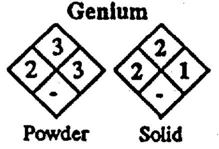
Iron (Fe) Description: Occurs naturally as the second most abundant metal (~5%) in the earth's crust. Its commercial form usually contains some carbon, phosphorus, silica, sulfur, and manganese. It has four naturally occurring isotopes: 54, 56, 57 and 58, and six artificial ones: 52, 53, 55, 59, 60, and 61. Iron is purified by smelting ore with limestone and coke in blast furnaces (purity 91 to 92 %), or by continuous direct reduction of iron ore with limestone heated to 1699 °F (926 °C), melted at 3499 °F (1926 °C), and then reduced to iron at 2998 °F (1648 °C) with powdered coal (purity 99%). The powder form is obtained by treating ore or scrap metal with hydrochloric acid to give ferrous chloride solution, then filtrating, vacuum crystallizing, dehydrating, and reducing it at 1472 °F (800 °C) to metallic iron (briquettes or powder); or by thermal decomposition of iron carbonyl. Solid iron is used to alloy with carbon, manganese, chromium, nickel, and other elements to form steel. Its radioisotopes (^{55}Fe and ^{59}Fe) are used in biological tracer studies. The powder form is used in metallurgy products, magnets, high-frequency cores, and auto parts; and as a catalyst in ammonia synthesis.
Other Designations: CAS No. 7439-89-6, Ancor En 80/150,® Armco iron,® carbonyl iron, Loha,® Suy B-2.®
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.



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* Sec. 8

Cautions: Iron is moderately toxic by ingestion and inhalation of iron dusts and powder. The powder form is pyrophoric (ignites spontaneously upon exposure to air and other substances).

Section 2. Ingredients and Occupational Exposure Limits

Iron, ca 91 to 99%

1990 OSHA PEL	1990-91 ACGIH TLV	1990 NIOSH REL	1985-86 Toxicity Data†
8-hr TWA: 10 mg/m³*	TWA: 5 mg/m³*	5 mg/m³*	Rabbit, intraperitoneal, LD_{Lo}: 20 mg/kg; no toxic effect noted

*As iron oxide fumes.
† See NIOSH, *RTECS* (NO4565500), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 4982 °F (2750 °C)
Melting Point: 2795 °F (1535 °C)
Vapor Pressure: 1 mm Hg at 3248 °F (1787 °C)
Electrical Resistivity: 9.71 μΩ/cm at 68 °F (20 °C)
Molecular Weight: 55.847
Density/Specific Gravity: 7.86 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: Pure, solid iron is a silvery-white or gray, soft, ductile, malleable (can be rolled, hammered, or bent), slightly magnetic (becoming more so as it is alloyed; for example, steel) metal. It is available as ingots, wire, sheets, or powder. The powder form is black-gray.

Section 4. Fire and Explosion Data

Flash Point: None reported*	**Autoignition Temperature:** None reported*	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fire, use water spray, carbon dioxide (CO_2), or regular foam. For large fires, use water spray or regular foam. Apply cooling water spray to fires-exposed container sides until fire is well out. If possible with no risk, remove containers from area.
Unusual Fire or Explosion Hazards: Since finely divided iron powder is pyrophoric and ignites upon exposure to air at normal temperatures, fires and dust explosions can occur in ducts or separators used to remove the dust during grinding and polishing operations.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Fight fire from as far a distance as possible. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

*Although no flash point or autoignition temperature is reported, remember that the powder form is pyrophoric and can ignite spontaneously in air at room temperatures.

Section 5. Reactivity Data

Stability/Polymerization: Iron is stable in dry air, but readily oxidizes in moist air to form rust. Highly divided powder forms are very unstable and can ignite spontaneously in air.
Chemical Incompatibilities: Solid or powdered iron ignites or explodes on contact with acetaldehyde, ammonium peroxodisulfate, chloroformamidinium, chloric acid, ammonium nitrate, halogens, dinitrogen tetraoxide, nitryl fluoride, polystyrene, sodium acetylide, potassium dichromate, peroxyformic acid, and nitryl fluoride. Hot iron wire burns in chlorine gas and iron with water forms rust.
Conditions to Avoid: Avoid generation of iron dusts and contact with the materials listed above.
Hazardous Products of Decomposition: Thermal oxidative decomposition of iron can produce toxic iron oxide fumes.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list iron as a carcinogen although the mining of one particular ore, hematite, ay be associated with an increased risk of lung cancer in miners. No other iron ores are identified specifically as a carcinogen.

ummary of Risks: Occupational exposures usually result from dust or fume inhalation during mining, ore preparation, production, and refining of the metal and its alloys. Acute and chronic toxicity can occur. Although rare, occupational toxicity by ingestion has occurred. Its effects are the same as those by ingestion of large amounts of iron tablets.

Medical Conditions Aggravated by Long-Term Exposure: Chronic respiratory diseases.

Target Organs: Eyes, respiratory tract, liver, and pancreas.

Primary Entry Routes: Eyes, inhalation, and ingestion.

Acute Effects: Inhalation may be irritating to the respiratory tract. Eye contact may cause conjunctivitis (inflammation of the eye's lining), and deposition of iron particles can leave a "rust ring" or brownish stain on the cornea. Iron's acute toxicity results primarily from accidental or suicidal ingestions (e.g., overdose of iron-containing vitamin pills). Initially, the patient may have vomiting, abdominal pain, bloody diarrhea, hematemesis (vomiting blood), lethargy, and shock. After several hours, the patient may improve, but should be observed carefully, as toxicity may progress to development of profound shock, severe acidosis (increased acidity in blood), cyanosis (bluish skin discoloration), and fever. Two to four days after exposure, liver damage may occur. Within several weeks after exposure, in several rare cases, gastrointestinal fibrosis (scarring) has occurred with obstruction of the digestive tract. Iron overdose may be fatal.

Chronic Effects: Chronic inhalation can produce mottling (spotting) of lungs (siderosis). This condition is often without symptoms and has been referred to as "benign radiopaque pneumoconiosis." Ingestion of greater than 50 to 100 mg of iron per day may result in pathological iron deposition in body tissues. Symptoms include fibrosis (scarring) of the pancreas, diabetes mellitus, and liver cirrhosis. Repeated iron ingestion can produce cardiac toxicity.

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 and alert* person drink 1 to 2 glasses of water, then induce vomiting. Consult poison control center.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Management of iron poisoning by ingestion is complex and beyond this MSDS's scope. Consult a medical toxicologist.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate hazard area, deny entry, and stay upwind. Shut off all ignition sources–no flares, smoking, or flames in hazard area. Avoid dust generation by cleaning small spills with a damp mop. Since finely divided iron powder is explosive, take special care during cleanup. For large spills, flush material with a stream of water and dike for later disposal. 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.

PA Designations

CRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed (as iron oxide fumes) 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). Since 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 NIOSH-approved respirator.

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent any 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 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: 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: Avoid physical damage to containers. Store in a cool, dry, well-ventilated area away from flammable gases or liquids, oxidizing materials, or organic peroxides (Sec. 5).

Engineering Controls: Avoid dust inhalation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Regularly service the ducting at grinding and polishing machines and finishing belts to maintain efficiency of exhaust ventilation and prevent explosion. Remote control operations of machinery is advisable when at all possible.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Iron mass *or* sponge, *not properly oxidized*
DOT Hazard Class: Flammable solid
No.: NA1383
OT Label: Flammable solid
DOT Packaging Exceptions: None
DOT Packaging Requirements: 173.174

MSDS Collection References: 26, 73, 103, 124, 126, 127, 132, 136, 138, 139, 143, 146, 148, 149, 159

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 713
Lead (Inorganic)

Issued: 8/90

Section 1. Material Identification

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* Sec. 8

Lead (Inorganic) (Pb) Description: Exists widely throughout the world in a number of ores. Its main commercial source is galena (lead sulphide). Lead mineral is separated from crude ores by blast-furnace smelting, drossing, or electrolytic refining. Lead is used mostly in manufacturing storage batteries. Other uses are in manufacturing tetraethyllead and both organic and inorganic lead compounds in ceramics, plastics, and electronic devices; in producing ammunition, solder, cable covering, sheet lead, and other metal products (brass, pipes, caulking); in metallurgy; in weights and as ballast; as a chemical intermediate for lead alkyls and pigments; as a constuction material for the tank linings, piping, and equipment used to handle the corrosive gases and liquids used in sulfuric acid manufacturing, petroleum refining, halogenation, sulfonation, extraction, and condensation; and for x-ray and atomic radiation protection.
Other Designations: CAS No. 7439-92-1, lead oxide; lead salts, inorganic; metallic lead; plumbum.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

Cautions: *Inorganic lead is a potent systemic poison.* Organic lead (for example, tetraethyl lead) has severe, but different, health effects. Occupational lead poisoning is due to inhalation of dust and fumes. Major affected organ systems are the nervous, blood, and reproductive systems, and kidneys. Health impairment or disease may result from a severe acute short- or long-term exposure.

Section 2. Ingredients and Occupational Exposure Limits

Lead (inorganic) fumes and dusts, as Pb, ca 100%

1989 OSHA PELs (Lead, inorganic compounds)
8-hr TWA: 50 µg/m^3
Action Level TWA*: 30 µg/m^3

29 CFR 1910.1025 Lead Standard
Blood Lead Level: 40 µg/100 g

1989-90 ACGIH TLV (Lead, inorganic, fumes and dusts)
TLV-TWA: 150 µg/m^3

1988 NIOSH REL
10-hr TWA: <100 µg/m^3

1985-86 Toxicity Data†
Human, inhalation, TC_{Lo}: 10 µg/m^3 affects gastrointestinal tract and liver
Human, oral, TD_{Lo}: 450 mg/kg ingested over 6 yr affects peripheral and central nervous systems
Rat, oral, TD_{Lo}: 790 mg/kg affects multigeneration reproduction

* Action level applies to employee exposure without regard to respirator use.
† See NIOSH, *RTECS* (OF7525000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 3164 °F (1740 °C)
Melting Point: 621.3 °F (327.4 °C)
Vapor Pressure: 1.77 mm Hg at 1832 °F (1000 °C)
Viscosity: 3.2 cp at 621.3 °F (327.4 °C)
Molecular Weight: 207.20
Specific Gravity (20 °C/4 °C): 11.34
Water Solubility: Relatively insoluble in hot or cold water*

Appearance and Odor: Bluish-white, silvery, gray, very soft metal.

* Lead dissolves more easily at a low pH.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Use dry chemical, carbon dioxide, water spray, or foam to extinguish fire.
Unusual Fire or Explosion Hazards: Flammable and moderately explosive in the form of dust when exposed to heat or flame.
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. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Lead is stable at room temperature in closed containers under normal storage and handling conditions. It tarnishes on exposure to air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Mixtures of hydrogen peroxide + trioxane explode on contact with lead. Lead is incompatible with sodium azide, zirconium, disodium acetylide, and oxidants. A violent reaction on ignition may occur with concentrated hydrogen peroxide, chlorine trifluoride, sodium acetylide (with powdered lead), ammonium nitrate (below 200 °C with powdered lead). Lead is attacked by pure water and weak organic acids in the presence of oxygen. Lead is resistant to tap water, hydrofluoric acid, brine, and solvents.
Conditions to Avoid: Rubber gloves containing lead may ignite in nitric acid.
Hazardous Products of Decomposition: Thermal oxidative decomposition of lead can produce highly toxic fumes of lead.

Section 6. Health Hazard Data

Carcinogenicity: Although the NTP and OSHA do not list lead as a carcinogen, the IARC lists it as probably carcinogenic to humans, but having (usually) no human evidence. However, the literature reports instances of lead-induced neoplasms, both benign and malignant, of the kidney and other organs in laboratory rodents. Excessive exposure to lead has resulted in neurologic disorders in infants. Experimental studies show lead has reproductive and teratogenic effects in laboratory animals. Human male and female reproductive effects are also documented.
Summary of Risks: Lead is a potent, systemic poison that affect a variety of organ systems, including the nervous system, kidneys, reproductive system, blood formation, and gastrointestinal (GI) system. The most important way lead enters the body is through inhalation, but it can also be ingested when lead dust or unwashed hands contaminate food, drink, or cigarettes. Much of ingested lead passes through feces without absorption into the body. Adults may absorb only 5 to 15% of ingested lead; children may absorb a much larger fraction. Once in the body, lead enters the bloodstream and circulates to various organs. Lead concentrates and remains in bone for many years. The amount of lead the body stores increases as exposure continues, with possibly cumulative effects. Depending on the dose entering the body, lead can be deadly within several days or affect health after many years. Very high doses can cause brain damage (encephalopathy).
Medical Conditions Aggravated by Exposure: Lead may aggravate nervous system disorders (e.g., epilepsy, neuropathies), kidney diseases, high blood pressure (hypertension), infertility, and anemia. Lead-induced anemia and its effect on blood presssure can aggravate cardiovascular disease.

Continue on next page

Section 6. Health Hazard Data, *continued*

Target Organs: Blood, central and peripheral nervous systems, kidneys, and gastrointestinal (GI) tract.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: An acute, short-term dose of lead could cause acute encephalopathy with seizures, coma, and death. However, short-term exposures of this magnitude are rare. Reversible kidney damage can occur from acute exposure, as well as anemia.
Chronic Effects: Symptoms of chronic long-term overexposure include appetite loss, nausea, metallic taste in the mouth, lead line on gingival (gum) tissue, constipation, anxiety, anemia, pallor of the face and the eye grounds, excessive tiredness, weakness, insomnia, headache, nervous irritability, fine tremors, numbness, muscle and joint pain, and colic accompanied by severe abdominal pain. Paralysis of wrist and, less often, ankle extensor muscles may occur after years of increased lead absorption. Kidney disease may also result from chronic overexposure, but few, if any, *symptoms* appear until severe kidney damage has occurred. Reproductive damage is characterized by decreased sex drive, impotence, and sterility in men; and decreased fertility, abnormal menstrual cycles, and miscarriages in women. Unborn children may suffer neurologic damage or developmental problems due to excessive lead exposure in pregnant women. Lead poisoning's severest result is encephalopathy manifested by severe headache, convulsions, coma, delirium, and possibly death.

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. Consult a physician if any health complaints develop.
Inhalation: Remove exposed person to fresh air and support breathing as needed. Consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If large amounts of lead were ingested, induce vomiting with Ipecac syrup. Consult a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: For diagnosis, obtain blood pressure, blood lead level (PbB), zinc protoporphyrin (ZPP), complete blood count for microcytic anemia and basophilic stippling, urinalysis, and blood urea nitrogen (BUN) of creatinine. Examine peripheral motor neuropathy, pallor, and gingival lead line. Use Ca-EDTA to treat poison, but *never* chelate prophylactically. Consult an occupational physician or toxicologist.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and evacuate all unnecessary personnel immediately. Cleanup personnel should protect against inhalation of dusts or fume and contact with skin or eyes. Avoid creating dusty conditions. Water sprays may be used in large quantities to prevent the formation of dust. Cleanup methods such as vacuuming (with an appropriate filter) or wet mopping minimizes dust dispersion. Scoop the spilled material into closed containers for disposal or reclamation. 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, Appendix II—EP Toxicity Test Procedures)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* 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-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. 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. Protective clothing made of man-made fibers and lacking turn-ups, pleats, or pockets retain less dust from lead.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations 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 washing hands 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 incompatible materials, direct sunlight, and heat and ignition sources.
Engineering Controls: Educate worker about lead's hazards. Follow and inform employees of the lead standard (29 CFR 1910.1025). Avoid inhalation of lead dust and fumes and ingestion of lead. Use only with appropriate personal protective gear and adequate ventilation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Avoid creating dusty conditions. Segregate and launder contaminated clothing. Take precautions to protect laundry personnel. Practice good personal hygiene and housekeeping procedures. For a variety of reasons, the lead concentration in workroom air may not correlate with the blood lead levels in individuals.
Other Precautions: Provide preplacement and periodic medical examinations which emphasize blood, nervous system, gastrointestinal tract, and kidneys, including a complete blood count and urinalysis. Receive a complete history including previous surgeries and hospitalization, allergies, smoking history, alcohol consumption, proprietary drug intake, and occupational and nonoccupational lead exposure. Maintain records for medical surveillance, airborne exposure monitoring, employee complaints, and physician's written opinions for at least 40 years or duration of employment plus 20 years. Measurement of blood lead level (PbB) and zinc protoporphyrin (ZPP) are useful indicators of your body's lead absorption level. Maintain worker PbBs at or below 40 µg/100 g of whole blood. To minimize adverse reproductive health effects to parents and developing fetus, maintain the PbBs of workers intending to have children below 30 µg/100 g. Elevated PbBs increase your risk of disease, and the longer you have elevated PbBs, the greater your chance of substantial permanent damage.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Lead compounds, soluble, n.o.s.
IMO Hazard Class: 6.1
ID No.: UN2291
IMO Label: St. Andrews Cross (X, Stow away from foodstuffs)
IMDG Packaging Group: III

MSDS Collection References: 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 142, 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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Material Safety Data Sheets Collection:

Sheet No. 148
Manganese Metal/Powder

Issued: 9/85 Revision: A, 11/89

Section 1. Material Identification

30

Manganese Metal/Powder Description: A metallic element associated with iron ores such as pyrolusite, manganite, psilomelane, and rhodochrosite found mainly in open-hearth slags. Manganese is obtained from the reduction of the oxide with aluminum or carbon. Pure manganese is obtained electrically from chloride or sulfate solution. Used in ferroalloys (steel manufacture); for wagon buffers, rock crushers, railway points and crossings; as a purifying and scavenging agent in metal production; in the manufacture of aluminum by Toth process, dry-cell batteries, glass, welding rods, inks, rubber and wood preservatives, paints, and ceramics; high-purity salt for various chemical uses.
Other Designations: Manganese; colloidal manganese; magnacat; Mn; CAS No. 7439-96-5.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

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Section 2. Ingredients and Occupational Exposure Limits

Manganese, ca 100%

OSHA PEL	ACGIH TLVs, 1988-89	NIOSH REL, 1987
Ceiling limit: 5 mg/m³ (manganese compounds, as Mn)	TLV-TWA: 5 mg/m³ (dust and compounds) TLV-TWA: 1 mg/m³ (fume) STEL: 3 mg/m³ (fume)	Ceiling limit: 5 mg/m³ (manganese and compounds, as Mn) **Toxicity Data*** Human, inhalation, TC_{Lo}: 2300 µg/m³

* See NIOSH, *RTECS* (OO9275000), for additional data with references to mutagenic and tumorigenic effects.

Section 3. Physical Data

Boiling Point: 3803 °F (2095 °C)*
Melting Point: 2300 °F (1260 °C)
Vapor Pressure: 1 mm Hg at 2358 °F (1292 °C)
Atomic Weight: 54.94
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 7.20
Water Solubility: Impure Mn decomposes slowly

Appearance and Odor: Reddish-grey or silvery powder or metal. No odor.

* Other sources (Genium refs. 7, 89, and 126) give 3807 °F (2097 °C), 3564 °F (1962 °C), and 3452 °F (1900 °C) boiling points, respectively.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: *	LEL: *	UEL: None reported

Extinguishing Media: Use dry chemical extinguishing agent designed for metal fires.
Unusual Fire or Explosion Hazards: Manganese dust or powder is flammable and moderately explosive when exposed to flame or heated in carbon dioxide. Mixtures of manganese dust and aluminum dust may explode in air. Ammonium nitrate and manganese may explode when heated. Flammable hydrogen gas is generated under certain conditions (Sec. 5).
Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

* Manganese metal/powder can present a dust explosion hazard under favoring conditions of particle size and airborne dust dispersion. The minimum explosive concentration of Mn is 0.125 oz/ft³, with a minimum ignition temperature of 842 °F (450 °C). Oxygen concentrations of less than 15% prevent ignition.

Section 5. Reactivity Data

Stability/Polymerization: Manganese is stable at room temperature in closed containers. Hazardous polymerization cannot occur.
Chemical Incompatibilities: The powdered metal ignites on contact with hydrogen peroxide, bromine pentafluoride, fluorine, chlorine and heat, and sulfur dioxide and heat. It reacts violently with oxidants and nitrogen dioxide (NO_2), and incandescently with nitric acid, phosphorus, and nitryl fluoride. Manganese reacts slowly with water at 21°F (100 °C), forming hydrogen gas (flammable). Contact with acids (including dilute acids) readily dissolves Mn, with the evolution of hydrogen. Hot, concentrated potassium and sodium hydroxides also dissolve Mn, forming hydrogen and manganese hydroxide.
Hazardous Products of Decomposition: Thermal oxidative decomposition of manganese can produce manganese oxides.

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists manganese as a carcinogen.

ummary of Risks: Although an essential element for man, manganese is also toxic to humans in several ways. Acute or chronic manganese poisoning can result from excessive inhalation or ingestion. The immune system reacts to acute exposures with "metal fume fever," characterized by: fever, chills, nausea, weakness, body aches, frontal headache, occasional blurred vision, low back pain, muscle cramping, shallow respiration, throat dryness and irritation, a dry cough, a sweet or metallic taste, and chest tightness occurring over several hours. Progressive and permanent injury can result from chronic, untreated Mn poisoning. Its most notable effects are the neurological disorders caused by its ability to inhibit the chemical transmission of electrical impulses in the central nervous system. The lungs may become inflammed (manganese pneumonitis), as reported in workers exposed to manganese ores and compounds. Sufficient evidence proves that in several species, manganese is embryolethal at toxic doses. Impotence is a common symptom in grossly contaminated men.

Medical Conditions Aggravated by Long-Term Exposure: Degenerative brain changes, muscle weakness, change in motor activity.

Target Organs: Central nervous system (CNS), respiratory system, kidneys, blood.

Primary Entry: Inhalation, ingestion.

Acute Effects: High-concentration exposures may cause metal fume fever, with its onset occurring over several hours. Inhalation of large concentrations may cause managanese pneumonitis. This material is a skin and eye irritant leading to dermatitis, conjunctivitis, and corneal damage.

Chronic Effects: Exposure to manganese fume over 6 months to 2 years may harm the central nervous system, with symptoms progressing from headache, restless sleep or sleepiness, personality changes, irritability and inappropriate laughing or crying to visual hallucinations, double vision, uncontrolled impulse behavior, euphoria, and to abnormal reaction to painful stimuli, excess salivation, trembling in the extremities and head, impaired walking, and other signs similar to Parkinson's disease.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: After rinsing affected area with flooding amounts of water, wash it 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, then induce repeated vomiting until vomit is clear.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Remove heat and ignition sources. Ventilate spill area. Cleanup personnel should wear appropriate respiratory protective equipment. Carefully scoop spilled material, avoiding dust generation, into a suitable salvage container.

Disposal: Return scrap material to supplier or processor for recovery. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

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: Wear a NIOSH-approved respirator where airborne concentrations exceed the ceiling limit. Fume or high-efficiency particulate filter respirators are acceptable for concentrations up to 50 mg/m^3 (250 mg/m^3 with full facepiece). Follow OSHA respirator regulations (29 CFR 1910.134). 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.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA, ACGIH, and NIOSH standards. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103). Consider the dust explosion potential of finely divided Mn powder when designing exhaust ventilation systems and other process equipment to contain heavily dust-laden air.

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. Launder contaminated clothing before wearing. Remove this material from your shoes and 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 ignition sources, acids, alkali, and other incompatible materials. Protect containers from physical damage.

Engineering Controls: Use with adequate ventilation. Avoid breathing dust and fumes. Maintain good housekeeping practices to prevent dust accumulation. Use cleanup procedures that minimize dust generation. Practice good personal hygiene. Examine exposed personnel at regular intervals with emphasis on the respiratory and central nervous systems.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection References: 2, 4, 7, 8, 9, 12, 14, 20, 25, 27, 38, 44, 47, 55, 58, 81, 89, 90, 100, 124, 126

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** Warren Silverman, MD

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Material Safety Data Sheet

From Genium's Reference Collection
Genium Publishing Corporation
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GENIUM PUBLISHING CORP.

No. 26

MERCURY
(Revision C)
Issued: September 1981
Revised: August 1988

SECTION 1. MATERIAL IDENTIFICATION 26

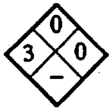
Material Name: MERCURY

Description (Origin/Uses): Used in barometers, thermometers, hydrometers, and pyrometers; in mercury arc lamps producing ultraviolet rays; in switches and fluorescent lamps; as a catalyst in oxidations of organic compounds; in alloys; in explosives; and for extracting gold and silver from ore.

Other Designations: Colloidal Mercury; Metallic Mercury; Quicksilver; Hg; Hydrargyrum; CAS No. 7439-97-6

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

Comments: Inorganic and organic mercury compounds are highly toxic, as is pure mercury.



Genium

HMIS			
H	3	R	1
F	0	I	4
R	0	S	1
PPG*		K	0
*See sect. 8			

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Mercury, CAS No. 7439-97-6	Ca 100	**OSHA PEL** Ceiling: 1 mg per 10 m³ **ACGIH TLV (Skin*), 1987-88** TLV-TWA: 0.05 mg/m³ as Hg (Mercury Vapor) **Toxicity Data**** Rabbit, Inhalation, LC_{Lo}: 29 mg/m³ (30 Hrs)
*Mercury can be absorbed through intact skin, which contributes to overall exposure. **See NIOSH, *RTECS* (OV4550000), for additional data with references to reproductive, mutagenic, and tumorigenic effects.		

SECTION 3. PHYSICAL DATA

Boiling Point: 673°F (357°C)
Specific Gravity (H_2O = 1): 13.546 at 68°F (20°C)
Vapor Pressure: 0.0018 Torr at 77°F (25°C)
Water Solubility (%): Insoluble
Molecular Weight: 201 Grams/Mole
Melting Point: -37.93°F (-38.85°C)

Appearance and Odor: A silver, heavy liquid; odorless. **Danger:** Mercury vapor has no warning properties.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air % by Volume	LOWER	UPPER
*	*		*	*

Extinguishing Media: *Mercury does not burn. Use extinguishing agents that will put out the surrounding fire.

Unusual Fire or Explosion Hazards: When exposed to the high temperatures that occur during a fire, mercury can vaporize to form extremely toxic fumes.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Mercury is stable in closed containers at room temperature under normal storage and handling conditions. It cannot undergo hazardous polymerization.

Chemical Incompatibilities: Hazardous reactions involving mercury and acetylene, ammonia, boron phosphodiiodide, chlorine, chlorine dioxide, methyl azide, sodium carbide, nitric acid, oleum, and sulfuric acid are reported (Genium ref. 84).

Conditions to Avoid: Do not expose mercury to incompatible chemicals.

Hazardous Products of Decomposition: Extremely toxic mercury metal fumes are likely to be produced during fires.

SECTION 6. HEALTH HAZARD INFORMATION

Mercury is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Mercury is very toxic due to its liquid and fat solubility, lack of charge, and membrane permeability. It is a slowly cumulative poison that concentrates in the brain, kidneys, and liver. It is very hazardous when spilled or heated. Mercury and its vapor are rapidly absorbed by the membranes lining the respiratory tract, the gastrointestinal (GI) tract, and the skin. Mercury is a teratogen (causes physical defects in embryos). **Medical Conditions Aggravated by Long-Term Exposure:** Preexisting problems of the target organs can be worsened. Provide preplacement and periodic medical exams emphasizing the target organs. **Target Organs:** Skin, eyes, respiratory system, central nervous system (CNS), kidneys. **Primary Entry:** Skin absorption/contact, inhalation. **Acute Effects:** Erosion of the respiratory/GI tracts, nausea, vomiting, bloody diarrhea, shock, headache, metallic taste. Inhalation of high concentrations for short periods can cause pneumonitis, chest pain, dyspnea, coughing, stomatitis, gingivitis, and salivation. **Chronic Effects:** Tremors, emotional problems, loss of concentration, depression, drowsiness, fatigue, insomnia, loss of memory, kidney problems, eye lesions, vision disturbances, sore mouth and throat, problems with the sense of taste or smell, nosebleeds, nasal inflammation, loss of weight or appetite, poor hand-eye coordination, awkwardness, and unsteadiness, as well as dermatitis. **FIRST AID: Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. **Skin.** Immediately wash the affected area with soap and water because of the increased exposure from skin absorption. **Inhalation.** Remove exposed person to fresh air; restore and/or support his or her breathing as needed. Have medical personnel administer oxygen to treat the chemical pneumonitis that may develop. **Ingestion.** Never give anything by mouth to someone who is unconscious or convulsing. Note to physician: If indicated by degree of ingestion, saline cathartics and charcoal should be used. Chelation therapy with d-penicillamine may also be indicated.

GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid. Treatment of chronic mercury poisoning requires expert medical care. At the first signs, immediately remove the exposed person from further exposure and have him or her examined and treated by a physician trained in occupational mercury poisoning.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, restrict access to the spill area to necessary personnel, and provide adequate ventilation. Clean up spills promptly. Specialized equipment and/or techniques may be required to safely deal with large mercury spills; if large quantities of mercury are used in the workplace, detailed, prior spill-management planning is recommended. Collect spilled mercury by using a suction pump and an aspirator bottle with a long capillary tube. For finely divided mercury in inaccessible cracks, corners, etc., treatment with calcium polysulfide and excess sulfur is recommended to convert the mercury globules into mercury sulfide. Vacuum cleaners may be used if they are equipped with specially designed mercury-absorbent exhaust filters. Collect the mercury into tightly sealed containers for later disposal or reclamation. Cleanup personnel must use the recommended personal protective equipment (see sect. 8).

Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Do not pour mercury down a drain. Mercury is very harmful to the environment. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Air Contaminant (29 CFR 19010.1000 Subpart Z)

EPA Designations (40 CFR 302.4)

RCRA Hazardous Waste No. U151

CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg)*

*Per the Clean Water Act, § 407 (a); Clean Air Act, § 112; and Resource Conservation and Recovery Act, § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of mercury may occur, wear a full face shield or splash guard. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Use a NIOSH-approved respirator per the *NIOSH Pocket Guide to Chemical Hazards* for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent any contact with mercury and the skin.

Ventilation: Install and operate general and local ventilation systems powerful enough to continuously maintain airborne levels of mercury below the OSHA PEL standard cited in section 2.

Safety Stations: Make emergency eyewash stations, washing facilities, and safety/quick-drench showers 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 mercury from shoes and equipment. Separate work and street clothes; store work clothes in special lockers and always shower before changing to street clothes.

Comments: Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of 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.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store mercury in a cool, dry, well-ventilated area in tightly closed unbreakable polyethylene containers. Protect these containers from physical damage.

Special Handling/Storage: Construct storage areas to have smooth, hard, nonporous floors with no cracks or spaces so that spilled mercury globules do not form in inaccessible areas.

Comments: Mercury evaporates slowly, but if it is spilled it can form many tiny globules that evaporate much faster than a single pool of it will. In an unventilated area, significant concentration of mercury vapor can develop from this enhanced evaporation effect. This poisonous vapor is particularly hazardous if breathed over a long period of time, so spills or releases of mercury require very meticulous cleaning procedures.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Mercury, Metal	**DOT Label:** None	**IMO Class:** 8
DOT Hazard Class: ORM-B	**DOT ID No.** NA2809	**IMO Label:** Corrosive

References: 1, 2, 8, 26, 38, 84-94, 100.

Prepared by PJ Igoe, BS

Industrial Hygiene Review: DJ Wilson, CIH

Medical Review: MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 723
Nickel Metal

Issued: 8/90

Section 1. Material Identification

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Nickel (Ni) Description: Found in ores in combination with sulphur, oxygen, antimony, arsenic, and/or silica. The Orford (sodium sulfide and electrolysis) and the Mond (nickel carbonyl) processes are used to refine nickel. Used in electroplating, casting operations for machine parts, manufacturing acid-resisting and magnetic alloys and tapes, synthesizing acrylic esters; in surgical and dental prostheses, coinage, catalytic gastrification of coal, paint pigments, Ni-Cd batteries, ceramics and glass; and as a catalyst in hydrogenation of fats and oils.

Other Designations: CAS No. 7440-02-0, Raney alloy, Raney nickel.*

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

Cautions: Nickel is an eye, skin, and respiratory tract irritant. *Chronic inhalation of nickel dust or fumes may cause cancer of the lungs and nasal passages. Nickel powder (Raney nickel) is a dangerous fire hazard.*

R 0
I 3
S 2
K 1

NFPA

catalyst
HMIS
H 2
F 4
R 0
PPG†

Genium

metal
HMIS
H 2
F 1
R 0
PPG†
† Sec. 8

* Raney nickel is prepared by leaching (with 25% caustic soda solution) aluminum from an alloy of 50% aluminum and 50% nickel. It is used as a catalyst for hydrogenation. Raney nickel, a silvery gray metal powder, is a dangerous fire risk and ignites spontaneously in air (Sec. 4). Nickel catalysts cause many industrial accidents.

Section 2. Ingredients and Occupational Exposure Limits

Nickel, ca 100%

1989 OSHA PEL	**1989-90 ACGIH TLV**	**1988 NIOSH REL**	**1985-86 Toxicity Data***
8-hr TWA: 1 mg/m^3	TLV-TWA: 1 mg/m^3	0.015 mg/m^3	Dog, intravenous, LD_{Lo}: 10 mg/kg Guinea pig, oral, LD_{Lo}: 5 mg/kg Rat, implant, TD_{Lo}: 250 mg/kg

* See NIOSH, *RTECS* (QR5950000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 4946 °F (2730 °C)
Melting Point: 2651 °F (1455 °C)
Vapor Pressure: 1 mm at 3290 °F (1810 °C)
Atomic Weight: 58.71
Density: 8.90 at 25 °C
Water Solubility: Insoluble

Appearance and Odor: A silvery-white, hard, malleable and ductile metal.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Smother with suitable dry powder or use large amounts of water.

Unusual Fire or Explosion Hazards: Nickel is combustible as dust or powder. Raney nickel ignites spontaneously in air. Nickel carbonyl (*MSDS Collection*, No. 226), a highly toxic substance, may form under fire conditions.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since nickel dust or powder is toxic if inhaled, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Nickel is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Nickel can react violently with fluorine, ammonium nitrate, hydrogen + dioxane, performic acid, selenium, sulfur, ammonia, hydrazine, phosphorus, and titanium + potassium chlorate. Nickel is also incompatible with oxidants. Raney nickel catalysts may initiate hazardous reactions with sulfur compounds, *p*-dioxane, hydrogen, hydrogen + oxygen, ethylene + aluminum chloride, magnesium silicate, methanol, and organic solvents + heat.

Conditions to Avoid: Avoid incompatibilities.

Hazardous Products of Decomposition: Thermal oxidative decomposition of nickel can produce highly toxic nickel carbonyl.

Section 6. Health Hazard Data

Carcinogenicity: The IARC and NTP classify nickel as, respectively, a human carcinogen (Group 1) and an anticipated human carcinogen.
Summary of Risks: Nickel dust or fume is a respiratory irritant that with chronic exposure may cause nasal or lung cancer in humans. The average latency period for the induction of these cancers appears to be about 25 yr (within a 4- to 51-yr range). Experimental studies show nickel also has neoplastigenic, tumorigenic, and teratogenic effects in laboratory animals. Hypersensitivity to nickel is common and can cause conjunctivitis, allergic contact dermatitis, and asthma. The allergic contact dermatitis ("nickel-itch," a pink papular erythema with pustulation and ulceration) usually clears within one week, but sensitization is permanent.
Medical Conditions Aggravated by Long-Term Exposure: Chronic pulmonary, upper respiratory tract, and skin disorders. Carcinoma of the paranasal sinuses, larynx, and lung may also develop.
Target Organs: Nasal cavities, lungs, skin.
Primary Entry Routes: Inhalation, dermal contact, and ingestion.
Acute Effects: Exposure to nickel fumes can cause upper respiratory tract irritation (with nonproductive cough, rapid breathing, dyspnea, chest tightness), metal fume fever (chills, fever, flu-like symptoms), asthma, inflammation of the lungs (noninfectious pneumonia), eye (conjunctiva) irritation, nausea, vomiting, and abdominal pain. Dermal contact causes "nickel itch." Ingesting large doses causes nausea, vomiting, and diarrhea.
Chronic Effects: Prolonged or repeated contact can cause nickel sensitization. Symptoms of sensitization include nickel dermatitis with eczematous skin and lichenification (hardened and leathery skin). Chronic inhalation exposure can cause chronic pulmonary irritation, chronic thickening of the mucous membranes of the nose, nasal sinusitis, anosmia (loss or impairment of the sense of smell), and perforation of the nasal septum. Chronic exposure to dust and fumes may cause carcinoma of paranasal sinuses, larynx, and lung.
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: Since oral toxicity for elemental nickel is low, inducing vomiting is seldom necessary. In cases of severe vomiting or diarrhea, treat for fluid replacement.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Chronic exposure to nickel dust may cause *eosinophilic pneumonitis* (Loeffler's syndrome) which responds well to systemic cortico-steroids. There are cases of host rejection of nickel-containing prostheses after development of nickel sensitivity.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personal should protect against vapor inhalation and dermal contact. Avoid dust generation. Using nonsparking tools, carefully scoop spilled material into appropriate containers for reclamation or disposal. After completing material pickup, wash spill site. Do not release to sewers or waterways. 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
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* 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-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. 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 below the OSHA PEL, ACGIH TLV, and NIOSH REL (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 incompatible materials (Sec. 2). Protect against physical damage. Store Raney nickel under inert gas or water in tightly closed containers away from heat or ignition sources, acids, caustics, and oxidizing materials.
Engineering Controls: Minimize all possible exposures to potential carcinogens. Avoid vapor inhalation and dermal contact. Use only with 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 preplacement and periodic medical examinations that emphasize the skin, nasal cavities, and lungs, including a 14" x 17" chest roentgenogram and urine nickel determinations.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Nickel catalyst, wetted with not less than 40% water or other suitable liquid, by weight, finely divided, activated, or spent
IMO Hazard Class: 4.2
ID No.: UN1378
IMO Label: Spontaneously combustible
IMDG Packaging Group: II

MSDS Collection References: 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 140, 142, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS