DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5001

IN REPLY REFER TO:
5090
Ser 095/U5205
14 JUL 1995

7-1-1995

U.S. Environmental Protection Agency, Region V
Region V Waste Management Division
Attn: Ms. Carol Witt-Smith (HRP-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Ms. Witt-Smith:

Crane Division, Naval Surface Warfare Center (NAVSURFWARCENDIV Crane) submits three copies of the final Risk Assessment Workplan (RAWP) for the Ammunition Burning Ground, Demolition Range, and Old Rifle Range as enclosure (1). This RAWP includes revisions made to the June 1993 draft RAWP, incorporating U.S. EPA comments. Rust Environment and Infrastructure request comments by July 24, 1995 in order to begin field activities on August 21, 1995. Enclosure (2) contains the required certification statement.

Encl:
(1) Final Risk Assessment Workplan
(2) Certification Statement

G. K. HILL
Deputy Director, Public Works Directorate
By direction of the Commander

Copy to: (w/o encl)
SOUTHNAVFACENGCOM, (CODE 18564)
COMNAVSEASYSCOM (SEA 07E)
RUST, CHARLIE ZEAL

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

SIGNATURE

G. K. HILL
Assistant Public Works Officer

TITLE

14 JUL 1996

DATE

Enclosure (2)

EPA ID No. IN5 170 023 498

RISK ASSESSMENT WORK PLAN
FOR THE
AMMUNITION BURNING GROUND (SWMU #03/10), DEMOLITION RANGE (SWMU #06/09), AND OLD RIFLE RANGE (SWMU #07/09)
NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

Submitted to:
Southern Division
Environmental Branch, Code 186ND
Naval Facilities Engineering Command
2155 Eagle Drive
Charleston, South Carolina 29411-0068

Submitted by:
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Contract No. N62472-90-D-1298
Contract Task Order 0076

July 1995

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LIST OF ACRONYMS/ABBREVIATIONS

ABG	Ammunition Burning Ground
ADI	Acceptable Daily Intake
ALPEC	Ammunition Loading and Production Engineering Center
ARAR	Applicable or Relevant and Appropriate Requirements
ATV	All-Terrain Vehicle
AWQC	Aquatic Information Retrieval
CAAA	Crane Army Ammunition Activity
CASCO	Central Ammunition Supply Control Office
CEHSD	Corporate Environmental Health and Safety Director
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
CMS	Corrective Measures Study
CTO	Contract Task Order
DOT	Department of Transportation
DR	Demolition Range
DRMO	Defense Reutilization Marketing Office
EMR	Environmental Monitoring Report
EOD	Explosive Ordnance Department
ERATL	Ecological Risk Assessment Team Leader
FDC	Field Data Coordinator
FTL	Field Team Leader
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
HEAST	Health Risk Assessment Summary
HHERA	Human Health and Ecological Risk Assessment
HHRATL	Human Health Risk Assessment Team Leader
HMX	Cyclotetramethylene Tetranitramine
HSWA	Hazardous and Solid Waste Amendments
IAS	Initial Assessment Study
IATA	International Air Transport Association
IDEM	Indiana Department of Environmental Management
IRIS	Integrated Risk Information System
MCL	Maximum Concentration Level
MDL	Method Detection Limit
MSL	Mean Sea Level
NAD	Naval Ammunitions Depot

LIST OF ACRONYMS/ABBREVIATIONS (Continued)

NAVSURFWARCENDIV	Naval Surface Warfare Center, Crane Division
NEIC	National Enforcement Investigation Center
NGVD	National Geodetic Vertical Datum
NIOSH	National Institute for Occupational Safety and Health
NOD	Notice of Deficiency
NOEL	No Observable Effect Level
NPDES	National Pollutant Discharge Elimination System
NWSCC	Naval Weapons Support Center Crane
ORR	Old Rifle Range
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCDD	Polychlorinated dibenzo dioxin
PCDF	Polychlorinated dibenzofuran
PCP	Pentachlorophenol
PEP	Propellants, Explosives, and Pyrotechnics
PHREAD	Public Health Risk Evaluation Database
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylene trinitramine = hexahydro-1,3,5-trinitro-1,3,5-triazine
RfD	Reference Dose
RFI	RCRA Facility Investigation
RPM	Remedial Project Manager
RTECS	Registry of Toxic Effects of Chemical Substances
SAP	Sampling and Analysis Plan
SBP	Sludge Burning Pans
SEAM	Superfund Exposure Assessment Manual
SOP	Standard Operating Procedure
SOW	Statement of Work
SSO	Site Safety Officer
SVOC	Semi-volatile Organic Compound
SWMU	Solid Waste Management Unit

LIST OF ACRONYMS/ABBREVIATIONS (Continued)

TCE	Trichloroethylene
TEF	Toxicity Equivalency Factor
TNT	2,4,6-Trinitrotoluene
TRC	Technical Review Committee
TSD	Treatment, Storage, or Disposal
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WES	Waterways Experiment Station
WP	Work Plan

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PREFACE

This preface is to inform the reader of a name change which occurred at Naval Weapons Support Center Crane (NWSCC) in 1992. The new name for the facility is Naval Surface Warfare Center, Crane Division (NAVSURFWARCENDIV). The former facility title of NWSCC may appear on Navy-modified figures or as a referenced information source. However, the work plan text correctly identifies the facility as NAVSURFWARCENDIV.

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This Risk Assessment Work Plan (RA WP) is submitted to the Southern Division, Naval Facilities Engineering Command in response to Contract Task Order (CTO) No. 0076 under Comprehensive Long-Term Environmental Action Navy (CLEAN) Prime Contract No. N62472-90-D-1298 and Subcontract No. GCPP-91-001-1298.

The purpose of the RA WP is to identify the activities associated with performing a human health and environmental risk assessment to address the human health and ecological impacts of past, present, and expected waste explosive open burning activities at Solid Waste Management Units (SWMUs) #03/10 (Ammunition Burning Ground) and #07/09 (Old Rifle Range), and detonation activities at SWMU #06/09 (Demolition Range) at the Naval Surface Warfare Center, Crane Division, Crane, Indiana (NAVSURFWARCENDIV). It should be noted that the Ammunition Burning Ground (ABG) includes an area known as the "Jeep Trail." The Jeep Trail is located approximately one-half mile southeast of the ABG. This RA WP also identifies the sampling and analytical activities associated with gathering the additional information necessary to perform the risk assessment. It should be noted that air emission and air dispersion modeling results, to be generated by CLEAN CTO Nos. 0052 and 0108, will be needed to perform the risk assessment in order to address impacts caused by inhalation and deposition of airborne contaminants resulting from the open burning and detonation activities. Since the air emission and air dispersion modeling are the focus of two other CTOs, details of these activities have not been included in this document. Rather, this RA WP addressed the type of output that will be generated from the CTOs and how that data will be incorporated in the risk assessment.

When implemented, the RA WP will generate a risk assessment document that addresses the applicable Resource Conservation and Recovery Act (RCRA) related operating requirements (40 Code of Federal Regulations (CFR) Part 264 Subpart X (Miscellaneous Units)) and Corrective Action requirements for the ABG, Demolition Range (DR), and Old Rifle Range (ORR) as identified in NAVSURFWARCENDIV's RCRA Part B permit.

1.2 SUMMARY OF HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT APPROACH

The approach proposed for the human health risk assessment of these SWMUs is consistent with the methods suggested by the U.S. Environmental Protection Agency

(USEPA) in Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989a). The approach proposed for the environmental risk assessment at these SWMUs is consistent with the methods suggested by the USEPA in Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989).

1.3 OVERVIEW OF THE RISK ANALYSIS PROCESS

A human health and environmental risk assessment is an organized approach that is used to evaluate the potential impacts of chemical contaminants associated with a site, e.g., SWMU, on regional public health and the environment. This approach is designed to investigate in a consistent manner the two components which contribute most to environmental risk - chemical toxicity (i.e., the ability of the chemical to adversely affect biota) and exposure (i.e., the extent of potential contact by people and other biota with site chemicals.) A baseline risk assessment is used to determine if humans or other environmental receptors could be adversely affected by the chemical substances presently associated with the site, assuming that no remediation of the present levels of site contamination will be conducted.

This risk assessment will incorporate various types of input information in order to calculate "risk" to receptor populations. These inputs take the form of scientific/engineering data, state and federal regulatory policies, and conservatively-based subjective assumptions. The two latter forms of inputs are utilized in risk assessments in order to compensate for current limitations in scientific knowledge concerning the toxic properties of chemicals toward humans, the fate of chemicals in a local (i.e., site-specific) environment, and the myriad of behaviors in a population. In general, these policies and assumptions have been designed for regulatory caution, i.e., they are designed to insure that the potential risks calculated for a site are not likely to underestimate actual risks that might be experienced by individuals currently or in the future. For example, among the potential human receptors that this risk assessment will address is an individual who resides near NAVSURFWARCENDIV. This person will be assumed to remain at this location 24 hours/day, 350 days/year, for a life-time (by convention, 70 years). Therefore, this risk assessment will address a hypothetical population of people who are considered (reasonably) maximally exposed to off-facility impacts. This conservative approach to risk assessment provides the risk managers the assurance that the true risk to public health in the project area will be insignificant if the risks calculated in the assessment indicate "safety/acceptability."

1.4 ORGANIZATION OF WORK PLAN

This work plan is structured to provide a sequential discussion of the components needed to assess the overall human health and environmental risks potentially posed by chemical releases from the three SWMUs (ORR, DR, and ABG). Section 2.0 describes project organization and personnel. Section 3.0 describes current conditions. Section 4.0 (Hazard Identification) the work plan progresses from the methods proposed to evaluate and select the chemicals of potential concern for this project, as well as the identification of appropriate populations, to descriptions of how often and how much exposure is potentially possible in these populations (Section 5.0 - Exposure Assessment), to a discussion of the toxicological effects of the contaminants in over-exposed individuals (Section 6.0 - Toxicity Assessment), and finally to a discussion on how the health risks to the impacted human population(s) will be assessed (Section 7.0 - Risk Characterization). Section 8.0 (Ecological Risk Assessment) discusses the approach proposed to evaluate the extent of risk to non-human receptors from these three SWMUs. Sections 9.0 through 15.0 as well as Appendices A (Standard Operating Procedures), B (Health and Safety Plan), and C (Quality Assurance Project Plan) comprise a Sampling and Analysis Plan (SAP) detailing the collection of additional data required to assess the human health and environmental risks.

1.5 SCOPE OF WORK

1.5.1 Objective

The primary objectives of this project are to develop conceptual risk assessment models, identify the activities associated with performing a baseline risk assessment for soil, air, groundwater, and surface water/sediment at the ABG, DR, and ORR, and to prepare a SAP that describes how the additional necessary information will be collected. The baseline risk assessment will address the human health and ecological impacts of the ABG, DR, and ORR in accordance with the requirements of 40 CFR Part 264 Subpart X, the RCRA Corrective Action requirements for ABG, DR, and ORR identified in NAVSURFWARCENDIV's RCRA Part B permit, and USEPA's December 1989 RAGS.

In order to respond to each of the risk-related issues raised in 40 CFR Part 264 Subpart X and to USEPA's Notice of Deficiency (NOD) of the NAVSURFWARCENDIV's RCRA Part B permit, three risk assessment exposure scenarios were designed. Each exposure scenario is applicable to each SWMU.

In Scenario A, burning and detonation activities will be assumed to occur indefinitely at ABG, ORR, and DR. Under this scenario, risk would be associated not only with the

current levels of contamination at each of these SWMUs, but also with air emissions (directly, and as they might contribute further to contamination in various secondary environmental media, i.e. soil and surface water). Scenario A thus provides a description of the total potential hazard associated with each SWMU under its current operation conditions.

In the second and third scenarios (Scenario B and C), burning and detonation activities will be assumed to continue at the SWMUs for 100 years, at which time all burning and detonation operations at NAVSURFWARCENDIV would cease. In Scenario B, NAVSURFWARCENDIV would then be converted into a park/natural area. In Scenario C, the facility is developed into a residential area. Under these scenarios, the potential risks would be associated with the projected concentrations of chemicals in site media at this future date. The projected chemical concentrations in site media will be based on present levels of contamination, the assumption being that steady-state conditions with respect to contaminant sources have been reached.

1.5.2 Project Planning

The project planning task includes activities from project initiation through completion of the project plans. The following project activities have been completed:

- A project scoping meeting involving Halliburton NUS Team technical specialists, and Navy and United States Army Corps of Engineers (USACE) representatives.
- A site visit.
- Collection and evaluation of existing available information.
- Preparation of the internal draft RA WP including the Work Plan, Health and Safety Plan (HASP) (Appendix B), and Quality Assurance Project Plan (QAPP) (Appendix C).
- Preparation of the draft RA WP including the Work Plan, HASP (Appendix B), and QAPP (Appendix C).
- Review of the draft RA WP by USEPA and NAVSURFWARCENDIV.
- Incorporation of USEPA and NAVSURFWARCENDIV comments on the draft RA WP.

1.5.3 Human Health and Ecological Risk Assessment

The recommended procedures for performing the Human Health and Ecological Risk Assessment (HHERA) are identified in Sections 4.0, 5.0, 6.0, 7.0, and 8.0 of this Work Plan.

1.5.4 Field Investigation

The recommended field investigation activities are specified in Sections 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, and 15.0, and the HASP (Appendix B) and QAPP (Appendix C) in this Work Plan. The field investigation activities will include surface soil sampling, surface water and sediment sampling, animal and vegetation sampling, borehole drilling and well installation, and groundwater sampling at or in the vicinity of the three SWMUs.

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2.0 PROJECT ORGANIZATION AND PERSONNEL

2.1 PROJECT ORGANIZATION

The project organization chart shown on Figure 2-1 shows the lines of communication and responsibility which will be adhered to during the RA. The Navy will solicit USEPA and Indiana Department of Environmental Management (IDEM) approval and input for the project.

The Navy Remedial Project Manager (RPM) is in direct contact with the EPA and the CLEAN Program Manager. The Halliburton NUS Team Project Manager is responsible for completing the RA scope of work, and for controlling the budget and schedule. The Project Manager will maintain day-to-day contact with the Navy RPM. The personnel responsible for quality assurance, health and safety, and project control report directly to the CLEAN Program Manager. The Field Team Leader (FTL) reports directly to the Project Manager. The Site Health and Safety Officer and Site Quality Assurance (QA) Manager report to the FTL and also report independently to the CLEAN Health and Safety Manager and CLEAN QA Manager, respectively.

2.2 QUALITY ASSURANCE

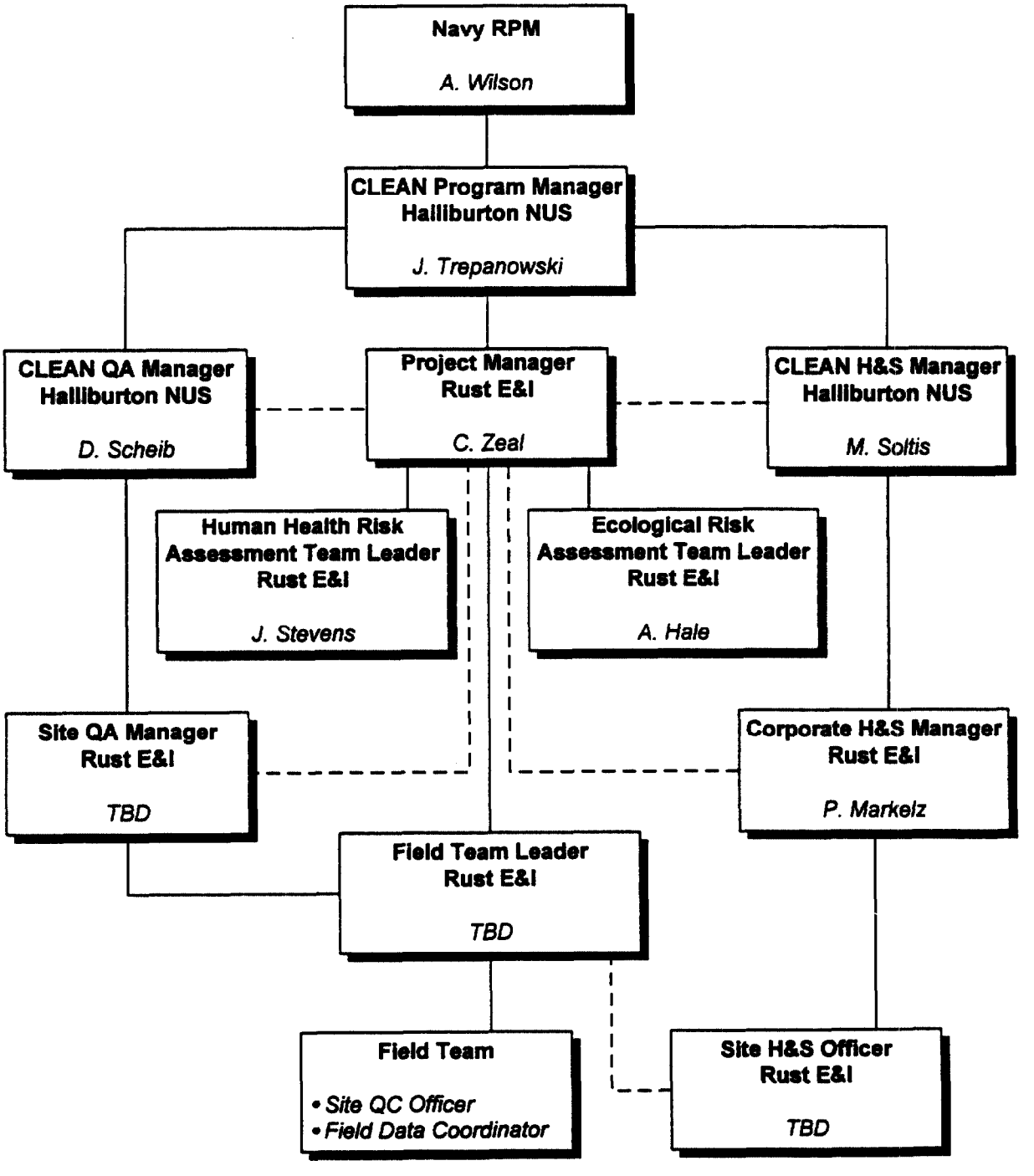
Quality assurance is maintained from sample collection through laboratory analysis and data evaluation. The FTL is responsible for Quality Assurance/Quality Control (QA/QC) in the field. Field QC reviews are conducted on field documentation and through daily on-site QC checks. Laboratory QC is the responsibility of the contract laboratory as identified in the laboratory's QA Plan which is an attachment to the QAPP. The laboratory reports go to the Site QA Manager and CLEAN QA Manager who track the QA process through data validation. The Site QA Manager is responsible for the evaluation of the field and laboratory QC measures for this project. The Site QA Manager acts as the liaison between on-site personnel, the CLEAN QA Manager, and laboratory QA personnel. The QAPP more fully explains field and laboratory QA/QC procedures.

2.3 FIELD TEAM ORGANIZATION AND RESPONSIBILITIES

The Halliburton NUS Team and subcontractors will perform field sampling activities under the direction of the FTL. Field team members and their responsibilities follow.

FIGURE 2-1

PROJECT ORGANIZATION CHART
ABG, DR, & ORR BASELINE RISK ASSESSMENT
NAVSURFWARCENDIV
CRANE, INDIANA



2.3.1 Field Team Leader

The FTL will have overall responsibility for completion of field activities according to the Work Plan. The FTL is the overall coordinator of activities at the site and is the communication link between field team members, the Site QC Officer, the Site Health and Safety Officer, the Field Data Coordinator (FDC), and the Project Manager. The FTL, in conjunction with the Project Manager, will assign specific field duties to team members. The FTL will be on-site during field activities and oversee operations. The FTL will be responsible for mobilization and demobilization of equipment and the field team and subcontractors. The FTL will oversee the activities of subcontractors on-site. Logistical problems hindering field activities such as equipment malfunctions or availability, personnel conflicts, or weather-dependent working conditions will be relayed to the FTL and resolved by the FTL. The FTL cannot be the Site Health and Safety Officer.

Field team members will report directly to the FTL and provide daily verbal progress reports of field activities. The FTL is responsible for completing the Site Daily Logbook. The FTL is responsible for informing the Project Manager of daily activities. The FTL is responsible for supplying field team members with appropriate field notebooks and field documentation forms.

2.3.2 Field Team

Field team members will report directly to the FTL. Field team members will collect samples, advance soil borings, and install groundwater monitoring wells. Decontamination of sampling equipment will be accomplished by the field team under the direction of the FTL. Field team members will complete field documentation forms as indicated in the Work Plan. Field team members will submit personal Daily Activities Reports to the FTL for compilation into the Site Daily Logbook; the FTL will subsequently submit Daily Activities Reports to the Site QC Officer for review and filing. Field team members will submit field documentation forms to the Site QC Officer and will relinquish custody of field samples to the FDC. Field team members will assist in sample packaging and shipping as directed by the FDC. All field team members, subcontractors, and site visitors will comply with the provisions of the Site-Specific HASP.

2.3.3 Site Quality Control Officer

The Site QC Officer will check the completion of Chain of Custody Records, packaging and shipment of samples, Sample Logbook entries, and paperwork for accuracy and compliance with USEPA protocols and other specified procedures. The Site QC Officer will check Daily Activities Reports and field data forms for accuracy and compliance with the QAPP and Work Plan. The Site QC Officer is responsible for reviewing the calibration

log sheets for field instruments. After review of these documents, the Site QC Officer is responsible for filing the field documentation. The Site QC Officer may be a member of the field team but cannot be the FDC.

2.3.4 Field Data Coordinator

The FDC will be responsible for maintaining an adequate supply of sample containers, preservatives, labels, and shipping materials in the field. The FDC will complete the Chain of Custody Records, assign Site-Specific Sample Numbers, and contact the laboratories regarding the shipment and arrival of samples. The FDC will receive samples from the field team and package them for shipment. The FDC will ensure that custody seals are on shipping containers and that samples are shipped promptly. The FDC will file the shipping airbills in a secure area. The FDC will maintain sample collection, labeling, and shipment documentation in the Sample Logbook. The FDC will receive field documentation reviewed by the Site QC Officer, copy the documentation, forward the copies to the Project Manager, and file the original documentation in a secure area. The FDC may also be a member of the field team but cannot be the Site QC Officer or FTL.

2.3.5 Site Health and Safety Officer

The Site Health and Safety Officer (SSO) will be present on-site during Level A, B, or C field operations and will be responsible for health and safety activities and the delegation of duties to the health and safety staff in the field. Because the Phase II RA activities are identified as low-hazard Level C or Level D, the SSO may direct site health and safety efforts through an Assistant SSO approved by the Corporate Environmental Health and Safety Director (CEHSD). The SSO will be responsible for implementing the site-specific HASP. The SSO may direct or participate in downrange activities as appropriate when this does not interfere with primary SSO responsibilities. The SSO has stop-work authorization which can be executed upon his/her determination of an imminent safety hazard, emergency condition, or other potentially dangerous situations, such as detrimental weather conditions. Authorization to proceed with work will be issued by the CEHSD in conjunction with the Project Manager. The SSO will initiate and execute contact with support facilities and personnel when this action is appropriate. The SSO cannot be the FTL.

2.3.6 Assistant Health and Safety Officer

On low-hazard Level C or Level D projects, the Assistant SSO may have collateral duties but must be qualified for the health and safety responsibility by the CEHSD. At Level A, B, or specific Level C sites, the Assistant SSO will be the downrange person who accompanies field sampling teams and will report to the SSO. Additionally, he/she will be

required to support the SSO when multiple operations are conducted that require monitoring and SSO surveillance. His/her primary responsibility is to provide appropriate monitoring to ensure safe field operations. He/she will have access to continuous communications with the Command Post. The number of Assistant SSOs will be dependent upon the number of downrange operations occurring simultaneously, the designated level of protection, and the individual assignments made by the SSO. The Assistant SSO will also share responsibility with the FTL and the SSO for ensuring that safety practices are followed by downrange teams. The assistant SSO cannot be the FTL.

2.4 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT TEAM

The Halliburton NUS Team will perform the risk assessment under the direction of team leaders as presented below.

2.4.1 Human Health Risk Assessment Team Leader

The Human Health Risk Assessment Team Leader (HHRATL) will have overall responsibility for completion of the human health risk assessment in accordance with the RA WP. The HHRATL is the overall coordinator of human health risk assessment activities and is the communication link between the human health risk assessment team members and the Project Manager.

2.4.2 Ecological Risk Assessment Team Leader

The Ecological Risk Assessment Team Leader (ERATL) will have overall responsibility for completion of the ecological risk assessment in accordance with the RA WP. The ERATL is the overall coordinator of ecological risk assessment activities and is the communication link between the ecological risk assessment team members and the Project Manager.

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3.0 DESCRIPTION OF CURRENT CONDITIONS

3.1 FACILITY LOCATION AND DESCRIPTION

NAVSURFWARCENDIV is located in southwestern Indiana, approximately 40 miles southwest of Bloomington, Indiana, and occupies the northern half of Martin County and small portions of Greene, Daviess, and Lawrence Counties (Figure 3-1) (Murphy, 1992a). The site encompasses more than 100 square miles (62,463 acres) including 800-acre Lake Greenwood. It is located in a rural, sparsely populated area. The majority of NAVSURFWARCENDIV is covered by forest with the surrounding acreage either wooded or farmed land. NAVSURFWARCENDIV provides naval support for equipment, shipboard weapons systems, and ordnance. In addition, NAVSURFWARCENDIV supports the Crane Army Ammunition Activity (CAAA) including production and renovation of conventional ammunition, and storage, shipment, demilitarization, and disposal of conventional ammunition (Murphy, 1992b). Detailed legal descriptions for each of the SWMUs addressed in this RA WP are given in subsequent SWMU-specific sections.

3.2 FACILITY HISTORY AND ACTIVITIES

3.2.1 History of Ownership and Operation

In 1940, Congress authorized construction of a Naval Ammunition Depot (NAD) in southern Indiana, and in late 1941 the Burns City Naval Ammunition Depot was commissioned. In 1943, NAD Burns City was renamed NAD Crane, and the Town of Crane was built to house the rapidly growing number of civil service employees. NAD Crane's overall mission was to load, prepare, renovate, receive, store, and issue ammunition to the fleet.

During World War II, NAD Crane's mission expanded to include pyrotechnics production, mine filling, rocket assembly, field storage, torpedo storage, and ordnance spare parts and mobile equipment storage. During the 1950s, several new departments were created, the Ammunition Loading and Production Engineering Center (ALPEC) was transferred to Crane, and the Central Ammunition Supply Control Office (CASCO) was established. NAD Crane supplied ammunition to the fleet during the Korean and Vietnam Conflicts. During the Southeast Asia crisis, the number of full-time employees at NAD Crane grew to 6,800.

In 1976, NAD Crane was designated Naval Weapons Support Center Crane (NWSCC). Its new mission was to provide support for ships and crafts equipment, shipboard weapons systems and assigned ordnance items, and to perform additional functions as directed.

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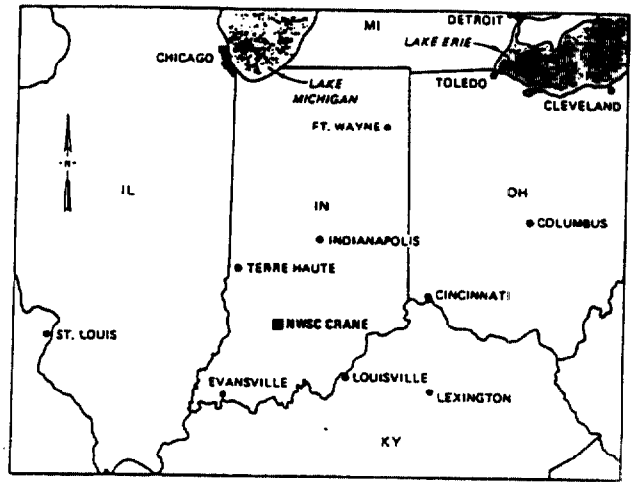

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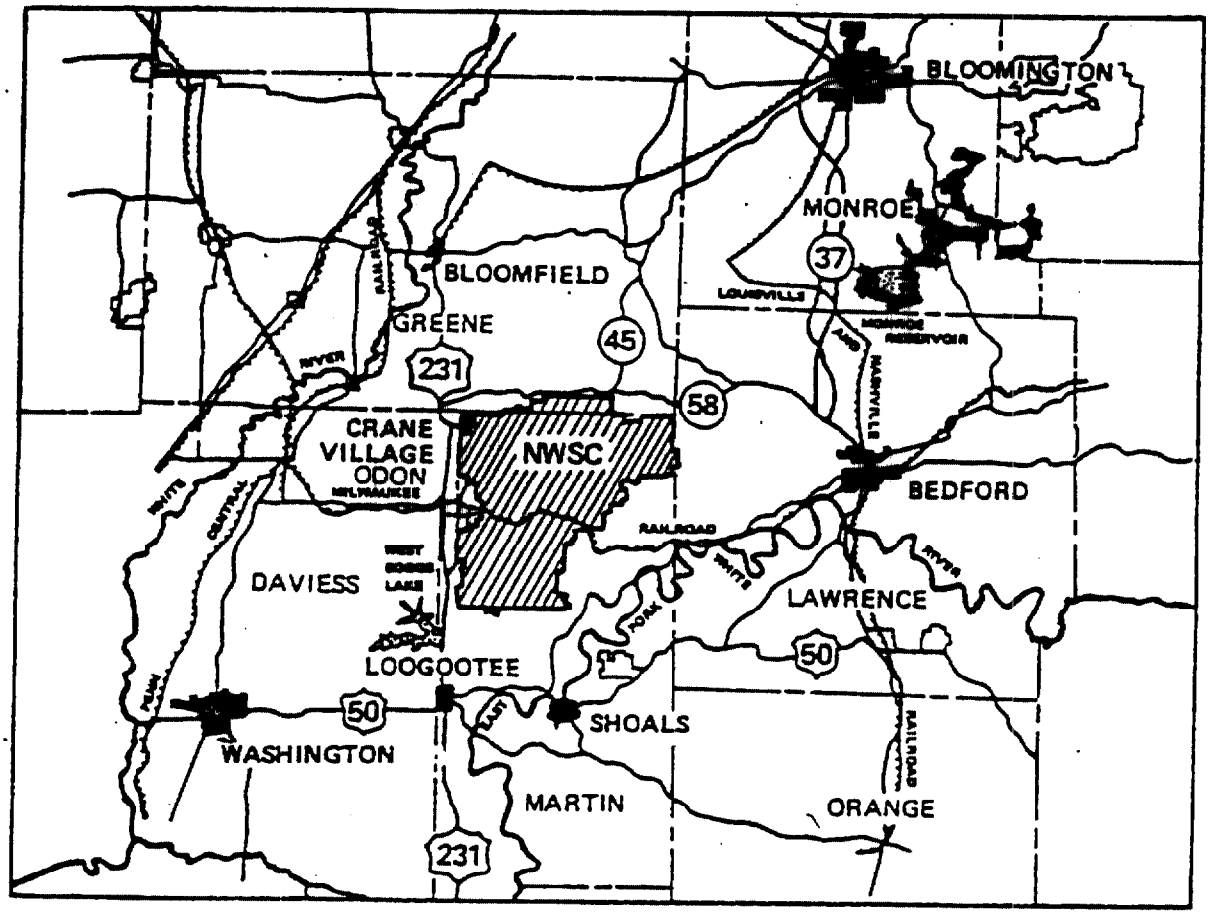

SOURCES: CHESAPEAKE DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, 1979 AND NAVAL ENERGY AND ENVIRONMENTAL SUPPORT AGENCY, 1983.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 3-1

20615

GENERAL LOCATION MAP
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

In 1977, the Single Manager Concept was implemented. The CAAA was created, and the Army assumed ordnance production, storage, and related responsibilities as a tenant organization. Other functions remained Navy, and currently the Navy retains ownership of all real estate and facilities at NWSCC. Responsibility for overall station safety, security, and environmental protection remains with the Commanding Officer, NWSCC.

Most recently in 1992, NWSCC was designated NAVSURFWARCENDIV. Presently, approximately 4,000 people are employed at NAVSURFWARCENDIV.

Operations specific to the ABG, DR, and ORR are detailed within Sections 3.4.1, 3.4.2, and 3.4.3, respectively. Operations within the ABG and ORR can be generalized as open burning of waste explosive and explosive-contaminated materials, and operations within the DR can be characterized as ordnance detonation.

3.2.2 History of Regulatory Actions

Following promulgation of the USEPA RCRA hazardous waste regulatory program, NAVSURFWARCENDIV filed notification and application to operate as a RCRA hazardous waste treatment, storage, or disposal (TSD) facility in October 1980. Interim status was granted subject to operating requirements and applicable technical standards found in Title 40 Code of Federal Regulations, Part 265 (40 CFR Part 265).

Corrective Action programs established as part of the 1984 RCRA Hazardous and Solid Waste Amendments (HSWA) required NAVSURFWARCENDIV to address past releases of hazardous waste or hazardous constituents at SWMUs. Accordingly, NAVSURFWARCENDIV submitted a Hazardous Waste Management Report to the USEPA in January 1985. Following the Hazardous Waste Management Report, a RCRA Facility Assessment (A.T. Kearney, Inc., 1987) was conducted to characterize the potential for releases of hazardous waste or constituents from 100 SWMUs.

On December 23, 1989, the USEPA issued the federal portion of the Final RCRA Part B permit for NAVSURFWARCENDIV to the U.S. Navy. This permit established the Corrective Action requirements and compliance schedules obligating the U.S. Navy to perform RCRA Facility Investigations (RFIs) at 30 SWMUs, to conduct Corrective Measure Studies (CMSs), and to implement Corrective Measures if needed. The Corrective Action requirements identified in the RCRA Part B permit are directed primarily at addressing the human health and ecological impacts of past waste management operations at NAVSURFWARCENDIV. The ABG, DR, and ORR were identified as SWMUs subject to further investigation pursuant to the Corrective Action requirements identified in the RCRA Part B permit.

On January 25, 1991, NAVSURFWARCENDIV filed a RCRA Part B permit application with USEPA in order to obtain a Part B permit to continue waste explosive open burning activities at ABG and ORR and to continue waste ordnance detonation activities at DR. These areas where open burning and detonation activities are occurring are considered "Miscellaneous Units" by the USEPA and are subject to the requirements of 40 CFR Part 264 Subpart X. The January 25, 1991, application was reviewed by USEPA and found to be deficient. Therefore, on April 24, 1992, USEPA sent a NOD letter to NAVSURFWARCENDIV requesting additional information.

One of the requirements of 40 CFR Part 264 Subpart X is that a miscellaneous unit must be designed and operated in a manner that will ensure protection of human health and the environment. Protection of human health and the environment includes, but is not limited to, prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in the groundwater or subsurface environment, in surface water or wetlands, on the soil surface, and in the air.

In order to determine the potential human health and ecological impacts caused by past operations at ABG, DR, and ORR as required by the RCRA Corrective Action requirements, and to determine the potential human health and ecological impacts that may be caused by current and proposed operations at ABG, DR, and ORR as required by 40 CFR Part 264 Subpart X, a baseline risk assessment addressing soil, groundwater, surface water/sediments, and air will need to be performed in accordance with this RA WP.

3.3 PHYSICAL CHARACTERISTICS

This section briefly describes the climate, topography, hydrology, soils, geology, hydrogeology, and biology of NAVSURFWARCENDIV. More detailed descriptions are included in Section 3.4.

3.3.1 Climate

NAVSURFWARCENDIV is located in a temperate climate zone displaying a wide temperature range among seasons. The summers are warm and humid, and the winters are generally mild with short periods of very cold weather. The mean minimum temperature in January is 26°F, and the mean maximum temperature in July is 89°F. The area receives an average of 44 inches of precipitation annually, with 42 inches of rainfall and 15 inches of snowfall (NEESA, 1983). The prevailing wind is from the south-southwest (McElrath, 1988).

3.3.2 Topography

The topography at NAVSURFWARCENDIV consists of undulating terrain dissected by many small drainageways. The elevation of the site ranges from 470 feet above mean sea level (MSL) at a southern drainageway to 860 feet MSL on a ridge in the west-central portion of the site. V-shaped drainageways in the north progress to 2,000-foot-wide floodplains in the south and rise to approximately 150 to 200 feet to the ridgelines (NEESA, 1983).

3.3.3 Hydrology

Six creeks receive drainage in five separate drainage basins at NAVSURFWARCENDIV (Figure 3-2). The six creeks are: Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, and Seed Tick Creek. Surface drainage from NAVSURFWARCENDIV eventually empties into the east fork of the White River, south of the facility. Situated within Crane are Lake Greenwood and several ponds. Lake Greenwood is the main source of water at NAVSURFWARCENDIV and is also used for recreation (NEESA, 1983). Each of the three SWMUs addressed in this work plan are in different drainage basins (separated by divides) from that of Lake Greenwood. Surface water flow within each of the three SWMUs is to the south, away from Lake Greenwood.

3.3.4 Soil

Four soil units have been mapped at NAVSURFWARCENDIV in the Soil Survey of Martin County, Indiana (McElrath, 1988), including Wellston-Gilpin, Wellston-Berks-Gilpin, Wellston-Berks-Ebal, and Wakeland-Wilbur-Haymond soils. These soils are primarily silt loams with permeabilities ranging from 0.6 and 2.0 in/hr. (McElrath, 1988).

3.3.5 Geology

NAVSURFWARCENDIV is located in the eastern flank Illinois Basin. Beneath unconsolidated colluvial and alluvial deposits, Paleozoic age sedimentary rocks underlying NAVSURFWARCENDIV have been deformed to yield a gentle dip of 50 feet per mile towards the west-southwest. Rock units in the basin are reported to exceed a thickness of 13,000 feet in some areas (Murphy and Ciocco, 1990). The distribution of the unconsolidated surficial deposits and bedrock units at NAVSURFWARCENDIV is presented in Figure 3-3.

The bedrock surface at NAVSURFWARCENDIV is made up of lower Pennsylvanian and upper Mississippian age sandstones, limestones, and shales. A generalized stratigraphic column of bedrock units in the NAVSURFWARCENDIV area is shown in Figure 3-4.

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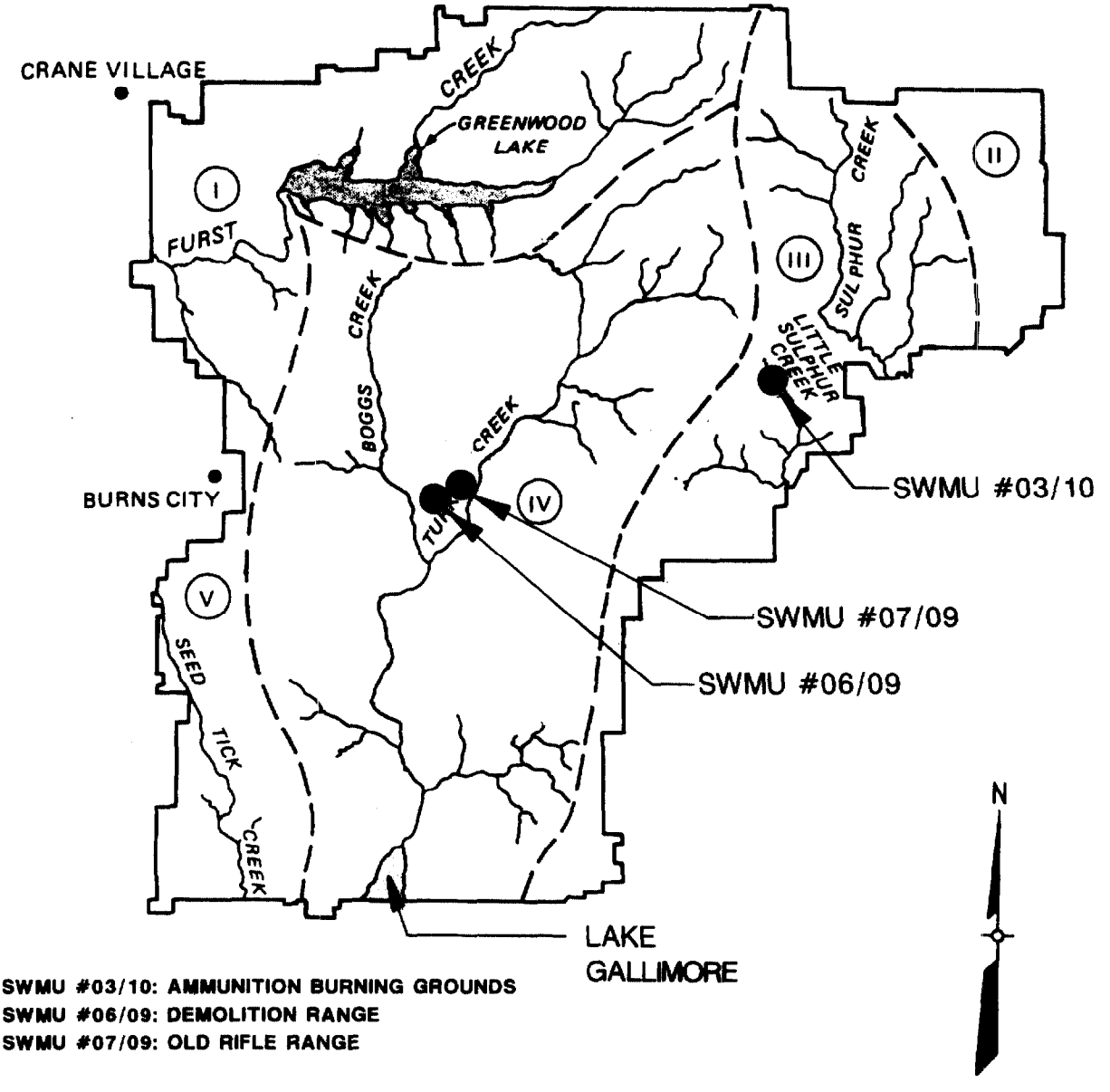


SWMU #03/10: AMMUNITION BURNING GROUNDS
SWMU #06/09: DEMOLITION RANGE
SWMU #07/09: OLD RIFLE RANGE

SCALE

2 0 2 4 MI

SOURCE: CHESAPEAKE DIVISION NAVAL FACILITIES COMMAND, 1979

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 3-2

20615

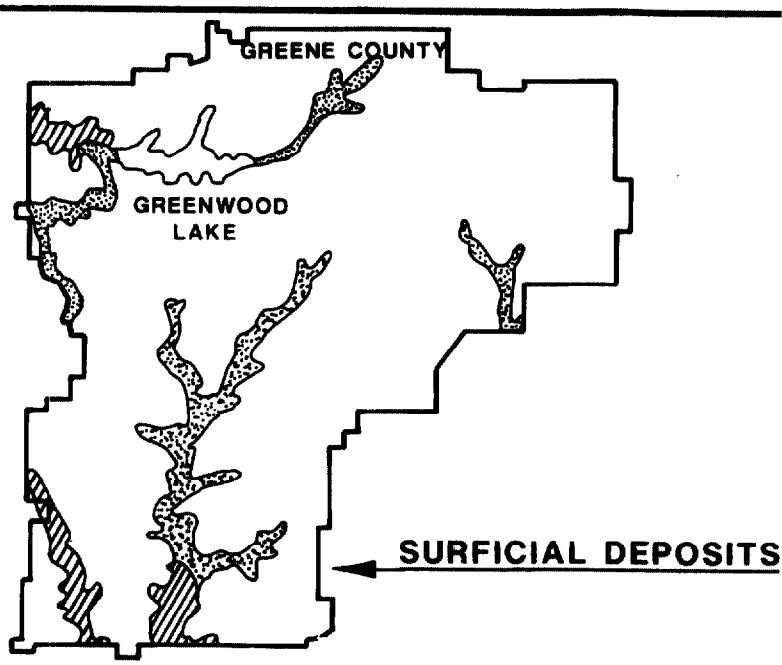
SURFACE DRAINAGE BASINS

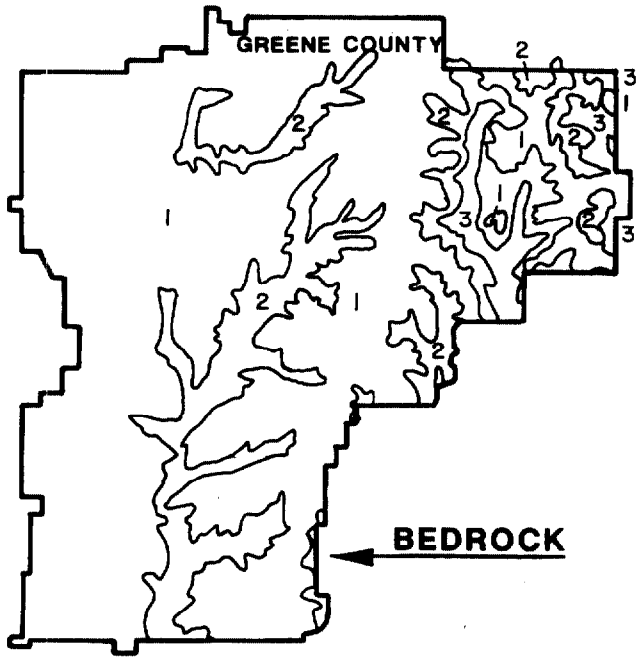
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

329965

CLEAN CTO #0076

EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA WP
JULY 1995





SCALE: NTS.

LEGEND

- QUARTERNARY SILT, SAND, AND GRAVEL MOSTLY ALLUVIUM BUT INCLUDES SOME COLLUVIAL AND PALUDAL DEPOSITS.
- QUATERNARY CLAY, SILT AND SAND. LACUSTRINE DEPOSITS.
- RESIDUAL CLAYS AND SILT FROM PENNSYLVANIAN RACCOON CREEK GROUP AND MISSISSIPPIAN STEPHENSPORT AND WEST BADEN GROUPS.

1. RACCOON CREEK GROUP
2. STEPHENSPORT GROUP
3. WEST BADEN GROUP

SOURCE: NAVAL ENERGY AND ENVIRONMENTAL SUPPORT AGENCY, 1983.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 3-3
SURFICIAL AND BEDROCK GEOLOGIC MAPS
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

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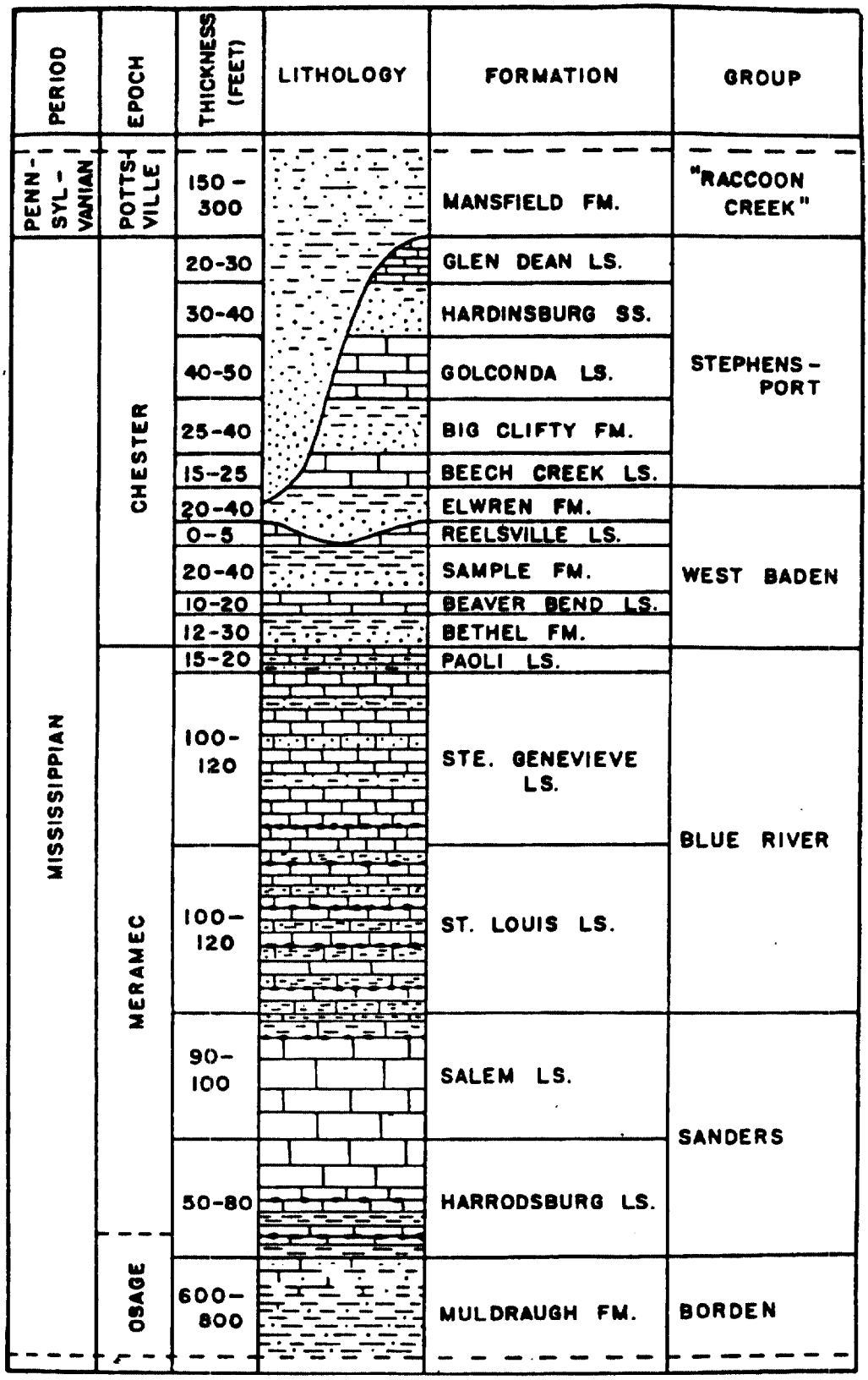
EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA WP
JULY 1995



SOURCE: PALMER, 1969

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995 **FIGURE 3-4** 20615

BEDROCK STRATIGRAPHIC COLUMN
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

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In general, Mississippian-age Chester Series sandstones, shales, and limestones are exposed in the valley walls of eastern portions of NAVSURFWARCENDIV and in the lower elevations of deep valleys in the western portions. Pennsylvanian-age Mansfield Formation sandstone, siltstones, claystones, and shale are found at the crests of hills and ridges in eastern portions of NAVSURFWARCENDIV and as the surficial bedrock unit further west. The contact between the Mississippian units and overlying Pennsylvanian units is an unconformity formed by long-term erosion of the Mississippian surface (Murphy and Ciocco, 1990).

3.3.6 Hydrogeology

Hunt (1988) discussed regional groundwater trends pertaining to the unglaciated southwest portion of Indiana. In general, groundwater is contained in joint openings of limestone and sandstone aquifers. Based on studies conducted in the eastern portion of NAVSURFWARCENDIV (Hunt, 1988; Murphy and Ciocco, 1990), rock units considered to be aquifers and aquicludes are presented in Figure 3-5. Although unit thicknesses may vary, the distribution of bedrock units at NAVSURFWARCENDIV (Figure 3-3) suggests similar aquifer characteristics throughout the facility. Surficial unconsolidated aquifers are thin and have limited potential as water supplies.

Aquifers beneath NAVSURFWARCENDIV are considered to be vertically isolated from each other by interlayered shale beds which act as aquitards. Groundwater recharge occurs where aquifer units outcrop. After entering an aquifer outcrop, groundwater flows by gravity down the dip of the aquifer unit. Since the regional dip of rock units is to the southwest, regional groundwater flow in all aquifers is directed towards the southwest. Local groundwater flow at each of the three SWMUs (see Section 3.4) is consistent with the regional flow direction. The locations of each of the three SWMUs relative to Lake Greenwood coupled with local and regional groundwater flow directions indicate that groundwater from the three SWMUs does not discharge to Lake Greenwood.

Local variations in bedding, dip, aquifer and aquitard, incision by surface drainage, and karstic conditions cause local groundwater movement at NAVSURFWARCENDIV to differ from regional trends. Where erosion resulting from surface drainage has cut through aquifer units, springs and seeps are produced which locally complicate groundwater flow. Springs and seeps are prevalent at contacts between aquicludes and overlying aquifers. Groundwater flowing from springs and seeps into surface water can potentially re-enter the groundwater system as recharge to a lower aquifer outcropping downstream.

In the eastern portion of NAVSURFWARCENDIV Hunt (1988) hypothesized that karstic conditions are present primarily in major drainage valleys where erosion has cut into permeable sandstones overlying easily dissolved limestone units. Rapid infiltration within

GEOLOGIC UNIT	THICKNESS (FEET)	HYDROGEOLOGIC UNIT TYPE
Golconda/Haney Formation	Few – 14	Upper Aquifer
Big Clifty Formation – Indian Springs Shale	20	Aquiclude–Aquitard
Big Clifty Formation – Lower Member	40	Middle Aquifer
Beech Creek Formation	18 – 22	
Elwren Formation	20	Aquitard
Reelsville Formation	10	
Sample Formation	40 – 45	
Beaver Bend Formation	10 – 12	Lower Aquifer

SOURCE: MURPHY ET AL., 1990 AND HUNT, 1988

NOTE:
REPORTED UNIT THICKNESS AND TYPE ARE BASED ON STUDIES COMPLETED IN THE EASTERN PORTION OF NWSCC. THE DISTRIBUTION OF BEDROCK UNITS AT NWSCC SUGGESTS SIMILAR AQUIFER CHARACTERISTICS THROUGHOUT NWSCC.

the Big Clifty sandstone units has caused dissolution and weathering of the underlying Beech Creek Limestone. The result of this occurrence has been the creation of karst and collapse conditions along major drainageways within the eastern part of NAVSURFWARCENDIV.

3.3.7 Biology

NAVSURFWARCENDIV biological characterization is presented in the Initial Assessment Study (IAS) (NEESA, 1983), and summarized in the Final Environmental Monitoring Report (EMR) (Halliburton NUS, 1992). Listings of plants and animals found at NAVSURFWARCENDIV are also included in the Final EMR (Halliburton NUS, 1992).

3.4 SWMU CHARACTERISTICS

The following sections present background information specific to ABG, DR, and ORR. However, before discussing the three SWMUs separately, a general discussion of the disposal of waste explosives and ordnance is presented.

In the interest of national security, enormous inventories of military ordnance items and bulk propellants, explosives, and pyrotechnics (PEP) are maintained at various military installations around the country. Because the ordnance items and PEP held in this military readiness stockpile are subject to deterioration and obsolescence, action has to be taken to safely remove and thermally treat these items on an ongoing basis. Other explosives wastes are generated at military manufacturing facilities such as NAVSURFWARCENDIV. This source of hazardous waste is generally composed of off-specification energetic materials. Off-specification materials are generally composed of the same ingredients that the specification materials are composed of, but do not meet all performance specifications. Off-specification items are sold as foreign sales to allied countries, reprocessed through a procedure known as renovation, or demilitarized. Off-specification materials are usually demilitarized. The term "demilitarize" means to render the item no longer functional for the intended military use and to free it of hazard to the point that materials (i.e., metal parts) may be sold as salvage to the general public (Murphy, W.L., 1992b).

Once ordnance or PEP is determined to be a waste material and designated for demilitarization, the proper demilitarization process is selected based upon a review of the physical and chemical characteristics of the waste material. If the waste material is determined to be highly energetic and expected to detonate with sufficient force, the demilitarization method of detonation is selected. Detonation can take place either

underground or on-grade (open detonation). Detonation of waste ordnance at NAVSURFWARCENDIV occurs at the DR as described in Section 3.4.2.

If the waste material is not expected to detonate, it may be able to be demilitarized by the thermal treatment process known as open burning or flashing. In general, the waste material is received in bulk or loose form (i.e., not confined), placed in a burn pan or other similar device, remotely initiated, and allowed to burn. Open burning activities can generate ash which accumulates in the burn pan. The ash generated by the thermal treatment process (open burning) is collected, burned a second time, containerized in bulk containers, and disposed of off-site at a permitted hazardous waste facility. The ash is burned a second time by placing the collected ash on top of the contaminated material and dunnage being burned on the contaminated material burn pads at the ABG. Double burning is conducted because both Army and Navy safety regulations require the facility to flash/burn twice to insure that the material is no longer reactive (NWSCC, 1992a). Some of the PEP solvents that are burned are also F001-F005 RCRA-listed (40 CFR Part 261) solvents. Since these solvents are restricted from land disposal unless established treatment standards are met for the waste, the ash from PEP/solvent treatment is placed in drums and kept segregated from the other ash prior to disposal off-site (NWSCC, 1992a). Open burning or flashing of waste materials at NAVSURFWARCENDIV occurs at the ABG and ORR. From approximately 1981 through 1983, the "Jeep Trail" area, located approximately one-half mile southeast of the ABG, was also used to burn-out bombs and flash powder. This Jeep Trail area has not been used since 1983 with the flashing operations now performed at the ORR (Murphy, 1992a).

3.4.1 Ammunition Burning Ground (SWMU #03/10)

3.4.1.1 Location and Description

The ABG covers approximately 20 acres and is located as shown in Figures 3-6 and 3-7. The ABG is located in a remote area near the east center boundary of the facility in the NW 1/4 of Section 28 and SW 1/4 of Section 21, T5N, R3W. The site lies in the valley of Little Sulphur Creek (Murphy, 1992b). Little Sulphur Creek is approximately 4.6 miles long from its northernmost headwaters to its intersection of Sulphur Creek south of the NAVSURFWARCENDIV. The stream consists of a north and a south fork from the headwaters to approximately the center of the ABG where it becomes a single channel (Murphy and Wade, 1994a). Surface drainage flows into and from the ABG via Little Sulphur Creek. The creek is intermittent in that its flow varies considerably with the seasons. Some flow is usually present in the north and south forks above the center of the ABG. Downstream, however, the surface flow ceases in the dry months as the surface water is captured by vertical infiltration into the sandstone and limestone aquifer underlying the ABG.

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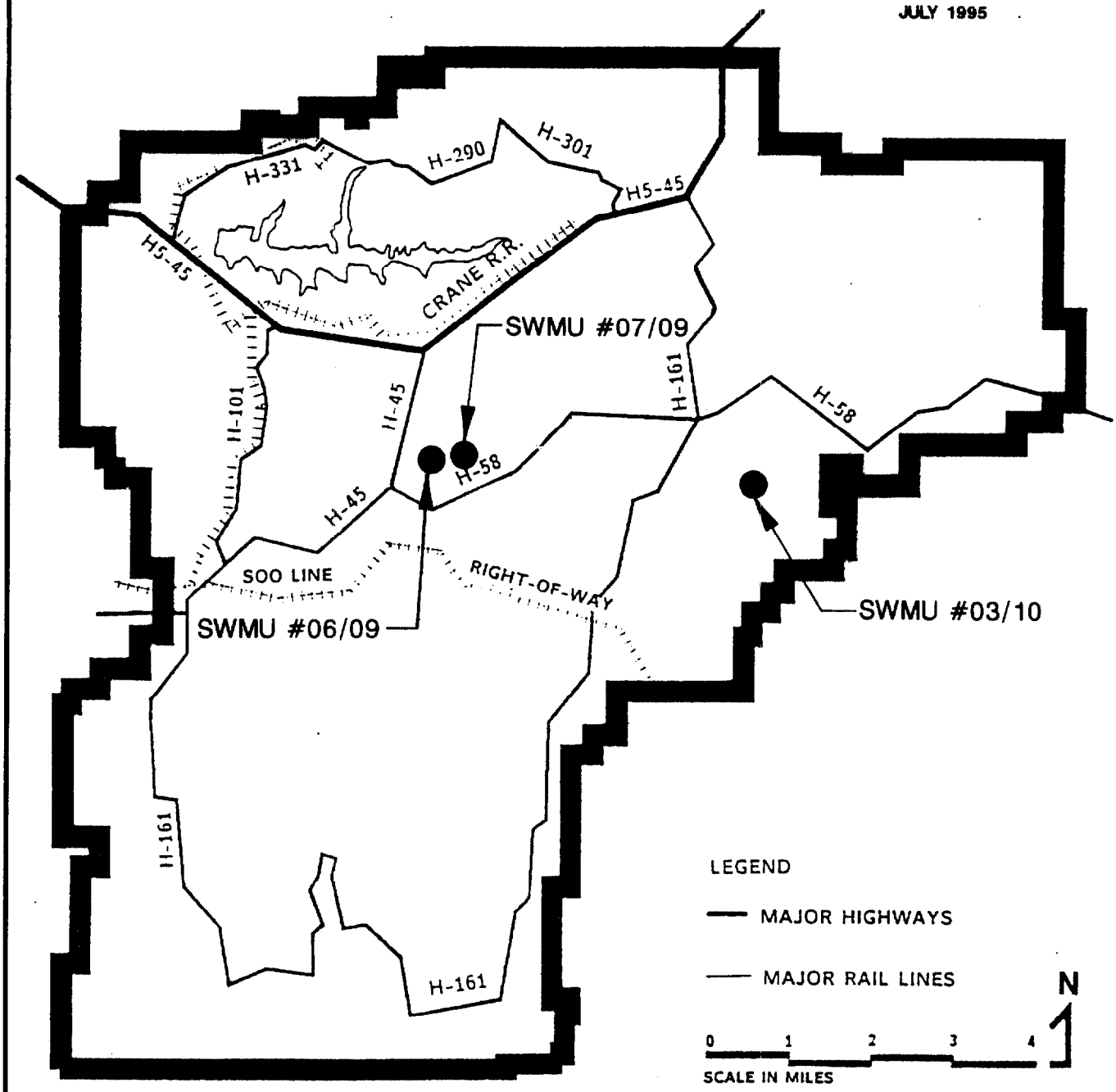

SWMU #03/10: AMMUNITION BURNING GROUNDS
SWMU #06/09: DEMOLITION RANGE
SWMU #07/09: OLD RIFLE RANGE

SOURCE: NORTHERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, NWSCC MASTER PLAN, 1986

RUST ENVIRONMENT & INFRASTRUCTURE

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FIGURE 3-6

SWMU - LOCATION MAP

RISK ASSESSMENT WORK PLAN
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Ordnance and ordnance-contaminated materials from NAVSURFWARCENDIV production areas have been taken to the ABG for disposal by burning since the 1940s. The burning ground is used extensively for destroying unwanted materials contaminated with explosives, bare explosives, rocket motors, candles, flares, solvents, detonators, and fuse materials. Several separate burning areas are located within the site proper. The largest quantities of materials were destroyed from 1956 to 1960, when 15,000 lbs per day of smokeless powder was destroyed. In the same period, about 46,000 lbs/per day of high explosives were burned. The area is also used for flashing the residue from bombs and projectiles after they have been subjected to melt-out or drill-out operations for removal of the bulk of the explosive (Murphy, 1992b). Powder flashing and bomb burn-out were also conducted at an area called "Jeep Trail", which is located approximately one-half mile southeast of the ABG between Little Sulphur Creek and Jeep Trail 25. The location of the Jeep Trail is shown on Figure 3-7 with the layout of the Jeep Trail area shown on Figure 3-8. Figure 3-9 shows the location of the various open burning/thermal treatment units in the ABG.

3.4.1.2 Description of Past Operations and Wastes Managed

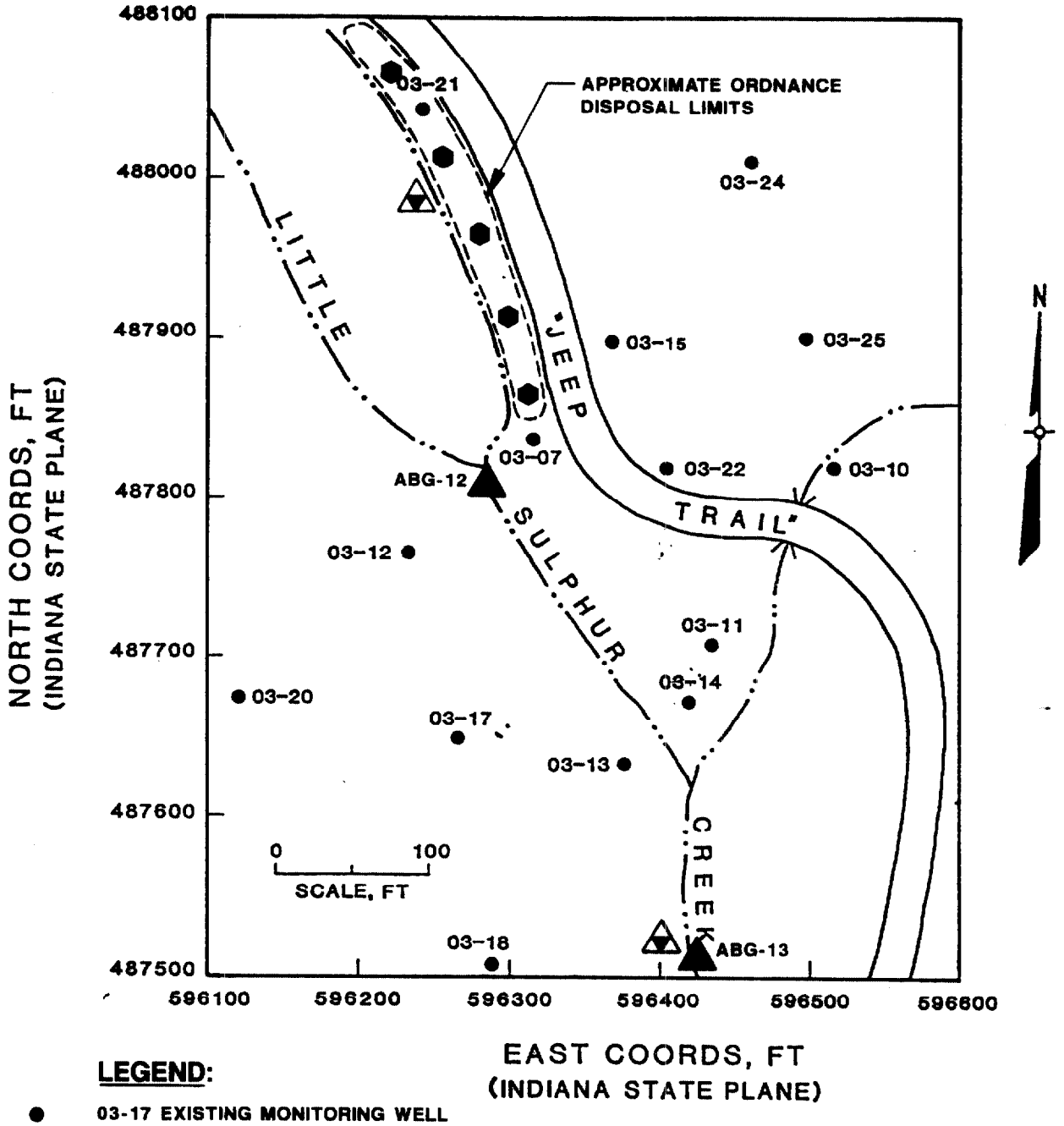
Many modifications have been made at the ABG to address changing military operating procedures and regulatory requirements. As a result of these modifications, several areas or activities addressed by this RA WP are no longer operational. These areas or activities are discussed below.

Former On-Grade Berm Pads and Flash Pits

Prior to construction and use of the steel pans (lined and unlined) used today for open burning operations, PEP was spread and ignited on pads or in pits (Murphy, 1992a). These burn pads and pits were reportedly in the area now occupied by the clay-lined steel burn pans shown as Area 2 in Figure 3-9.

Former Surface Impoundments

Three surface impoundments were used for the purpose of removing liquids from otherwise combustible sludges resulting from the blending and loading of munitions. In 1982 the impoundments were modified to include a liner and leachate collection system for each one. Each of the impoundments were approximately 40 feet in diameter. The former covered impoundments are shown as open circles (Area 6) on Figure 3-9. The two impoundments next to one another held TNT, RDX, and breakdown compounds in water from the Rockeye and other locations within NAVSURFWARCENDIV. The impoundment in the upper left corner of Figure 3-9 held phosphorus compounds. The three impoundments have been replaced by the three sludge burn pads and associated tanks



LEGEND:

- ● 03-17 EXISTING MONITORING WELL (WELLS TO BE SAMPLED ARE LISTED IN TABLE 4-12)
- ⬢ SOIL GRAB SAMPLE (0-6")
- ABG-12 ▲ SURFACE WATER AND SEDIMENT SAMPLE / MACROINVERTEBRATE
- △▽ PROPOSED STAFF GUAGE LOCATION

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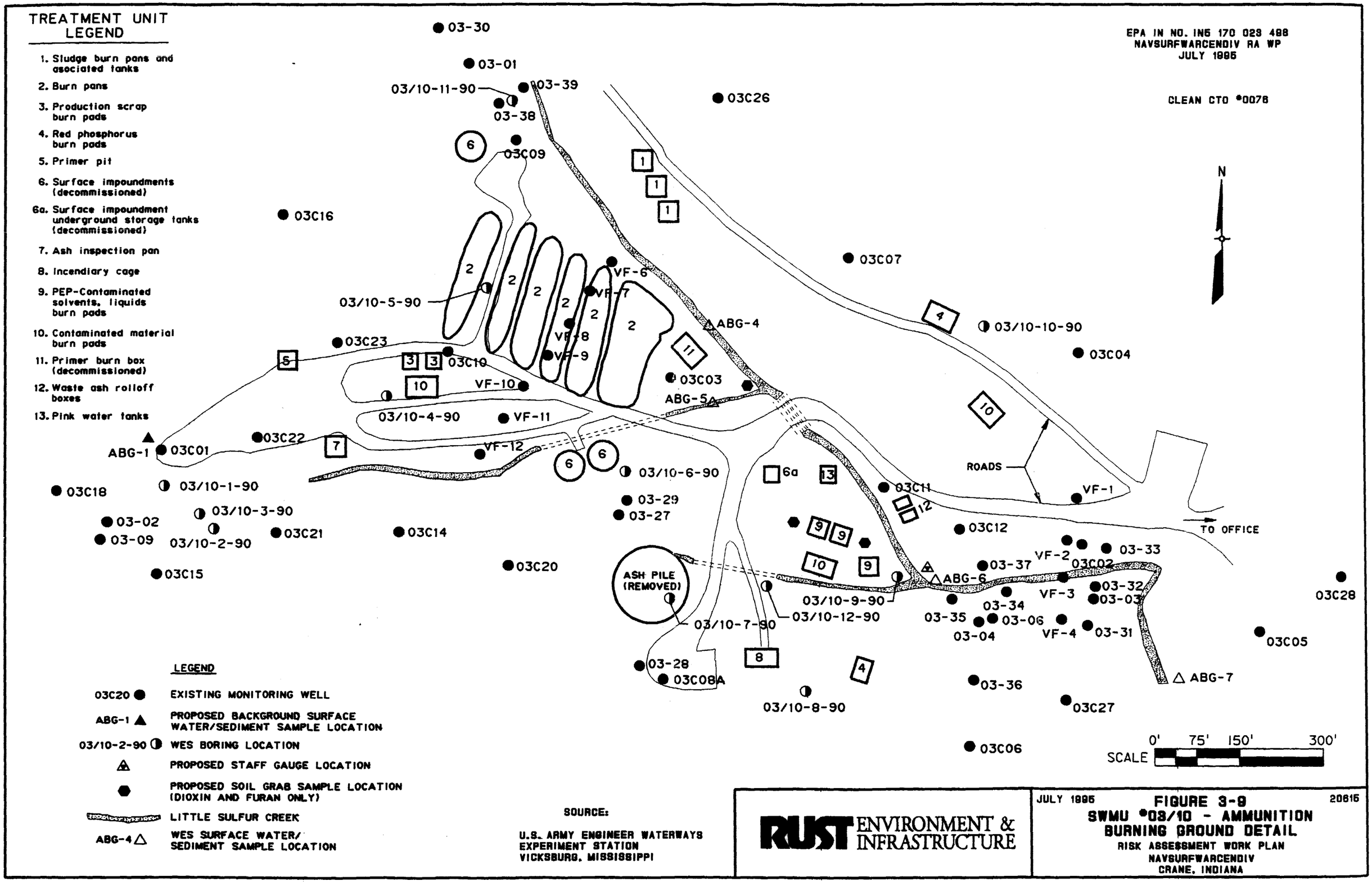
FIGURE 3-8

JEEP TRAIL DETAIL

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA


TREATMENT UNIT LEGEND
1. Sludge burn pans and asociated tanks
2. Burn pans
3. Production scrap burn pads
4. Red phosphorus burn pads
5. Primer pit
6. Surface impoundments (decommissioned)
6a. Surface impoundment underground storage tanks (decommissioned)
7. Ash inspection pan
8. Incendiary cage
9. PEP-Contaminated solvents, liquids burn pads
10. Contaminated material burn pads
11. Primer burn box (decommissioned)
12. Waste ash rolloff boxes
13. Pink water tanks
EPA IN NO. IN6 170 023 498
NAVSURFWARCENDIV RA WP
JULY 1995
CLEAN CTO #0076
N
03-30
03-01
03/10-11-90
03-39
03-38
03C26
03C09
03C16
03C07
03/10-5-90
VF-6
VF-7
VF-8
VF-9
ABG-4
03/10-10-90
03C04
03C23
03C10
VF-10
03C03
ABG-5
03/10-4-90
VF-11
VF-12
ABG-1
03C01
03C22
03/10-6-90
ROADS
VF-1
03C18
03/10-1-90
03-29
03-27
03C11
03/10-3-90
03-02
03-09
03/10-2-90
03C21
03C14
03C12
TO OFFICE
03-33
VF-2
03C02
03-37
ABG-6
03-32
VF-3
03-03
03C20
03C15
ASH PILE (REMOVED)
03/10-9-90
03/10-12-90
03/10-7-90
03-35
03-34
03-06
03-04
VF-4
03-31
03C28
03C05
03-28
03C08A
03/10-8-90
03-36
ABG-7
03C27
03C06
SCALE
0'
75'
150'
300'
LEGEND
03C20 EXISTING MONITORING WELL
ABG-1 PROPOSED BACKGROUND SURFACE WATER/SEDIMENT SAMPLE LOCATION
03/10-2-90 WES BORING LOCATION
PROPOSED STAFF GAUGE LOCATION
PROPOSED SOIL GRAB SAMPLE LOCATION (DIOXIN AND FURAN ONLY)
LITTLE SULFUR CREEK
ABG-4 WES SURFACE WATER/ SEDIMENT SAMPLE LOCATION
SOURCE:
U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI
RUST ENVIRONMENT & INFRASTRUCTURE
JULY 1995
FIGURE 3-9
SWMU #03/10 - AMMUNITION BURNING GROUND DETAIL
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA
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shown as Area 1 on Figure 3-9. The impoundments are now empty and scheduled for closure. Two empty underground storage tanks (UST), scheduled for closure, were used to store runoff and leachate from the three Area 6 impoundments. Another underground tank (Area 6A) holds explosives wastes contaminated with pink water (Murphy, 1992a). The impoundments and USTs will be closed pursuant to a RCRA closure plan.

Former Ash Pile

The area labeled Ash Pile on Figure 3-9 is the site of a former stockpile of burn residue. The pile consisted of approximately 12,290 pounds of burn residue and was removed between July 1986 and February 1987 pursuant to a RCRA closure plan (Murphy, 1992a). The function served by the former Ash Pile has been replaced by use of tarped ash roll-off boxes shown as Area 12 on Figure 3-9.

Pink Water Burn Pit

Prior to approximately 1985, red water sludge was placed in and burned in an unlined pit in the location of the Pink Water Tanks (see Area 13 on Figure 3-9). This flashing process was relocated to the burn pads in approximately 1985 (NWSCC, 1992b; NWSCC, 1993b). The pink color of the water and sludge is caused by the presence of the explosives in the water and sludge.

Former Primer Burn Box

The former primer burn box (see Area 11 on Figure 3-9) was used for thermal treatment of ammunition components (for example, small impact sensitive primers) and pyrotechnic munitions. The burn box has been decommissioned with these activities now performed at the Primer Pit (Area 5 on Figure 3-9) and the Incendiary Cage (Area 8 on Figure 3-9) (Murphy, 1992a).

Former Jeep Trail Burn Area

From approximately 1981 through 1983 the Jeep Trail area shown on Figure 3-9 was used to burn-out bombs and flash powder. Bombs were tilted up on-end west of Jeep Trail 25, filled with initiating powder, and flashed to finish the demilitarization process following wash-out. A trench was reportedly excavated west of Jeep Trail 25 to flash powder. The area has not been used for any operations since 1983 (Murphy, 1992a). The powder flash function served by this area has been relocated to the ORR.

3.4.1.3 Current Operations

All treatment devices listed below are equipped with run-on and run-off controls in the form of lids for pans or drains with sumps (NWSCC, 1992a).

Bulk Propellant and Explosive Burn Pans

Solid bulk propellant and explosives are open-burned (thermally treated) in 18 clay-lined steel pans (see Area 2 on Figure 3-9). The pans are 14 feet by 7 feet, 12 inches in depth. The pans have aluminum lids to be used when the pans are not in operation. The maximum net bulk propellant weight for each pan is 1,500 pounds, while the maximum net bulk explosive weight is 500 pounds. The operator pours and spreads the propellant/explosive evenly and uniformly across the width of the pan. Every other pan in each row is loaded in this fashion. Remote initiation for each pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on each pan and then exits the area and goes to the office at the ABG. The average time taken for 1,500 pounds of bulk propellant to burn is 15 to 30 seconds, while 500 pounds of bulk explosive can take 5 to 10 minutes depending upon the type of explosive being burned (NWSCC, 1992a).

Production Scrap Burn Pads

High explosive production scrap is thermally treated in two pans of identical construction as the ones used for bulk propellant (see Area 3 on Figure 3-9). The maximum net explosive weight permitted for each pan is 500 pounds. The same burn procedure as outlined above for the Bulk Propellant and Explosive Burn Pans is followed. Length of burn time varies from 4 minutes to 1 hour for this operation due to the type of high explosive production scrap being burned and depending on amounts of wax or moisture (NWSCC, 1992a).

Primer Pit

The primer pit operation involves treatment of small explosive components such as hand grenade fuses and cartridge primers. This operation consists of a small building, two gravity feed chutes, and two heavy steel pans with graded covers (see Area 5 on Figure 3-9). The top of the pans are 7 feet by 5.5 feet tapering to 2.5 feet by 3.5 feet at the bottom. The pans stand approximately 2.5 feet to 3 feet tall. The lids have half-inch slots which allow oxygen to enter and hot gases to vent. A 12-inch hole is provided in the lid through which the primers are directed into the burn box. The two pans are separated and contained on three sides by metal-clad concrete walls. The walls are approximately 3 feet tall. The feed chutes are designed with double gates which allow the items to be directed into the fire box without a direct opening being present which would expose operators to

possible fragmentation hazards. The amount of items to be fed in each increment is limited by explosive safety standards (NWSCC, 1992a). Burn times are typically 3 to 4 hours in length (NWSCC, 1993b).

Primer Pit Ash Inspection Pan

One additional 14-foot by 7-foot pan is provided near the primer pit area for the purpose of inspection of treated primers (see Area 7 Figure 3-9). No thermal treatment occurs in this inspection pan. Primers which have been treated at the primer pit are placed in this pan and visually inspected by the CAAA personnel to insure all have functioned. These treated primers, after they have been inspected, are then transported to the Defense Reutilization Marketing Office (DRMO) to be offered for sale as scrap metal (NWSCC, 1992a).

PEP-Contaminated Solvent Burn Pan

PEP-contaminated solvents are burned in one unlined steel pan (see Area 9 Figure 3-9). This pan is the westernmost pan of the three in Area 9 (Murphy, 1992a). This pan is 4 feet by 8 feet, 12 inches in depth. The maximum net explosive weight permitted to be treated at one time in this pan is 100 pounds. The operator pours the contaminated solvent into the pan. Remote initiation for each pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pan and then exits the area and goes to the office at the ABG. Average length of time required for burn is 30 to 45 minutes. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out.

The PEP-contaminated solvents are generated by the following operations:

- Solvents are used in munition production process to clean equipment and tools. These solvents when used for cleaning become contaminated with the PEP.
- Solvents are used in the production of pyrotechnic compositions as carriers for rubber binders. RCRA F-listed solvents most commonly used for this purpose are hexane and/or acetone. After mixtures are blended, they are allowed to settle, and then solvents are then decanted and sent to ABG to be managed as a PEP-contaminated waste.
- Solvents are also used during the production of explosive munition items. The solvents used during these operations include toluene, cyclohexanone, 1,1,1-trichlorethane, and carbon disulfide.
- Toluene and acetone are currently used for tool and machine/equipment cleaning. The primary waste generated in these operations are rags soaked with explosive-contaminated solvents.

The waste ash generated by the burning of these waste solvents is collected and segregated from other ash streams at the ABG. This operation generates a very minimal amount of ash (NWSCC, 1992a).

Desensitized Waste Scrap Pyrotechnics Burn Pan

Waste scrap pyrotechnics desensitized in No. 2 fuel oil is burned in one unlined steel pan (see Area 9 Figure 3-9). This pan is the middle pan in Area 9 (Murphy, 1992a). This pan is 4 feet by 8 feet, 12 inches in depth. The maximum net explosive weight permitted to be treated in this pan is 100 pounds. The operator pours the fuel oil/pyrotechnic mixture into the pan. Remote initiation for the pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pan and then exits the area and goes to the office at the ABG. Average length of burn is 30 to 45 minutes. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out (NWSCC, 1992a). Pop out refers to the materials that are ejected from the burn pan during the burn event.

Desensitized Scrap Block Powder Burn Pan

Scrap black powder desensitized in water is burned in one unlined steel pan (see Area 9 on Figure 3-9). This pan is the easternmost pan in Area 9 (Murphy, W.L., 1992a). This pan is 4 feet by 8 feet, 12 inches in depth. The maximum net explosive weight permitted to be treated at one time in this pan is 120 pounds. The same procedure described above for the Waste Scrap Pyrotechnics Burn Pan is used here. Average length of time required for a burn is 60 minutes (NWSCC, 1992a).

Red Phosphorous Burn Pans

The waste red phosphorous and No. 2 fuel mixture is burned in unlined steel pans. Currently at the site, two sets of four pans are setup for this operation (see Area 4 Figure 3-9). These pans are 4 feet by 4 feet by 12 inches in depth and are elevated 2 to 3 feet off the ground by metal stands. The maximum net explosive weight permitted to be treated in these pans is 100 pounds per pan. The operator pours the red phosphorous/fuel oil mixture into the pan. Remote initiation for the pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pan and then exits the area and goes to the office at the ABG. Average length of time required for burn is 2 hours. After initial ignition the operators are allowed to enter areas not immediately adjacent to these operations. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out (NWSCC, 1992a).

Pink Water Tanks

Two steel aboveground tanks were installed (see Area 13 on Figure 3-9) in approximately 1985 to replace the function served by the former Pink Water Burn Pit. Pink water sludge is flashed in the burn pads with the water pumped to the B-160 treatment plant (NWSCC, 1992b; NWSCC, 1993b).

Incendiary Cage

The incendiary cage is set up primarily to allow the functioning of pyrotechnic devices and components. One mechanized conveyor runs from an adjacent building and ends over a caged burn box (see Area 8 on Figure 3-9). The burn box is contained within a reinforced concrete structure that has three walls, concrete floor, and heavy steel frame covered with a fine stainless steel screen. The screening serves to contain burning embers. The structure is equipped with run-on, run-off protection in the form of graded, perforated pipe, collection trough, and covered sump. The floor of the structure is insulated with sand to protect the concrete from the intense heat (NWSCC, 1992a).

Contaminated Material Burn Pads

Three concrete-lined burn pads have been provided for the flashing or thermal treatment of suspect explosive-contaminated materials (see Area 10 Figure 3-9). Only two of the three pads are currently used. The pad near Area 9 in Figure 3-9 is not used (Murphy, 1992a). These contaminated materials include primarily cardboard, paper, or metal packaging which have been in physical contact with PEP materials. Also included are expended flare casings which have been generated from lot-acceptance function tests.

The concrete burn pads have 18-inch high sidewalls with 8-inch thick reinforced concrete floor sloped towards the center where a graded collection system directs any precipitation to a collection sump. The pads are surrounded by 6-foot tall chain link fencing and gates to aid in containing small bits of paper or cardboard prior to flashing or thermal treatment. The floor of these concrete pads is covered with 6 inches of sand to prevent the concrete floor from spalling due to intense heat of the burning operations. If materials to be treated are readily combustible, additional materials are not needed. If materials are primarily metal, uncontaminated lumber (dunnage) is used. Strict procedures are enforced to prohibit the use of PCP (pentachlorophenol)-treated materials for this purpose.

Remote initiation of the burn pads is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pad and then exits the area and goes to the office at the ABG. After initial ignition the operators are allowed to enter areas not immediately

adjacent to these operations. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out (NWSCC, 1992a; NWSCC, 1993b).

Sludge Burn Pans and Tanks

Three Sludge Burning Pans (SBPs) with double-walled underground tanks equipped with automatic leak detection receive explosive and pyrotechnic contaminated sludges from production operations at Minefill A Area, the Rockeye Area, and the Pyro-Production Building 133 (See Area 1 Figure 3-9). The northernmost pan is for RDX sludge, the southernmost for phosphorus sludge, and the middle pan has not been used to date (Murphy, 1992a). The maximum amount of sludge that can be treated per month in the SBPs is 10,000 gallons. These units replace treatment operations previously provided by the surface impoundments. These sludges are transported to the ABG in a 1,250-gallon tank truck and placed in the SBPs, dewatered by gravity and an under-drain system, air-dried to an optimum point, ignited, and burned in-place. Each of the three subunits is separate from the others and has its own under-drain and filtrate storage system (double-walled underground tanks). Each subunit is equipped with a cover when the pan is not in use.

Remote initiation for each pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pan and then exits the area and goes to the office at the ABG. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out (NWSCC, 1992a; NWSCC, 1993b).

3.4.1.4 Topography

The ABG is located in the eastern part of NAVSURFWARCENDIV within the northern reaches of the valley of Little Sulphur Creek. The ABG is characterized by rugged relief with ground surface elevations ranging from approximately 580 to 800 feet MSL. Along the Jeep Trail portion of the ABG, to the southeast, the average elevation is approximately 500 feet MSL. However, the valley slopes adjacent to Little Sulphur Creek rapidly approach elevations of 700 feet MSL. Ground surface elevations greater than 800 feet MSL occur within 1 mile of the ABG to the north, west, and southwest.

3.4.1.5 Physiography and Hydrology

Surface runoff at the ABG drains almost exclusively to the south and southeast through Little Sulphur Creek. Little Sulphur Creek exits the southeast boundary of NAVSURFWARCENDIV approximately 1.5 miles southeast of the ABG. Little Sulphur Creek merges with Sulphur Creek which in turn continues to flow south before discharging to Indian Creek.

3.4.1.6 Geology

Soils

Detailed soil mapping (McElrath, 1988) in the vicinity of the ABG indicates the presence of primarily two soil units. These two soil units include the Burnside loam and Wellston-Berks-Gilpin complex (18 to 70 percent slopes).

The Burnside loam is described as deep, well drained, moderately permeable soil. At the ABG this soil occurs on the Little Sulphur Creek valley floor. Consistent with McElrath (1988), this soil formed in loamy, skeletal alluvium derived from sandstone, siltstone, and shale residuum. Bedrock in areas mapped as covered with Burnside loam generally occurs at depths between 4 and 5 feet below ground surface.

The Wellston-Berks-Gilspin complex consists of moderately deep to deep, well drained, moderately permeable soils on uplands. At the ABG, these soils occur on the Little Sulphur Creek valley sideslopes ranging from 18 to 70 percent. These soils formed in material weathered from sandstone, siltstone, and shale.

Bedrock

Bedrock at the ABG has been described in detail by the U.S. Army Waterways Experiment Station (WES) (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1992a). The bedrock surface beneath the ABG is composed of sandstone, shale, and limestone of the Pennsylvanian Age Raccoon Creek Group and the Upper Mississippian Age Stephensport Group (Figure 3-10). The contact between the Mississippian and Pennsylvanian strata is an unconformity formed by erosion of the Mississippian surface. The regional dip of the bedrock units is to the southwest at approximately 50 feet/mile. As presented by Murphy and Ciocco (1990), the bedrock units at the AGB are briefly described in the following subsections. A vertical profile of the subsurface bedrock units along the axis of the Little Sulphur Creek valley from west to east is presented in Figure 3-11.

Raccoon Creek Group (Pennsylvanian Mansfield Formation)

The Mansfield Formation caps the hills and ridges at the ABG and ranges from 0 to 65 feet thick. The formation consists of interfingered sandstones, thin-bedded and laminated shale and sandstone, thin-bedded to massive carbonaceous shale, massive claystone, siltstone, and occasional thin seams of coal. The strata tend to pinch out laterally.

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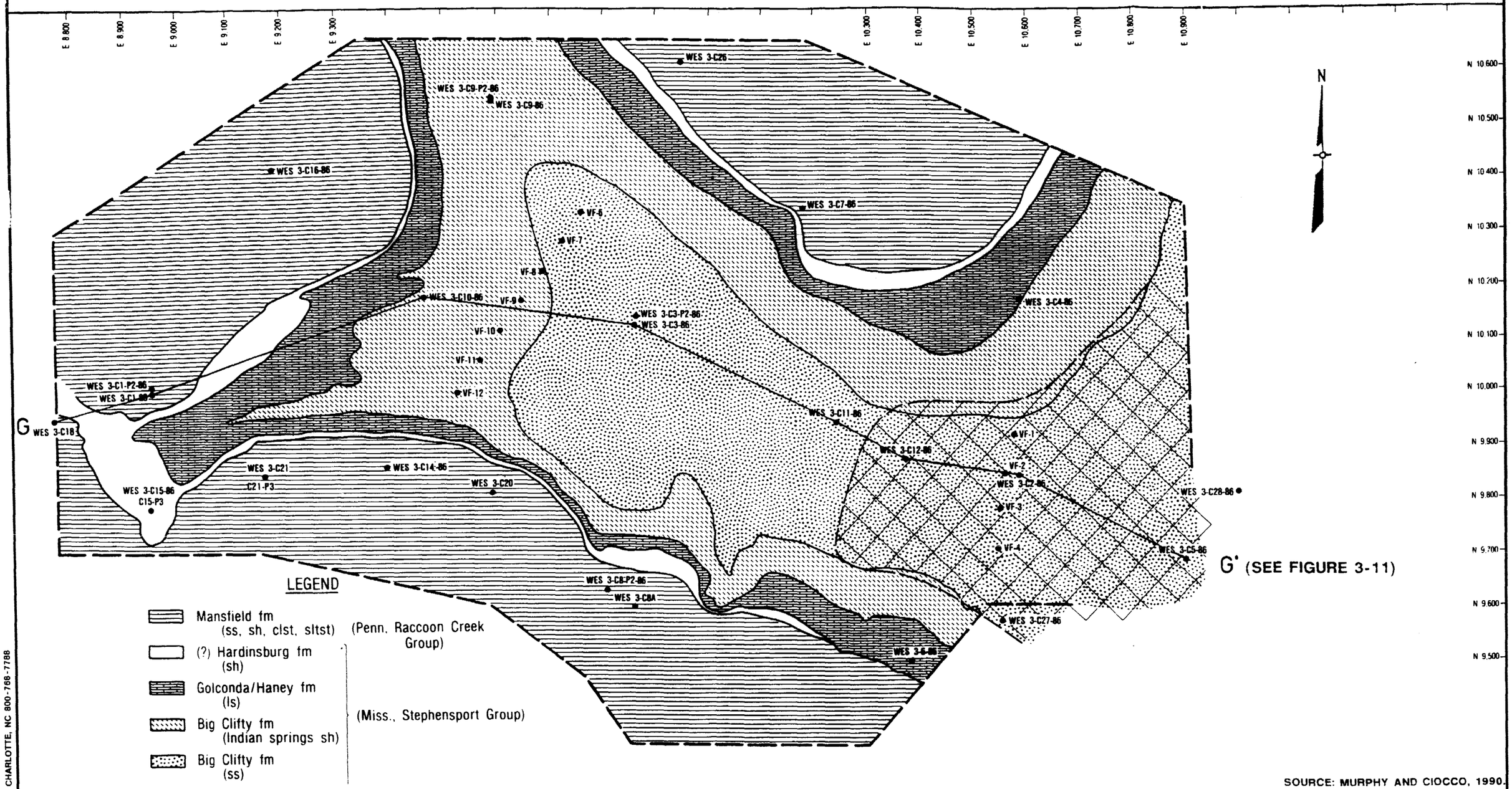

SOURCE: MURPHY AND CIOCCO, 1990.

RUST ENVIRONMENT & INFRASTRUCTURE

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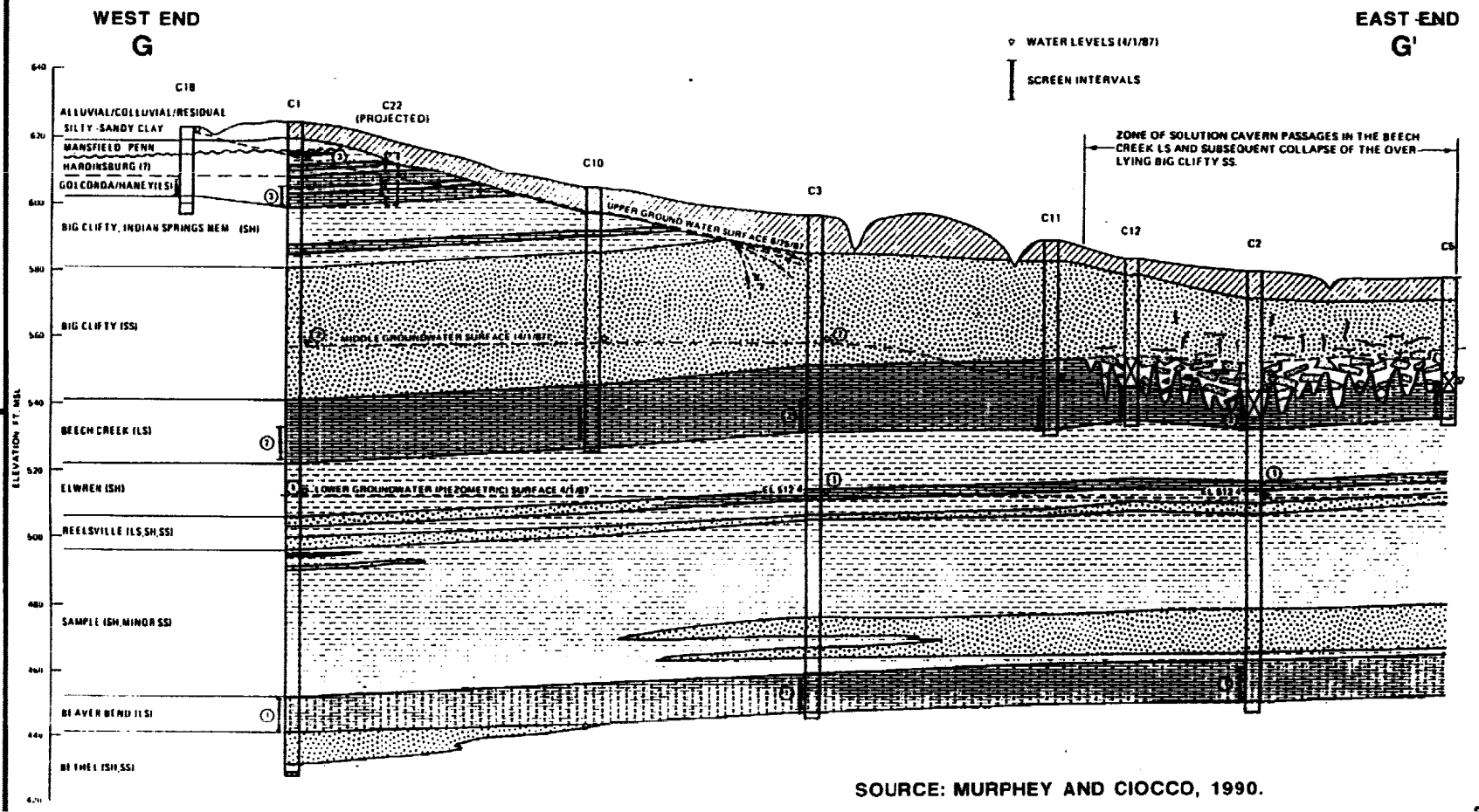
FIGURE 3-10
ABG SITE GEOLOGIC MAP

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788



SOURCE: MURPHEY AND CIOCCO, 1990.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 3-11

PROFILE OF SUBSURFACE GEOLOGY AND HYDROLOGY ALONG ABG VALLEY FLOOR

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

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Hardinsburg Formation

The Hardinsburg Formation occurs immediately below the Mississippian/Pennsylvanian unconformity in many parts of the ABG. Its maximum reported thickness at the ABG is approximately 47 feet (Murphy and Ciocco, 1990). The formation consists of thick, laterally variable beds of fine-grained, friable sandstone, thickly bedded sandstone and shale, and carbonaceous shale.

Golconda/Haney Formation

The Golconda/Haney Formation is present immediately below the Mississippian/Pennsylvanian unconformity where the Hardinsburg Formation has been removed by erosion. The Golconda/Haney Formation varies from a few to 14 feet in thickness. It consists of crystalline, very hard limestone in beds 2 to 14 feet thick with interbeds of shaley limestone. The Golconda/Haney Formation forms the uppermost aquifer at the ABG.

Big Clifty Formation

The Big Clifty is divided into two distinct lithologic members. The upper member is the Indian Springs Shale and consists of 20 feet of dark gray, platey to fissile carbonaceous shale. The Indian Springs serves locally as an aquiclude at the base of the Golconda/Haney aquifer in the western portion of the ABG, but is absent by erosion in the eastern portion. The lower member of the Big Clifty Formation consists of 40 feet of tan, massive fine-grained permeable sandstone that is cut by abundant intersecting joints. The lower portion of the Big Clifty and the underlying Beech Creek Limestone form the middle aquifer of the ABG.

Beech Creek Formation

The Beech Creek Formation consists of very hard and dense limestone ranging from 18 to 22 feet thick except in areas where dissolution has removed the upper portion. The limestone has numerous intersecting joints. Previously completed rock corings in the Beech Creek Limestone encountered voids interpreted as solution cavities, indicating that dissolution of the formation has produced buried karst conditions in the valley areas southeast and southwest of the ABG.

Elwren Formation

The Elwren is a 20-foot thick unit of relatively impervious shale with claystone. It forms an effective aquiclude at the base of the Beech Creek Limestone. The base of the Beech Creek (top of the Elwren) is exposed in several outcrops in the valleys within the ABG.

3.4.1.7 Hydrogeology

The geologic units previously described comprise three aquifers and three aquitards beneath the ABG. The Golconda/Haney Limestone, the Big Clifty Sandstone/Beech Creek Limestone, and the Beaver Bend Limestone comprise the upper, middle, and lower aquifer respectively. The three shale aquitards include the Indian Springs, Elwren, and Sample. The Indian Springs Shale underlies the Golconda/Haney Limestone in the western and upper slopes portion of the ABG. The Elwren Shale is an effective aquitard to groundwater moving through the Beech Creek Limestone and directs water laterally along the bedding contact and through joints in the Beech Creek (Murphy, 1992a). Where exposed in the valleys within the ABG, groundwater flowing along the top of the Elwren forms springs. The Sample Shale lies between the Elwren Shale and Beaver Bend Limestone. The Sample and Elwren collectively separate the Beaver Bend Limestone (lowermost aquifer) from the upper and middle aquifer.

Analysis and interpretation of groundwater conditions at the ABG has been performed by Hunt (1988) and further summarized by Murphy (1992a). Groundwater from the Golconda/Haney flows into the ABG by seepage eastward along the top of the underlying Indian Springs Shale. Groundwater seeping from the Golconda/Haney eventually infiltrates the Big Clifty/Beech Creek aquifer (Hunt, 1988).

The Big Clifty sandstone is hydraulically connected to the Beech Creek Limestone. Surface water enters the Big Clifty Sandstone outcrop in the central part of the ABG. During dry seasons, surface water becomes groundwater in the Beech Creek Limestone through the Big Clifty Sandstone outcrop area. During periods of heavy rainfall, the runoff flows out the east end of the site as surface flow (Murphy, 1992a).

Groundwater in the Beech Creek enters the ABG from the north-northwest. Primary groundwater flow at the AGB is to the east and south down the Little Sulphur Creek drainageway (Figure 3-12). Secondary groundwater flow components are to the southwest and south through Johnson Hollow. Figure 3-12 indicates a low groundwater divide trending approximately northeast-southwest along a line running between wells 03C26 and 03C14. Surface and Golconda/Haney aquifer waters enter the Beech Creek east of this divide and exit the ABG to the southeast through Little Sulphur Creek drainage. The occurrence of the Indian Springs Shale in the western and west-central portion of the ABG

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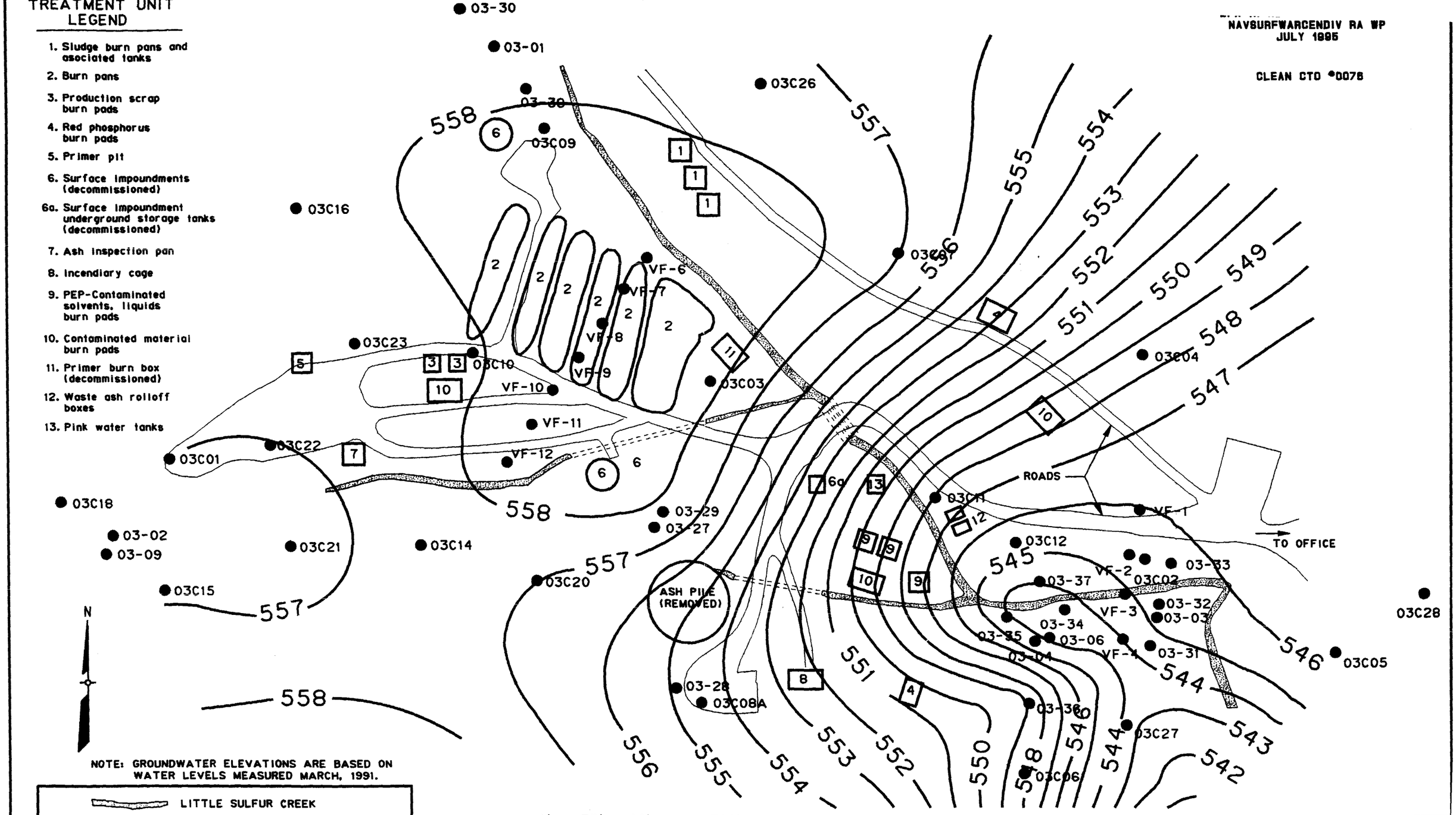
TREATMENT UNIT LEGEND

1. Sludge burn pans and asociated tanks
2. Burn pans
3. Production scrap burn pads
4. Red phosphorus burn pads
5. Primer pit
6. Surface impoundments (decommissioned)

6a. Surface impoundment underground storage tanks (decommissioned)

7. Ash inspection pan
8. Incendiary cage
9. PEP-Contaminated solvents, liquids burn pads
10. Contaminated material burn pads
11. Primer burn box (decommissioned)
12. Waste ash rolloff boxes
13. Pink water tanks



RUST ENVIRONMENT & INFRASTRUCTURE

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FIGURE 3-12
SWMU #03/10 - AMMUNITION BURNING GROUND GROUNDWATER CONTOURS
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

User 16 3905
REFERENCE FILE 01 = sec11x17.wmo
FEN TABLE= G:\PLOT\TABLES\ver4.tbl
Levels = 1-53
Levels are 1-62
PRF = G:\PLOT\PLOTS\F16312A.PRF
DATE =
DGN =ar\projects\103120\jul95\11p3120a.dgn

prevents direct recharge to the Beech Creek and restricts subsequent groundwater flow to the southwest through Johnson Hollow (Hunt, 1988). The occurrence of groundwater within the respective aquifers is shown on Figure 3-11.

Dye trace studies performed by WES (Murphy and Ciocco, 1990; Murphy, 1992a) indicated that Spring A (Figure 3-7), located approximately 1.5 miles south of the ABG, and Little Sulphur Creek below Spring A are prime outlets for groundwater originating at the ABG.

3.4.2 Demolition Range (SWMU #06/09)

3.4.2.1 Location and Description

The DR is located as shown in Figure 3-6. The DR covers an area of 40 to 50 acres (A.T. Kearney, Inc., 1987). The DR lies on two steep-sided ridgetops in the SW 1/4 of Section 26, SE 1/4 of Section 27, NE 1/4 of Section 34, and NW 1/4 of Section 35, T5N, R4W (Dunbar, 1982a). The east ridge is utilized by the U.S. Navy Explosive Ordnance Disposal (EOD) Detachment to detonate ordnance with an explosive limit of 500 pounds per detonation (Naval EOD, 1993). The south ridge is utilized by the CAAA to detonate ordnance. The majority of detonation activities at the DR are performed by the CAAA personnel on the south ridge. Four sedimentation ponds, as shown on Figure 3-13, receive runoff from the DR area. Pond No. 1 has NPDES Outfall No. 008, Pond No. 2 has NPDES Outfall No. 002, Pond No. 3 has NPDES Outfall No. 003, and Pond No. 4 has NPDES Outfall No. 004 (NWSCC, 1993a).

3.4.2.2 Description of Operations and Wastes Managed

NAVSURFWARCENDIV conducts detonation of munitions, deteriorated compressed gas cylinders, suspect inert items, white phosphorus munitions, and lithium batteries at the DR as shown in Figure 3-13. The DR was placed in operation during the 1940s.

Ammunition or explosives to be destroyed by detonation are usually placed in pits 6 to 12 feet deep. The depth of a hole is based on encasement of the munitions item and fragmentation range. Items are placed in these pits in a position that exposes the largest surface area to the influence of the initiating explosive charge. An adequate number of detonating blocks are placed in intimate contact with the items to be detonated.

The detonating blocks are primed, and the pits are covered with 6 to 12 feet of earth. The earthen cover provides a muffling of the sound and blast effects, and reduction of fragmentation. Detonation is performed remotely using dual non-electrical initiation devices. Residual material from the detonation is usually left in place (A.T. Kearney, Inc., 1987).

Detonation of items such as lithium batteries, white phosphorus munitions, suspect inert items, and deteriorated compressed gas cylinders with unknown contents is done on the surface, not buried.

The existing detonation unit consists of 70 subunits (pits). The demolition range where these pits are located is approximately 2,500 feet in length and 1,000 feet in width. Each pit measures approximately 12 feet (width) by 12 feet (length) by 10 feet (depth). The materials to be detonated are typically palletized (unitized), packed into open-top drums, banded to pallets, and placed into the pits by use of all-terrain forklifts. Lids are placed back on the drums after they are packed with the item(s) to be detonated.

Quantities of explosives detonated per pit varies depending on atmospheric conditions and the explosive item being treated. Generally, 500 pounds net explosive weight per pit are detonated between late spring and early fall, 250 pounds net explosive weight per pit are detonated between early fall and late spring. The DR ceases operation when the soil is frozen or extremely wet. The maximum amount of material treated per week (7 days) is 245,000 pounds. On the average, the amount of material treated would be 87,500 pounds per week (5 days). During peak operational summer months, a minimum of 9 feet of earthen cover is required to provide adequate noise attenuation. After the range has been loaded, the area supervisor ensures all personnel have been cleared from the range. The supervisor and one other employee remain to initiate the time fuses. All personnel assemble at a safe distance and independently count the number of detonations. After detonations, the supervisor tours the range to ensure all units have fired and no unsafe conditions have resulted. As a result of the supervisor's verification, range personnel are allowed to again enter the area, pick up metal fragmentation, and prepare pits for reloading the next round of shots. Any scrap metal retrieved from the range is "flashed" or exposed to fire in pans at the ABG to assure no explosive contamination remains prior to being excessed as scrap metal (NWSCC, 1992a; NWSCC, 1993b).

3.4.2.3 Topography

The DR occupies a primarily north-south trending, steep-sided ridgetop at elevations ranging from approximately 630 to 700 feet MSL (Figure 3-13). Steep slopes east, west, and south bottom out at approximately 500 feet MSL. Near the base of the slope, immediately east of the DR, the ORR lies at elevations between approximately 530 and 500 feet MSL.

3.4.2.4 Physiography and Hydrology

Surface drainage from the upland area encompassing the DR drains to ravines and tributary drainageways to the west, south, and east. Surface water runoff is intercepted

by sediment ponds (Figure 3-13) as it descends the adjacent steep-sided slopes. Ultimately, runoff directed east may reach Turkey Creek, runoff directed west may reach Boggs Creeks, and runoff directed south may reach the confluence of Turkey and Boggs Creek. Runoff draining east and downslope of the DR reaches the ORR. Drainage at the ORR is directed east to Turkey Creek.

Turkey Creek flows south-southwest to merge with Boggs Creek. Boggs Creek continues to flow south, eventually exiting the southern boundary of NAVSURFWARCENDIV.

3.4.2.5 Geology

Soils

Detailed soil mapping near the DR (McElrath, 1988) shows the area to be covered primarily by Zanesville-Udorthents complex soils and Wellston-Gilpin complex soils. Zanesville soils are found on the ridge top, while the udorthents correspond to areas which have been affected by earth-moving activities. At the DR these two soil types are intricately intermixed. Soils of the Zanesville-Udorthents complex are characteristically well drained to moderately well drained and have a fragipan. They formed in loess and in underlying material weathered from sandstone, siltstone, or shale.

The Wellston-Gilpin complex soils occur on the sideslopes (12 to 70 percent slope) at the DR. These soils are well drained and moderately permeable. They also are formed in loess and material weathered from sandstone, siltstone, or shale.

Bedrock

As characterized by WES (Dunbar, 1982), bedrock occurs between 2 and 13 feet below ground surface at the DR. Borings completed by WES (Figure 3-13) reveal that bedrock consists of interfingered and interbedded sandstone, shale, and coal seams from the Mansfield Formation of the Pennsylvanian Age Raccoon Creek Group (Figure 3-14). The shale and sandstone are thinly interbedded in nearly equal proportions.

3.4.2.6 Hydrogeology

Information on the hydrogeology of the DR was obtained from Dunbar (1982) and Murphy and Wade (1994b). Groundwater elevation data, obtained in 1991, depict a water table which mirrors the surface topography (Figure 3-15). The historical water level measurements indicate groundwater elevations ranging from between approximately 650 and 595 feet MSL. Groundwater elevations are highest in the northern part of the SWMU and decrease to the south. Flow in the Big Clifty-Beech Creek is generally to the south

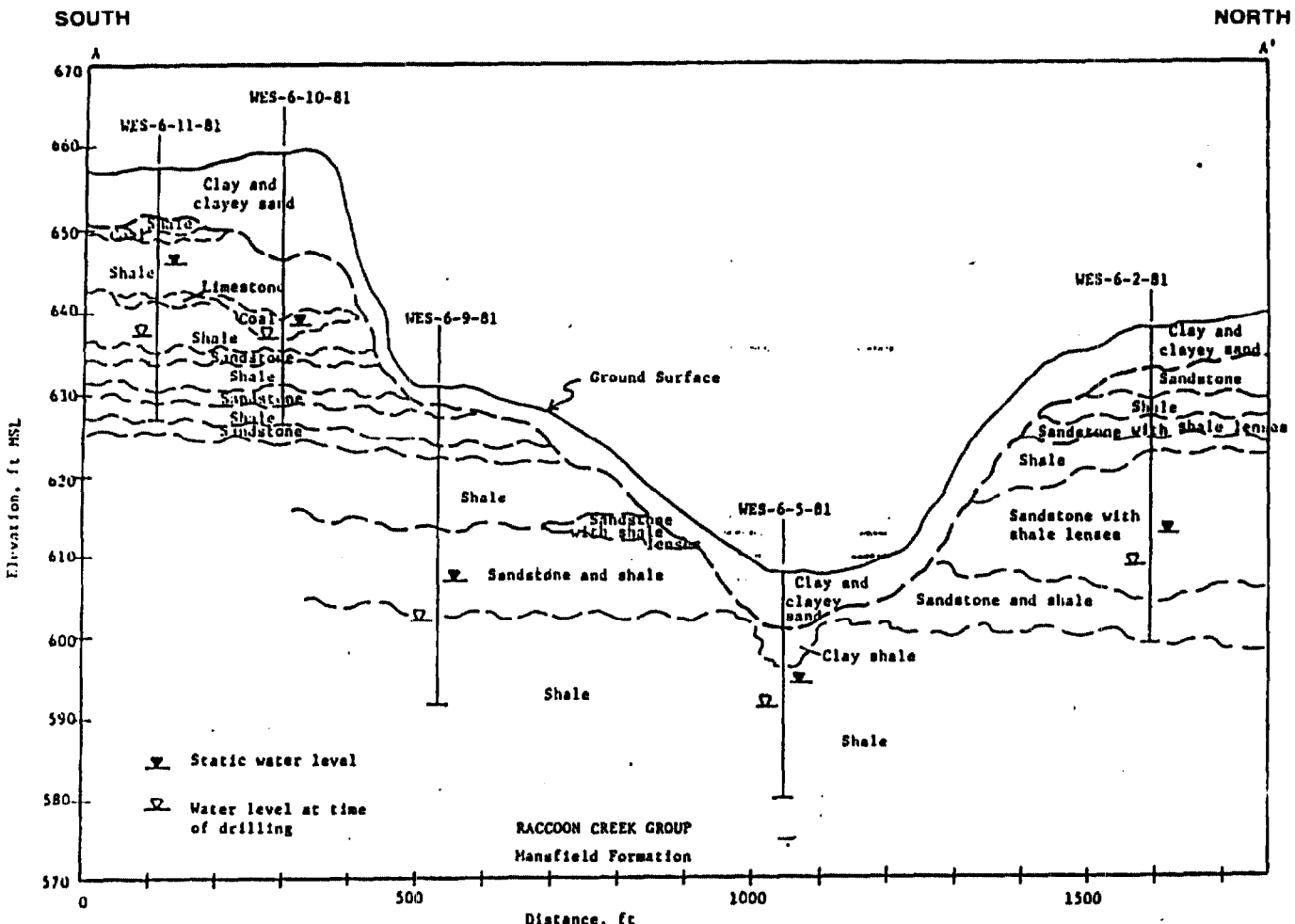

Figure 31. Geological Cross Section A-A' of Demolition Range.

SOURCE: DUNBAR, 1982.

RUST ENVIRONMENT & INFRASTRUCTURE

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FIGURE 3-14

DR GEOLOGIC CROSS SECTION A-A'

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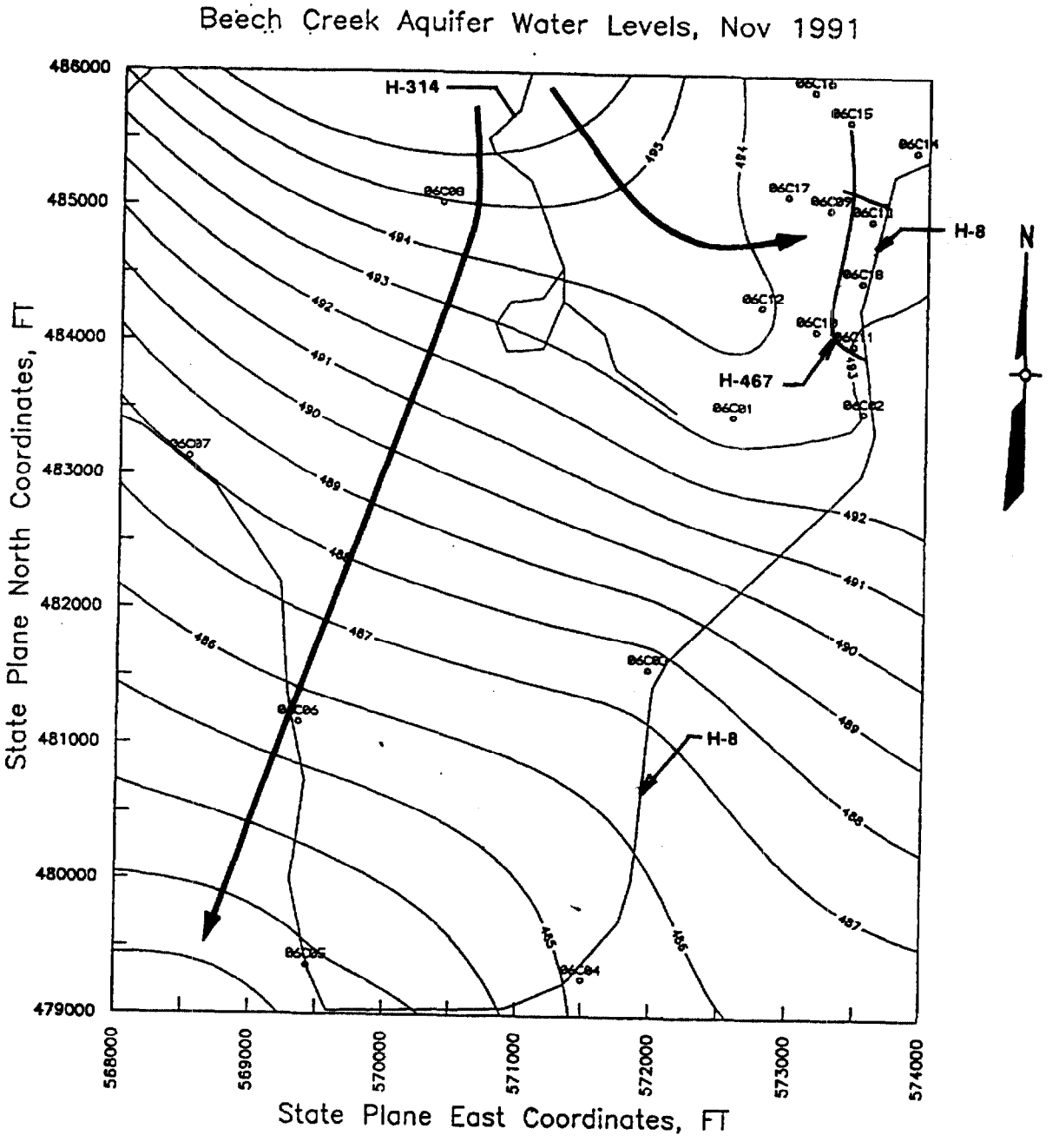
NAVSURFWARCENDIV
CRANE, INDIANA

CLEAN CTO #0076

EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA WP
JULY 1995



LEGEND:

06C06	MONITORING WELL
492	GROUNDWATER ELEVATION CONTOUR LINE
	GROUNDWATER FLOW DIRECTION
H-8	ROAD

SOURCE: MURPHY AND WADE, 1994B.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 3-15
DR BEECH CREEK AQUIFER GROUNDWATER CONTOUR MAP

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

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and southwest, but locally flows southeast toward Turkey Creek near the Old Rifle Range in the northeast corner of Figure 3-15. The shape of the water table in the northeast corner of Figure 3-15 is distorted from the regional trend. The distortion is caused by drainage of the Big Clifty-Beech Creek aquifer through that portion of the aquifer that is exposed to near-surface flow through the alluvial soils at the Old Rifle Range (Murphy and Wade, 1994b). The occurrence of groundwater at the DR appears to be tied to fractures with the interbedded shale and sandstone of the Mansfield Formation.

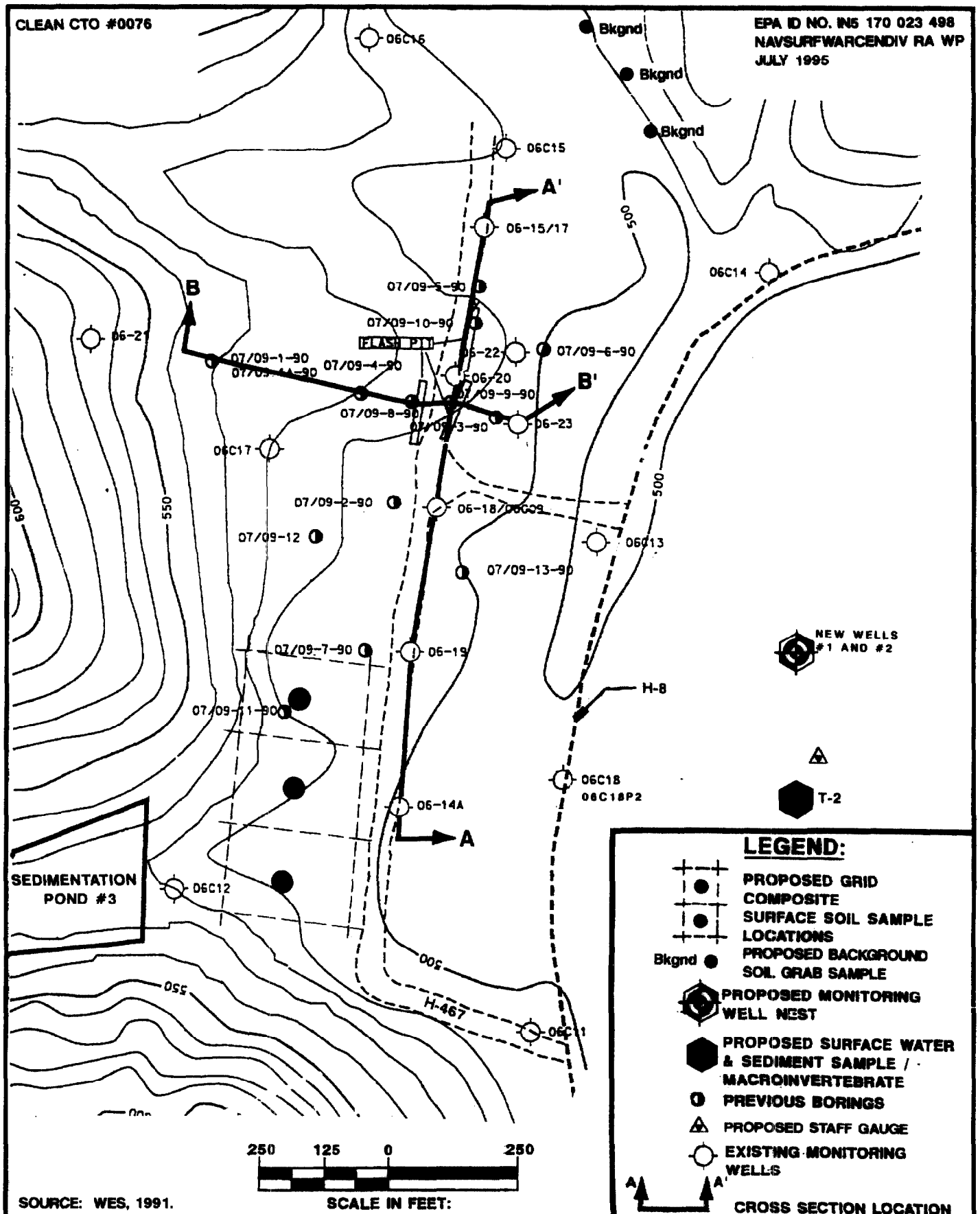
3.4.3 Old Rifle Range (SWMU #07/09)

3.4.3.1 Location and Description

The ORR is a 10-acre site located near the center of the facility in the NW 1/4 of Section 35 and the SW 1/4 of Section 26, T5N, R4W (Figure 3-6). The ORR is another open burning area at NAVSURFWARCENDIV. Open burning/flashing, a thermal destruction process for explosive wastes, was and is operated at the ORR. The flashing operations were carried out in earthen containment structures or flash pits. Today, earth-filled steel pans are used (USACE, 1991). The area has also been used for "bomb cook-off" tests (A.T. Kearney, Inc., 1987).

3.4.3.2 Description of Operations and Wastes Managed

The majority of the open burning activity which takes place at the ORR is thermal treatment of projectiles which have been loaded with ammonium picrate (also known as Composition D, Comp D, or "yellow D"). Ammonium picrate is bright yellow in color and is water soluble. Projectiles are commonly drilled out to remove the majority of the explosive filler. The remaining contamination is removed by providing an open fire under and around the projectiles. The operation is conducted within the standard 14-foot by 7-foot steel pans, 12 inches deep, constructed of 3/8-inch carbon steel. These pans are elevated above the surface of the ground on concrete parking blocks. A 6-inch bed of sand under and around the immediate pan area is provided to aid in the potential clean-up of any kick-out material. After being inspected for complete removal of explosive contamination, the steel projectile bodies are excessed as scrap metal. Currently, 16 steel pans are provided for this purpose (See Figure 3-16). The pans are arranged in groups of seven, five, and four. Each set is situated over lined containment. A net explosive weight limit has been established for explosive safety considerations. This limit is 6,000 pounds per lined containment area. For example, as much as 6,000 pounds of explosive in projectiles can be distributed among the seven pans in one contained area, the five pans in the second area, or the four pans in the third area. One pan contains a 4-foot by 8-foot pan used to thermally treat liquids which have contacted ammonium picrate. Typical liquids include water or denatured alcohol. In practice, the dissolved



RUST ENVIRONMENT & INFRASTRUCTURE

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FIGURE 3-16

ORR DETAIL

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

ammonium picrate is thermally consumed after the liquid portion is boiled and vaporized or burned.

The operator places the projectiles which are loaded with ammonium picrate into the pan. Remote initiation for the pan is accomplished by using a non-electric time fuse. The operator pulls the time fuse on the pan and then exits the area and goes to the office at the DR. Personnel are not allowed to work in the immediate area until the burn is complete. Average length of time required for a burn is 2 hours for projectiles and 30 minutes for bulk yellow D. Personnel can work at the DR while burning is taking place at the ORR. After all visible flames have subsided, the operators then go back in and clean up ash and any pop out (NWSCC, 1992a; NWSCC, 1993b).

3.4.3.3 Topography

Near the base of the slope, immediately east and downslope of the DR, the ORR lies at elevations between approximately 530 and 500 feet MSL. The ORR occupies a roughly rectangular cleared area bordered on the east by NAVSURFWARCENDIV, Road H-8. The area east of the ORR continues to slope eastward toward Turkey Creek, where the minimum elevation is approximately 485 feet MSL.

3.4.3.4 Physiography and Hydrology

Runoff draining east and downslope of the DR reaches the ORR. Drainage at the ORR is directed east to Turkey Creek. The northern end of the ORR is drained by a perennial stream that flows southeast and east into Turkey Creek.

Turkey Creek flows south-southwest to merge with Boggs Creek. Boggs Creek continues to flow south, eventually exiting the southern boundary of NAVSURFWARCENDIV.

3.4.3.5 Geology

Soils

At the ORR, the northern portion of the site is covered with occasionally flooded Burnside loam, the western portion with Wellston silt loam, and the eastern portion with frequently flooded Haymond silt loam (McElrath, 1988). The Burnside loam is adjacent to tributary drainageways and consists of deep, well drained, moderately permeable soil. The Wellston silt loam occurs adjacent to Wellston-Gilpin complex soils of the DR and is similarly characterized. The Haymond silt loam was formed in silty alluvium on the floodplain of Turkey Creek. The variability of soil thickness of the ORR reflects the erosional effects of the ancestral Turkey Creek and its tributaries. The thickest soil

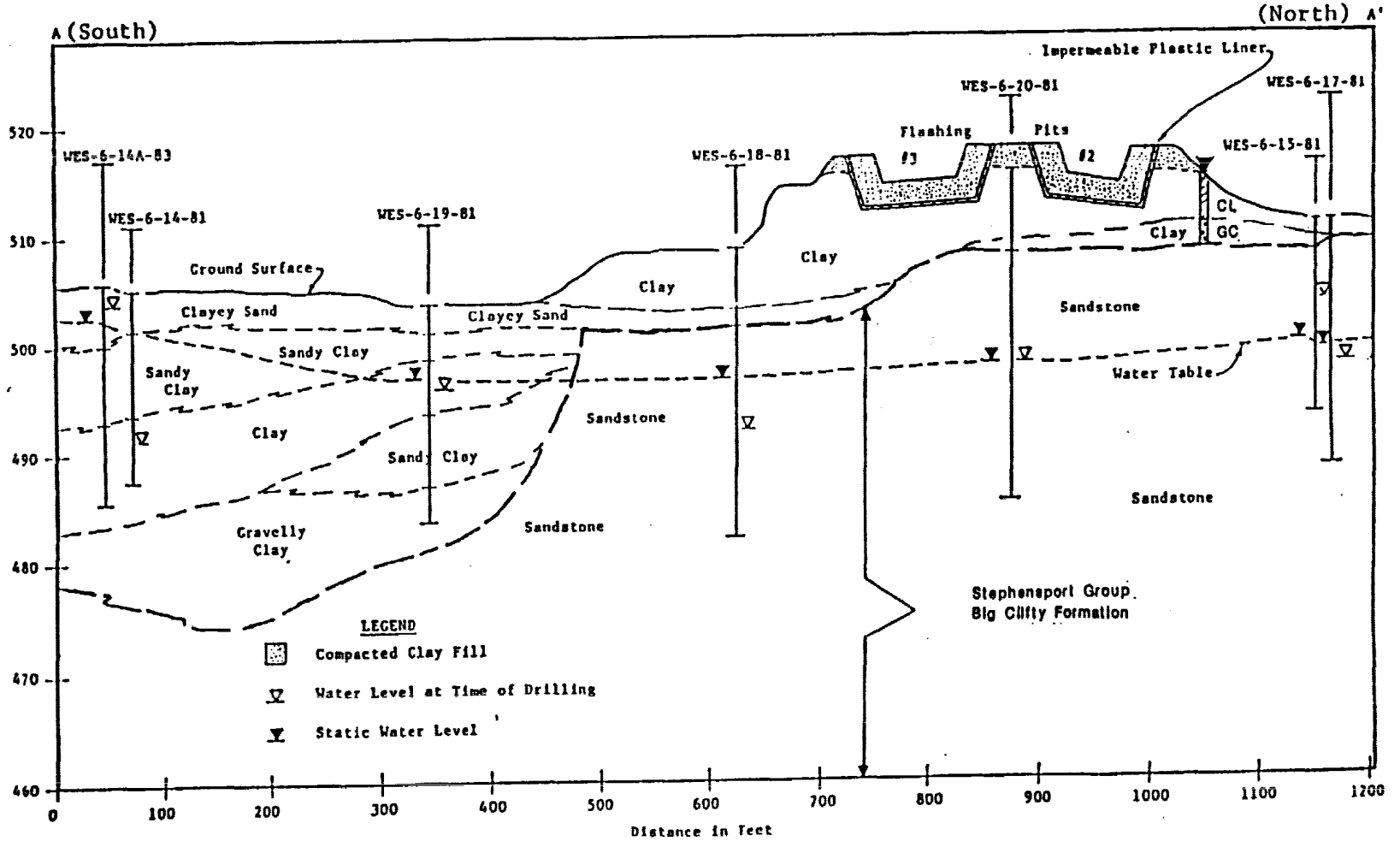
corresponds to areas of deepest fluvial incision of the rock surface and subsequent alluvial (stream-deposited) and colluvial (slope debris) filling of the Turkey Creek Valley.

Bedrock

At the ORR, the geologic setting has been characterized by WES during several investigations (Dunbar, 1982; Dunbar 1984; U.S. Army, 1991). The ORR is situated adjacent to the DR, but lower within the stratigraphic sequence than the DR. Accordingly, bedrock underlying the ORR is comprised of the Mansfield Formation of the Pennsylvanian Age Raccoon Creek Group (as at the DR) and the Golconda/Haney Formation and Big Clifty Formation of the Mississippian Age Stephensport Group. Borings completed by WES are shown in Figure 3-13. The interrelationships between the respective soil and bedrock units at the ORR are represented by the cross-sections presented in Figures 3-17 and 3-18. The lithologic-characteristics of the bedrock units at the ORR and DR are consistent with regional descriptions previously presented in Section 3.3.5.

3.4.3.6 Hydrogeology

Hydrogeologic information for the ORR was obtained from Dunbar (1982), Dunbar (1984), and U.S. Army (1991), and Murphy and Wade (1994b). Groundwater level information and water table maps presented in these sources indicate that the uppermost occurrence of groundwater is within the alluvium which occurs over much of the ORR. Groundwater elevations within the underlying Big Clifty-Beech Creek aquifer are similar to those in the alluvium. The two units are hydraulically connected and considered one unconfined aquifer (Murphy and Wade, 1994b). Groundwater flow beneath the ORR is primarily to the east-southeast, toward Turkey Creek (Figure 3-19). The occurrence and movement of groundwater is closely tied to the bedrock surface (U.S. Army, 1991). Groundwater elevations range between approximately 510 and 495 feet MSL. Dunbar (1984) notes rather significant seasonal fluctuations in groundwater elevations (on the order of 5 feet).



SOURCE: WES, 1991.

RUST ENVIRONMENT & INFRASTRUCTURE

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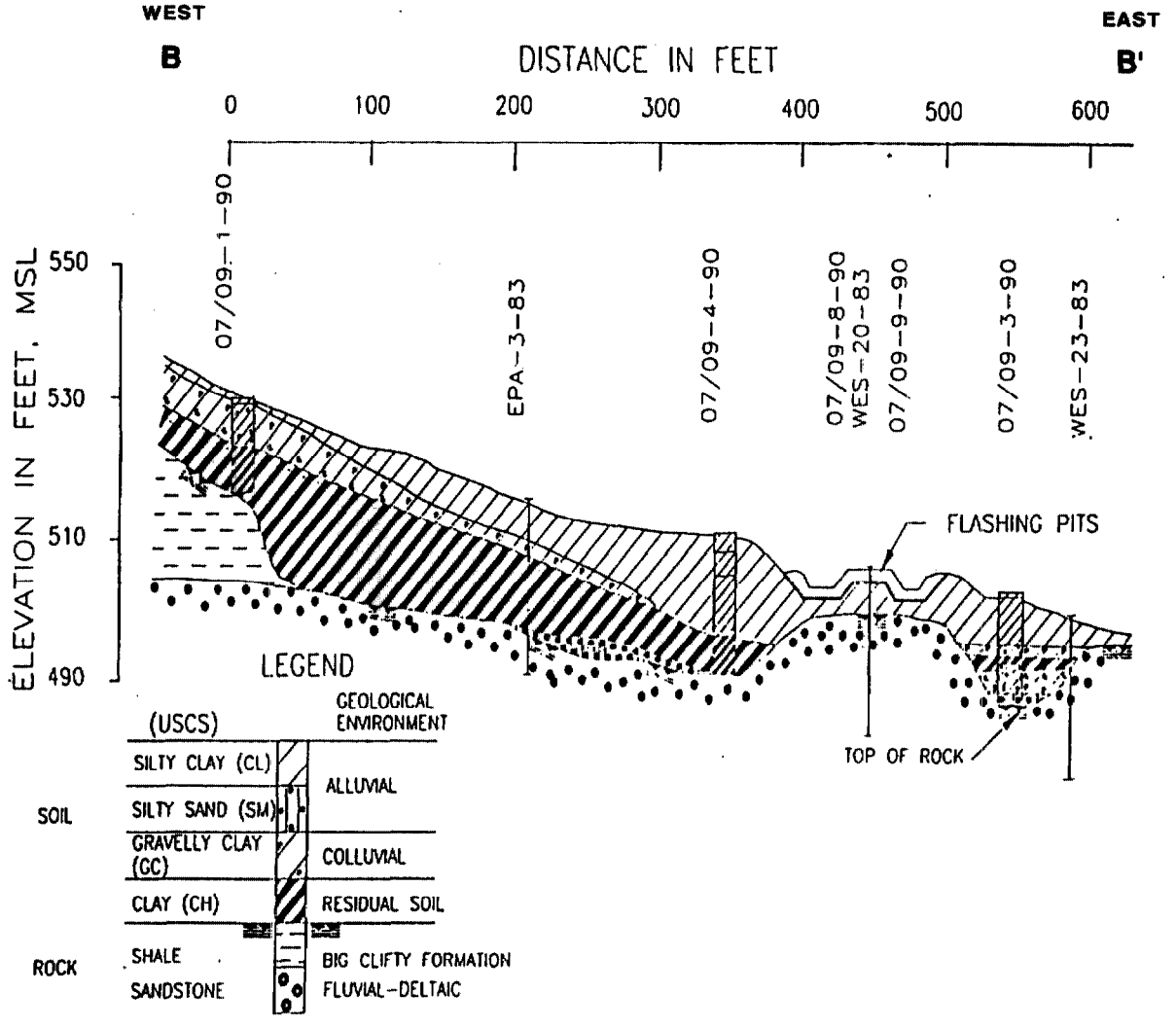
FIGURE 3-17

ORR GEOLOGICAL CROSS SECTION A-A'

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615



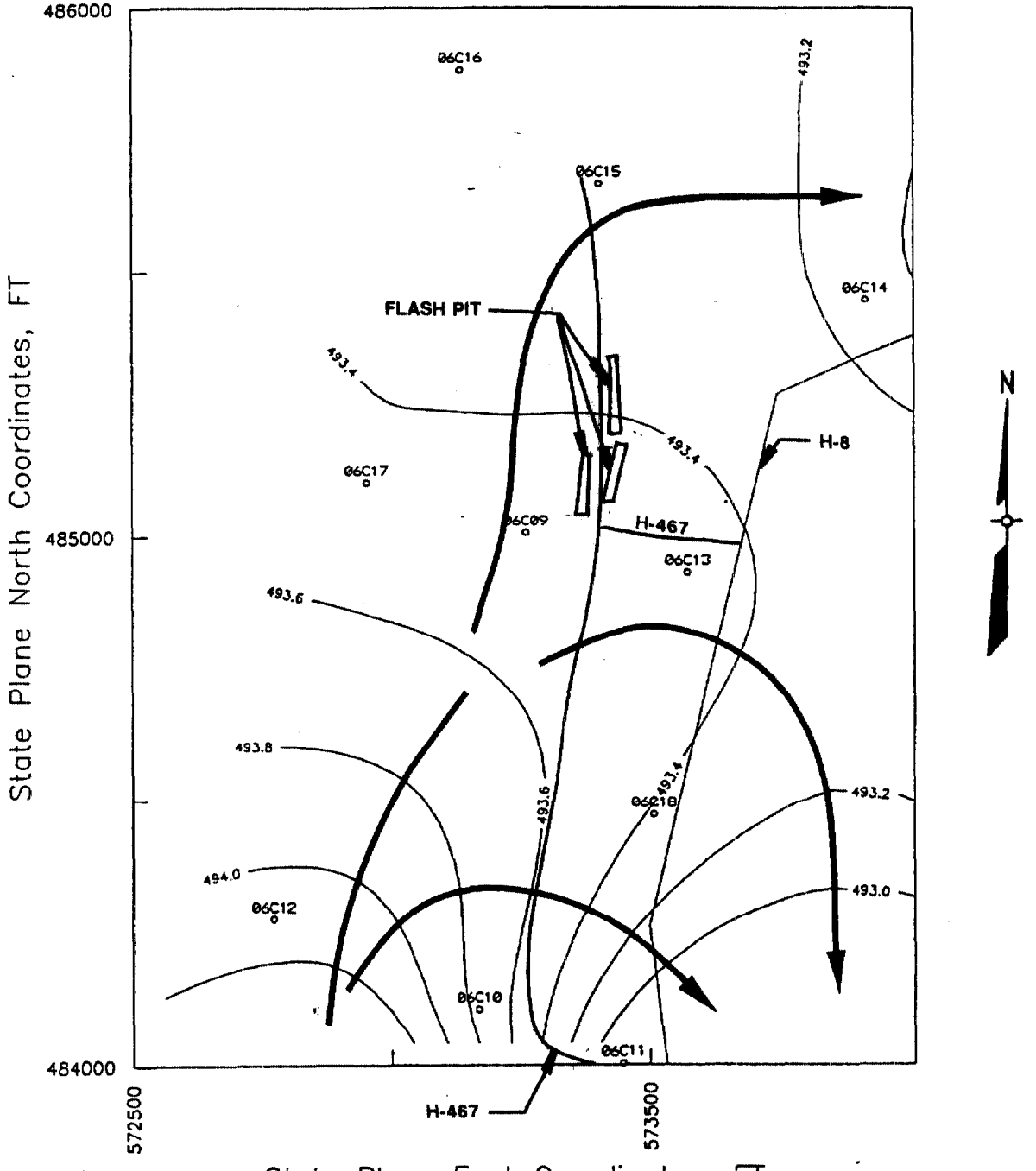
RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995 **FIGURE 3-18** 20615

ORR GEOLOGICAL CROSS SECTION B-B'

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

Old Rifle Range Lower Water Levels, Nov. 1991



LEGEND:

06C06 — MONITORING WELL

492 — GROUNDWATER ELEVATION CONTOUR LINE

GROUNDWATER FLOW DIRECTION

SOURCE: MURPHY AND WADE, 1994B.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995 **FIGURE 3-19** 20615

ORR GROUNDWATER CONTOUR MAP

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

4.0 HAZARD IDENTIFICATION

4.1 INTRODUCTION

The first step in the risk assessment process is hazard identification (NRC, 1983). Hazard identification characterizes in a qualitative manner the potential hazard(s) posed by the site, focusing on the sources and chemicals likely to be responsible for the majority of the risk, the populations most likely to be exposed to these chemicals, and how, where, and over what time period this exposure would likely occur.

A site visit to NAVSURFWARCENDIV was conducted by project personnel on November 16 and 17, 1992. Based upon the information obtained during this visit, a preliminary conceptual model was developed for the project. This preliminary model addressed the known chemical release sources for the three SWMUs, the human population(s) that are likely to be receptors, and the critical exposure routes for these chemicals.

Subsequent to this initial site visit and discussions with base personnel, project personnel received a number of documents describing past and currently on-going environmental studies at these three SWMUs. These documents, listed below, provided the basis for the refinement of the preliminary risk assessment conceptual model for these three SWMUs.

- Dunbar, J.B. 1982. Hydrogeologic Investigation of Waste Disposal Sites at the Naval Weapons Support Center, Crane, Indiana. U.S. Army Engineer Waterways Experiment Station (prepared for the Naval Weapons Support Center, Crane, Indiana), Vicksburg, MS.
- Dunbar, J.B. 1984a. Definition of Contaminated Ground-water Plumes at Selected Waste Disposal Sites, Naval Weapons Support Center, Crane, Indiana. U.S. Army Engineer Waterways Experiment Station (prepared for the Naval Weapons Support Center Crane, Indiana), Vicksburg, MS.
- Dunbar, J.B. 1984b. Hydrogeological Site Characterization for Old Rifle Range for Hazardous Waste Disposal Facility, Naval Weapons Support Center, Crane, Indiana. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Halliburton NUS. 1992a. Air Dispersion Modeling for the Open Detonation of White Phosphorus Munitions at the Naval Surface Warfare Center, Crane, Indiana.
- Halliburton NUS. 1992b. Clean Air Act Amendments Work Plan for Naval Surface Warfare Center, Crane, Indiana (Draft).

- Hunt, R.W. 1988. Geology and Hydrogeology of the Ammunition Burning Ground, Crane Naval Weapons Support Center. Technical Report GL-88-27, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Hunt, R.W. 1989 and 1990. Boring logs for RFI exploration borings at Demolition Area/Old Rifle Range. Well installation diagrams. (Provided through personal correspondence with William L. Murphy, U.S. Army Waterways Experiment Station, Vicksburg, MS, January, 1993).
- Murphy, W.L. 1992a. Draft Phase III Groundwater Release Characterization Report SWMU 03/10 Ammunition Burning Ground. U.S. Army Waterways Experiment Station, Vicksburg, MS. [Phase III Report]
- Murphy, W.L. 1993. Personal correspondence: Groundwater contour maps (1991) for ORR/DR.
- Murphy, W.L. and J. Ciocco. 1990. Dye Trace of Beech Creek Aquifer, Ammunition Burning Ground, Naval Weapons Support Center, Crane, Indiana. Technical Report GL-90-21, U.S. Army Waterways Experiment Station, Vicksburg, MS.
- Murphy, W.L. and R. Wade. 1994a. Draft RCRA Facility Investigation, Phase II Release Assessment for Surface Water, SWMU 03/10 Ammunition Burning Ground. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
- Murphy, W.L. and R. Wade. 1994b. Draft RCRA Facility Investigation, Phase II Groundwater Release Assessment, SWMU 06/09 Demolition Area and Phase III Release Characterization Report SWMU 07/09 Old Rifle Range. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
- Naval Facilities Engineering Command. 1992. Air Quality Assessment at the Ammunition Burning Ground, Demolition Range and Old Rifle Range.
- U.S. Army Corps of Engineers, 1992. Draft Part 1 RFI Phase III Soils Report for Ammunition Burning Ground, SWMU 03/10, Naval Weapons Support Center, Crane, Indiana, prepared by U.S. Army Corps of Engineers, Wilmington District, Wilmington, North Carolina, for U.S. Army Waterways Experiment Station, Vicksburg, Mississippi.
- U.S. Army Corps of Engineers, 1991b. RFI Phase II Old Rifle Range Report for SWMU 03/10, Naval Weapons Support Center, Crane, Indiana.
- U.S. Army. 1986. Groundwater Quality Data for Jeep Trail Area. U.S. Army Waterways Experiment Station, Vicksburg, MS.
- U.S. Army. 1990-1991. Groundwater Quality Data for Quarterly Sampling Events at ORR/DR. U.S. Army Waterways Experiment Station, Vicksburg, MS.
- U.S. Army. 1992. Surface Water and Sediment Analytical Data for March, 1992. ABG and Jeep Trail Area. U.S. Army Waterways Experiment Station, Vicksburg, MS.

Lastly, these preliminary conceptual models were finalized based on a risk assessment work plan meeting held at the USEPA Region V office in Chicago on August 3, 1994, and on subsequent correspondences.

4.2 ABG CONCEPTUAL MODEL

4.2.1 General Overview

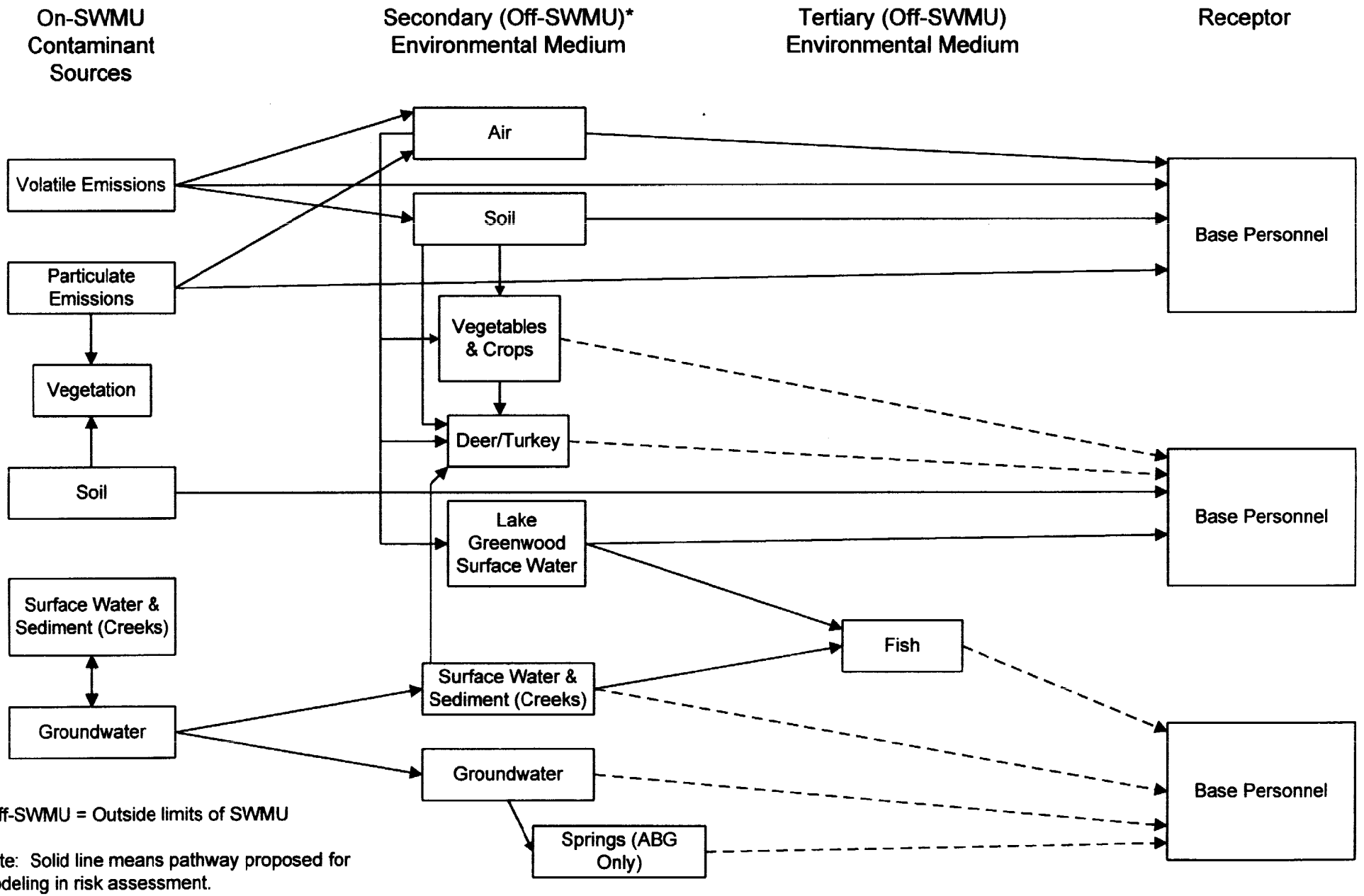
Based on the above descriptions of the past and present open burning activities at ABG (Sections 3.4.1.2 and 3.4.1.3), two observations pertinent to the risk assessment are noted. First, it is likely that hazardous constituent contamination due to past activities has occurred in site soil, surface water, sediments and groundwater. Secondly, this site is comprised of many independent activities, each conducted at varying frequencies, using different waste streams, and containing some similar and some unique contamination pathways. Thus, each of these 'subsites' should be considered a potential source of chemical contamination in the risk assessment. Current activities also lead to contaminants being emitted into the ambient air from each distinct activity area.

4.2.2 Conceptual Model Detailed Description

Figures 4-1A, 4-1B, 4-1C, 4-1D, 4-2, and 4-3 depict the currently proposed risk assessment conceptual models for ABG under the three land use scenarios. Scenario A (Figures 4-1A, 4-1B, 4-1C, and 4-1D) describes the model proposed if the current activities at ABG are assumed to continue indefinitely. Under this scenario, receptors would be exposed to current levels of contaminants in SWMU-impacted media as well as contaminants in ambient air as a result of the open burning activities. The ambient air concentrations of OB contaminants that will be used in this risk assessment will be modeled data, as generated from two other CTOs (Nos. 0052 and 0108). Surface soil data at ABG will be treated as a single database, with the exception of the Jeep Trail Area. The Jeep Trail Area will be treated as a separate area at the SWMU. Soil data will be combined and screened to determine the chemicals of potential concern (Section 4.5) and statistically evaluated to ascertain the appropriate exposure concentrations for the exposure assessment portion of the study. Surface water data and sediment data will be evaluated as two sets of data in the risk assessment. For Scenario A, the existing production well at ABG represents the only on-SWMU exposure pathway for groundwater. Agricultural and vegetable plant materials at ABG are not currently planned to be sampled. Deer and turkey tissue will be sampled, however, as part of this assessment.

Under Scenario A, three receptor populations are envisioned. Base personnel and any of their family members (Figures 4-1A, 4-1B) would be assumed to be exposed to surface soil as well as contaminants in ambient air while at home near Lake Greenwood as a result of

Figure 4 - 1A
Scenario A
(Current OB/OD Operations Continue Indefinitely)



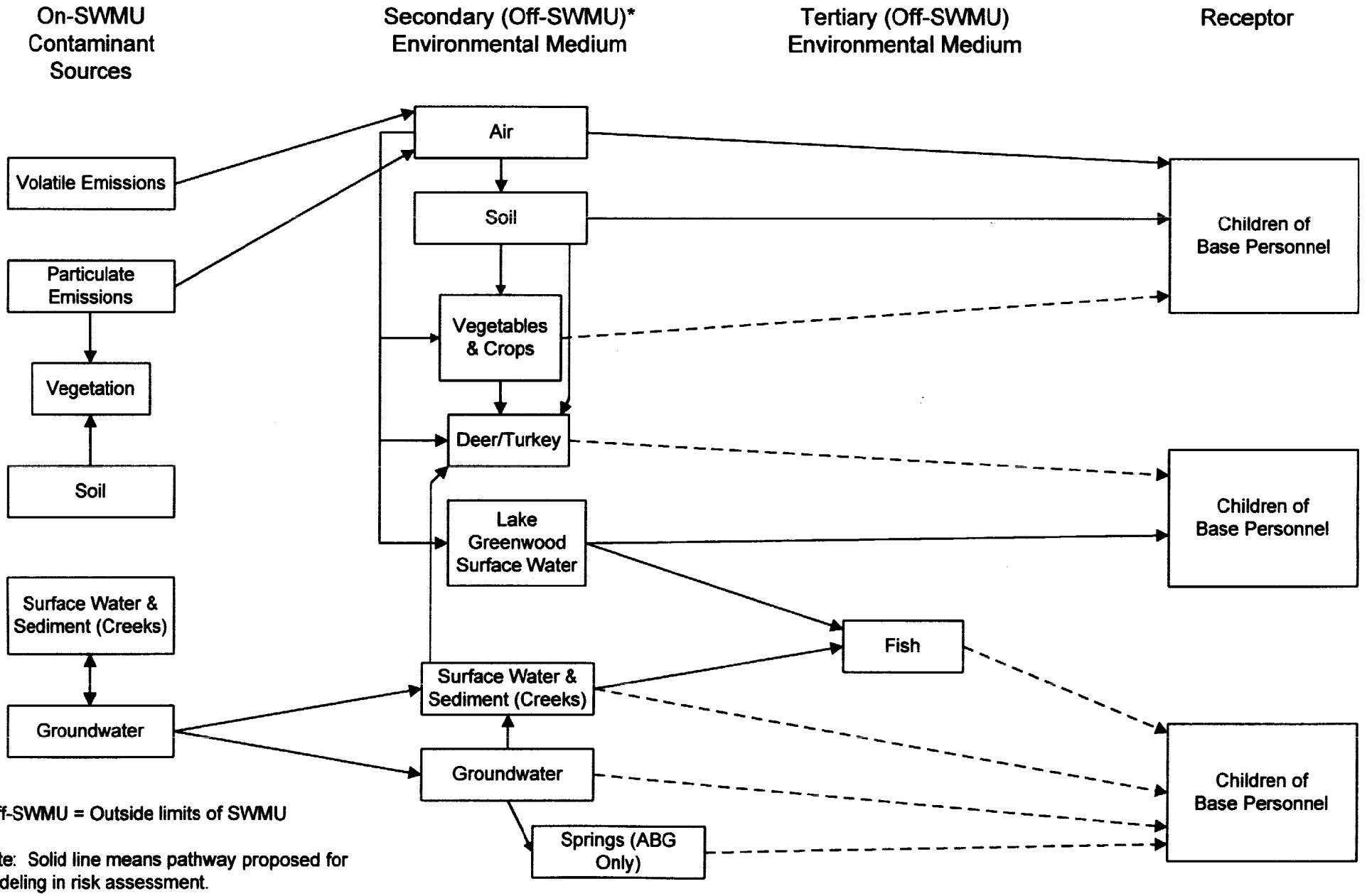
*Off-SWMU = Outside limits of SWMU

Note: Solid line means pathway proposed for modeling in risk assessment.

Dashed (- - -) means pathway not proposed for modeling in risk assessment.

D:\CTO7(P1\FIG4-1C.VSD

Figu - 1B
Scenario A
(Current OB/OD Operations Continue Indefinitely)



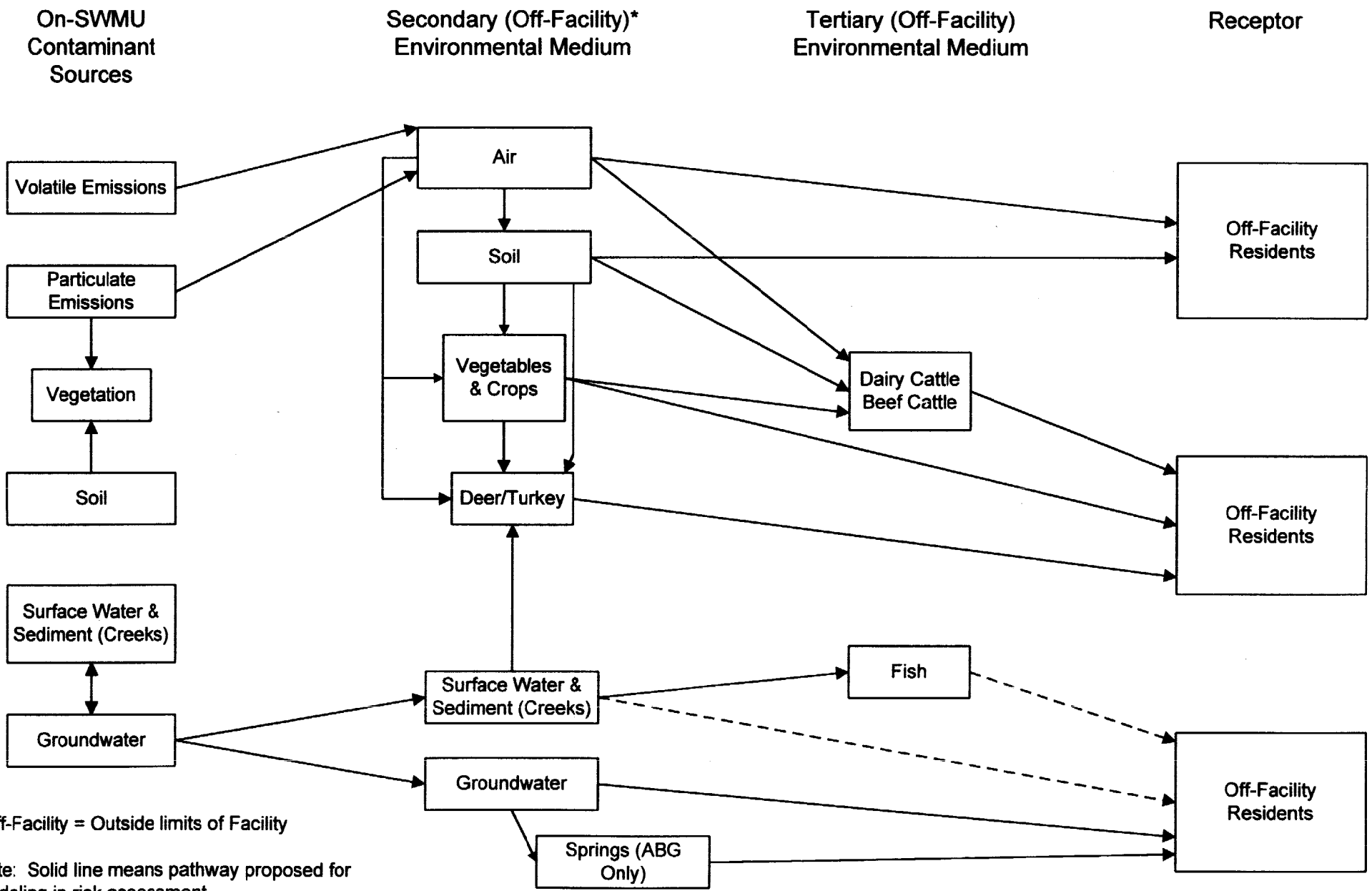
*Off-SWMU = Outside limits of SWMU

Note: Solid line means pathway proposed for modeling in risk assessment.

Dashed (- - -) line means pathway not proposed for modeling in risk assessment.

D:\CTO7601\WP1\FIG4-1B.VSD

Figure 4 - 1C
Scenario A
(Current OB/OD Operations Continue Indefinitely)



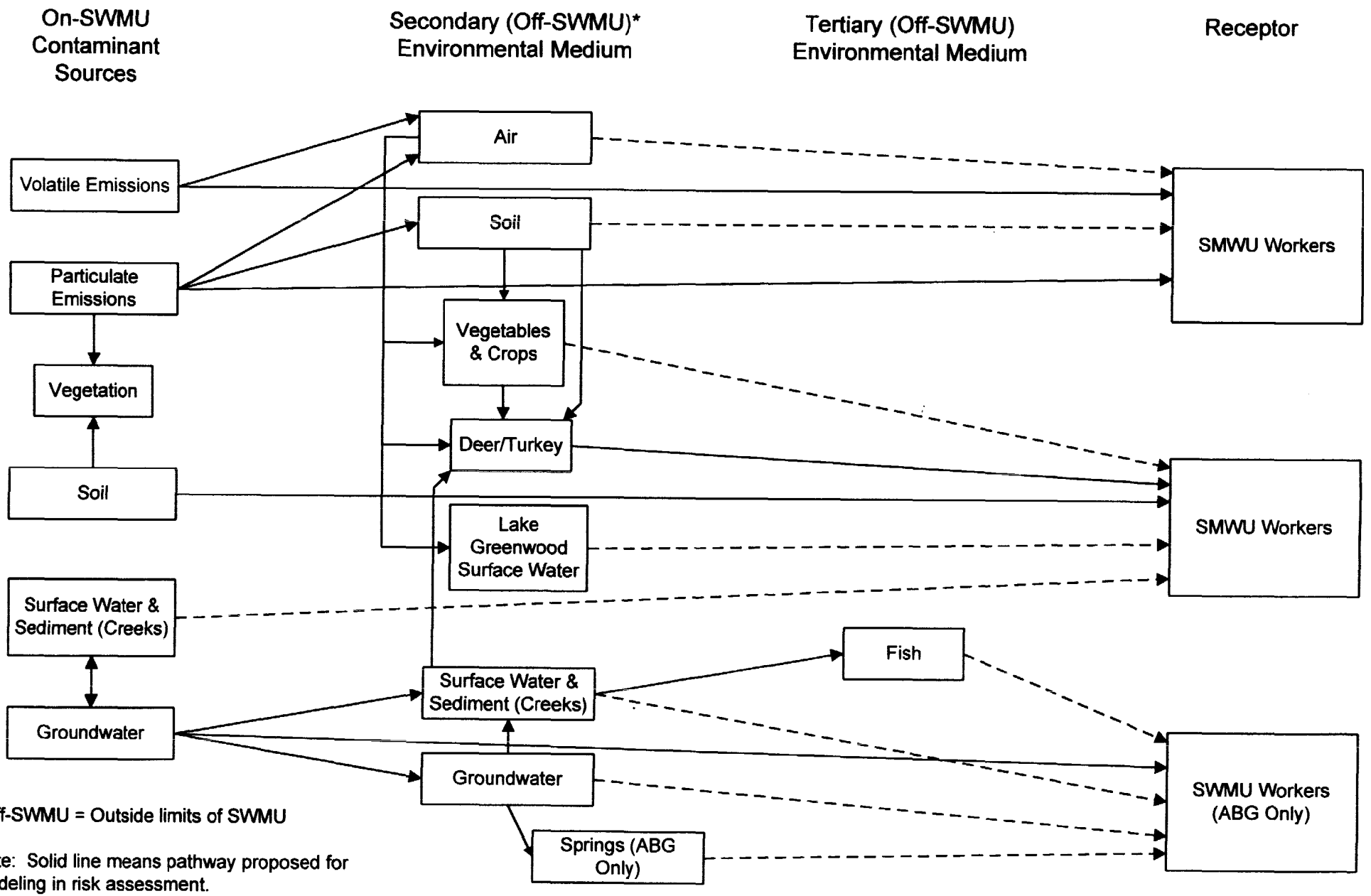
*Off-Facility = Outside limits of Facility

Note: Solid line means pathway proposed for modeling in risk assessment.

Dashed (- - - means pathway not proposed for modeling in r assessment.

D:\CTO7 P1\FIG4-1D.VSD

Figu - 1D
Scenario A
(Current OB/OD Operations Continue Indefinitely)



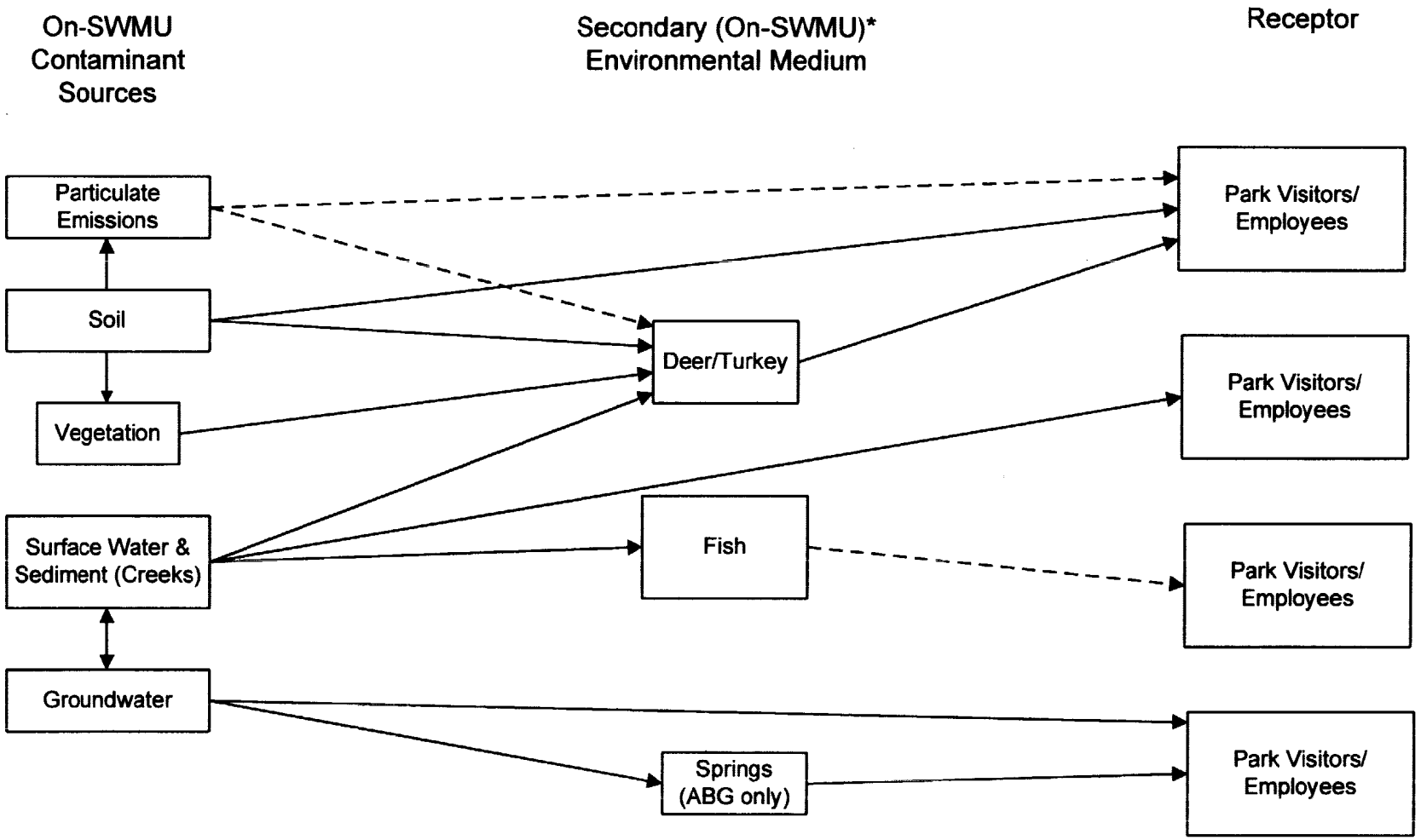
*Off-SWMU = Outside limits of SWMU

Note: Solid line means pathway proposed for modeling in risk assessment.

Dashed (- - -) line means pathway not proposed for modeling in risk assessment.

D:\CTO7601\WP1\FIG4-1A.VSD

Figure 4 - 2
Scenario B
(OB/OD Activities Cease; SWMU Developed Into a Public Park)



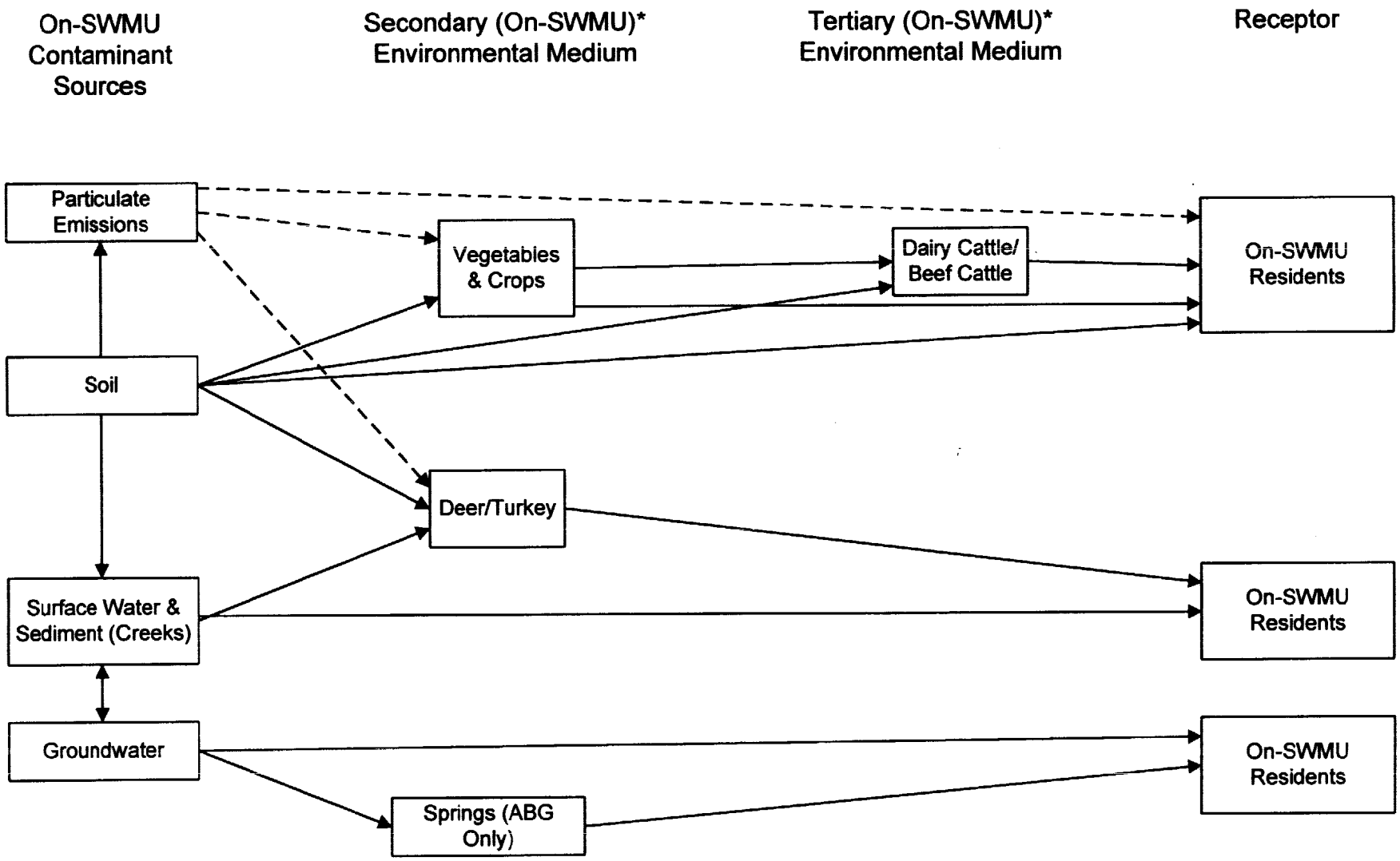
*On-SWMU = Within limits of SWMU

Note: Solid line means pathway proposed for modeling in risk assessment.

D ed (- - -) line means pathway not proposed for r ing in risk assessment.

D:\CTO7601\WP1\FIG4

Fig 4 - 3
Scenario C
(Current OB/OD Activities Cease; SWMU Developed Into a Residential Area)



*On-SWMU = Within limits of SWMU

Note: Solid line means pathway proposed for modeling in risk assessment.

Dashed (- - -) line means pathway not proposed for modeling in risk assessment.

D:\CTO7601\WP1\FIG4-3.VSD

the activities. In addition, family members would be expected to be exposed to contaminants in surface water as Lake Greenwood is their primary source of drinking water and while swimming in the lake. An adult in this family will also be assumed to enter this SWMU 20-days each year as part of his/her job responsibilities at the base.

A second receptor population envisioned in this scenario would be off-facility residents (Figure 4-1C), who could primarily become exposed to the existing chemical contamination in groundwater at this SWMU, after it has migrated away from ABG and from beneath NAVSURFWARCENDIV. These nearby residents, located off NAVSURFWARCENDIV property to the southwest of AGB would also be expected to come into contact with SWMU-related hazardous constituents via surface water (springs) outflow. In addition, the off-facility residents would be expected to be exposed to airborne emissions from the open burning activities. If toxic bioaccumulative metals and environmentally persistent organic chemicals are found to be emitted into the ambient air from ABG, there is the potential for contamination of secondary and tertiary media, e.g., soil and plants, in the vicinity of these off-facility receptors, due to deposition of particulate matter from ambient air.

Lastly, because the open burning activities are assumed to continue at ABG indefinitely, exposure of SWMU workers to SWMU-related contamination is expected to occur (Figure 4-1D). SWMU workers would be expected to be exposed to contaminated air, surface soil, and groundwater at this SWMU. These receptors may also occasionally hunt deer and turkey which have been impacted by SWMU-related contamination. SWMU workers are not assumed to have significant contact with the springs which are located a considerable distance from the SWMU itself.

In Scenario B (Figure 4-2), ABG activities are assumed to stop at some time in the future (e.g. 100 years). This area would then be converted into a public park/natural area. Visitors to and employees of this park/natural area would thus be expected to come into contact with contaminated surface soil, surface water (including springs at ABG), sediment, and groundwater at this site. Hunting activities in the park/natural area might expose receptors to contaminants via venison/turkey ingestion. With respect to groundwater contamination at ABG, a drinking water well should be assumed to be placed in any aquifer below this area and at any location within this SWMU. Thus, exposure to groundwater will be based on monitoring well data aggregated separately for each aquifer at ABG, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well.

In Scenario C (Figure 4-3), ABG activities are also assumed to continue for 100 years, but the base is then developed into a rural residential area. Rural residents living on the former SWMU would be expected to come into contact with contaminated surface soil, surface water (including springs), sediment, and groundwater. As in Scenario B, exposure

to groundwater will be based on monitoring well data aggregated separately for each aquifer at ABG, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well. These future residents would also be expected to consume vegetables grown in contaminated soil in home gardens, and consume contaminated beef and milk from cattle raised for their own consumption. Finally, future residents would be expected to consume local deer and turkeys that they hunt.

4.2.3 Review and Analysis of Existing Analytical Databases for ABG

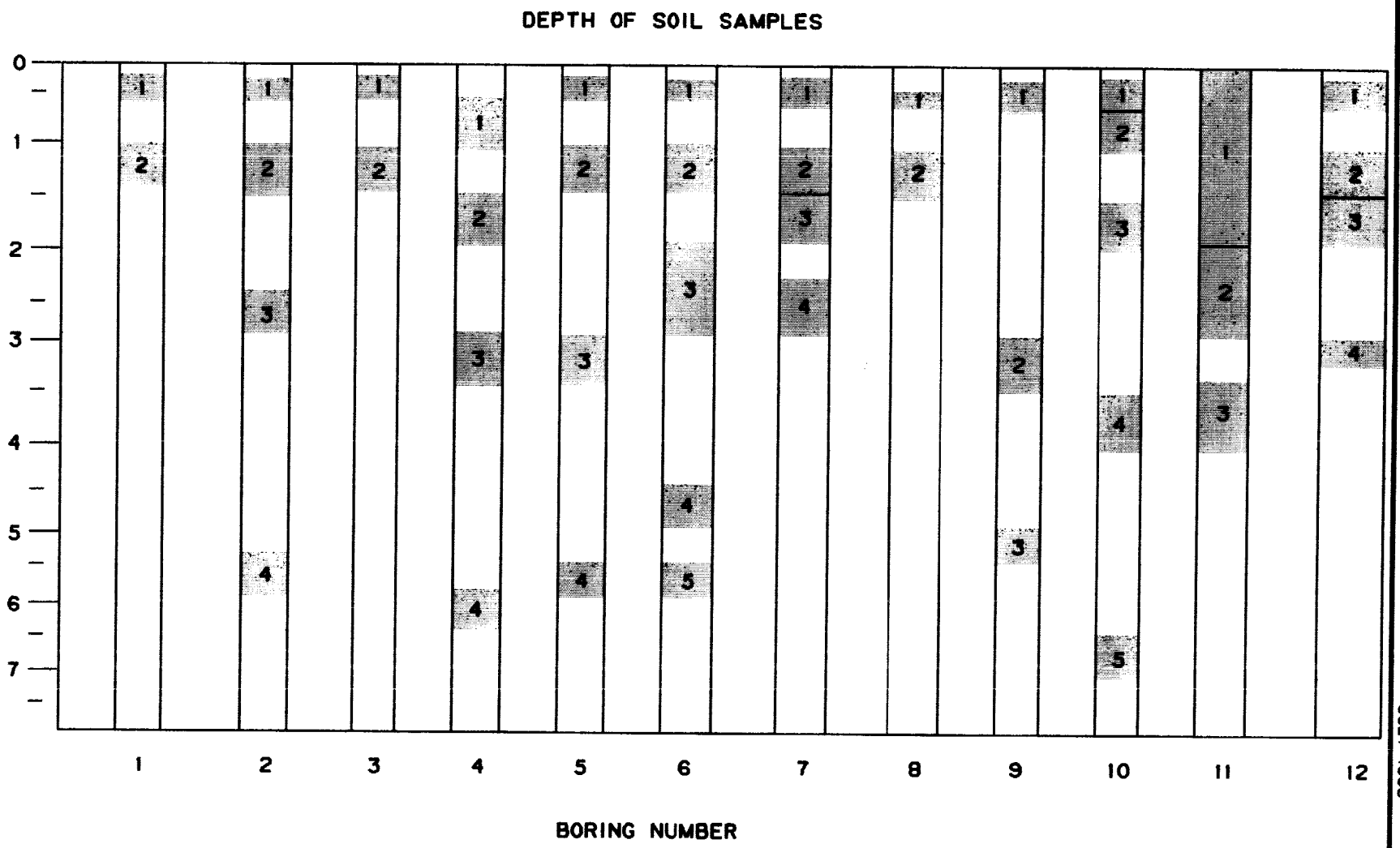
4.2.3.1 Soil

As part of a RFI at NAVSURFWARCENDIV, a Phase III Release Characterization Study is being conducted by the USACE at ABG in order to identify the nature, degree and extent of hazardous constituents in the soil. The objectives of Part 1 of the Phase III study (which has been completed) were to investigate background conditions and to locate probable sites of surface and subsurface releases and contamination. The second part of the Phase III study will define the limits of the contamination. At the time of the writing of this work plan, however, the Phase III, Part 2 work plan had not yet been completed. Therefore, the extent of soil data at ABG presently available is only that contained in the Phase III Part 1 investigation.

Soil samples in Part 1 were collected from 12 boring locations at the ABG. These boring locations are shown in Figure 3-9. When soil thickness allowed, soil samples for chemical analyses were collected at the following depth intervals: 3 to 6 inches, 12 to 18 inches, 18 to 24 inches, 36 to 42 inches, and 6 inches above the top-of-rock. Actual sample depths and their corresponding sample numbers are shown in Figure 4-4. Three samples (numbers 1, 2, and 3) were selected to be background borings and were located several hundred feet to the southwest of the ammunition burning activities in the ABG area.

All of the Part 1 soil samples were analyzed for explosives, inorganics, volatile and semivolatile organic chemicals, and pesticides/herbicides. All data underwent a QA/QC review. In general, the contaminants found in the highest concentrations were explosive compounds, including 2,4-DNT, 2,6-DNT, TNT, Tetryl, DNB, TNB, RDX, and HMX, and metals including antimony, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, aluminum, cobalt, magnesium, manganese, and tin. Other contaminants found at much lower concentrations included other inorganics, polycyclic aromatic hydrocarbons (PAHs), volatile organics, and pesticides and herbicides.

Based on the results of Part 1 of the Phase III soils study (USACE, 1992), the Halliburton NUS Team concurs with the USACE that soils at the ABG have been sufficiently



SOURCE: ACE, 1992

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 4-4
DEPTH OF SOIL SAMPLES AT ABG

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

2061E

characterized with these two exceptions: 1) no soil samples collected previously at this SWMU have been analyzed for chlorinated dioxins, and 2) no soil samples have been collected from the Old Jeep Trail Area.

To address the dioxin issue, three soil samples will be collected from ABG from around the burn pans and pads (the most likely sources of dioxin/furan compounds at this SWMU). These three samples will be analyzed for dioxins/furans (PCDD/PCDF) only. Three soil samples are being collected as background for DR (Table 4-1), and these samples will also be analyzed for dioxins/furans. If dioxins/furans are detected in the ABG soil samples, these concentrations will be compared to the concentrations in the DR background samples. The concentrations will also be compared to published anthropogenic background concentrations of dioxins found in the soils (Bumb et al., 1980; Nestrick et al., 1983; Smith et al., 1983). If the concentrations in the ABG soil samples are consistent with those found in DR background soil and/or with concentrations commonly reported in background soils, dioxins/furans will be treated in the assessment as anthropogenic contaminants that are unrelated to SWMU activities.

An area of ABG that was not addressed by the Phase III Part 1 soils study is the former open burning area adjacent to the Old Jeep Trail. This area should also be viewed as a potential source of soil contamination due to the burning activities that occurred adjacent to the trail in the past. For the purposes of this risk assessment, it is suggested that soil contamination adjacent to the Old Jeep Trail be treated as a contamination source separate from the ABG proper. It is recommended that two to five surface soil samples (grid composites) be collected from the old burn area. Chemical concentrations in these samples will be averaged for comparison to background samples.

The "control" surface soil samples collected at ABG in the Phase III Part 1 study (USACE, 1992) contained no explosives and no volatile or semivolatile organics. Several pesticides were detected at estimated levels in these samples, but are not felt to be related to ABG-specific burning activities. USACE interpreted these low levels of pesticides as due to their general past use at NAVSURFWARCENDIV. Therefore, Halliburton NUS Team views these three existing samples as acceptable background samples, with the pesticide levels considered as anthropogenic background. Table 4-2 summarizes the results of the analyses of the surface soil background samples from the Phase III Part 1 study.

4.2.3.2 Surface Water/Sediment

As part of a RFI at NAVSURFWARCENDIV, surface water and sediment samples were collected by the USACE in March and July, 1992 at ABG and downstream of ABG (U.S. Army, 1992; Murphy and Wade, 1994a). The purpose of this sampling event was to evaluate the degree and extent of potentially hazardous constituents in surface water and

TABLE 4-1
Page 1 of 3
SWMUs #03/10, #06/09, #07/09
SURFACE SOIL
SAMPLING AND ANALYSIS PLAN

Primary Contaminant Source	Analytical Data Currently Available[1]	Samples Needed[2]
SWMU #03/10 AMMUNITION BURNING GROUND		
Sludge Burn Pads and Associated Tanks (1)	None	None per USEPA direction.
Burn Pans (2)	One location (4 depths) between two western-most burn pans (10/5/90).	One grab sample downgradient from pans within Little Sulphur Creek drainage (PCDD, PCDF).
Production Scrap Burn Pads (3)	None	None per USEPA direction.
Red Phosphorus Burn Pads (4)	One location (5 depths) east of burn pads (10/10/90).	None per USEPA direction.
Primer Pit (5)	None	None, activity such that soil contamination unlikely.
Surface Impoundments (6)	One location (5 depths) southeast of one impound-ment (10/6/90).	None per USPEA direction.
Surface Impoundment Underground Storage Tanks (6a)	None	None per USEPA direction.
Ash Inspection Pan (7)	None	None per USEPA direction.
Incendiary Cage (8)	One location (2 depths) southeast of cage (10/8/90)	None per USEPA direction.
PEP-contaminated solvents, liquids Burn Pads (9)	None	Two grab samples from burn pad area (PCDD, PCDF).

TABLE 4-1 (Continued)
Page 2 of 3
SWMUs #03/10, 06/09, 07/09
SURFACE SOIL
SAMPLING AND ANALYSIS PLAN

Primary Contaminant Source	Analytical Data Currently Available[1]	Samples Needed[2]
SWMU #03/10 AMMUNITION BURNING GROUND		
Contaminated Material Burn Pads (10)	One location (4 depths) southwest of burn pads (10/4/90).	None per USEPA direction.
Primer Burn Box (11)	None	None per USEPA direction.
Waste Ash Rolloff Boxes (12)	None	None.
Pink Water Tanks (13)	None	None per USEPA direction.
Old Jeep Trail Area	None	Five discreet grab samples collected within the approximate limits of the former ordnance disposal pit.
Background	Three locations (8 depths) southwest portion of ABG. None for the PCDD, PCDF.	None, previous data will be utilized as representative of background conditions. See background at Demolition Range.
SWMU #06/09 DEMOLITION RANGE		
Army Detonation Area	None	Eight grid composite samples (subsamples collected within the four quadrants of each grid square).
Navy Detonation Area	None	Three grid composite samples.
Background	None	Three grab samples within Wellston-Gilpin Complex soils, north of the active detonation area will also serve as background for PCDD, PCDF at ABG.

TABLE 4-1 (Continued)
Page 3 of 3
SWMUs #03/10, 06/09, 07/09
SURFACE SOIL
SAMPLING AND ANALYSIS PLAN

Primary Contaminant Source	Analytical Data Currently Available[1]	Samples Needed[2]
SWMU #07/09 OLD RIFLE RANGE		
Target Area	None	Three grid composite samples.
Background	——	Three grab samples within Wellston Silt Loam, north-northeast of ORR.

[1]From U.S. Army Corps of Engineers, Waterway Experiment Station, RFI ABG Phase III Soils Report, Part 1 (1992) and RFI ORR Phase II Soils Report (1991).
[2]At each location soil will be collected from 0 to 6 inches below ground surface.

TABLE 4-2

SUMMARY OF INORGANIC CHEMICALS AND PESTICIDES DETECTED IN SURFACE SOIL BACKGROUND SAMPLES[a] AMMUNITION BURNING GROUND

Chemical	Frequency of Detection[b]	Range of Detection (mg/kg)	Arithmetic Mean Concentration[c] (mg/kg)
Antimony	0/3	NA	NA
Arsenic	3/3	7.5 - 9.4	8.7
Beryllium	3/3[d]	2.2 - 2.8	2.4
Cadmium	1/3	0.7	NA
Chromium	3/3	21.9 - 25.6	23.3
Copper	3/3	7.7 - 18.5	12.6
Lead	3/3	23.1 - 20.4	24.3
Mercury	2/3	0.26 - 0.28	0.27
Nickel	3/3	16.8 - 23.5	19.8
Selenium	3/3	0.3 - 0.5	0.39
Silver	0/3	NA	NA
Thallium	2/3	0.2 - 0.3	0.25
Zinc	3/3	60.6 - 102	78.6
Aluminum	3/3	10,300 - 12,200	11,500
Barium	3/3	109 - 135	119.7
Cobalt	3/3	14.8 - 18.5	16.3
Iron	3/3	25,400 - 16,100	34,100
Magnesium	3/3	860 - 1,080	980
Manganese	3/3	1,220 - 1,490	1,317
Tin	0/3	NA	NA
Sodium	0/3	NA	NA
Heptachlor	2/3	0.0016J - 0.0022J	0.0019
2,4-D	1/3	0.0050J	NA
2,4,5-T	2/3	0.0069J - 0.010J	0.0085
Endrin	1/3	0.0006J	NA

[a] Background consists of surface soil samples 01#1, 02#1, and 03#1 from Part 1 Phase III Soils Report (USACE, 1992).
[b] Total number of samples in which the contaminant was detected divided by the total number of samples analyzed.
[c] Average of detect concentrations.
[d] Spiked sample recovery not within control limits.
J = Estimated value below the statistical quantitation limits.

Note: Heptachlor was frequently found in method blanks.

sediment related to past activities at ABG. In addition, as part of the Phase III Groundwater Release Characterization Study (Phase III Report; Murphy, 1992a; see Section 4.3.2.1), seven regional springs were sampled for water quality analyses on six occasions during the period from December, 1987 through January, 1992. One of the springs, Spring A, was also sampled a seventh time, in February, 1990. The springs were sampled in order to evaluate the potential for groundwater that discharges from the Beech Creek aquifer to impact surface water quality (streams and creeks) south of ABG (and south of the Jeep Trail area).

Eleven locations were selected by USACE for the surface water and sediment sampling events in March (Round 1) and July (Round 2), 1992 (see Figures 3-7, 3-8, and 3-9). Table 4-3 summarizes the analytical parameters which were chosen for the analyses. In general, samples were analyzed for selected inorganic and organic constituents including volatile and semivolatile organic compounds (VOCs and SVOCs), explosives and pesticides/polychlorinated biphenyls (PCBs). However, surface water was analyzed for pesticides/PCBs only during Round 2 (July, 1992).

The eleven sampling locations include three background (upstream) samples (north and west of ABG): ABG-1, ABG-2 and ABG-3. Two locations were selected for on-SWMU sampling at ABG (ABG-4 and ABG-5) to reflect distinct surface drainage pathways from the northern and western portions of the SWMU. A third on-SWMU sampling location, (ABG-6) was used to monitor surface water/sediment downstream of ABG-4 and ABG-5, along the axis of the valley. The remaining sample locations (ABG-7 through ABG-11) were located progressively downstream of ABG and, ultimately, downstream of the Jeep Trail Area, along Little Sulphur Creek. Sampling locations ABG-9, ABG-10, and ABG-11 were appropriately located to monitor potential impacts related to surface water recharge from the Beech Creek limestone at nearby springs (Springs A and C).

The results of the two sampling rounds conducted in 1992 indicate that potential contaminants were generally detected less frequently in surface water than in sediments (Murphy and Wade, 1994a). For surface water, several inorganic constituents, such as aluminum, barium, manganese, magnesium and nitrates, were detected at most of the sampling locations. Chromium, cadmium, copper, lead and zinc were detected less frequently in surface water. Three explosives (2,4-DNT, HMX and RDX) were detected only in those surface water samples collected at downstream locations: ABG-7, -8 and -9. No VOCs were detected in surface water, and bis(2-ethylhexyl)phthalate was the only SVOC detected (occurred only at ABG-6). Metals, nitrates and explosives were found somewhat more frequently or at higher levels in the surface water samples collected during Round 2 (summer) than during Round 1 (spring) (Murphy and Wade, 1994a). The greatest frequency of surface water detections was associated with locations ABG-7 and -8. In addition, some of the most elevated parameter concentrations (i.e., for aluminum,

TABLE 4-3

ABG SURFACE WATER, SEDIMENT AND SPRINGS SUMMARY OF ANALYTICAL PARAMETERS FOR EXISTING DATABASE *

Parameter Group		Surface Water	Sediment	Springs
Inorganics		3/92 & 7/92	3/92 & 7/92	1/92 (I)
Volatile Organic Chemicals		3/92 & 7/92	3/92 & 7/92	1/92
Semi-volatile Organic Chemicals		3/92 & 7/92	3/92 & 7/92	
Pesticides/PCBs		7/92 (only)	3/92 & 7/92	
Explosives:				
	HMX	3/92 & 7/92	3/92 & 7/92	1/92
	RDX	3/92 & 7/92	3/92 & 7/92	1/92
	TNT	3/92 & 7/92	3/92 & 7/92	1/92
	DNB	3/92 & 7/92	3/92 & 7/92	
	TETRYL	3/92 & 7/92	3/92 & 7/92	
	TNB	3/92 & 7/92	3/92 & 7/92	
	2,4-DNT	3/92 & 7/92	3/92 & 7/92	
	2,6-DNT	3/92 & 7/92	3/92 & 7/92	

NOTES: *: Table lists the dates (i.e., "3/92") for the most recent sampling events that include the designated parameters.

(I): I = incomplete; not all the analytes recommended for the health risk assessment were included for the parameter group (but a significant number of the analytes were included in the existing database). For those parameter groups in which none of the analytes were monitored (or in which only a few analytes were analyzed), the table is left blank.

Source: Murphy and Wade, 1994a.

chromium, HMX, manganese, nitrates and RDX) were associated with locations ABG-7 and/or -8.

All of the monitored metals (USEPA Methods 6010/Series 7000) were detected in sediment samples. Antimony, mercury and thallium were characterized by limited distributions, but nitrates and all other metals were detected at almost all of the sampling locations (Murphy and Wade, 1994a). Among explosives, detections were associated with five constituents: 2,4-DNT, HMX, RDX, TNB, and TNT. Several VOCs were detected and were widely distributed among the sampling locations. A few SVOCs were also detected in sediment samples but usually at levels below the sample quantitation limits. Several pesticides/herbicides were detected at several locations (mostly downstream of ABG-5) but were present at only low levels (<0.0097 mg/kg). PCB detections in two samples (ABG-4 and -9) were considered to be artifactual, based on comparisons with the detected levels reported in associated blanks. PCBs were detected at only two other locations (for one sampling round each), at ABG-1 and ABG-8, and these detections were at low concentrations (0.0023 and 0.046 mg/kg, respectively).

The existing analytical database is viewed as usable for risk assessment purposes for the chemicals evaluated and thus is proposed for use as the primary surface water and sediment databases for ABG. These existing databases need to be supplemented, however, with additional data as recommended in Table 4-4.

Two new surface water/sediment sampling locations are recommended to address potential impacts related to the Jeep Trail area, designated ABG-12 and ABG-13 in Figure 3-8. No analytical data exist for the central portion of the Jeep Trail area or for surface water/sediment immediately downstream of this area (along Little Sulphur Creek). Sampling of surface water and sediment is also recommended for three background (upstream) locations in order to expand the number of sampling rounds and sampling points which comprise the background database: a repeat sampling event at ABG-1 and sampling at two new points, ABG-14 and -15, to be located approximately 500 and 1000 feet westerly (upstream) from ABG-1 (Figure 3-7).

Inorganics, VOCs, SVOCs, explosives, and water quality parameters should be evaluated in the new samples representing ABG-12, ABG-13, ABG-14 and ABG-15. These data would then be added to the existing databases for the risk assessment. Analyses for pesticides/PCBs are not proposed due to the low level and/or infrequent detections of these constituents, as demonstrated in the existing surface water/sediment databases (Murphy and Wade, 1994a). Furthermore, a review of past activities and practices for ABG does not indicate that this group of chemicals has been handled at ABG.

TABLE 4-4

ABG/JEEP TRAIL PROPOSED SAMPLING OF SURFACE WATER, SPRINGS AND SEDIMENT

At Sample Designation	Location	Sample Types	Rationale
ABG-1	Upstream, western edge of ABG area	Surface Water & Sediment	Data to supplement existing database for background.
ABG-12, ABG-13	Jeep Trail Area	Surface Water & Sediment	No analytical data currently exists for these locations; analyze for inorganics, VOCs, SVOCs, and explosives; evaluate potential impacts to Little Sulphur Creek related to past waste disposal activities at Jeep Trail area.
ABG-14, ABG-15	Upstream, 500-1,000 feet west of ABG-1	Surface Water & Sediment	New background sampling locations to supplement existing database for background.
Spring-A	Southern portion of Little Sulphur Creek valley; north of confluence with Johnson Hollow	Water	Data to verify existing database; previous dye tracer studies indicate Spring-A is the most important spring with respect to potential hydraulic connection with ABG (Beech Creek) ground water; analyze for inorganics, VOCs, SVOCs.
Spring-B, Spring-C	Little Sulphur Creek valley	Water	Data to supplement existing database (Al, Sb, Be, Ni, Th, Zn, cyanide, SVOCs, explosives).
Spring-8, Spring-10	Located off-facility, below the confluence of Little Sulphur Creek with Johnson Hollow	Water	No data currently exists for these springs; springs used by public; analyze for inorganics, VOCs, SVOCs, and explosives.

For the risk assessment, surface water and sediment analytical results will be evaluated separately (evaluated by medium). Within each medium, analytical data should be grouped according to location and evaluated by individual groups. It is suggested that the data be segregated into the following groups (listed below), which reflect whether the samples were collected at on-SWMU locations, upstream locations, or downstream locations:

Upstream ABG	On-SWMU ABG	Downstream ABG (Off-SWMU)
ABG-1	ABG-4	ABG-7
ABG-2	ABG-5	ABG-8
ABG-3	ABG-6	
ABG-14		
ABG-15		

Jeep Trail Area	Downstream Little Sulphur Creek
ABG-12	ABG-9
ABG-13	ABG-10
	ABG-11

4.2.3.3 Springs

Springs A, B, and C are located along the southern portion of the Little Sulphur Creek valley, south of ABG and the Jeep Trail area (see Figure 3-7). Springs D, E, F, and Mountain Spring are located north of ABG (see Figure 3-7).

The existing analytical database for the three springs along Little Sulphur Creek, documented in the Phase III Report (Murphy, 1992a), is also viewed as usable for those analytes evaluated and should be used as the primary data source for the risk assessment. The most recent data available from this database (data collected on January, 1992) will constitute this database. Data from the earlier sampling events should also be examined and summarized for any parameters that may have varied significantly over time.

The analytical database should be supplemented with additional data, recommended for sampling in 1995. Additional sampling is recommended to address current data needs. Table 4-3 summarizes the analytical parameters included in the existing database. The data deficiencies include certain metals, cyanide, and SVOCs.

In general, the contaminants found in samples collected from springs south of ABG (Springs A, B, and C) include TCE, RDX, TNT, and barium. Detections from the remaining four springs located north of ABG include trichlorethylene (TCE), di-n-butyl phthalate, RDX, mercury, and methoxychlor. These analytes were each detected for singular events and only from a single spring. In addition, barium was detected on one or two occasions at each of the northern springs. Because dye tracer results do not suggest a link between Beech Creek groundwater and the northern springs, the source of these contaminants is not likely to be related to ABG.

The Phase III Report summarizes dye tracer studies conducted in 1990 and 1991 which were used to evaluate the relationship between regional springs and groundwater at ABG. Based on these previous studies, Spring A appears to be the primary outlet for ABG water with respect to the Beech Creek aquifer (when compared to other regional springs). Limited hydraulic connections with the Beech Creek unit (and ABG groundwater) possibly exist for Springs B and C (Murphy, 1992a). For this reason, these three springs are recommended for additional sampling. Spring A should be sampled for all analytes (inorganics, VOCs, SVOCs, explosives) to provide verification of the existing database. These data are currently lacking in the existing database. Springs B and C should be sampled for a selected number of metals, cyanide, SVOCs, and explosives (Table 4-4). These latter two springs will therefore be sampled only for those key parameters currently lacking (from a risk assessment perspective) in the existing analytical database.

In addition, Spring 8 and Spring 10 should be sampled for VOCs, SVOCs, inorganics, explosives, and water quality parameters. These springs are located off-facility south of Springs A and B, near the boundary wells ("B" monitoring wells). A weak dye tracer test response was noted at Spring 8 in 1991, suggesting a possible relationship with ABG groundwater (Murphy, 1992a). This spring reportedly has a long history of use by the public. No analytical data currently exist for Spring 8 and Spring 10.

For the risk assessment, it is proposed to group the spring data into two distinct data sets and evaluate them separately: the southern on-facility springs (Springs A, B, C) and the off-facility springs (Spring 8 and Spring 10). In addition, the analytical data from the upgradient Beech Creek monitoring well 03C17 will serve as the background database for the springs.

4.2.3.4 Groundwater

As part of an RFI at NAVSURFWARCENDIV, a Phase III Groundwater Release Characterization Study (Phase III Report) has been conducted by the USACE (Murphy, 1992a) to evaluate the hydrogeology and the degree and extent of chemical release to groundwater at ABG. The objectives of the Phase III Study were to characterize geologic

conditions and groundwater flow and to identify the nature and distribution of potential contaminants.

A total of 98 monitoring wells have been installed in the ABG study area since 1981. Of these, 71 wells have been sampled on a quarterly basis since September, 1987. Analytical parameters selected were referred to as RCRA Group 1 parameters, RCRA Group 2 parameters, RCRA Group 3 parameters, explosives, organics, and PCBs. Table 4-5 lists these parameters. Appendix F of the Phase III Report provides a detailed compilation of which parameters were chosen for any given sampling event.

Table 4-6 is a summary of the analytical data (parameters) available from the sampling program for the ABG monitoring wells, with respect to each aquifer of concern. The table indicates the date(s) of the data most recently available for each parameter group shown. In general, the available data includes inorganics, VOCs, PCBs, and explosives. With respect to risk assessment purposes, the inorganic data lacks cyanide and ten metals: aluminum, antimony, beryllium, cobalt, copper, nickel, thallium, tin, vanadium, and zinc. Only four SVOCs were included with the sampling events: acrylonitrile, di-n-butyl phthalate, phenol and bis(2-ethylhexyl)phthalate. In addition, only six pesticides and three explosives were monitored in the wells, as shown on Table 4-5.

The Beech Creek limestone appears to be the most significantly impacted aquifer at ABG and is the most important hydrogeologic unit in terms of conducting groundwater off-site. Consistently detected contaminants on-site include TCE, the explosive RDX, and the metal barium. Significant levels of TCE have persisted in numerous Beech Creek wells at ABG, during the entire sampling period from September, 1987, through January, 1992.

The analytical data from the Phase III Report is viewed as usable for risk assessment purposes. It therefore is proposed for use as the primary database for groundwater quality at ABG. If there is a trend in the historical data (either up or down) in terms of contaminant levels, the most recent data from this study (data collected in April 1991, and/or through January 1992) are viewed as the most appropriate data for the assessment. However, if there is no obvious trend, it is proposed that all of the data for a given well be averaged. For some parameters, such as inorganics, the most recent data available is from April or July, 1989 (Table 4-6). The use of these older analytical data is also viewed as appropriate for the risk assessment since the Phase III study has shown that some analyte levels have not changed significantly from a historical perspective.

New water quality data from wells used for RCRA compliance monitoring purposes will be used to update the risk assessment database. For the risk assessment, the analytical data at ABG will be evaluated in terms of well groupings, as discussed below.

TABLE 4-5

ABG ANALYTICAL PARAMETERS
EXISTING DATABASE FOR GROUNDWATER AND SPRINGS
(1987 - 1992)

RCRA GROUP 1 PARAMETERS

Arsenic
Barium
Cadmium
Chromium
Fluoride
Lead
Mercury
Nitrate-N
Selenium
Silver
Endrin
Lindane
Methoxychlor
Toxaphene
2,4-D
2,4,5-TP
Coliform
Radium
Gross alpha
Gross beta

RCRA GROUP 2 PARAMETERS

Ammonia-N
Bicarbonate
Calcium
Chloride
Iron
Potassium
Magnesium
Manganese
Phenol
Sodium

RCRA GROUP 3 PARAMETERS

pH
Specific conductivity
Total organic carbon
Total organic halogens

ORGANICS

Acetone
Acrolein
Acrylonitrile
Benzene
Bromomethane
Bromodichloromethane
Bromoform
2-Butanone
Carbon disulfide
Carbon Tetrachloride
Chlorobenzene
Chloroethane
Chloromethane
4-Methyl-2-pentanone
Methylene chloride
Trans-1,2-Dichloropropene
Trans-1,2-Dichloroethene
1,1,1-Trichloroethane
Trichloroethene
1,1,2-Trichloroethane
Tetrachloroethene
1,1,2,2-Tetrachloroethane
Toluene
Styrene
Vinyl acetate
Vinyl chloride

TABLE 4-5 (Continued)

ABG ANALYTICAL PARAMETERS
EXISTING DATABASE FOR GROUNDWATER AND SPRINGS
(1987 - 1992)

ORGANICS

Chloroform
2-Chloroethyl vinyl ether
cis-1,3-Dichloropropene
Dibromochloromethane
1,1-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethane
1,2-Dichloropropane
Ethylbenzene
2-Hexanone
Xylene (total)
Di-n-butyl phthalate
Bis(2-ethylhexyl)phthalate
PCB

EXPLOSIVES

TNT
RDX
HMX

TABLE 4-6

ABG GROUNDWATER SUMMARY OF ANALYTICAL PARAMETERS FOR EXISTING DATABASE (1990 - 1991)

Group Parameter	HYDROGEOLOGIC UNIT *				
	Beaver Bend	Beech Creek	Big Clifty	Golconda	Alluvium
Inorganics	7/89 (I)	7/89 (I,N)	7/89 (I,N)	4/89-1/91 (I)	7/89 (I,N)
Volatile Organic Chemicals	12/91-1/92	10/91-1/92	4/91-1/92	7/91-1/92	7/91-1/92
Semi-volatile Organic Chemicals					
Pesticides/PCBs					
Explosives:					
HMX	12/91-1/92	10/91-1/92	4/91-1/92	7/91-1/92	7/91-1/92
RDX	12/91-1/92	10/91-1/92	4/91-1/92	7/91-1/92	7/91-1/92
TNT	12/91-1/92	10/91-1/92	4/91-1/92	7/91-1/92	7/91-1/92
DNB					
TETRYL					
TNB					
2,4-DNT					
2,6-DNT					

NOTES: *: Table lists the dates (i.e., "7/89") for the most recent sampling events that include the designated parameters. In some cases, a range in dates is shown because not all of the monitoring points within a given group were sampled on the same schedule.

(I): I = incomplete; not all the analytes (recommended for the health risk assessment) were included for the parameter group (but a significant number of the analytes were included in the existing database). For those parameter groups in which none of the analytes were monitored (or in which only a few analytes were analyzed), the table is left blank.

(N): N = never; for some of the monitoring points within a given grouping, samples were never analyzed for this parameter group.

The database for one off-SWMU well (03C17) should be supplemented with additional data, recommended for collection in 1995. Additional sampling is recommended to verify the existing database and to address data gaps for this well (as discussed further below).

Groundwater monitoring wells at ABG will first be grouped according to aquifer and/or geologic formation. For the risk assessment, each aquifer will be evaluated individually. In some cases, wells will be further grouped within a given aquifer to account for variability in hydrogeologic conditions underlying the site (i.e., the direction of groundwater flow and the distribution of aquitards). For each aquifer group with a limited number of wells, such as the Beaver Bend and Golconda units, all on-SWMU analytical data will be combined and evaluated as a separate data set in order to select the chemicals of potential concern for the health risk assessment. For each aquifer group with a large number of wells, such as the Beech Creek, on-SWMU analytical data for each sub-grouping (i.e., Beech Creek - - On-SWMU - - Western Third of ABG, see below) will be combined and evaluated as a separate data set in order to select the chemicals of potential concern for the health risk assessment.

The five main aquifers and/or geologic units that have been identified at ABG include (Murphy, 1992a):

- Beaver Bend limestone — Table 4-7
- Beech Creek limestone — Table 4-8
- Big Clifty sandstone — Table 4-9
- Golconda limestone — Table 4-10
- Alluvium — Table 4-11

The summary tables cited above have been prepared to list the monitoring wells installed within each aquifer group.

Beaver Bend

The Beaver Bend (Table 4-7) is the deepest aquifer monitored at ABG. All five of the existing wells which are screened in this unit are on-SWMU (see Figures 3-7 and 3-9). TCE has been detected in this aquifer on more than one occasion in most of these wells, at levels generally lower than those observed in the Beech Creek limestone. The greatest frequency of TCE detections (and the highest level) in the Beaver Bend aquifer occurred in well 03C09 (seven detections in the range of 1 to 20 ug/l TCE for the period October, 1987, through January, 1992; the most recent detection at 03C09 was 3 ug/l TCE in July, 1991). The explosive RDX was also detected in this well at 230 ug/l (singular detection only). RDX was detected in only one other Beaver Bend Well (03C01), at levels in the range of 20 to 30 ug/l. Well 03C09 is located in the upgradient side of ABG with respect

TABLE 4-7

ABG GROUNDWATER WELL GROUPING FOR BEAVER BEND AQUIFER [A]

On SWMU	Off SWMU
03C01	None
03C02	
03C03	
03C08A	
03C09	

NOTE: [A] All wells belong to well nests with adjacent wells screened in the Beech Creek and/or Golconda formations.

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TABLE 4-8
ABG GROUNDWATER WELL GROUPINGS FOR BEECH CREEK AQUIFER[A,B]

On SWMU			Off SWMU					
North-Northwest Corner	Western Third	Eastern Two-Thirds	Jeep Trail Little Sulfur Creek	Downgradient Perimeter Little Sulfur Creek	Downgradient East/Southeast	Downgradient Southwest	Up Gradient North	Northeast
03C16	03C14	03C03P2	03-10	03C37	03C28	03C15	03C26	02C09
03C09P2	03C10	03C11	03-11	03B10	03C05	03C24	03C13	02C10
	03CO1P2	03C04	03-12	03C38	03C34	03C25	03C17	02C11
	03C21	03C06	03-13		03C35	03C29	03C19	02C12
		03C07	03-14		03C36	03C30	03C32	02C14
		03C08AP2	03-15			03C31	03C33	02C20
		03C20	03-16			03C33		02C22
		03-04	03-17					
		03-06	03-18					
		03-35	03-19					
		03-37	03-20					
		03C02P2	03-21					
		03C12	03-22					
		03C27	03-23					
		03-08	03-24					
		03-36	03-25					

[A] Underlining indicates well is recommended to be sampled.
[B] P indicates nested well(s) which are located at well base number shown on figures.

TABLE 4-9

ABG GROUNDWATER WELL GROUPINGS FOR BIG CLIFTY FORMATION

On SWMU		Off SWMU	
Western Third	Eastern Two-Thirds	Southwest	North
03-38	03-31 [A]	03-09	03-30
	03-32 [A]		03-01
	03-33 [A]		
	03-34 [A]		
	03-26		
	03-27		
	03-29		

NOTES: [A] Wells located in zone of collapse of Big Clifty formation due to solution cavern passages within underlying Beech Creek formation.

03-26, 03-27, 03-29: No analytical database available for these wells.

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TABLE 4-10

ABG GROUNDWATER WELL GROUPINGS FOR GOLCONDA AQUIFER

On SWMU	Off SWMU	
	North	Southwest Upgradient
03-28[A]	03C19P3[B]	03C15P3[B]
03C01P3[B]		03C18
03C08AP3[B]		
03C21P3[B]		
03C22		
03C23		
03-02[C]		

NOTES:

A Well screened in Golconda and Mansfield formations.

B All P3 wells belong to well nest with adjacent wells screened in Beech Creek and/or Beaver Bend formations. P well(s) located at well base number shown on figures.

C Actually, Mansfield formation well (included here with 03-28 since there are no other Mansfield wells at ABG, on-SWMU/off-SWMU). This well has not been sampled.

TABLE 4-11

ABG GROUNDWATER WELL GROUPINGS FOR ALLUVIUM

Off SWMU	
Jeep Trail Little Sulfur Creek	Boundary Wells[B]
03-07[A]	03B01
	03B02
	03B03
	03B04
	03B05
	03B06
	03B07
	03B08
	03B09

NOTES: 03-07 Underlining indicates well is recommended for sampling.

A 03-07: Screen 9.3 feet in length placed in valley alluvium within the projected elevation of the Beech Creek formation as observed in the adjacent valley wall (Murphy, 1992).

B Wells screened in alluvium are located at the confluence of Johnson Hollow drainage and Little Sulphur Creek, at the south NAVSURFWARCENDIV property boundary.

to potential flow in this aquifer. (The Phase III Report indicated that the Beaver Bend piezometric surface is fairly flat, 0.0012 ft/ft, and flow is generally to the south.)

Well 03C08A (Beaver Bend) monitors the downgradient side of ABG. It is also located downgradient of well 03C20 in terms of flow within the overlying Beech Creek. The highest TCE levels on-site were detected in well 03C20 within the Beech Creek unit. Well 03C08A is characterized by five TCE detections for the period from November, 1987, through January, 1992 (range of 3 to 10 ug/l TCE; most recent detection was 3 ug/l in October, 1989).

Three heavy metals have been detected in Beaver Bend wells: barium, cadmium, and mercury. The latter two metals have exceeded their MCLs but have been detected infrequently. Cadmium was detected once in well 03C02 at 30 ug/l and twice in well 03C03 at levels of 30 and 90 ug/l. The MCL for cadmium is 5 ug/l. The MCL for mercury is 2 ug/l. Mercury was detected on one occasion in well 03C02 at a level of 10 ug/l and on one occasion in well 03C09 at a level of 14 ug/l. Group 2 metals were not analyzed in Beaver Bend samples collected after July 1989. Therefore, it is not possible to comment on these metals with more recent data.

Organic compound detections, other than TCE, have also occurred in Beaver Bend wells. In most cases, these compounds have been reported as singular detections in three (or fewer) wells. These compounds are benzene, chloroform, 1,1-dichloroethene, 1,1,1-trichloroethane, bis(2-ethyl hexyl) phthalate, and di-n-butyl phthalate. Historically, benzene and bis(2-ethyl hexyl) phthalate have exceeded their MCLs. However, none of these compounds have been detected more recently than 1987 and/or 1989.

TCE detections, mentioned previously, have also occurred less frequently in Beaver Bend wells since 1989. Overall, TCE levels may be decreasing in magnitude over time, as well. TCE detections have not exceeded the MCL of 5 ug/l since January 1989, except on one occasion; a level of 7 ug/l was reported in well 03C09 for April 1991.

Beech Creek

The on-SWMU wells within this aquifer have been organized into three groups. Additional sampling is recommended for only the upgradient (off-SWMU) group (to confirm existing data and to address data deficiencies; Tables 4-8 and 4-12).

The North-Northwest Corner group is upgradient (see Figures 3-7 and 3-9). The Western Third group includes wells located in the area in which the overlying Indian Springs Shale member of the Big Clifty Formation is present (potential aquitard to vertical flow to the Beech Creek). The Eastern Two-thirds group includes several wells along the valley axis

where the Indian Springs Shale is absent. The western half of this latter group also includes wells with the highest TCE levels detected on-site.

Well 03C09P2 monitors the Beech Creek aquifer beneath the northwestern portion of ABG (also where the Indian Springs Shale aquitard is present). Well 03C09P2 is located on the upgradient side to ABG. Historically, usually the highest TCE levels (for the north-northwest corner and the western one-third of the site) have been detected in this well. TCE has been detected consistently and at persistent levels in the range of 51 to 136 ug/l for the period from October, 1987 to January, 1992. In addition, the explosive RDX was detected on 13 occasions in the range of 20 to 70 ug/l. Well 03C09P2 is located with another well (03C09 screened in the Beaver Bend) as a well nest.

Samples from wells 03C10 and 03C14 should be representative of groundwater quality beneath this portion of the site. TCE has been detected historically in these wells, possibly decreasing levels occurring at well 03C14.

Well 03C15 is located in a downgradient area with respect to secondary groundwater flow from the western portion of ABG. TCE has been detected infrequently in this well (at levels in the range of 7 to 640 ug/l). TCE has not been detected in this well since July 1989. This well demonstrates low potential for off-SWMU TCE impacts (towards the southwest).

Five wells located on-site are representative of current groundwater quality beneath the eastern two-thirds of ABG:

- 03C03P2
- 03C08AP2
- 03C11
- 03C20
- 03C0 2P2

Three of these wells, 03C03P2, 03C11, and 03C02P2, are located within a vulnerable zone with respect to potential contaminant impacts in the Beech Creek aquifer. This vulnerable zone is characterized by the absence of the Indian Springs Shale aquitard along the valley bottom in the eastern two-thirds of ABG (as mentioned previously). Well 03C03P2 has demonstrated persistent and elevated detections of TCE (usually above 100 ug/l for the period from October, 1987, through January, 1992). Three explosives (HMX, TNT and RDX) have been detected in this well, including the highest RDX levels on-site (up to 709 ug/l RDX on April, 1988; RDX levels above 100 ug/l on eleven occasions).

Well 03C11 has consistently demonstrated the second highest TCE levels on-SWMU (after well 03C20, see below) with TCE levels possibly increasing since April, 1991 (since then, TCE has exceeded 1,200 ug/l on four occasions).

Well 03C02P2 is located in the easternmost portion of ABG, south and southeast of well 03C12. Sampling at this well monitors an area characterized by both the absence of the Indian Springs Shale aquitard and the presence of solution cavern passages in the Beech Creek limestone which has caused the collapse of the overlying Big Clifty sandstone. This area is believed to be characterized by a high gradient, high flow velocity karst conduct system, as described in the Phase III Report (Murphy, 1992a). TCE and RDX have consistently been detected at 03C02P2 at moderate to low levels.

Well 03C05 is located potentially downgradient of the eastern-most portion of ABG. Although TCE has been detected only infrequently in this well, TNT and RDX were recently detected (1992) at levels of 10 ug/l and 50 ug/l, respectively.

Well 03C20 is located along the southern edge of ABG, west of the former ash pile. The highest TCE levels detected at ABG have occurred on a consistent basis at this well. TCE levels generally exceed 1,000 ug/l (maximum of 17,849 ug/l in October, 1990).

Well 03C08AP2 is located downgradient of well 03C20 and monitors potential downgradient impacts with respect to 03C20. TCE has been detected at 03C08AP2 on 17 occasions (of 18 sampling events from November, 1987 through January, 1992). TCE has been detected in the range of 8 to 52 ug/l and may possibly be increasing since October, 1991. This well is also characterized by the highest average barium level at ABG (131 ug/l, as presented in the Phase III Report (Murphy, 1992a). Well 03C08AP2 is located at a well nest (with well 03C08A screened in the Beaver Bend aquifer).

Well 03C17 (off-SWMU) has been selected for re-sampling to verify current background water quality for this aquifer and the southern springs (Table 4-12). This well is located upgradient to ABG (2,000 feet north of ABG) and was used as the regional background well in the Phase III Groundwater Release Characterization Report (Murphy, 1992a).

Other than the upgradient (background) well 03C17, the Halliburton NUS Team is not recommending that any additional samples be collected from Beech Creek wells, except with respect to those in the Jeep Trail Area (discussed below). The highest groundwater contaminant levels historically have been on-SWMU at ABG, and the risk assessment database will rely primarily on the on-SWMU water quality results. No plumes of chemical contamination have been detected to date emanating from ABG. The major exception is the Jeep Trail area along Little Sulphur Creek, which will be addressed separately at the end of this Section of the Work Plan.

TABLE 4-12

ABG PROPOSED SAMPLING FOR GROUNDWATER(1)

Monitoring Well	Aquifer	Parameters	Rationale
03C17	Beech Creek	Inorganics, VOCs, SVOCs, and explosives	Supplement existing database for parameters currently lacking; off-SWMU/upgradient well, to provide background data for Beech Creek aquifer and southern springs.

NOTE: (1) P indicates nested well(s) which are located at well base number shown on figures.

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Big Clifty

A limited number of Big Clifty (sandstone) wells are present on-SWMU at ABG (see Table 4-9 and Figures 3-7 and 3-9). For some of these wells, the screened interval apparently includes the contact zone with the underlying Beech Creek limestone (03-01, 03-31, 03-32, 03-33, 03-34, 03-38 (Hunt, 1988)). The Phase III Report considered the Beech Creek and Big Clifty to be one aquifer (middle aquifer zone). For the risk assessment, an attempt will be made to distinguish Big Clifty sandstone wells, where possible. As part of the preparation for the risk assessment, the boring logs for the Big Clifty wells will be reviewed to confirm the screened intervals listed in the Phase III Report. Data obtained from wells screened in the Big Clifty will be grouped and evaluated separately from the data obtained from Beech Creek wells.

TCE has been consistently detected in several Big Clifty wells, including 03-38, located in a potentially upgradient portion of the SWMU characterized by the presence of the Indian Springs Shale. RDX has also been detected on eight occasions at well 03-38.

Four wells (03-34, 03-32, 03-33, and 03-31) are located in an area characterized by collapse of the Big Clifty formation due to solution cavern passages within the underlying Beech Creek (Murphy, 1992a). The stratigraphic location of the well screens in these wells apparently spans the contact between the Big Clifty sandstone and the underlying Beech Creek limestone (zone of solution cavern collapse). Past detections at these wells include TCE, TNT, RDX, lead, bis(2-ethylhexyl)phthalate and barium.

The analytical data in the existing database is adequate for use in the risk assessment. No supplemental data is recommended for Big Clifty sandstone wells since the most significant contamination in groundwater at ABG has been documented to occur in the Beech Creek limestone (which directly underlies and communicates with the Big Clifty sandstone). The existing Big Clifty wells which have been sampled are located in the general proximity of Beech Creek wells which usually have demonstrated comparable (or greater) detections of contaminants such as TCE and RDX.

The existing database for Big Clifty wells includes analytical results for three off-SWMU Big Clifty wells: 03-01, 03-09 and 03-30. No additional data collection (water quality sampling) is recommended for the off-SWMU wells.

Golconda

The Golconda limestone occurs near the northern, southern, and western edges of ABG, west and north of the SWMU, and south along a topographic high zone located between Johnson Hollow and Little Sulphur Creek. This unit has been removed by erosional

processes (and is therefore absent) in the central portions of the SWMU and in the valleys of Little Sulphur Creek and Johnson Hollow. "Groundwater flow in the monitored portion of the Golconda/Haney at the ABG is toward the east and north from the west and south, where the formation drains into the valley. Contamination in the Golconda/Haney, which has been shown to be primarily TCE, is probably limited to the southwest quadrant of the ABG with ultimate migration into the lower Big Clifty/Beech Creek aquifer in the central and east portions of the ABG" (Murphy, 1992a).

Analytical data exist for all the Golconda wells on-SWMU at ABG and for the three off-SWMU wells (see Table 4-10 and Figures 3-7 and 3-9). TCE has been detected on at least three occasions (on five occasions at well 03C22). Well 03C22 monitors the southwestern portion of the SWMU. The maximum TCE level (300 ug/l) for all of the Golconda wells occurred at this well. Well 03C08AP3 is located south of the former ash pile near the southern edge of ABG. The maximum barium level was detected at this well (140 ug/l). The explosive RDX was detected in only one Golconda well (03C08AP3: detected on three occasions, at a maximum level of 30 ug/l).

The existing analytical database is adequate and useable for the risk assessment.

Well 03-28 is located near 03C08AP3 and the Phase III Report indicates this well has also been sampled since September, 1987; however, the analytical data for this well were not included in the Phase III Report. It should be obtained and reviewed as part of the risk assessment.

Alluvial Wells

The majority of these wells are located south of ABG and the Jeep Trail area, at the confluence of Little Sulphur Creek with Johnson Hollow ("B" well series, Table 4-11). These alluvial wells are shown on Figure 3-7. As previously noted, groundwater from ABG (within the Beech Creek) discharges to springs and to Little Sulphur Creek (alluvium); therefore, the "B" wells are used to monitor impacts (from upgradient and upstream contaminant sources) to surficial (alluvial) groundwater at the facility boundary.

The existing analytical database for these wells will be summarized for the risk assessment and will be used qualitatively to address potential contaminant migration. Data such as that representing the "B" wells is recommended for use to assess the potential extent of any contaminants that may have migrated off-facility and downgradient. In addition, two of the "B" wells (03B02 in alluvium and 03B10 in the Beech Creek) will be used quantitatively to calculate exposure to off-facility residents (see Section 4.2.4).

Well 03-07 (alluvial well) is located in the Jeep Trail area and will be discussed separately (below).

Jeep Trail Area

The Jeep Trail area is located south of ABG, along Little Sulphur Creek (see Figure 3-8). It is recommended that this area of past activities be evaluated separately in the risk assessment.

Seventeen monitoring wells have been installed in the Jeep Trail area (Dunbar, 1984a; Murphy, 1992a) (Tables 4-8 and 4-11). According to the Phase III Report, the majority of these wells were screened in the Beech Creek aquifer. Well 03-07 was installed in the valley alluvium within the projected elevation of the Beech Creek formation as observed in the adjacent valley wall (Murphy, 1992a). Well 03-07 is the only well that was sampled in conjunction with ABG wells during the period from September, 1987, through January, 1987. The analytical data for this well were not included in the Phase III Report but were summarized in the text. TCE reportedly was detected in all eleven sampling events with an average level of 1,304 ug/l TCE (maximum TCE detected was 7,102 ug/l in October, 1991). The database for this well is incomplete (analyses did not include metals, and only four organic compounds were monitored). It is recommended that this well be sampled for the parameters identified in Table 4-13.

A limited and incomplete database exists for groundwater samples collected prior to 1987 for the majority of Jeep Trail wells. It is recommended that existing Jeep Trail wells be tested for integrity before committing them to a sampling program. Integrity testing would consist of bailing the wells and allowing them to recover to ensure that the wells are still operative. Subsequently, all wells with established integrity in the Jeep Trail Area should be sampled in 1995 to provide a current and complete database for the risk assessment. The analytical data for all of the newly sampled wells will be combined and evaluated as a single data set in order to select the chemicals of potential concern for the risk assessment for the Jeep Trail area.

Based on the analytical data collected prior to 1987, TCE was detected in several wells. The highest TCE levels were observed in the following six wells:

- 03-12
- 03-15
- 03-20
- 03-23
- 03-24
- 03-25

The maximum TCE level (except for that occurring at well 03-07) was measured at well 03-12 (386 ug/l). 1,1,1-Trichloroethane was also detected in several wells (maximum of

TABLE 4-13

JEEP TRAIL AREA PROPOSED SAMPLING FOR GROUND WATER

Monitoring Well	Aquifer	Parameters	Rationale
03-07	Alluvium/Beech Creek	(a)	Verify existing database; high levels TCE detected (7,102 ppb in October, 1991).
03-12	Beech Creek [A]	(a)	Recent and complete analytical database lacking; historically elevated TCE levels; representative of Jeep Trail wells.
03-15	Beech Creek [A]	(a)	Recent and complete analytical database lacking; historically elevated TCE levels; representative of Jeep Trail wells.
03-24	Beech Creek	(a)	Recent and complete analytical database lacking; historically elevated TCE levels; representative of Jeep Trail wells; deepest well at Jeep Trail area (screened internal 42.0 - 51.4 feet in depth).
03C34	Beech Creek	(a)	Verify that a significant groundwater pathway does not exist to east and southeast of Jeep Trail area (in lieu of groundwater modeling).

NOTES: "(a)" = Inorganics, VOCs, SVOCs, explosives.

[A] Phase III Report (Murphy) lists screened interval for most of Jeep Trail wells as Beech Creek; based on well depths (base of screened intervals being less than 30 feet), some of these wells may actually be screened in alluvium but are within the projected elevation of the Beech Creek formation, as observed in the adjacent valley walls; the risk assessment for Jeep Trail wells will present verification of their screened intervals.

40 ug/l at well 03-25). Other VOCs detected (prior to 1987) at the Jeep Trail area include chloroform, methylene chloride, tetrachloroethylene, trichlorofluoromethane, and trans-1,2-dichloroethylene. The highest priority wells recommended for sampling are wells 03-12, 03-15, and 03-24 (deepest well at Jeep Trail). These wells should be sampled for all analytes, in addition to well 03-07 (which was recommended previously). These wells are listed on Table 4-13. It is also recommended that all other Jeep Trail wells with established integrity be sampled (well integrity testing may also necessitate that other Jeep Trail wells be substituted for the highest priority wells listed on Table 4-13 in the event that these wells are no longer in usable condition). As part of the preparation for the risk assessment, additional information should be obtained to confirm exact well locations, elevations, and screened intervals (formations) for these Jeep Trail wells.

Proposed New Wells

No new wells have been proposed at ABG or off-SWMU (including the Jeep Trail area). Although no wells have been installed in the Beaver Bend aquifer off-SWMU, this aquifer has been sufficiently characterized on-SWMU at ABG. This aquifer has not been impacted to the same degree as the Beech Creek aquifer. TCE detections have occurred less frequently and at lower levels in the Beaver Bend when compared to the Beech Creek. In addition, only one TCE detection in the Beaver Bend (since January 1989) has exceeded the MCL for TCE (as discussed previously). The Elwren Shale has been interpreted to be an effective hydraulic barrier to groundwater moving through the Beech Creek aquifer, limiting the potential for contaminants to migrate into the Beaver Bend aquifer. For these reasons, it is unlikely that the Beaver Bend has been impacted off-SWMU by contaminants originating from past activities at ABG and at the Jeep Trail area.

4.2.3.5 Air

At the time of the writing of this risk assessment work plan no ambient air data have been collected at ABG. Two separate CTOs have been issued by the Navy to address chemical emissions and air dispersion modeling, respectively, at these three SWMUs. Below is a discussion of how the outputs from these CTOs will be incorporated into this baseline risk assessment.

Air dispersion modeling of volatile and particulate emissions associated with the operation of the ABG, ORR, and DR has been conducted for the purpose of obtaining maximal ambient air concentrations of the various constituents in the emissions database (Halliburton NUS). Chemical emissions will be calculated for each of the thermal treatment processes (ENSR), taking into consideration the waste-specific quantities involved and the frequency of use of each activity. An appropriate computer model will be utilized to calculate emission rates when they cannot be ascertained empirically. Chemical emission

rates will then be incorporated as inputs to an approved air dispersion model for each SWMU. Meteorological data from the National Weather Service in Evansville, Indiana, covering a five-year period, is also suggested as input into the air dispersion models.

The output of the air dispersion modeling analysis will be a SWMU-specific topographic map overlaid with a combined (all activities) air dispersion isopleth map. An isopleth as used here is a line linking points/locations having identical predicted ambient air concentrations for an analyte. The combined data will identify the maximum on-facility and off-facility ambient air concentrations of contaminants resulting from the thermal treatment processes from all three SWMUs, as well as the ambient air concentrations of the various chemicals of potential concern at the various exposure point locations of the risk assessment receptor populations. These air concentrations will be used to assess the risk to on- and off-facility receptors from inhalation of contaminated air associated with the operation of each SWMU.

Additionally, the deposition rates of the chemicals of potential concern in ambient air will be used to calculate future chemical accumulation in all off-facility environmental media that will be addressed and on-facility in the area of Lake Greenwood, e.g. soil and surface water. The contribution of continued air emissions to the concentration of chemicals in these environmental media will be necessary for the calculation of exposure doses of those receptors modeled in Scenario A.

The air emissions associated with the detonation of white phosphorus munitions at the Demolition Range (DR) have already been modeled by Halliburton NUS (1992a). It was determined through a review of experimental data that the only potentially toxic by-product of this process was phosphorus pentoxide (P_2O_5). A model developed by Sheih (1978) was used to evaluate the air dispersion of the cloud of combustion products associated with this detonation process.

Three detonation configurations were modeled: 20, 30, and 40 shells with each shell containing 15.6 pounds of phosphorus. The output of the modeling was the maximum impact distance (the maximum downwind distance at which the air concentration exceeds the threshold value) for a number of stability/windspeed classes for each configuration. The 15-minute average concentration for phosphoric acid mist of 3 mg/M^3 (ACGIH, 1990) was selected as the threshold value. The deposition velocity of phosphoric acid was determined to be 0.001 m/s from the scientific literature. Halliburton NUS will provide the isopleth maps showing the maximum on- and off-facility ambient air concentrations of P_2O_5 for use in the risk assessment.

4.2.4 Environmental Fate/Disposition of ABG Contaminants

The currently existing groundwater contamination database at ABG shows: a) that some site contaminants have varied little in concentration over the past several years, and b) that no identifiable plumes of contamination are emanating from ABG. These findings suggest that the groundwater contamination, as presently measured at ABG, may be in a steady-state condition. Thus, for the risk assessment, no groundwater transport modeling of contaminants from ABG is proposed. Rather, the database as it exists will be used for estimating risk to on-facility receptors, and data from two wells placed at the furthest location downgradient, but on NAVSURFWARCENDIV property, will be used to represent exposure to off-facility residents. These latter two wells are the existing Beech Creek well 03B10 and the existing Alluvium well 03B02, located near the confluence of Johnson Hollow and Little Sulphur Creek (Tables 4-8 and 4-11).

The current chemical levels in surface soil, surface water, and sediment will be used as exposure assessment input to all three of the exposure scenarios for on-SWMU receptors. The assumptions being made in this approach are that: a) the present loading and cleanup activities at this SWMU are unlikely to further degrade these media due to the recent facility upgrades at this SWMU, and b) that the air emissions in the future, because they will be essentially identical to those in the past, also will not lead to further degradation of these on-SWMU media, i.e. steady-state conditions with respect to this source of contamination are assumed to exist.

For off-facility receptors in Scenario A, the air emissions data will be used to estimate concentrations of hazardous constituents in off-facility environmental media (soil, plants) for the purpose of estimating exposure to nearby residents if bioaccumulative and/or particulate-bound chemicals are present in air. Air emissions data of bioaccumulative/ particulate-bound chemicals will also be used to estimate contaminant concentrations in the vicinity of Lake Greenwood water and nearby soil to assess exposure to base personnel/families.

4.3 ORR CONCEPTUAL MODEL

4.3.1 General Overview

Based on the descriptions of the past and present open burning activities at ORR (Section 3.4.3), two observations pertinent to the risk assessment are noted. First, it is likely that hazardous constituent contamination due to past activities has occurred in SWMU soil, surface water, sediments, and groundwater. Secondly, this SWMU is comprised of two separate activities - - the flash pit area and an area to the south that is used for target practice. Thus, each of these 'subsites' should be considered a potential

source of chemical contamination in the risk assessment. Current activities also lend to contaminants being emitted into the ambient air from both of these activity areas.

4.3.2 Conceptual Model Detailed Description

Scenario A (Figure 4-1 A-D) is the scenario wherein the current activities at ORR are assumed to continue indefinitely. Under this scenario, base personnel and their families would be assumed to be exposed to SWMU-impacted media near Lake Greenwood, including contaminants in ambient air as a result of the open burning activities. Likewise, the off-facility residents would be expected to be exposed to airborne emissions from exposure from these open burning activities. If toxic, bioaccumulative metals and/or environmentally persistent organic chemicals are found to be emitted into the ambient air from ORR, there is the potential for contamination of secondary and tertiary media, e.g. soil, plants, in the vicinity of these off-facility receptors. Lastly, because this open burning activity is assumed to continue at ORR indefinitely, exposure of SWMU workers to site contamination is expected to occur. SWMU workers would be expected to be exposed to contaminated air and surface soil.

In Scenario B (Figure 4-2), ORR activities are assumed to stop at some time in the future (e.g. 100 years). This area would then be converted into a public park/natural area. Visitors to and employees of this park/natural area would thus be expected to come into contact with contaminated surface soil, surface water, sediment, and groundwater at this site. With respect to groundwater contamination at ORR, a drinking water well would be assumed to be placed in any aquifer below this area and at any location within this site. Thus, exposure to groundwater will be based on monitoring well data aggregated separately for each aquifer at ORR, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well.

In Scenario C (Figure 4-3), ORR activities are also assumed to stop at some time in the future (e.g. 100 years), but the base is assumed to be converted into a rural residential area. Residents living on the former SWMU would be expected to come into contact with contaminated surface soil, surface water, sediment and groundwater. As in Scenario B, exposure to groundwater will be based on monitoring well data aggregated separately for each aquifer at ORR, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well. Future residents would also be expected to consume vegetables grown in contaminated soil in home gardens, and consume contaminated beef and milk from cattle raised for their own consumption. Finally, future residents would be expected to consume local deer and turkeys that they hunt.

4.3.3 Review and Analysis of Existing Analytical Database for ORR

4.3.3.1 Soil

The ORR is one of NAVSURFWARCENDIV's open burning areas. Flashing, a thermal treatment process for explosive wastes, was and is carried out at this site in flash pits. The USACE (USACE, 1991) conducted a RFI Phase II soil investigation at the ORR to: 1) describe soil conditions around the site, 2) identify and characterize the flashing operation residuals, and 3) determine if operation residues have spread away from the flash pits.

Thirteen test borings were advanced at the ORR to collect soil samples for physical characterization and chemical pollutant identification (Figure 3-16). The samples were grouped for the purpose of analyses into "control or background" borings, located several hundred feet to the southwest of the flash pits and up-slope from those waste disposal facilities; "inside the flash pits", "west of the flash pits", and "east of the flash pits." Soil samples were taken from specific layers within the sample borings; the depth from which each soil sample was taken is shown in Figure 4-5.

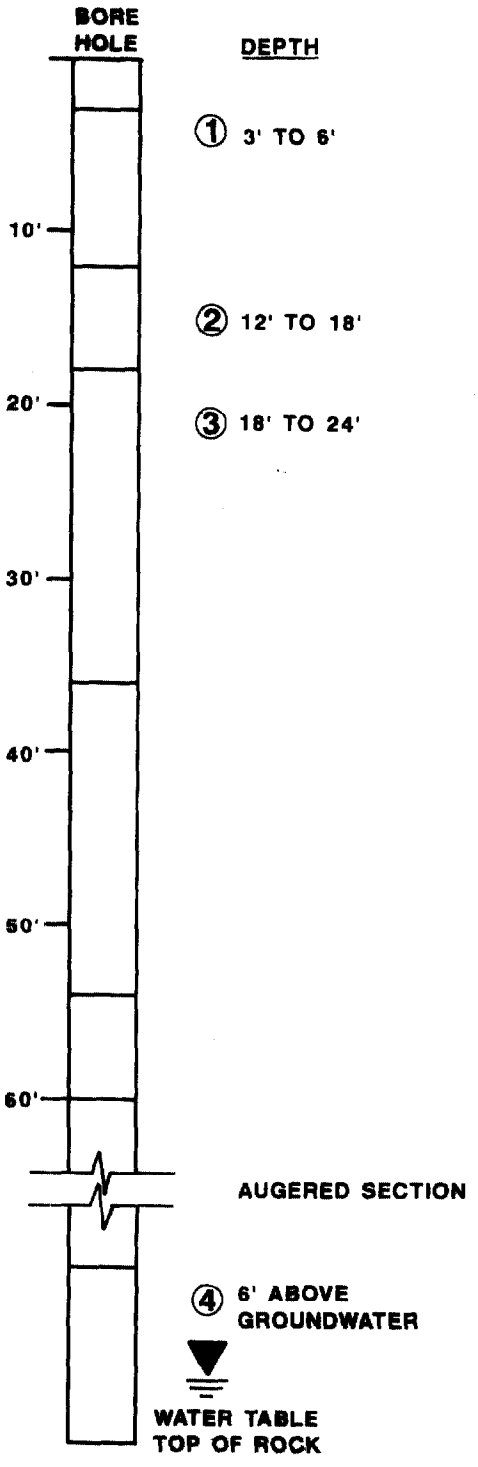
Flash pit soils contained residues of magnesium, copper, lead, tin, and sodium. Total phosphorus was not evident as a waste activity residue within the flash pits but was observed in greater concentrations in soil near the flash pits.

Several soil samples collected outside of the flash pits, including control samples, had distinct concentration peaks of a number of different metals which were not observed in the flash pit soils. These concentration peaks were thought to be either the result of natural variability in the chemical characteristics of these soils or some anthropogenic effect unrelated to the flashing activity (U.S. Army, 1991).

Some explosive compounds were detected in soil within the flash pits and in nearby surface soil. ORR soil also contained low concentrations of several VOCs. Soil samples within the flash pits contained PAHs and a phenol at low concentrations. However, there was no clear pattern of contamination of ORR soils with SVOCs which could be attributed to waste disposal activities at the flash pits.

The Phase II soil samples collected in the vicinity of the flash pits are viewed as being adequate for characterizing soil contamination in the flash pit area at the ORR.

An area of the ORR not addressed by the Phase II soils report, however, is the target practice area. Lead, in particular, is expected to be a chemical of potential concern in this location. Therefore, it is recommended that three surface soil samples (0-6" grid composites) be collected from the target area. Chemical concentrations in these samples



	DEPTH	ANALYTE	
①	3' TO 6'	METALS, EXPLOSIVES	
②	12' TO 18'	METALS, EXPLOSIVES	
③	18' TO 24'	METALS, EXPLOSIVES	
		SOIL CHARACTERIZATION SIZE DISTRIBUTION, MOISTURE CONTENT	
④	6' ABOVE GROUNDWATER	METALS, EXPLOSIVES	
		VOLATILE ORGANICS	8240
		SEMIVOLATILE ORGANICS	8270

SOURCE: USACE, 1991

RUST ENVIRONMENT & INFRASTRUCTURE

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FIGURE 4-5
DIAGRAM OF BORING LOG WITH SAMPLE POINTS NWSC CRANE PHASE II SOILS
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

will be averaged with those selected for inclusion from the ORR for comparison with background samples.

Background samples collected in the Phase II soils report for the ORR contained the highest levels of some metals of all samples collected on site. For this reason, there is some question as to whether or not these are truly representative of background levels of analytes at ORR. Therefore, three new background samples will be collected for ORR (Table 4-2). See Table 4-1 for recommended additional surface soil sampling at ABG, ORR, and DR. Proposed background surface soil sampling locations are shown on Figure 3-16. These locations are located to the north (upgradient) of the ORR within the same soil type (Wellston Silt Loam) as mapped by the SCS (McElrath, 1988).

4.3.3.2 Surface Water/Sediment

To date there have been no surface water nor sediment investigations at the ORR or at the DR. Therefore, a sampling plan has been designed in this Work Plan to characterize potential contamination of surface water and sediments which may have occurred as a result of waste disposal activities at these two SWMUs. The analytical parameters selected (VOCs, SVOCs, inorganics, explosives, and water quality parameters) are discussed with the proposed sampling plan (Section 9). The analytical results provided through this sampling plan will be screened as described in Section 4.5 to determine the chemicals of potential concern in surface water and sediment for the risk assessment.

Table 4-14 lists the surface water and sediment sampling locations proposed for ORR and DR. This table also summarizes the rationale for sample selection. The locations are shown on Figure 3-13. Single one-time surface water and sediment samples should be collected from Turkey Creek and Boggs Creek, as described in Table 4-14. The creek sampling locations include an upstream (background) sample site for both Turkey Creek and Boggs Creek. USEPA has recommended that sampling of surface water and sediment in the four man-made ponds used to control surface erosion and run-off from both ORR and DR: Pond #001, Pond #002, Pond #003, and Pond #004 not be conducted. These ponds are cleaned out every two to six years and are already regulated through the NPDES program. These ponds, therefore, will not be evaluated in the risk assessment.

For the risk assessment, creek surface water and sediment analytical results will be evaluated separately (evaluated per medium). Within each medium, analytical data will be grouped (where possible) according to sample location and evaluated independently. For example, surface water data collected from the upstream sampling location (SWMU background) for Turkey Creek (T-1) will be combined with the data from the upstream location (SWMU background) for Boggs Creek (B-1), as long as analytical results are qualitatively similar (uniform). Finally, analytical data for downstream sample locations in

TABLE 4-14

DR AND ORR PROPOSED SAMPLING OF SURFACE WATER AND SEDIMENTS[A]

Sample Designation	Location	Sample Types	Rationale
T-1	Turkey Creek; 1,800 feet northeast of ORR	Water and sediment	Upstream (background) of SWMU; currently, no analytical data exists.
T-2	Turkey Creek; opposite ORR; near well 06C11	Water and sediment	Identify potential impacts to Turkey Creek related to surface run-off and potential groundwater discharge from ORR; currently, no analytical data exists.
T-3	Turkey Creek, opposite southeastern edge DR; 800 feet south of well 06C03	Water and sediment	Identify potential impacts to Turkey Creek related to surface run-off and potential groundwater discharge from DR; currently, no analytical data exists.
B-1	Upper Boggs Creek; 500 feet south of Highway 45, northwest of DR.	Water and sediment	Upstream (background) of SWMU; currently no analytical data exists.
B-2	Boggs Creek: opposite western portion of DR.	Water and sediment	Identify potential impacts to Boggs Creek related to surface run-off and potential groundwater discharge from DR; currently no analytical data exists.
B-3	Boggs Creek, opposite southern portion of DR; opposite Pond #001	Water and sediment	Identify potential impacts to Boggs Creek related to surface run-off and potential groundwater discharge from DR; currently, no analytical data exists.

[A] Single one-time sampling events.

Boggs Creek will be grouped and evaluated separately from downstream Turkey Creek data.

4.3.3.3 Groundwater

As part of a RFI at NAVSURFWARCENDIV, hydrogeologic investigations have been conducted by the USACE to evaluate subsurface conditions and the degree and extent of potential chemical release to groundwater at ORR. Well logs, well construction diagrams, groundwater contour maps, and groundwater quality data were prepared and presented in three previous reports (which were reviewed in preparation of this work plan):

- Draft RFI Phase III Release Characterization Report SWMU 07/09 ORR (Murphy and Wade, 1994b).
- Hydrogeologic Investigations of Waste Disposal Sites at the Naval Weapons Support Center, Crane, Indiana (Dunbar, 1982).
- Hydrogeologic Site Characterization of Old Rifle Range for Hazardous Waste Disposal Facility, Naval Weapons Support Center, Crane, Indiana (Dunbar, 1984b).

Eleven monitoring wells were installed in 1982 and 1984 at ORR, to characterize the surficial hydrogeology. An additional 19 monitoring wells were then installed at ORR in 1990 by USACE ("06C" wells) in order to further characterize both surficial aquifers and to evaluate the Beech Creek limestone aquifer which represents the deepest unit currently monitored at ORR (see Figures 3-13 and 3-16). In preparation of this work plan, all well logs and well construction diagrams for these wells were reviewed in detail (Hunt, 1990). In addition, groundwater contour maps for the Beech Creek aquifer and for the Golconda aquifer (May/June and November, 1991) were reviewed for this work plan (Murphy, 1993). Groundwater contour maps for the surficial aquifer zone (May/June and November 1991) were also reviewed to confirm flow directions.

Twenty-eight monitoring wells were sampled for four consecutive quarterly sampling events ending in April 1992. The analytical parameter list (Table 4-15) is generally complete for the risk assessment, with respect to inorganics, VOCs, SVOCs, pesticides/PCBs, and explosives. Table 4-16 is a summary of the analytical data parameters available from the sampling program for the ORR monitoring wells, organized in terms of each water-bearing zone that was monitored. These existing analytical data will be used as the primary database for groundwater for the risk assessment.

TABLE 4-15

ORR/DR ANALYTICAL PARAMETERS
EXISTING DATABASE FOR GROUNDWATER
(1990 - 1991)

INORGANICS

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Cyanide
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Sulfide
Thallium
Tin
Vanadium
Zinc

VOLATILE ORGANICS

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Carbon Tetrachloride
Carbon Disulfide
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
cis-1,2-Dichloroethene
cis-1,3-Dichloropropene
Dibromochloromethane
Ethylbenzene
Methylene Chloride
Styrene
Tetrachloroethene
Toluene
Trans-1,2-Dichloroethene
Trans-1,3-Dichloropropene
Trichloroethene
T-Xylene
Vinyl Acetate
Vinyl Chloride
1,1-Dichloroethane
1,1-Dichloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
1,2-Dichloroethane
1,2-Dichloropropane
2-Butanone
2-Hexanone
4-Methyl-2-Pentanone

SEMI-VOLATILE ORGANICS

Acenaphthene
Acenaphthylene
Aniline
Anthracene
Benzidine
Benzoic Acid
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Benzyl alcohol
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl)phthalate
Butylbenzylphthalate
Chrysene
Dibenzofuran
Dibenzo(a,h)anthracene
Dibutylphthalate
Diethyl phthalate
Dimethyl phthalate
Di-n-octylphthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-c,d)pyrene
Isophorone
Naphthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitroso-di-n-propylamine
N-Nitrosodiphenyl amine
Pentachlorophenol
Phenanthrene
Phenol
Pyrene
1,2-Dichlorobenzene
1,2-Diphenylhydrazine
1,2,4-Trichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Chloronaphthalene
2-Chlorophenol
2-Methyl-4,6-dinitrophenol
2-Methylnaphthalene
2-Methylphenol
2-Nitroaniline
2-Nitrophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,6-Dinitrotoluene
3-Nitroaniline
3,3'Dichlorobenzidine
4-Bromophenyl ether
4-Chloro-3-methylphenol
4-Chloroaniline
4-Chlorophenyl phenyl ether
4-Methylphenol
4-Nitroaniline
4-Nitrophenol

TABLE 4-15 (Continued)

ORR/DR ANALYTICAL PARAMETERS
EXISTING DATABASE FOR GROUNDWATER
(1990 - 1991)

PESTICIDES/PCBs		EXPLOSIVES
A-BHC	PCB-1016	DNB
a-Chlordane	PCB-1221	HMX
A-Endosulfan	PCB-1232	RDX
Aldrin	PCB-1242	TETRYL
B-BHC	PCB-1248	TNB
B-Endosulfan	PCB-1254	TNT
D-BHC	PCB-1260	2,4-DNT
Dieldrin	Phorate	2,6-DNT
Disulfoton	PPDDD	
Endosulfan sulfate	PPDDE	
Endrin	PPDDT	
Endrin aldehyde	Toxaphene	
Ethyl parathion		
Famphur		
G-BHC		
g-Chlordane	2,4-D	
Heptachlor	2,4,5-T	
Heptachlor epoxide	2,4,5-TP	
Kepone	Dinoseb	
Methoxychlor		
Methyl parathion		

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TABLE 4-16

ORR GROUNDWATER SUMMARY OF ANALYTICAL PARAMETERS FOR EXISTING DATABASE (1990 - 1992)

	HYDROGEOLOGIC UNIT *	
Parameter Group	Beech Creek	Surficial Aquifers
Inorganics	11/91-4/92	6/91-4/92
Volatile Organic Chemicals	11/91	6/91-11/91
Semi-volatile Organic Chemicals	11/91	6/91-11/91
Pesticides/PCBs	11/91	6/91-11/91
Explosives:		
HMX	11/91-4/92	6/91-4/92
RDX	11/91-4/92	6/91-4/92
TNT	11/91-4/92	6/91-4/92
DNB	11/91-4/92	6/91-4/92
TETRYL	11/91-4/92	6/91-4/92
TNB	11/91-4/92	6/91-4/92
2,4-DNT	11/91-4/92	6/91-4/92
2,6-DNT	11/91-4/92	6/91-4/92
Nitrate	4/92	4/92

NOTES: *: Table lists the dates (i.e., "11/91") for the most recent sampling events that include the designated parameters. In some cases a range in dates is shown because not all of the monitoring points within a given group were sampled for the entire analyte list on the most recent sampling date.

The existing analytical data will be evaluated according to well groupings (discussed below). In addition, this database will be supplemented with new data, recommended for collection in 1995. Additional sampling at selected wells will be conducted to provide confirmation of the existing database and to establish that potential contaminant levels have not changed significantly since April 1992.

In general, contaminants detected in groundwater at ORR include metals (in both the surficial aquifer and in the Beech Creek limestone), explosives and nitrate. A few metals have been reported at levels exceeding primary or secondary MCLs such as antimony, iron, and manganese. Antimony has been consistently detected above the MCL of 6 mg/l (at levels 2 to 3 times the MCL) in several wells. Other metals detected include aluminum, copper, lead, nickel, and zinc. Metals present in Beech Creek wells at statistically elevated levels above background (Well 06C07) were manganese and arsenic (arsenic had "borderline" significance only, according to Murphy and Wade, 1994b). Metals detected in the surficial zone wells at statistically elevated levels above background (Well 06C07) were arsenic, manganese and nickel (Murphy and Wade, 1994b).

Explosives (TNT, RDX, HMX, and 2,6-dinitrotoluene) have been detected in a few wells, at low to moderate levels (up to 148 ug/l). Explosives were detected only at ORR. The explosives HMX, RDX, and TNT were detected in only five wells, and these wells are located in the northern portion of ORR (Murphy and Wade, 1994b). These five wells include both the Beech Creek aquifer and the surficial zone, although detections were usually more frequent and at higher levels in the surficial wells. Four of these wells were also associated with the highest detected concentrations of nitrate (>3 mg/L) when compared to all other wells at ORR and DR (Murphy and Wade, 1994b).

In addition, a few organic chemicals and pesticides, frequently detected in blank samples, were reported for various wells. PCBs have also been detected at low levels (less than 1.0 ug/l).

Groundwater monitoring wells at ORR were grouped according to aquifer and/or hydrogeologic position (i.e., surficial wells). For the risk assessment, each aquifer zone will be evaluated individually. In some cases, wells were further grouped within a given aquifer to reflect well locations with respect to estimated groundwater flow directions and proximity to surface water bodies (such as Turkey Creek). Summary tables have been prepared which list the monitoring wells installed within each aquifer zone: Beech Creek limestone, surficial aquifers zone (Big Clifty sandstone and/or clay), and Golconda limestone (Tables 4-17, 4-18, and 4-19, respectively). Wells recommended for additional (confirmational) sampling were selected from several of the groupings shown in these tables. The six wells to be sampled have been designated ("underlined") on each of these tables. The rationale for sampling is summarized in Table 4-20.

TABLE 4-17

ORR GROUNDWATER WELL GROUPINGS FOR BEECH CREEK AQUIFER

North	South [B]	Perimeter Turkey Creek [C]
06C16 [A]	06C10	06C14
06C15	06C12	06C13
06C09		06C18
06C17		06C11

NOTES:

06C16: Underlining indicates well recommended for sampling.

[A] 06C16 located in an upgradient/side-gradient position with respect to local Beech Creek flow (groundwater contour maps for 5/91 and 11/91, provided by Murphy, 1993).

[B] These wells are located in an upgradient/side-gradient position with respect to local Beech Creek flow (groundwater contour maps for 5/91 and 11/92, provided by Murphy, 1993).

[C] This well grouping generally in a downgradient position with respect to local Beech Creek flow (groundwater contour maps for 5/91 and 11/91, provided by Murphy, 1993).

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TABLE 4-18

ORR GROUNDWATER WELL GROUPINGS FOR SURFICIAL AQUIFERS [A,B]

North	South	Perimeter Turkey Creek
06C16P2(BC) [C]	06-19 (CL)	06C14P2 (BC)
06C15P2 (BC)	06-14A (CL)	06C13P2 (CL/BC)
06-15 (BC)	06C12P2 (BC)	06C18P2 (CS/BC)
06-17 (BC)	06C10P2 (BC)	06C11P2 (CL/BC)
06-16 (BC)		
06-18 (BC)		
06-20 (BC)		
06-22 (BC)		
06-23 (BC)		

NOTES:

06-09: Underlining indicates well recommended for sampling.

A Water table zone wells (though well screens for some wells may be deeper than actual static water level); generally excluding potential perched water zones in surficial overburden; excluding Golconda Wells; formations screened indicated by the following abbreviations:

CL: Clay
CS: Clayey sand
BC: Big Clifty sandstone and weathered sandstone

B P indicates nested well(s) located at well base number shown on figures.

C 06C16P2: this well screened below 06C16P3 (nest); 06C16P3 is screened in Golconda limestone which may actually represent the water table or a perched water zone above the Big Clifty sandstone, in this location.

TABLE 4-19

ORR GROUNDWATER WELL GROUPINGS FOR GOLCONDA AQUIFER[A]

North

06-21 [B]

06C16P3

NOTES:

[A] P indicates nested well(s) located at well base number shown on figures.

[B] 06-21 originally logged as Mansfield (siltstone) and Glen Dean Limestone (Dunbar, 1984); based on area "C" well (deep) borings and logs, 06-21 probably screened in Hardinsburg/Golconda (logs prepared by Hunt, 1990). 06-21 is upgradient of ORR with respect to local water table.

TABLE 4-20

ORR PROPOSED SAMPLING FOR GROUNDWATER[A]

Monitoring Well	Aquifer	Parameters	Rationale
06C12	Beech Creek	(a)	Verify existing database.
06C18	Beech Creek	(a)	Verify existing database; representative of perimeter well grouping (Turkey Creek); elevated arsenic and manganese levels.
06C16	Beech Creek	(a)	Regional upgradient/background well; verify existing database. Data may be used to eliminate inorganic chemicals from the risk assessment's "chemicals of potential concern."
06C16P2	Surficial aquifers (Big Clifty Sandstone)	(a)	Regional upgradient/background well; verify existing database. Data may be used to eliminate inorganic chemicals from the risk assessment's "chemicals of potential concern."
06-17	Surficial aquifers (Big Clifty sandstone)	(a)	Verify existing database; representative of northern portion of SWMU; elevated nickel levels.
06C18P2	Surficial aquifers (clayey sand and Big Clifty sandstone)	(a)	Verify existing database; representative of perimeter wells (Turkey Creek), downgradient side to ORR; several metals detected including elevated levels of arsenic and manganese, and very elevated levels of iron.
06-22	Surficial aquifers (Big Clifty sandstone)	(a)	Verify existing database; near the flash pits; consistently positive for TNT.

NOTE: (a) = Inorganics, VOCs, SVOCs, Explosives, Nitrate.

[A] P indicates nested well(s) located at well base number shown on figures.

New water quality data from wells used for RCRA compliance monitoring purposes will also be used to update the risk assessment database.

Analytical data will be grouped and evaluated according to aquifer, and within each aquifer zone, according to on-SWMU wells versus perimeter wells. Within the surficial aquifer group, the northern wells will be evaluated separately from the southern wells (as listed on Table 4-18).

The zone of the surficial aquifers includes wells screened in the Big Clifty sandstone. The interpretation of the stratigraphic position (above) was based on a review of the "06C" well logs (Hunt, 1990). Dunbar (1982, 1984b) had previously described the uppermost bedrock as belonging to the Hardinsburg Formation. In preparation of the risk assessment, it is recommended that current/recent groundwater contour maps be obtained/prepared for the surficial aquifer zone. These maps should be used to confirm flow directions and to verify screen placements (depths) with respect to the water table elevation.

Proposed New Wells

One new well nest has been proposed for installation at ORR: "New Wells #1 and #2." This well nest will be located near Turkey Creek (Figures 3-13 and 3-16), directly downgradient of ORR with respect to groundwater flow in the surficial aquifer zone (Table 4-21). The objective of installing this well nest is to ensure that potential pathways for groundwater to migrate from ORR (and ultimately discharge to Turkey Creek) are adequately monitored.

Analytical data (VOCs, SVOCs, inorganics, explosives, nitrate, and selected water quality parameters) should be collected from this well nest and combined with the analytical databases for the surficial aquifer and for the Beech Creek aquifer (perimeter wells).

4.3.3.4 Air

No ambient air monitoring data have been collected to date at ORR. Chemical emissions and air dispersion modeling of site chemicals at ORR are the focus of two separate Contract Task Orders issued by NAVSURFWARCENDIV (see Section 4.2.3.5 - Air).

4.3.4 Environmental Fate/Disposition of ORR Contaminants

The currently existing groundwater contamination database at ORR shows that only occasional "hits" of contaminants are present (for the majority of the monitoring wells). Also, no identifiable plumes of contamination have been shown to exist at ORR. Thus, for the purposes of this risk assessment, no groundwater transport modeling of contaminants

TABLE 4-21

ORR PROPOSED NEW GROUNDWATER MONITORING WELLS

Well Designation	Location	Target Aquifer	Estimated Depth (ft)	Rationale
New Well #1 and New Well #2	Eastern perimeter of ORR (Turkey Creek), east of 06C18 and southeast of 06C13. See Figure 3-13.	Alluvium and/or Big Clifty sandstone; deeper well in upper Beech Creek aquifer.	25;55	This proposed well nest would be located directly downgradient of the ORR with respect to surficial (water-table) groundwater flow. The risk assessment would use data collected from this well nest to address potential SWMU impacts via groundwater discharge to Turkey Creek and to verify that groundwater quality has been adequately characterized along the site perimeter (existing Turkey Creek wells). Elevated levels of iron (up to 70,000 ppb) have been detected in the surficial aquifer at well 06C18P2.

from ORR is proposed. Rather, the database as it will exist after the latest round of sampling will be used for estimating risk to on-facility receptors. It is currently viewed as unlikely that this SWMU could contribute to off-facility groundwater contamination.

The current chemical levels in surface soil, surface water, and sediment will also be used as exposure inputs for all three risk assessment scenarios for on-SWMU receptors. The assumptions being made in this approach are that a) the present loading and clean-up activities at this SWMU are unlikely to further degrade these media due to the recent facility upgrades at this SWMU, and b) that the air emissions in the future, because they will not be substantially different than they have been in the past, also will not lead to further degradation of these on-SWMU media, i.e. steady-state conditions with respect to this source of contamination are assumed to exist. For off-facility residents, in Scenario A, the air emissions data will be used to estimate concentrations of hazardous constituents in off-facility environmental media (e.g. soil and vegetation) for the purpose of estimating exposure of off-facility residents, if particulate-bound/bioaccumulative chemicals are determined to likely be present.

The air emissions data will also be used to estimate contaminant concentrations in and within the vicinity of Lake Greenwood to assess exposure of base personnel and their families in Scenario A, if particulate-bound/bioaccumulative chemicals are determined to likely be present.

4.4 DR CONCEPTUAL MODEL

4.4.1 General Overview

Based on the descriptions of the past and present detonation activities at DR (Section 3.4.2.2), two observations pertinent to the risk assessment are noted. First, it is likely that hazardous constituent contamination due to past activities has occurred in site soil, surface water, sediments, and groundwater. Secondly, this site is comprised of two separate activities - - the Navy detonation activities and the Army detonation activities. Thus, each of these activities and their associated locations should be considered a potential source of chemical contamination in the risk assessment. Current activities also lead to contaminants being emitted into the ambient air from both of these activity areas.

4.4.2 Conceptual Model Detailed Description

Scenario A (Figures 4-1A, 4-1B, 4-1C and 4-1D) is the scenario wherein the current activities at DR are assumed to continue indefinitely. Under this scenario, base personnel and their families would be assumed to be exposed to SWMU-impacted media near Lake Greenwood, including contaminants in ambient air as a result of the detonation activities.

Likewise, the off-facility residents would be expected to be exposed to airborne emissions from exposure to these detonation activities. If bioaccumulative metals and/or environmentally persistent organic chemicals are found to be emitted into the ambient air from DR, there is the potential for contamination of secondary and tertiary media, e.g. soil, plants, in the vicinity of these off-facility receptors. Lastly, because the detonation activity is assumed to continue at DR indefinitely, exposure of SWMU workers to SWMU contamination is expected to occur. SWMU workers would be expected to be exposed to contaminated air and surface soil at the SWMU.

In Scenario B (Figure 4-2), DR activities are assumed to stop at some time in the future (e.g.100 years). This area would then be converted into a public park/natural area. Visitors to and employees of this park/natural area would thus be expected to come into contact with contaminated surface soil, surface water, sediment, and groundwater at this SWMU. With respect to groundwater contamination at DR, a drinking water well would be assumed to be placed in any aquifer below this area and at any location within this SWMU. Thus, exposure to groundwater will be based on monitoring well data aggregated separately for each aquifer at DR, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well.

In Scenario C, (Figure 4-3), DR activities are also assumed to stop at some time in the future (e.g.100 years), but the base is converted into a rural residential area. Residents living on the former SWMU would be expected to come into contact with contaminated surface soil, surface water, sediment and groundwater. As in Scenario B, exposure to groundwater will be based on monitoring well data aggregated separately for each aquifer at DR, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well. Future residents would also be expected to consume vegetables grown in contaminated soil in home gardens, and consume contaminated beef and milk from cattle raised for their own consumption. Finally, future residents would be expected to consume local deer and turkeys that they hunt.

4.4.3 Review and Analysis of Existing Analytical Database for DR

4.4.3.1 Soil

To date there has been no soil investigation at the DR. The Halliburton NUS Team recommends six to eight surface soil samples (0-6" grid composites) and three surface soil samples (0-6" grid composites) be collected from the Army Detonation Area and Navy Detonation Area, respectively. In addition, three soil samples will be collected to represent background soils for DR. See Table 4-1 for recommended additional surface soil sampling

(Mansfield Formation) located in the southern portion of DR: wells 06-02, 06-03, 06-04, 06-05, 06-09, 06-10 and 06-11.

For the wells sampled, the analytical parameter list is generally complete for the risk assessment, with respect to inorganics, VOCs, SVOCs, pesticides/PCBs, and explosives. Table 4-22 is a summary of the analytical data parameters available from the sampling program for the DR monitoring wells, organized in terms of each water-bearing zone that was monitored.

The existing analytical database should be used as the primary data source for groundwater for the risk assessment. The current analytical data will be evaluated according to well groupings, similar to those outlined for ORR (Section 4.5). In addition, this database will be supplemented with new data, recommended for collection in 1995. Additional sampling at selected wells is suggested in order to provide confirmation of the existing data and to establish that potential contaminant levels have not changed significantly since April 1992.

In general, the contaminants detected in groundwater at DR include metals, which in some wells were measured at levels above MCLs. Metals detected include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, thallium, tin, and zinc. Very high levels of some metals were observed for November, 1991, at well 06-07 (surficial well in the northeast portion of DR), where seven metals exceeded their respective MCLs (such as nickel detected at 2.0 mg/l, aluminum at 139.0 mg/l, iron at 84,200 mg/l, and manganese at 12.7 mg/l).

Metals present in Beech Creek wells at statistically elevated levels above background (Well 06C07) were aluminum, arsenic and manganese (Murphy and Wade, 1994b). Metals detected in the surficial zone wells (on-SWMW northeast group) at statistically elevated levels above background (Well 06-01A) were aluminum, arsenic, beryllium, cobalt, manganese, nickel and zinc (Murphy and Wade, 1994b). The detected levels of these latter metals were much higher in this group of wells, screened in the surficial aquifer zone at DR, than in any other group of wells or aquifer in the DR/ORR study areas (Murphy and Wade, 1994b).

Groundwater monitoring wells at DR were grouped according to aquifer and/or hydrogeologic position (i.e., surficial wells). For the risk assessment, each aquifer zone should be evaluated individually. In some cases, wells were further grouped within a given aquifer zone to reflect well locations with respect to groundwater flow directions, surface activities (Navy versus Army detonation areas), and proximity to surface water bodies (such as Boggs Creek and Turkey Creek). Summary tables have been prepared which list the monitoring wells installed within each aquifer zone (Tables 4-23, 4-24, and 4-25):

TABLE 4-22

DR GROUNDWATER SUMMARY OF ANALYTICAL PARAMETERS FOR EXISTING DATABASE (1990 - 1992)

	HYDROGEOLOGIC UNIT *	
Parameter Group	Beech Creek	Surficial Aquifers
Inorganics	11/91-4/92	11/91-4/92
Volatile Organic Chemicals	11/91	11/91
Semi-volatile Organic Chemicals	11/91	5/91-11/91
Pesticides/PCBs	11/91	5/91-11/91
Explosives:		
HMX	11/91-4/92	5/91-4/92
RDX	11/91-4/92	5/91-4/92
TNT	11/91-4/92	5/91-4/92
DNB	11/91-4/92	5/91-4/92
TETRYL	11/91-4/92	5/91-4/92
TNB	11/91-4/92	5/91-4/92
2,4-DNT	11/91-4/92	5/91-4/92
2,6-DNT	11/91-4/92	5/91-4/92
Nitrate	4/92	4/92

NOTES: *: Table lists the dates (i.e., "11/91") for the most recent sampling events that include the designated parameters. In some cases, a range in dates is shown because not all of the monitoring points within a given group were sampled for the entire analyte list on the most recent sampling date.

Beech Creek limestone, intermediate zone (base of Mansfield formation), and the zone of the surficial aquifers (Mansfield formation, Big Clifty sandstone, Golconda limestone, and/or overburden). The intermediate zone well (06C01P2) was dry for all three sampling periods (November, 1990, through November, 1991). Therefore, samples have not been collected from this well.

Analytical data will be grouped and evaluated according to aquifer, and within each aquifer zone, according to on-SWMU wells versus perimeter wells. The downgradient/sidegradient well nest at 06C07 will be evaluated separately as a background well location, as recommended by Murphy and Wade (1994b) because Well 06C08 was found to have elevated levels of metals..

Wells recommended for additional sampling were selected to be representative of each well grouping (except for the intermediate zone well which has been dry in the past). The ten wells to be sampled have been designated ("underlined") on Tables 4-23 and 4-25. Well 06C07 and Well 06-01A will provide background water quality since these wells (Beaver Bend and surficial zone wells, respectively) are characterized by low levels of metals. The rationale for sampling is summarized in Table 4-26. New water quality data from wells proposed for compliance monitoring will also be used to update the risk assessment database.

Sampling has not been recommended for the seven wells (to the south) which were installed in the surficial aquifer zones (Mansfield Formation) beneath the Army Detonation Area. NAVSURFWARCENDIV has indicated that these wells have not been maintained in usable condition. However, data from perimeter wells 06C03P2, 06C04P2, and 06C06P2 will be collected and used to characterize groundwater quality potentially downgradient from the Army Detonation Area.

The surficial aquifer zone (mentioned above) has been used to group wells at both DR and ORR, for the risk assessment. The surficial wells are interpreted to monitor surficial groundwater flow, which probably occurs through fractures in a variety of lithologies. Dunbar (1982) used several of the older wells to construct water table contour maps, although not all wells intercept the same lithologic horizon. The current review of well logs for both sites (DR, ORR) has indicated that not all surficial wells intercept the water table surface, nor are all of the screened intervals located at precisely comparable elevations. For example, the Mansfield Formation consists of interbedded lenses of sandstone and shale (Dunbar, 1982). The Mansfield Formation may be characterized by perched aquifers separated from each other laterally due to stratigraphic discontinuities. Some Mansfield wells apparently intercept different stratigraphic lenses, but have been interpreted nonetheless as monitoring surficial groundwater flow (Dunbar, 1982). For the risk assessment, it is recommended that current/recent groundwater contour maps be

TABLE 4-23

DR GROUNDWATER WELL GROUPINGS FOR BEECH CREEK AQUIFER

On SWMU	Off SWMU		
	Perimeter Turkey Creek	Perimeter Boggs Creek	North
06C01	06C02 [A]	06C05 [C]	06C08 [D]
	06C03 [B]	06C06 [C]	
	06C04	06C07 [E]	

NOTES:

06C02 Underlining indicates wells recommended for sampling.

[A] Potential side-gradient position to 06C01 with respect to regional groundwater flow in this aquifer.

[B] Potential downgradient position to 06C01 area at DR, with respect to regional groundwater flow in this aquifer.

[C] Regional downgradient wells (with respect to potential groundwater flow from DR in this aquifer).

[D] Regional upgradient well (with respect to potential groundwater flow to DR in this aquifer), but analytical results to date show elevated metal levels here.

[E] Well 06C07 recommended as background sampling point by Murphy and Wade (1994b).

TABLE 4-24

DR GROUNDWATER WELL GROUPING FOR INTERMEDIATE ZONE

On SWMU

Northeast

06C01P2[A,B]

NOTE: [A] Well Screened in basal sandstone unit in Mansfield Formation.

[B] P indicates nested well located at well base number shown on figures.

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TABLE 4-25

DR GROUNDWATER WELL GROUPINGS FOR SURFICIAL AQUIFERS[A]

On SWMU (Mansfield Formation) [B]		Off SWMU		
Northeast	South	Perimeter Turkey Creek	Perimeter Boggs Creek	North
06-01 A (C/M)	06-02	06C02P2 (BC)	06C06P2 (CS/M?)	06C08P2 (M?
06-01 B	06-03 (C/M)	06C03P2 (G)		
06-01 C	06-04	06C04P2 (G/I)		
06-06	06-05			
06-07	06-09			
06-08	06-10			
06-12	06-11			
06-13				
06C01P3				

NOTES: 06-07 Underlining indicates well recommended for sampling.

A P indicates nested well(s) located at well base number shown on figures.

B Mansfield Formation unless indicated otherwise by abbreviation in parentheses, as explained in "C" below.

C Formations screened indicated by the following abbreviations:

- C: Clay
- CS: Clayey sand
- M: Mansfield Formation
- (?): Formation name not identified on well boring log
- BC: Big Clifty Sandstone
- G: Golconda Limestone
- I: Indian Springs Shale

TABLE 4-26
DR PROPOSED SAMPLING FOR GROUNDWATER[A]

Monitoring Well	Aquifer	Parameters	Rationale
06C01	Beech Creek	(a)	Verify existing database; representative well for deep aquifer beneath Naval detonation area (on-SWMU well).
06C03	Beech Creek	(a)	Verify existing database; potentially downgradient of Naval detonation area with respect to regional flow in this aquifer; perimeter well (Turkey Creek). Elevated arsenic and iron levels.
06C06	Beech Creek	(a)	Verify existing database; potentially downgradient of Army activities at DR in terms of regional flow in this aquifer; perimeter well (Boggs Creek).
06C07	Beech Creek	(a)	Recommended as background sampling point by Murphy and Wade (1994b). Data may be used to eliminate inorganic chemicals from risk assessments "chemicals of potential concern."
06-01A	Surficial Aquifers	(a)	Verify existing database. Used as background well for this aquifer zone by Murphy and Wade (1994b). Data may be used to eliminate inorganic chemicals from risk assessment's "chemicals of potential concern."
06-07	Surficial aquifers (Mansfield Formation)	(a)	Verify existing database; centrally located in area of Naval activities; very high levels of several metals detected (arsenic, beryllium, cobalt, zinc, nickel, aluminum, iron, manganese).
06C06P2	Surficial aquifers	(a)	Verify existing database; perimeter well (Boggs Creek); potentially downgradient to Army Detonation Area.
06C08P2	Surficial aquifers	(a)	Verify existing database; regional upgradient/background well. Data may be used to eliminate inorganic chemicals from risk assessment's "chemicals of potential concern."

TABLE 4-26 (Continued)
DR PROPOSED SAMPLING FOR GROUNDWATER[A]

Monitoring Well	Aquifer	Parameters	Rationale
06C03P2	Golconda	(a)	Verify existing database; only Golconda wells at DR. These wells are potentially downgradient to Army Detonation Area.
06C04P2	Golconda		

NOTE: (a) = Inorganics, VOCs, SVOCs, Explosives, Nitrate.
[A] P indicates nested well(s) located at well base number shown on figures.

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obtained/prepared for the surficial wells. These maps should be used to confirm flow directions and to verify screen placements (depths) with respect to water table elevations.

4.4.3.4 Air

No ambient air monitoring data have been collected to date at DR. Chemical emissions and air dispersion modeling of site chemicals at DR are the focus of two separate Contract Task Orders issued by NAVSURFWARCENDIV (see Section 4.2.3.5).

4.4.4 Environmental Fate/Disposition of DR Contaminants

The currently existing groundwater contamination database at DR shows that only occasional "hits" of contaminants are present (for the majority of the monitoring wells). Also, no identifiable plumes of contamination have been shown to exist at DR. Thus, for the risk assessment, no groundwater transport modeling of contaminants from DR is proposed. Rather, the database as it exists will be used for estimating risk to on-facility receptors. It is currently viewed as unlikely that this SWMU could contribute to off-facility groundwater contamination.

The current chemical levels in surface soil, surface water, and sediments will also be used as exposure assessment input for all three scenarios with respect to on-SWMU receptors. The assumption being made in this approach is that the air emissions in the future, because they will not be substantially different than they have been in the past, will not lead to further degradation of these media, i.e. steady-state conditions with respect to this source of contamination are assumed to exist.

For off-facility residents in Scenario A, the air emissions data will be used to estimate concentrations of hazardous constituents in off-facility environmental media (e.g. soil, plants) for the purpose of estimating exposure of the nearby residents if particulate-bound/ bioaccumulative chemicals are determined to likely be present in air. Air emissions data will also be used to estimate contaminant concentrations in SWMU-impacted environmental media near Lake Greenwood to assess exposure of base personnel/families while at home (Scenario A), again, only if particulate-bound/bioaccumulative chemicals are likely to be present in air.

4.5 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

4.5.1 Screening for Chemicals of Potential Concern

Before the chemicals of potential concern can be selected, the relevant risk assessment data must be grouped and summarized. The procedures to be used in summarizing the data (in accordance with USEPA procedures, USEPA, 1989a) are described below:

- All data used in the risk assessment should first be collected, analyzed and validated.

- The initial grouping of the risk assessment data should be done according to SWMU (e.g., ABG, ORR, DR). Further grouping should then be done by environmental medium (e.g., soil, groundwater) as described in the previous section of this work plan. Additional grouping within an environmental medium will allow independent investigation of specific areas within a medium (e.g., comparison of background samples with chemicals detected within specific areas of a SWMU).

- The distributional properties of the data should then be tested in order to apply the appropriate statistical tests and procedures for proper interpretation of the risk assessment results. It is suggested that the Shapiro-Wilk test of normality (Gilbert, 1987) be used to determine the underlying distribution of data for all environmental media.

- Duplicate sample data, when available, will be averaged. If a chemical is detected in only one of two duplicate samples, the detect concentration will be used. Concentration data from multiple samples in an area (e.g., within a SWMU) will be averaged. If a chemical is detected at least once in a grouping, the average concentration for that area will be calculated by averaging the detected concentration(s) with a fraction of the quantitation limit of the non-detected sample concentration. The USEPA (1992c) provides the following guidance for choosing between the method detection limit (MDL) and the practical quantitation limit (PQL) in characterizing "nondetect" concentrations: 1) If a measurement is reported as "not detected", the actual concentration is assumed to be between zero and the MDL. The appropriate substitution would then be to replace the measurement by one-half of the MDL; 2) If the measurement is "detected but not quantified," the actual concentration should be somewhere between the MDL and the larger PQL. In this case, the appropriate substitution would be halfway between the MDL and the PQL, or (MDL + PQL)/2. If it cannot be determined whether a nondetect sample has

been detected or not, the EPA recommends that the nondetect be replaced by one-half the MDL, since the PQL is often too high to adequately characterize many nondetect concentrations.

- The USEPA (1992c) also recommends the following procedures for handling nondetects: 1) If less than 15% of all samples are nondetect values for an analyte, replace each nondetect by half its detection or quantitation limit and proceed with parametric analysis; 2) if the percent of nondetects is between 15 and 50, either use Cohen's adjustment to the sample mean and variance in order to proceed with a parametric analysis or employ a non-parametric procedure by using the ranks of the observations and by treating all nondetects as tied values; 3) if the percent of nondetects is greater than 50 percent, use the Test of Proportions.

- Samples in which a chemical is not detected will be compared to the maximum detected concentration for that chemical to determine if the nondetects should be included in calculating the mean concentration. If one-half of the PQL for a nondetect sample is higher than the maximum detected concentration in the same medium for that chemical, the sample will not be included in the calculation of the average for that chemical. This will prevent the average from being artificially biased upwards by high detection limits.

The summarized data will be presented in the risk assessment, grouped by environmental medium within each SWMU. Parameters to be included in data summary tables will include frequency of detection, the range of detected concentrations, the mean concentration, and the upper 95 percent confidence limit value (UCL) for the mean. The 95 percent UCL will be calculated according to guidance in "Calculating the Concentration Term," (U.S. EPA, 1992). Chemicals selected for further evaluation in the risk assessment should be those likely associated with current and/or past site activities. Therefore, an initial selection process is recommended to eliminate chemicals found to be associated with sampling or laboratory artifacts and naturally-occurring chemicals that are considered to be at background levels. The following methodology is recommended as the next step in the selection of chemicals of potential concern to the project.

- Inorganic chemicals present at naturally-occurring levels may be eliminated from the quantitative risk assessment by using a statistical method to determine whether chemical concentrations detected at the site are within, or elevated above, background levels (USEPA, 1989a). The statistical method that is used should be appropriate for the data under evaluation and should account for data below the limit of detection (USEPA, 1988a). The statistical test(s) to be used for comparing site data with background data should be selected after the data

are examined using the procedures described above. Justification for the statistical methods selected should be provided in the risk assessment. If a sufficient number of samples is not available for a standard statistical test, alternative statistical methods should be considered. If an insignificant number of samples occurs, specific guidance will be sought from USEPA Region V.

- According to the USEPA (1989a), if the detected concentration in a sample is less than 10 times the blank concentration for common laboratory contaminants (e.g., acetone and the phthalate esters) the chemical should not be selected for evaluation in the risk assessment. For those organic or inorganic chemicals that are not considered by USEPA to be common laboratory contaminants (all other compounds), if the detected concentration is less than 5 times the maximum detected concentration in the blanks, the chemical is not selected for evaluation in the risk assessment.

Following the preliminary screening, Halliburton NUS Team suggests that the USEPA Superfund concentration/toxicity screening approach be used to further identify the "chemicals of most concern" to the project. The rationales forwarded by the USEPA to narrow an original list of site-specific chemicals to the "chemicals of most concern" to a project fall into four categories:

- Certain chemicals may be grouped by structure-activity relationships (e.g., non-carcinogenic PAHs are frequently combined into one group).

- Nutrient metals (e.g., iron and magnesium) may be dropped from further consideration if their presence is not excessive.

- Chemicals which do not possess current USEPA health criteria (e.g., titanium) cannot be quantitatively evaluated. These chemicals are dropped from the database, and only a qualitative evaluation of these substances will be made.

- A concentration-toxicity screening procedure may be used to rank the remaining chemicals according to their relative risk. Chemicals with the highest relative risk are then selected for inclusion in the quantitative risk assessment.

Since this screening procedure estimates the relative hazard of each chemical based on its concentration in site media and its toxicity, chemicals are scored according to their projected environmental concentrations at the site within each environmental medium and their relative toxicities. Carcinogens and non-carcinogens are screened separately. The following equation should be utilized (USEPA, 1989a):

$$R_{ij} = (C_{ij})(T_{ij})$$

where:

R_{ij} = relative risk factor for chemical 'i' in medium 'j'
C_{ij} = concentration of chemical 'i' in medium 'j'
T_{ij} = toxicity value for chemical 'i' in medium 'j'

The USEPA suggests in their Superfund guidance that each contaminated medium at a site be scored individually, and chemicals of concern are to be selected as media-specific analytes.

All of the relative risk factors (R_{ij}) calculated from both chemical databases (carcinogenic and non-carcinogenic) for each environmental medium or medium sub-grouping are then summed to arrive at both a total cancer and a total non-cancer relative risk factor (R_j). Those chemicals in each database that exhibit the highest individual relative risk scores (R_{ij}/R_j) and that collectively account for at least 99 percent of the total relative risk for the medium will be selected as the chemicals of most concern to the project. These chemicals will be evaluated quantitatively in the body of the risk assessment report. All site chemicals with health criteria, including those chemicals that collectively account for the remaining 1 percent or less of the total relative risk will be evaluated and included in an appendix.

4.5.2 Toxicity Equivalency Factors

As mentioned previously, one of the rationales forwarded by the USEPA in selecting the chemicals of potential concern for a project is to group those substances of similar structure. Halliburton NUS Team recommends that PAHs and dioxins/furans, if they are determined to be present in environmental media at the SWMUs, be evaluated in this manner.

The USEPA (1993) has provided provisional guidance for assessing the risk of the carcinogenic PAHs. This methodology is based on the relative potency of each compound to the potency of benzo(a)pyrene (BaP). The Halliburton NUS Team is proposing that these TEFs be used for this assessment.

The TEFs recommended by the USEPA (1993) are as follows:

PAH	TEF
benzo(a)pyrene	1.0
benzo(a)anthracene	0.1
benzo(a)fluoranthene	0.1
benzo(k)fluoranthene	0.01
chrysene	0.001
dibenzo(a,h)anthracene	1.0
indeno(1,2,3-c,d)pyrene	0.1

All noncarcinogenic PAHs present in the SWMU emissions without toxicity values should also be grouped together. The toxicity value calculated for pyrene will be used to screen this group since this analyte possesses the lowest Reference Dose (RfD) (USEPA, 1991).

The USEPA (1989) has also provided guidance for assessing the risk of TCDDs/TCDFs, based on the relative potency of each compound to 2,3,7,8-TCDD. These TEFs, which are listed below, are also recommended to be used in this risk assessment:

Compound	TEF
2,3,7,8-TCDD	1
2,3,7,8-PeCDD	0.5
2,3,7,8-HxCDDs	0.1
2,3,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
2,3,7,8-HxCDFs	0.1
2,3,7,8-HpCDFs	0.01

Compound	TEF
OCDF	0.001

4.6 ENVIRONMENTAL FATE CHARACTERISTICS OF THE CHEMICALS OF POTENTIAL CONCERN

As part of this site-specific hazard assessment, information on the environmental behavior of the chemicals of potential concern will be presented. This type of information indicates which environmental media and therefore which exposure pathways are most important to address in the quantitative risk assessment for each of the SWMUs.

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5.0 EXPOSURE ASSESSMENT

5.1 INTRODUCTION

An exposure pathway consists of four main elements: (a) a source and mechanism of chemical release to the environment; (b) an environmental transport medium for the released chemical; (c) a point of potential contact by a receptor with the contaminated medium (referred to as the exposure point); and (d) a route of exposure (e.g., ingestion, inhalation, dermal contact) at the exposure point. If any of these factors is absent, the pathway is incomplete, and exposure cannot occur. Therefore, the objectives of the exposure assessment section of the risk assessment report are: (a) to select the specific locations of each of the identified potentially exposed receptor populations; and (b) to quantify the extent of receptor exposure to the chemicals of potential concern at these locations from the most significant exposure pathways.

A general principle of exposure assessment is to use conservative assumptions (i.e., assumptions that tend to overestimate chemical exposure) so that the final estimates of chemical contact that are calculated will likely be higher than the range of actual exposures in the surrounding populace. Estimates of exposure developed for this workplan will be conservative in this sense, in two ways. First, for each exposure scenario, the assessment will focus on the geographic locations at each SWMU where exposure is expected to be greatest, and on the subpopulations likely to be most exposed (for example, SWMU workers contacting surface soils). For this reason, the estimates of exposure will not be valid for most of the population. Secondly, exposure assessments for these receptors will incorporate conservative physical and behavioral assumptions which also influence the exposure estimates. These include estimates of chemical emission rates associated with the SWMU burning/detonation activities, particle deposition rates, environmental persistence of the chemicals, chemical bio-uptake, chemical bioavailability, and human activity. For these reasons, the exposure estimates that are calculated in this risk assessment are intended to represent hypothetical reasonably maximally-exposed individuals. Chemical exposures to any individual currently residing on or near the project SWMUs are thus expected to be less than those calculated.

5.2 FINAL PROPOSED CONCEPTUAL MODELS

5.2.1 Current Use (Scenario A)

Burning/detonation activities at ABG, ORR and DR continue indefinitely.

Three human receptor populations are suggested to quantify the potential magnitude of the current level of contaminant exposure at each SWMU operation. These populations are:

- Navel Base Personnel and their Families
- SWMU Workers
- Off-facility Residents

These populations currently reside on and around the base. Base personnel and their families are those individuals who live within the borders of NAVSURFWARCENDIV, near Lake Greenwood. This family will be assumed to consist of adults and toddlers, and will be assumed to live at NAVSURFWARCENDIV for a period of 4 years.

These receptors will be exposed to contaminants in air, water (Lake Greenwood) and soil while in residence at the base. This family will also be assumed to swim in Lake Greenwood. The contaminant concentrations in the soil around Lake Greenwood, as well as in Lake Greenwood, will be modeled using air emissions data from all three SWMUs combined if particulate-bound/bioaccumulative chemicals are believed to be present in air.

The adult base employee will also be assumed to enter the SWMUs 20-days during the year as part of his/her job responsibilities. This employee on any given contact day will be assumed to enter each SWMU equally. Therefore, the total intake for a given environmental medium (e.g., air, soil) will be proportioned equally among the SWMUs.

SWMU workers will be assumed to be adults only, who work at this facility for 20 years. The SWMU worker is an individual who works only at one SWMU. However, within a SWMU, the worker is assumed to come into contact with media in each distinct area of contamination. For example, the worker at ABG will be assumed to spend most of the time in the area of the burn pads, but will occasionally enter the jeep trail area. The exposure point concentration from each area of contamination will be proportional to the amount of time spent in that area. The exception will be the DR, where it will be assumed that there are two separate workers: an army worker and a navy worker. Each of these workers will be assumed to come into contact only with the areas within this SWMU contaminated by army and navy activities, respectively.

Off-facility residents are local residents living downgradient (groundwater) and within the air dispersion plume of the SWMUs. At the present time, one off-facility residential group has been selected for evaluation, the Padanaram Community. These off-facility residents will be assumed to remain off the facility and not venture onto the base. Therefore, all media that this community (assumed to be adults and toddlers) comes into contact with will be outside of the facility. Contaminant concentrations in certain off-facility media (e.g., soil, vegetation) will be modeled using combined SWMU air emissions data if particulate-bound/ bioaccumulative chemicals are determined to likely be present in air. The off-facility community will be assumed to use groundwater as well as off-facility spring water for drinking and bathing. These receptors will be assumed to live in this area for a period of 70 years (worst case).

The likely exposure routes to be modeled for each of the above receptors are summarized below. Tables 5-1A, 5-2A, and 5-3A detail our inclusion/exclusion exposure pathway analyses for each of these receptor populations associated with ABG, ORR, and DR.

<u>SWMU Workers</u> (Adults Only)

- Inhalation of vapor-phase chemicals
- Inhalation of airborne fugitive particulates
- Ingestion of airborne fugitive particulates secondary to inhalation
- Ingestion of on-SWMU soil
- Dermal contact with on-SWMU soil
- Ingestion of production well water (ABG only)

<u>Base Personnel and Families</u> (Adults and Toddlers)

- Inhalation of vapor-phase chemicals
- Inhalation of airborne fugitive particulates
- Ingestion of airborne fugitive particulates secondary to inhalation
- Ingestion of soil (near Lake Greenwood, adults & toddlers; SWMU soil, adult)
- Dermal contact with soil (near Lake Greenwood, adults & toddlers; SWMU soil, adults)
- Ingestion of surface water (Lake Greenwood)
- Dermal contact with surface water (Lake Greenwood)

<u>Off-facility Rural Residents</u> (Adults and Toddlers)

- Inhalation of vapor-phase chemicals
- Inhalation of airborne fugitive particulates

Table 5-1A: Ammunition Burning Ground - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A - Burning and Detonation Activities at NAVSURFWARCENDIV Continue Indefinitely				
Burn pads, etc., ordnance	SWMU workers	Inhalation of vapor-phase chemicals	High	Potential for direct exposure to air emissions from ordnance burning and detonation is high.
Soil contamination at old burn area adjacent to jeep trail and former ash pile		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	Medium	Potential for workers on site to occasionally ingest water from production well at ABG.
		Dermal contact with contaminated groundwater	Low	Magnitude of exposure from washing hands, etc., expected to be very low
		Inhalation of vapor-phase chemicals while showering	Low	Off-site source for base water for showering.
		Incidental ingestion of contaminated water in Little Sulphur Creek	Low	SWMU workers unlikely to have contact with Little Sulphur Creek.
		Dermal contact with contaminated water in Little Sulphur Creek	Low	
		Incidental ingestion of contaminated sediment in Little Sulphur Creek	Low	
		Dermal contact with contaminated sediment in Little Sulphur Creek	Low	
		Ingestion of contaminated fish from Little Sulfur Creek	Low	Fishing by these receptors in Little Sulphur Creek may occur, however, creek is not viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Low potential for SWMU workers to receive high percentage of their dietary foodstuffs from local sources.
		Ingestion of contaminated vegetables	Low	
		Ingestion of venison/turkey	Medium	Hunting by these receptors does occur.

Table 5-1A: Ammunition Burning Ground - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
Burn pads, etc., ordnance Soil contamination at old burn area adjacent to jeep trail and former ash pile	Base personnel/ families	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air near Lake Greenwood is high. Adults may have direct exposure occasionally while working.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated soil near Lake Greenwood	High	High potential for direct contact with contaminated soil while at home. Adults may have direct exposure at SWMUs while working.
		Dermal contact with contaminated soil near Lake Greenwood	High	
		Ingestion of contaminated drinking water	High	Lake Greenwood serves as the source of base water for drinking and showering/bathing.
		Dermal contact with contaminated groundwater	High	
		Inhalation of vapor-phase chemicals while showering	Low	Airborne VOC impact on Lake Greenwood expected to be minor.
		Incidental ingestion of contaminated water in Little Sulphur Creek	Low	Low potential for these receptors to play in Little Sulphur Creek.
		Dermal contact with contaminated water in Little Sulphur Creek	Low	
		Incidental ingestion of contaminated sediment in Little Sulphur Creek	Low	
		Dermal contact with contaminated sediment in Little Sulphur Creek	Low	
		Ingestion of contaminated fish from Little Sulfur Creek	Low	Fishing by these receptors in Little Sulphur Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	No livestock are raised on base.
		Ingestion of contaminated vegetables	Low	Crops are raised on base by personnel stationed for short periods of time.
		Ingestion of venison/turkey	Low	Hunting by these receptors occurs infrequently.

Table 5-1A: Ammunition Burning Ground - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
	Base personnel/ families	Incidential ingestion of contaminated water in Lake Greenwood	High	High potential for these receptors to recreate in this lake, which is near where they live.
		Dermal contact with contaminated water in Lake Greenwood	High	
Burn pads, etc., ordnance	Off-facility rural residents	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air off the facility is high.
Soil contamination at old burn area adjacent to jeep trail and former ash pile		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated off-facility soil	High	Potential for air emissions to disperse and deposit on off-facility soil.
		Dermal contact with contaminated off-facility soil	High	
		Ingestion of contaminated drinking water	Medium	Potential for exposure to drinking water in downgradient well.
		Dermal contact with contaminated groundwater	Medium	
		Inhalation of vapor-phase chemicals while showering	Medium	If VOCs are present in downgradient well.
		Incidental ingestion of contaminated water in Little Sulphur Creek	Low	Low potential for air emissions to impact Little Sulphur Creek off the facility due to continuous recharge and flow-through.
		Dermal contact with contaminated water in Little Sulphur Creek	Low	
		Incidental ingestion of contaminated sediment in Little Sulphur Creek	Low	
		Dermal contact with contaminated sediment in Little Sulphur Creek	Low	
		Ingestion of contaminated fish from Little Sulfur Creek	Low	Fishing by these receptors in Little Sulphur Creek may occur, however, creek is not a viable recreational resource.

Table 5-1A: Ammunition Burning Ground - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
Burn pads, etc., ordnance	Off-facility rural residents	Ingestion of contaminated beef/milk	High	Potential for chemicals in air emission to accumulate in livestock, crops, and deer/turkeys off the facility.
Soil contamination at old burn area adjacent to jeep trail and former ash pile		Ingestion of contaminated vegetables	High	
		Ingestion of venison/turkey	High	
		Ingestion of spring water	High	
		Dermal contact with spring water while bathing	High	Off-facility residents reported to drink/bathe in spring water near ABG.

Table 5-2A: Old Rifle Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A - Burning and Detonation Activities at NAVSURFWARCENDIV Continue Indefinitely				
Burn pads ordnance; soil contamination at target area	SWMU workers	Inhalation of vapor-phase chemicals	High	Potential for direct exposure to air emissions from ordnance burning and detonation is high.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil on site.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	Low	Off-site source for base water for drinking/showering.
		Dermal contact with contaminated groundwater	Low	
		Inhalation of vapor-phase chemicals while showering	Low	
		Incidental ingestion of contaminated water in Turkey Creek	Low	SWMU workers unlikely to have regular contact with Turkey Creek.
		Dermal contact with contaminated water in Turkey Creek	Low	
		Incidental ingestion of contaminated sediment in Turkey Creek	Low	
		Dermal contact with contaminated sediment in Turkey Creek	Low	
		Ingestion of contaminated fish from Turkey Creek	Low	Fishing by these receptors in Turkey Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Low potential for SWMU workers to receive high percentage of their dietary foodstuffs from local sources.
		Ingestion of contaminated vegetables	Low	
		Ingestion of venison/turkey	Medium	Hunting by these receptors does occur.

Table 5-2A: Old Rifle Range - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
Burn pads ordnance; soil contamination at target area	Base personnel/ families	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air near Lake Greenwood is high. Adults may have direct exposure at SWMU occassionally while working.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated soil near Lake Greenwood	High	High potential for direct contact with contaminated soil while at home. Adults may have direct exposure at SWMU while working.
		Dermal contact with contaminated soil near Lake Greenwood	High	
		Ingestion of contaminated drinking water	High	Lake Greenwood serves as source of base water for drinking and showering/bathing.
		Dermal contact with contaminated groundwater	High	
		Inhalation of vapor-phase chemicals while showering	Low	Airborne VOC impacts on Lake Greenwood expected to be minor.
		Incidental ingestion of contaminated water in Turkey Creek	Low	Low potential for base personnel and families to play in Turkey Creek.
		Dermal contact with contaminated water in Turkey Creek	Low	
		Incidental ingestion of contaminated sediment in Turkey Creek	Low	
		Dermal contact with contaminated sediment in Turkey Creek	Low	
		Ingestion of contaminated fish from Turkey Creek	Low	Fishing by these receptors in Turkey Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	No livestock are raised on base.
		Ingestion of contaminated vegetables	Low	Crops are raised on base by personnel stationed for short periods of time.
		Ingestion of venison/turkey	Low	Hunting by these receptors occurs infrequently.

Table 5-2A: Old Rifle Range - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
Burn pads ordnance; soil contamination at target area	Off-facility rural residents	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air off the facility is high.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated off-facility soil	High	Potential for air emissions to disperse and deposit on off-facility soil is high.
		Dermal contact with contaminated off-facility soil	High	
		Ingestion of contaminated drinking water	Low	Low potential for exposure to drinking water impacted by ORR.
		Dermal contact with contaminated groundwater	Low	
		Inhalation of vapor-phase chemicals while showering	Low	
		Incidental ingestion of contaminated water in Turkey Creek	Low	Low potential for air emissions to impact Turkey Creek off the facility due to continuous recharge and flow-through.
		Dermal contact with contaminated water in Turkey Creek	Low	
		Incidental ingestion of contaminated sediment in Turkey Creek	Low	
		Dermal contact with contaminated sediment in Turkey Creek	Low	
		Ingestion of contaminated fish from Turkey Creek	Low	Fishing by these receptors in Turkey Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	High	Potential for chemicals in air emissions to accumulate in livestock, crops, and deer/turkeys off the facility
		Ingestion of contaminated vegetables	High	
		Ingestion of turkey/venison	High	

Table 5-3A: Demolition Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A - Burning and Detonation Activities at NAVSURFWARCENDIV Continue Indefinitely				
U.S. Army underground blast area ordnance; U.S. Navy above-ground blast area ordnance; Associated soil contamination	SWMU workers	Inhalation of vapor-phase chemicals	High	Potential for direct exposure to air emissions from ordnance burning and detonation is high.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil on site.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	Low	Off-site source for base water for drinking and showering.
		Dermal contact with contaminated ground water	Low	
		Inhalation of vapor-phase chemicals while showering	Low	
		Incidental ingestion of contaminated water in Boggs Creek, holding ponds	Low	SWMU workers unlikely to have contact with Boggs Creek and holding ponds.
		Dermal contact with contaminated water in Boggs Creek, holding ponds	Low	
		Incidental ingestion of contaminated sediment in Boggs Creek, holding ponds	Low	
		Dermal contact with contaminated sediment in Boggs Creek, holding ponds	Low	
		Ingestion of contaminated fish from Boggs Creek	Low	Fishing by these receptors in Boggs Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Low potential for SWMU workers to receive high percentage of their dietary food-stuffs from local sources.
		Ingestion of contaminated vegetables	Low	
		Ingestion of venison/turkey	Medium	Hunting by these receptors does occur.

Table 5-3A: Demolition Range - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
U.S. Army underground blast area ordnance; U.S. Navy above-ground blast area ordnance; Associated soil contamination	Base personnel/ families	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air near Lake Greenwood is high. Adults may have direct exposure at SWMU while working.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated soil near Lake Greenwood	High	High potential for direct contact with contaminated soil at home. Adults may have direct contact at SWMU while working.
		Dermal contact with contaminated soil near Lake Greenwood	High	
		Ingestion of contaminated drinking water	High	Lake Greenwood serves as source of base water for drinking and showering/bathing.
		Dermal contact with contaminated groundwater	High	
		Inhalation of vapor-phase chemicals while showering	Low	Airborne VOC impacts on Lake Greenwood expected to be minor.
		Incidental ingestion of contaminated water in Boggs Creek	Low	Low potential for base personnel and families to play in Boggs Creek.
		Dermal contact with contaminated water in Boggs Creek	Low	
		Incidental ingestion of contaminated sediment in Boggs Creek	Low	
		Dermal contact with contaminated sediment in Boggs Creek	Low	
		Ingestion of contaminated fish from Boggs Creek	Low	Fishing by these receptors in Boggs Creek may occur, however, creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	No livestock are raised on base.
		Ingestion of contaminated vegetables	Low	Crops are raised on base by personnel stationed for short periods of time.
		Ingestion of venison/turkey	Low	Hunting by these receptors occurs infrequently.

Table 5-3A: Demolition Range - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO A (cont'd)				
U.S. Army underground blast area ordnance; U.S. Navy above-ground blast area ordnance; Associated soil contamination	Off-facility rural residents	Inhalation of vapor-phase chemicals	High	Potential for air emissions from ordnance burning and detonation to impact ambient air off the facility is high.
		Inhalation of contaminated airborne particulates	High	
		Ingestion of contaminated airborne particulates	High	
		Ingestion of contaminated off-facility soil	High	Potential for air emissions to disperse off site and deposit on off-facility soil is high.
		Dermal contact with contaminated off-facility soil	High	
		Ingestion of contaminated drinking water	Low	Low potential for exposure to drinking water impacted by DR.
		Dermal contact with contaminated ground water	Low	
		Inhalation of vapor-phase chemicals while showering	Low	
		Incidental ingestion of contaminated water in Boggs Creek	Low	Low potential for air emissions to impact Boggs Creek off the facility due to continuous recharge and flow-through.
		Dermal contact with contaminated water in Boggs Creek	Low	
		Incidental ingestion of contaminated sediment in Boggs Creek	Low	
		Dermal contact with contaminated sediment in Boggs Creek	Low	
		Ingestion of contaminated fish from Boggs Creek	Low	Fishing by these receptors in Boggs Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	High	Potential for chemicals in air emissions to accumulate in livestock, crops, and deer/turkeys off the facility.
		Ingestion of contaminated vegetables	High	
		Ingestion of turkey/venison	High	

- Ingestion of airborne fugitive particulates secondary to inhalation
- Ingestion of drinking water off-site (Boundary well data to be used as surrogates)
- Dermal contact with drinking water off-site
- Inhalation of vapor-phase chemicals while showering
- Ingestion of off-facility spring water
- Dermal contact with off-facility spring water
- Ingestion of venison/turkey
- Ingestion of off-facility soil
- Dermal contact with off-facility soil
- Ingestion of locally-grown vegetables and locally-raised beef and milk

5.2.2 Future Use Scenarios (Scenario B and C)

Scenario B: Burning/detonation activities continue for 100 years; facility is then turned into a park/natural area.

Two receptor groups have been chosen as the receptor populations. These groups are:

- Park Employees
- Park Visitors

Base personnel have stated that upon closure of this Base, the land is planned for redevelopment into a park/natural area. Under this land use scenario, it is prudent to examine the existing contamination at the site with respect to recreational users (families) of the future park/natural area. Each SWMU will be evaluated independently as a park.

For the purposes of this risk assessment, park visitors (adults and toddlers) will be assumed to visit the park for 20 years. Park employees (adults) will be assumed to work at the park also for 20 years. The likely exposure routes to be modeled for each of the above receptors are provided below. Tables 5-1B through 5-3C detail the exposure pathway analyses for potential sources of contamination at the ABG, ORR, and DR.

Park/Natural Area Visitors (Adults and Toddlers) and Park Employees (Adults)

- Ingestion of on-SWMU soil
- Dermal contact with on-SWMU soil
- Ingestion of contaminated drinking water
- Incidental ingestion of surface water (creeks at all SWMUs; springs at ABG)
- Dermal contact with surface water (creeks at all SWMUs; springs at ABG)

Table 5-1B: Ammunition Burning Ground - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO B - Burning and Detonation Activities at NAVSURFWARCENDIV Cease after 100 Years, and Site is Then Turned into a Park/Natural Area				
Burn pads, etc., ordnance	Park visitors/ employees	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the site turned into a park.
Soil contamination at old burn area adjacent to jeep trail and former ash pile		Inhalation of contaminated airborne particulates	Low	Low potential for exposure to site air emissions due to fugitive dust.
		Ingestion of contaminated airborne particulates	Low	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil on site.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on-site source of contaminated ground water.
		Dermal contact with contaminated groundwater	Low	Magnitude of exposure due to washing hands, etc., expected to be low.
		Inhalation of vapor-phase chemicals while showering	Low	Route of exposure not expected to be applicable to this receptor.
		Incidental ingestion of contaminated water in springs and Little Sulphur Creek	High	Potential for park visitors to play in Little Sulphur Creek and associated on-facility springs is high.
		Dermal contact with contaminated water in springs and Little Sulphur Creek	High	
		Incidental ingestion of contaminated sediment in Little Sulphur Creek	High	
		Dermal contact with contaminated sediment in Little Sulphur Creek	High	
		Ingestion of contaminated fish from Little Sulfur Creek	Low	Fishing by these receptors in Little Sulphur Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Route of exposure not expected to be applicable to this receptor.
		Ingestion of contaminated vegetables	Low	Route of exposure not expected to be applicable to this receptor.

Table 5-1B: Ammunition Burning Ground - Exposure Pathway Analysis (cont'd)

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO B (cont'd)				
Burn pads, etc., ordnance Soil contamination at old burn area adjacent to jeep trail and former ash pile	Park visitors/ employees	Ingestion of venison/turkey	High	Deer and turkey hunting does occur at base, albeit infrequently. Hunting activity could increase substantially if land converted to park/natural area.

Table 5-1C: Ammunition Burning Ground - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO C - Burning and Detonation Activities at NAVSURFSARCENDIV Cease after 100 Years, and Site is Then Turned into a Residential Area				
Burn pads, etc., ordnance	On-SWMU residents	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the SWMU is turned into a residential area. Low potential for volatilization of organics from soil
Soil contamination at old burn area adjacent to jeep trail and former ash pile		Inhalation of contaminated airborne particulates	Low	Low potential for exposure to SWMU air emissions due to fugitive dusts.
		Ingestion of contaminated airborne particulates	Low	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on SWMU source of contaminated groundwater.
		Dermal contact with contaminated groundwater	High	
		Inhalation of vapor-phase chemicals while showering	High	
		Incidental ingestion of contaminated water in Little Sulphur Creek	High	Potential for residents to play in Little Sulphur Creek and associated springs is high.
		Dermal contact with contaminated water in springs and Little Sulphur Creek	High	
		Incidental ingestion of contaminated sediment in springs and Little Sulphur Creek	High	
		Ingestion of contaminated fish from Little Sulphur Creek	Low	Fishing by these receptors may occur, however, creek is not viable recreational source.
		Ingestion of contaminated beef/milk	High	High potential for livestock to be raised in rural area.
		Ingestion of contaminated vegetables	High	Potential high for residents to consume garden vegetables grown at home.
		Ingestion of venison/turkey	High	High potential for hunting in a rural area.

Table 5-2B: Old Rifle Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO B - Burning and Detonation Activities at NAVSURFWARCENDIV Cease after 100 Years, and Site is Then Turned into a Park/Natural Area				
Burn pads ordnance: soil contamination at target area	Park visitors/ employees	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the site turned into a park.
		Inhalation of contaminated airborne particulates	Low	No potential for exposure to air emissions.
		Ingestion of contaminated airborne particulates	Low	Low potential for volatilization of organics from soil; low potential for generation of fugitive dusts.
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil at the SWMU.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on-site source of contaminated ground water.
		Dermal contact with contaminated groundwater	Low	Magnitude of exposure due to washing hands, etc., expected to be low.
		Inhalation of vapor-phase chemicals while showering	Low	Route of exposure not expected to be applicable to this receptor.
		Incidental ingestion of contaminated water in Turkey Creek	High	Potential for park visitors to play in Turkey Creek is high.
		Dermal contact with contaminated water in Turkey Creek	High	
		Incidental ingestion of contaminated sediment in Turkey Creek	High	
		Dermal contact with contaminated sediment in Turkey Creek	High	
		Ingestion of contaminated fish from Turkey Creek	Low	Fishing by these receptors in Turkey Creek may occur, however creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Route of exposure not expected to be applicable to this receptor.
		Ingestion of contaminated vegetables	Low	Route of exposure not expected to be applicable to this receptor.
		Ingestion of venison/turkey	High	Deer and turkey hunting does occur at base, albeit infrequently. Hunting activity could increase substantially if land is converted to park/natural area.

Table 5-2C: Old Rifle Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO C - Burning and Detonation Activities at NAVSURFSARCENDIV Cease after 100 Years, and Site is Then Turned into a Residential Area				
Burn pads ordnance; soil contamination at target area	On-SWMU residents	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the SWMU is turned into a residential area. Low potential for volatilization of organics from soil.
		Inhalation of contaminated airborne particulates	Low	Low potential for exposure to SWMU air emissions due to fugitive dusts.
		Ingestion of contaminated airborne particulates	Low	
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on-SWMU source of contaminated groundwater.
		Dermal contact with contaminated groundwater	High	
		Inhalation of vapor-phase chemicals while showering	High	
		Incidental ingestion of contaminated water inTurkey Creek	High	Potential for residents to play in Turkey Creek.
		Dermal contact with contaminated water in Turkey Creek	High	
		Incidental ingestion of contaminated sediment in Turkey Creek	High	
		Dermal contact with contaminated sediment in Turkey Creek	High	
		Ingestion of contaminated fish from Turkey Creek	Low	Fishing by these receptors may occur, however, creek is not a vialbe recreational source.
		Ingestion of contaminated beef/milk	High	High potential for livestock to be raised in a rural area.
		Ingestion of contaminated vegetables	High	High potential for hunting in a rural area.
		Ingestion of venison/turkey	High	

Table 5-3B: Demolition Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO B - Burning and Detonation Activities at NAVSURFWARCENDIV Cease after 100 Years, and Site is Then Turned into a Park/Natural Area				
U.S. Army underground blast area ordnance; U.S. Navy above-ground blast area ordnance; Associated soil contamination	Park visitors/ employees	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the site turned into a park.
		Inhalation of contaminated airborne particulates	Low	No potential for exposure to air emissions.
		Ingestion of contaminated airborne particulates	Low	Low potential for volatilization of organics from soil; low potential for generation of fugitive dusts.
		Ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil at the SWMU.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on-SWMU source of contaminated ground water.
		Dermal contact with contaminated ground water	Low	Magnitude of exposure due to washing hands, etc., expected to be low.
		Inhalation of vapor-phase chemicals while showering	Low	Route of exposure not expected to be applicable to this receptor.
		Incidental ingestion of contaminated water in Boggs Creek	High	Potential for park visitors to play in Boggs Creek is high.
		Dermal contact with contaminated water in Boggs Creek	High	
		Incidental ingestion of contaminated sediment in Boggs Creek	High	
		Dermal contact with contaminated sediment in Boggs Creek	High	
		Ingestion of contaminated fish from Boggs Creek	Low	Fishing by these receptors in Boggs Creek may occur, however, creek is not a viable recreational resource.
		Ingestion of contaminated beef/milk	Low	Route of exposure not expected to be applicable to this receptor.
		Ingestion of contaminated vegetables	Low	Route of exposure not expected to be applicable to this receptor.
		Ingestion of venison/turkey	High	Deer and turkey hunting does occur at base, albeit infrequently. Hunting activity could increase substantially if land is converted to park/natural area.

Table 5-3C: Demolition Range - Exposure Pathway Analysis

Contaminant Source	Potentially-exposed Population	Exposure Route	Likelihood of Pathway Selection for Evaluation	Reason for Selection or Exclusion
SCENARIO C - Burning and Detonation Activities at NAVSURFSARCENDIV Cease after 100 Years and Site is Then Turned into a Residential Area				
U.S. Army underground blast area ordnance; U.S. Navy above-ground blast area ordnance; Associated soil contamination	On-SWMU residents	Inhalation of vapor-phase chemicals	Low	Under this scenario, burning/detonation activities have ceased and the site turned into a residential area. No potential for exposure to air emissions. Low potential for volatilization of organics from soil.
		Inhalation of contaminated airborne particulates	Low	
		Ingestion of contaminated airborne particulates	Low	Low potential for exposure to SWMU emissions due to fugitive dusts.
		Incidental ingestion of contaminated on-SWMU soil	High	High potential for direct contact with contaminated soil.
		Dermal contact with contaminated on-SWMU soil	High	
		Ingestion of contaminated drinking water	High	Potential on-SWMU source of contaminated groundwater.
		Dermal contact with contaminated ground water	High	
		Inhalation of vapor-phase chemicals while showering	High	
		Incidental ingestion of contaminated water in Boggs Creek	High	Potential for residents to play in Boggs Creek is high.
		Dermal contact with contaminated water in Boggs Creek	High	
		Incidental ingestion of contaminated sediment in Boggs Creek	High	
		Dermal contact with contaminated sediment in Boggs Creek	High	
		Ingestion of contaminated fish from Boggs Creek	Low	Fishing by these receptors may occur, however, creek is not a viable recreational source.
		Ingestion of contaminated beef/milk	High	High potential for livestock to be raised in a rural area.
		Ingestion of contaminated vegetables	High	Potential high for residents to consume garden vegetables grown at home.
		Ingestion of venison/turkey	High	High potential for hunting in a rural area.

- Ingestion of sediment (creeks)
- Dermal contact with sediments (creeks)
- Ingestion of venison/turkey

Scenario C: Burning/detonation activities continue for 100 years; facility is then turned into a rural residential area.

Another possible future scenario for this facility is redevelopment into a rural residential area. Under this scenario, existing contamination will be evaluated with respect to a rural families (adults and toddlers) living on the former SWMUs. Each SWMU will be evaluated independently as the location of a residence.

For the purposes of this assessment, residents will be assumed to live on the former SWMUs for 70 years (6 years as a toddler and 64 years as an adult). The likely exposure routes for the resident family are summarized below:

- Incidental ingestion of on-SWMU soil
- Dermal contact with on-SWMU soil
- Ingestion of drinking water
- Dermal contact with drinking water
- Inhalation of vapor-phase chemicals while showering
- Incidental ingestion of surface water (creeks at all SWMUs; springs at ABG)
- Dermal contact with surface water (creeks at all SWMUs; springs at ABG)
- Ingestion of sediment (creeks)
- Dermal contact with sediments (creeks)
- Ingestion of vegetables grown in home gardens
- Ingestion of locally-raised beef and milk
- Ingestion of venison/turkey

Tables 5-4A and 5-4B summarize the pathways to be evaluated for receptors in the current and future use scenarios, respectively.

5.3 EXPOSURE POINT LOCATIONS FOR ANTICIPATED RECEPTORS

The reasonably maximally-exposed human receptors selected for inclusion in the risk assessment include potential current receptors (on-site SWMU workers, on-site base personnel and their families, and off-site local residents) and potential future receptors (park/natural area visitors and employees and on-SWMU residents). In general, these receptors will be assumed to work or live in the geographic locations predicted to be maximally impacted either by the current levels of contaminants at these sites or by the

Table 5-4A

Exposure Pathways to be Evaluated for Current Use Scenario Receptors

Scenario A - Burning and Detonation Activities Continue Indefinitely

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Exposure Pathways	ABG			ORR			DR		
	SWMU Workers	Base Personnel and Families	Off-facility Residents	SWMU Workers	Base Personnel and Families	Off-facility Residents	SWMU Workers	Base Personnel and Families	Off-facility Residents
Inhalation of VOCs	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)
Inhalation/ingestion of particulates	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)
Soil - ingestion/dermal contact	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)	X	X (near Lake Greenwood - adults and toddlers; at SWMU - adults)	X (off facility)
Groundwater - ingestion/dermal contact - inhalation of VOCs	X (ingestion only)		X (off facility)						
Creek water Incidental ingestion/dermal contact									
Creek sediment Incidental ingestion/dermal contact									
Springs - Ingestion/dermal contact			X (off facility)						
Lake Greenwood water - Incidental ingestion/dermal contact and as drinking water		X							

Table 5-4A

Exposure Pathways to be Evaluated for Current Use Scenario Receptors

Scenario A - Burning and Detonation Activities Continue Indefinitely

Exposure Pathways	ABG			ORR			DR		
	SWMU Workers	Base Personnel and Families	Off-facility Residents	SWMU Workers	Base Personnel and Families	Off-facility Residents	SWMU Workers	Base Personnel and Families	Off-facility Residents
Fish - ingestion									
Beef/milk - ingestion			X (off facility)			X (off facility)			X (off facility)
Veggies - ingestion			X (off facility)			X (off facility)			X (off facility)
Venison/turkey - ingestion	X		X (off facility)	X		X (off facility)	X		X (off facility)

NOTES:

"X" indicates the pathway will be evaluated for the receptor.

SWMU workers will be assumed to work only at one SWMU (i.e., each SWMU will be evaluated independently), but within that SWMU they will enter all of the different areas of contamination. The SWMU exposure point concentration will be modified to account for media contact at more that one location. The exception is the DR, where there will be two distinct workers, an army worker and a navy worker, who will be exposed only to media impacted by army and navy activities, respectively.

Base personnel/families (adults/toddlers) will be assumed to live near Lake Greenwood, and will be exposed to impacted environmental media primarily while at base housing and while swimming in Lake Greenwood. The contaminant concentrations in environmental media in and around Lake Greenwood will be modeled using the air emissions data from all three SWMUs combined. The adult will also be assumed to enter each of the SWMUs (and consequently have occasional direct contact with media at all of the SWMUs) as part of his/her job responsibilities at the base. The exposure point concentration for the adult base personnel will be modified to account for contact at more than one location.

Off-facility residents(adults and toddlers) will be assumed to remain off the facility and not venture onto the base. Therefore, all media exposure will take place off the facility. The concentrations of contaminants in off-facility media (soil, vegetation) will be modeled using air emissions data from all three SWMUs combined. These receptors will be exposed to groundwater impacted by activities at ABG only. They will also be assumed to drink the water and bathe in the springs located outside the base property where the property boundary crosses Little Sulphur Creek.

Table 5-4B

Exposure Pathways to be Evaluated for Future Use Scenario Receptors

Scenarios B and C - Burning and Detonation Activities at NAVSURFWARCENDIV Cease after 100 Years

Exposure Pathways	Scenario B - SWMU is Developed into a Park/Natural Area			Scenario C - SWMU is Developed into a Residential Area		
	ABG	ORR	DR	ABG	ORR	DR
	Park Visitors/ Employees	Park Visitors/ Employees	Park Visitors/ Employees	On-SWMU Residents	On-SWMU Residents	On-SWMU Residents
Inhalation of VOCs						
Inhalation/ingestion of particulates						
Soil - ingestion/dermal contact	X	X	X	X	X	X
Groundwater - ingestion/dermal contact - inhalation of VOCs	X (ingestion only)	X (ingestion only)	X (ingestion only)	X	X	X
Creek water Incidental ingestion/dermal contact	X (Little Sulphur Creek)	X (Turkey Creek)	X (Boggs Creek)	X (Little Sulphur Creek)	X (Turkey Creek)	X (Boggs Creek)
Creek sediment Incidental ingestion/dermal contact	X (Little Sulphur Creek)	X (Turkey Creek)	X (Boggs Creek)	X (Little Sulphur Creek)	X (Turkey Creek)	X (Boggs Creek)
Springs - Incidental ingestion/dermal contact	X (on facility)			X (on facility)		
Lake Greenwood water - Incidental ingestion/dermal contact						

Table 5-4B

Exposure Pathways to be Evaluated for Future Use Scenario Receptors

Scenarios B and C - Burning and Detonation Activities at NAVSURFWARCENDIV Cease after 100 Years

Page 2 of 2

	Scenario B - SWMU is Developed into a Park/Natural Area				Scenario C - SWMU is Developed into a Residential Area		
	ABG	ORR	DR		ABG	ORR	DR
Exposure Pathways	Park Visitors/ Employees	Park Visitors/ Employees	Park Visitors/ Employees		On-SWMU Residents	On-SWMU Residents	On-SWMU Residents
Fish - ingestion							
Beef/milk - ingestion					X	X	X
Veggies - ingestion					X	X	X
Venison/turkey - ingestion	X	X	X		X	X	X

NOTES:

"X" indicates the pathway will be evaluated for the receptor.

Under both future use scenarios, each SWMU will be evaluated independently, i.e., receptors will be assumed to have contact with environmental media at only one SWMU and the associated surface water. At ABG, the burn pan area and the jeep trail area will be evaluated independently as a park or residential area.

emissions (groundwater, air) released from ABG, ORR, and DR. These individuals are anticipated to be exposed to hazardous constituents present in the environment from many sources and through a wide variety of routes. The most significant exposure routes have been summarized in the previous section of this work plan.

The frequency, extent, and duration of exposure for any individual person will depend on many factors, including location of residence, age, and activity patterns. Behavioral patterns are likely to be highly variable among individuals. For example, the amount of fish consumed by individuals varies from none for people who do not eat fish to relatively large amounts in people who use sportfishing as an important means of supplementing their diet. This potential wide variation in likely exposure to environmental contaminants in any receptor population necessitates the use of simplified, conservative assumptions in the process of exposure assessment. Halliburton NUS Team has suggested the standard assumptions presented in the Superfund Exposure Assessment Manual (USEPA, 1988), the Superfund Human Health Assessment Manual (RAGS, USEPA, 1989a), the supplemental guidance to RAGS regarding "Standard Default Exposure Factors," (USEPA, 1991) and the Exposure Factors Handbook (USEPA, 1989b) in preparing this site-specific exposure assessment work plan.

5.4 QUANTITATIVE ENVIRONMENTAL FATE ANALYSIS

Discussions of the environmental media concentrations for use in the risk assessment for the on-SWMU chemical contaminants have been provided earlier in Section 4.0. This section will only discuss the anticipated chemical fate modeling for this assessment.

The only environmental fate modeling proposed for use in this baseline risk assessment at the present time involves the air dispersion modeling of the emission substances from each SWMU (by other CTOs), the quantification of volatile chemicals in the air during showering (Section 5.4.1) and the possible accumulation of airborne chemicals in secondary, off-SWMU environmental media (Sections 5.4.2 through 5.4.5). A shower model will be evaluated only if VOCs are found in the groundwater monitoring wells. Chemical accumulation in plants and animals will be modeled only if bioaccumulative and/or persistent chemicals are shown to be emitted from those SWMUs into the ambient air.

5.4.1 Chemical Concentrations in the Air While Showering

For the purpose of quantifying human exposure to VOCs while showering in contaminated groundwater, the concentration of each VOC of concern in the air in the shower will be calculated from the chemical concentration in groundwater at each receptor location.

Halliburton NUS Team has developed an environmental fate model, adapted from a "shower model" developed by Foster and Chrostowski (1987), to quantify air levels of volatile chemicals in a shower.

5.4.2 Soil Accumulation of Analytes

5.4.2.1 Inorganic Substances

Metals present in the air emissions of the open burning/open detonation activities from these SWMUs will bind to airborne particulates and subsequently deposit onto soil. The approach selected for estimating the soil accumulation of metals is consistent with the current USEPA guidance on indirect exposure to combustion emissions (guidance documents: USEPA, 1990; 1993b). The mass-balance equation recommended for estimating the accumulation of these contaminants in soil as a function of time is (USEPA, 1990; 1993b):

$$\overline{CS} = \sum_{i=1}^{100} \frac{Dyd\ (1 - e^{-Ks\ T_i})}{(K_s)\ (Z)\ (BD)\ (100)}$$

where $\overline{CS}$ = average contaminant level in soil (mg/kg); Dyd = annual deposition rate of contaminant (mg/m^2-yr - output from air dispersion model); K_S = soil loss constant (chemical-specific); T_i = 1.0 through 100 years to give average contaminant level over assumed 100 years of SWMU operation (Scenario A); BD = soil bulk density (assume 1500 kg/m^3; USEPA, 1990); and Z = soil mixing depth = 0.20 m for tilled soil (crops/garden soil default value) or 0.01 m for untilled soil (dermal exposure and soil ingestion default value).

For inorganics, the soil loss constant, K_S, is equated to the elimination rate constant due to leaching: K_{SL} . Inorganics such as metals do not degrade environmentally but are assumed to leach through soil. This approach is consistent with the calculations of cumulative soil concentrations from the deposition of combustor-derived contaminants, as presented in the recent U.S. EPA guidance documents (USEPA, 1990; 1993b). Inorganic loss due to volatilization is assumed to be negligible.

The soil loss constant due to leaching (K_{SL}) will be obtained by estimating the water availability in the soil and the influence of soil properties on water and contaminant mobility using the equation shown below. The input parameters for calculating the chemical-specific K_{SL} values are also defined below. If site-specific values are not readily available,

several default parameters will be taken directly from the current USEPA guidance documents on combustor emissions, as indicated below (USEPA, 1990; 1993b):

$$K_{SL} = \frac{P + I - E_V}{(\Theta)\ (Z)\ [1 + (BD \times K_d / \Theta)]}$$

where:

K_{SL} = loss constant due to leaching (yr^{-1}) = chemical-specific value;

P = average annual precipitation (cm/yr) = site-specific value or default value of 120 cm/yr (USEPA, 1990);

I = average annual irrigation (cm/yr) = site-specific value or default value of 25 cm/yr (USEPA, 1990);

E_v = average annual evapotranspiration (cm/yr) = site-specific value or default value of 100 cm/yr (USEPA, 1990);

Θ = soil volumetric water content (mL/cm^3) = default value of 0.22 mL/cm^3 (USEPA, 1990);

Z = soil depth from which leaching removal occurs (cm) = 20 cm for tilled soil and 1.0 cm for untilled soil (USEPA, 1990);

BD = soil bulk density (g/cm^3) = default value of 1.5 g/cm (USEPA, 1990);

K_d = soil water partitioning coefficient (mL/g) = chemical-specific value obtained from published scientific literature.

The water available for leaching, estimated by ($P + I - E_v$), represents a mass balance of water inputs and outputs from the area in consideration (USEPA, 1990). As reported in the guidance document (USEPA, 1990), precipitation values range from 18.06 to 164.19 cm/yr for 69 selected U.S. cities (U.S. Bureau of the Census, 1987). Irrigation values range from 0 to 100 cm/yr for 69 selected cities (Baes et al., 1984; cited in USEPA, 1990). Evapotranspiration values vary from 35 to 100 cm/yr (Baes et al., 1984; cited in USEPA, 1990). The soil water content (Θ) is influenced by the available water and by the

soil structure/soil type, and values for this parameter typically range from 0.03 to 0.40 mL/cm^3 (Hoffman and Baes, 1979; cited in USEPA, 1990).

5.4.2.2 Organic Chemicals

Halliburton NUS Team recommends the use of a single-compartment, first-order reaction rate approach to calculate the accumulation of particulate-bound, non-volatile organic chemicals such as PAHs and PCBs in soil (USEPA, 1990). This approach requires the incorporation of published soil half-life data for each chemical into the equation for estimating soil contaminant levels (CS)identified in the previous section. Soil losses of non-volatile organic chemicals are assumed to be related to abiotic and biotic degradation in addition to leaching. For these chemicals, the soil loss constant, K_s, is equated to the sum of the individual rate constants for degradation, K_{SG} (based on published soil half-life data) and leaching, K_{SL}. Losses due to volatilization are assumed to be negligible. This approach is consistent with the calculations of cumulative soil concentrations from the deposition of combustor-derived contaminants, as presented in recent U.S. EPA guidance documents (USEPA, 1990; 1993b).

5.4.3 Vegetation Bioaccumulation of Analytes

Chemical contamination of garden produce, as well as crops grown on local farms for livestock feed, can arise from aerial deposition of airborne particulates emitted from the SWMUs onto plant surfaces and via chemical uptake from contaminated soil. Contaminant levels in vegetation will be calculated as follows:

$$CV = CVR + CVD$$

where CV = total contaminant level in vegetation (mg/kg); CVR = contaminant level in vegetation from root uptake (mg/kg); and CVD = contaminant level in vegetation from deposition on plants (mg/kg).

Vegetation accumulation will be calculated for the following food and livestock crops:

- potatoes
- carrots
- tomatoes
- beans/peas
- lettuce
- hay
- corn (silage)

Contaminant levels in fruits and vegetables will be expressed on a wet-weight basis. Levels in cattle feed will be expressed on a dry-weight basis because cattle feed consumption rates are typically provided on a dry-weight basis.

5.4.3.1 Chemical Accumulation via Root Uptake (CVR)

Root uptake of chemical contaminants in vegetation will be calculated as follows:

$$CVR = RUF \times CS \times DWF$$

where CVR = contaminant level in vegetation via root uptake (mg/kg); RUF = root uptake factor (kg/kg); CS = contaminant level in soil (mg/kg) (0.20 m mixing depth); DWF = dry-to-wet weight conversion factor (unitless) (not applicable to livestock crops) = 0.25 (potatoes); 0.06 (tomatoes); 0.05 (lettuce); 0.12 (carrots); and 0.18 (beans) (Wenck, 1983; Wiersma et al., 1986).

The scientific literature will be reviewed for data from which to estimate root uptake factors for the chemicals of potential concern.

5.4.3.2 Chemical Accumulation via Direct Deposition (CVD)

The mass-balance equation for particulate deposition onto vegetation (applicable only to lettuce, beans/peas, tomatoes, and hay) is:

$$CVD = \frac{A\ (1 - e^{-kt})}{y \times k}$$

where CVD = contaminant level in vegetation from direct deposition (mg/g); A = analyte deposition onto plant surface (regional deposition rate x fraction of surface area occupied by plant (f_{plant}); (mg/m^2-day)); f_{plant} = 0.72 (lettuce); 0.56 (tomatoes); 0.18 (beans); 0.48 (hay); and 0.87 (corn) (Baes et al., 1984); k = rate constant for chemical loss from plant surface due to weathering (day^{-1}) = 0.05 day^{1} (Baes et al., 1984); y = vegetation yield (kg/m^2), a site-specific value; and t = length of growing season (days), a site-specific value.

The values for y and t for each crop will be determined through interviews with local farmers and/or Indiana agricultural extension specialists.

5.4.4 Terrestrial Food Chain Bioaccumulation of Analytes

5.4.4.1 Bioaccumulation in Beef/Venison/Turkey

Beef cattle or local wild deer and turkey consuming contaminated vegetation and soil may accumulate contaminants in their muscle tissue (including fat). The equation that is recommended to estimate potential contaminant concentration in beef is:

$$CB = ICB \times BB$$

where CB = concentration of contaminant in beef (mg/kg); ICB = daily contaminant intake by beef cattle (mg/d); and BB = biotransfer factor for beef (d/kg).

Daily contaminant intake (ICB) by beef cattle will be calculated as follows:

$$ICB = IH + ICS + IS + II$$

where IH = contaminant intake from hay (beef animal) (mg/d); ICS = contaminant intake from corn silage (mg/d) and IS = contaminant intake from soil (mg/d); II = contaminated intake from inhalation (mg/d).

IH and ICS will be calculated with the following general equation:

$$I_i = CV_i \times CR_i$$

where I_i = contaminant intake via feed type 'I' (mg/d); CV_i = contaminant level in feed type 'I' (mg/kg); CR_i = cattle consumption rate of feed type 'I' on a dry weight basis(kg/d) = 1.62 kg alfalfa hay; 8.71 kg corn silage (Neumann, 1977).

Contaminant intake for cattle via soil ingestion (IS) will be calculated as follows:

$$IS = CS \times SCR$$

where CS = contaminant level in soil at 0.20 m mixing depth (mg/kg); SCR = cattle soil consumption rate (kg/d) = 0.19 kg/d (Fries, 1987).

Contaminant intake for cattle via inhalation (II) will be calculated as follows:

$$II = CA \times IR$$

CA = contaminant concentration in air (mg/m^3)
IR = inhalation rate (m^3/d)
= 20.5 m^3/d (beef animal; Mitchell, 1990)

Halliburton NUS Team recommends that the beef biotransfer factors published by Stevens (1992) be utilized, if applicable, in the risk assessment. For chemicals of concern for which no beef biotransfer factor is currently available, the transfer factors should be derived from data gathered through a review of the scientific literature.

Samples of tissue from deer and turkeys killed on the site will be analyzed for chemical contamination as part of the Ecological Risk Assessment (Section 8.0). These tissue concentrations will also be used in the Human Health Risk Assessment to estimate human doses of the contaminants of potential concern from ingesting deer and turkeys harvested at the site. Should adequate data not be available, contaminant concentrations in venison and turkey will be modeled in a manner similar to that used for beef. The literature will be reviewed for appropriate input parameters (e.g., deer and turkey food consumption).

5.4.4.2 Bioaccumulation in Milk

Dairy cattle may also be exposed to chemicals of potential concern via inhalation of air and ingestion of contaminated soil and vegetation. These chemicals could then bioaccumulate in milk to a steady-state condition. The general equation that will be used to calculate the potential concentration of chemicals in bovine milk is:

$$CM = ICM \times BM$$

where CM = concentration of contaminant in milk (mg/kg); ICM = daily contaminant intake by dairy cattle (mg/d); and BM = biotransfer factor for milk (d/kg).

ICM for the dairy cow will be calculated in the identical manner that ICB was calculated for the beef animal. The dairy cow will be assumed to consume 4.86 kg alfalfa hay and 5.61 kg corn silage a day (dry-weight basis (Linn et al., 1981)) and 0.4 kg soil a day (Fries, 1987). Milk biotransfer factors for six metals and Polychlorinated dibenzo-dioxin (PCDD)/Polychlorinated dibenzofuran (PCDF) have recently been derived by Stevens (1991), and these are recommended for use in the risk assessment if applicable. The literature can be reviewed to derive milk biotransfer factors for those chemicals of concern for which one has not been provided by Stevens.

5.4.5 Surface Water Accumulation of Analytes

Particulate-bound contaminants present in the air emissions of the open burning/open detonation activities from the three SWMUs have the potential to deposit into on-facility surface water such as Lake Greenwood and off-facility surface water such as Little Sulphur Creek south of the facility boundary. Surface water bodies within the potential air dispersion impact zone of the open burning/open detonation activities could receive contaminants as direct fallout and indirectly in runoff and erosion from fallout to watershed soils. However, the magnitude of potential impacts to creek water is expected to be minimized by environmental fate and transport processes including chemical degradation and also dilution, recharge and "flow-through" within this surface water. Modeling of potential air impacts to Little Sulphur Creek, therefore, is not being recommended for the risk assessment.

Modeling will be used, however, to evaluate the potential impacts to Lake Greenwood related to the air dispersion and deposition of particulate-bound contaminants present in the air emissions from the open burning/open detonation activities. The modeling algorithm selected to evaluate this pathway is consistent with the calculations of cumulative concentrations in surface waters from the deposition of combustor-derived contaminants, as presented in recent USEPA guidance documents (USEPA, 1990; 1993b).

Since Lake Greenwood is presumed to be located within the potential impact zone of the open burning/open detonation activities, a fraction of the mass of particulate-bound emissions (metals and non-volatile organics) is expected to deposit directly into the lake and onto watershed soils. The water concentrations of contaminants are determined through the modeling algorithm by quantifying the direct deposition of particulate-bound contaminants to the surface water and also the contaminant fallout to watershed soils, a portion of which reaches the lake as constituents dissolved in runoff water and as material adsorbed to soils eroding into the surface water. The model also accounts for dissipation processes which remove contaminants from the lake's water column:

- decay of contaminants within the water column;
- decay of contaminants within bed sediments; and
- removal of contaminants through burial beneath the surficial bed sediment layer.

It will assumed, for the purposes of this risk assessment, that gaseous diffusion of contaminants (into watershed soils and into the lake) and volatilization (from watershed soils and from the lake) are negligible.

Overall Chemical Mass Balance

Using the USEPA modeling approach for combustor emissions, contaminant concentrations in the receiving water will be determined from the annual mass loading of contaminants (including fallout deposition, runoff and erosion), the total area of the watershed, the dilution volume of the water body and the annual advective flow through the water body. The contaminant concentrations in Lake Greenwood will thus be calculated using the following chemical mass balance equation (USEPA, 1993b):

$$\underset{(mg/L)}{C_{WTOT}} = \frac{(L_T)\ (CF)}{(Vf_X)\ (f_{WATER}) + (k_{WT})\ (V_T)}$$

Where:

C_{WTOT} = total water body concentration, including water column and benthic sediment;
L_T = total chemical load into the lake from direct fallout and runoff/erosion (mg/yr);
CF = conversion factor = 1E-03 M^3/L;
Vf_X = average volumetric flow rate through the lake (M^3/yr);
V_T = total lake volume, including water column and benthic sediment (M^3);
k_{WT} = total first order dissipation rate constant, including water column and benthic degradation and burial (yr^{-1});
f_{WATER} = fraction of the total contaminant concentration that occurs in the water column (unitless).

Total chemical loading to the water body, L_T, is comprised of three inputs:

$$\underset{(mg/yr)}{L_T} = (L_{DEP}) + (L_R) + (L_E)$$

Where:

L_T = total chemical load into the lake from direct fallout and runoff/erosion;
L_{DEP} = direct deposition of particle bound contaminant to the lake (mg/yr);
L_R = watershed runoff load (mg/yr);
L_E = watershed soil erosion load (mg/yr).

The load due to direct deposition to the lake is solved as:

$$\underset{(mg/yr)}{L_{DEP}} = (Dyd)\ (WA_W)$$

Where:

L_{DEP} = deposition of particle bound contaminant;
Dyd = annual deposition rate of contaminant, as output from the air dispersion model (mg/M^2-yr);
WA_W = water body area = surface area of Lake Greenwood (M^2) to be estimated from a topographic map showing Lake Greenwood.

The runoff and erosion loads require estimation of average contaminant concentrations in watershed soils that comprise the depositional area. The estimation methodologies are described below.

Load Due to Surface Runoff

The load due to surface runoff, as dissolved chemical concentrations derived from watershed soils during rain events, is given by:

$$\underset{(mg/yr)}{L_R} = \frac{(R)\ (WA_L)\ (\overline{CS})\ (BD)\ (CF_1)}{[\ \Theta\ +\ (K_d)\ (BD)\ (CF_2)\ ]}$$

Where:

L_R = watershed runoff load;
R = average annual runoff (cm/yr), see discussion below;
WA_L = total watershed area receiving particulate deposition (M^2), to be estimated from a topographic map showing the Lake Greenwood watershed with an overlay of the isopleth dispersion pattern;
$\overline{CS}$ = average contaminant level in soil (mg/kg) over assumed 100 years of SWMU operation, derived using the algorithm presented previously in Section 5.4.2 for the soil accumulation of analytes related to particulate deposition;
BD = soil bulk density (assume 1500 kg/M^3, from USEPA 1990);

CF_1 = conversion factor = 1E-02 M/cm;
Θ = soil volumetric water content (mL/cm^3) = default value of 0.22 mL/cm^3 (USEPA, 1990);
K_d = soil water partitioning coefficient (mL/kg) = chemical-specific value obtained from published scientific literature;
CF_2 = conversion factor = 1E-06 M^3/cm^3.

The average annual runoff, R (cm/yr), from the watershed is defined as the net flow contribution to the surface water body, reflecting the interactions of direct runoff from precipitation events with shallow interflow and ground water recharge. For the purposes of this risk assessment, the runoff will be approximated from published information. For example, one source which may be consulted is "The Water Atlas of the United States" (Geraghty et al., 1973), which provides maps with isolines of annual average surface runoff. The range of values for R given in this atlas range from 12 to 102 cm/yr for various parts of the U.S. (USEPA, 1993b).

Load Due to Soil Erosion

During periodic erosion events, particulate chemical concentrations in the watershed soils are transported to the lake. This environmental fate process, and the soil erosion load (L_E), will be modeled by the following equation:

$$\underset{(mg/yr)}{L_E} = \frac{(X_E)\ (WA_L)\ (SD)\ (ER)\ (\overline{CS})\ (K_d)\ (BD)}{[\ (\Theta)\ (CF)\ +\ (K_d)\ (BD)\ ]}$$

Where (for only those parameters not previously defined above):

X_E = annual soil loss rate per unit area of watershed (kg/m^2-yr), see discussion below;
SD = watershed sediment delivery ratio (unitless), see discussion below;
ER = soil enrichment ratio (unitless), see discussion below;
CF = conversion factor = 1E+06 cm^3/M^3.

The soil loss rate, X_E, for the watershed will be computed using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978; cited in USEPA, 1990):

$$\underset{(kg/M^2 - yr)}{X_E} = (R_E)\ (K_E)\ (LS)\ (C)\ (P_S)\ (CF_1)\ (CF_2)$$

Where:

R_E = erosivity factor [$(yr)^{-1}$], will consult compilation of values for various U.S. regions available in Wischmeier and Smith (1978) or use default value of 400 $(yr)^{-1}$ (USEPA, 1990);
K_E = erodability factor (tons/acre), will use default value of 0.21 (tons/acre) (USEPA, 1990);
LS = topographic or slope length factor (unitless), an appropriate value will be selected based on the average slope grade and the width of the watershed (as determined from a topographic map) following the guidance in USEPA (1993b);
C = cover management factor (unitless), a value of 0.1 will be used to represent dense vegetative cover such as grass across inactive (non-agricultural) watershed terrain (USEPA, 1993b);
P_S = supporting practice factor (unitless), default value of 1.0 will be used (USEPA, 1993b);
CF_1 = conversion factor = 907.18 kg/ton;
CF_2 = conversion factor = 2.471E-04 acre/M^2.

The sediment delivery ratio, SD (used as an input parameter to the equation shown previously above for estimating the load due to soil erosion), can be calculated based on the area of the watershed using the relationship proposed by Vanoni (1975; cited in USEPA, 1993b):

$$\underset{(unitless)}{SD} = (a)\ (WA_L)^B$$

Where:

WA_L = watershed area receiving fallout (M^2);
B = empirical slope coefficient = 0.125 (USEPA, 1993b);
a = empirical intercept coefficient (see below).

Based on studies of sediment yields from watersheds (Vanoni, 1975; cited in USEPA, 1993b), the empirical slope coefficient - "a" - varies with the size of the watershed. USEPA (1993b) recommends the following values for "a":

Watershed Area (square-miles)	"a" Coefficient (unitless)
<= 0.1	2.1
1	1.9
10	1.4
100	1.2
1,000	0.6

The soil enrichment ratio (ER), used in the equation shown previously above that estimates the load due to soil erosion, is generally assigned values in the range of 1 to 5 (USEPA, 1993b). Enrichment refers to the fact that erosion favors the lighter soil particles, which typically have higher surface area to volume ratios and are also higher in organic matter content. Therefore, concentrations of organic contaminants, which are a function of organic carbon content of sorbing media, would be expected to be higher in eroded soil as compared to in-situ soil. The enrichment ratio would also be expected to be higher in sandy soils as compared to silty or loamy soils. For the purposes of this risk assessment, a value of 3 for ER is proposed.

Surface Water Dilution and Advective Flow

The discussions above have documented the algrorithm which will be used to estimate the total chemical loading, L_T, to Lake Greenwood. L_T is an input parameter to the surface water model's overall mass balance equation. As presented earlier, the contaminant concentrations in Lake Greenwood will be calculated using the following chemical mass balance equation (USEPA, 1993b):

$$\underset{(mg/L)}{C_{WTOT}} = \frac{(L_T)\ (CF)}{(Vf_X)\ (f_{WATER}) + (k_{WT})\ (V_T)}$$

The derivations of the remaining input parameters (shown in the equation denominator) are presented in the discussion below.

The first term in the denominator, (Vf_X) (f_{WATER}), accounts for contaminant dilution due to advective flow from the lake. It is the product of the average annual volumetric flow rate, Vf_X, and the fraction (f_{WATER}) of the chemical mass load to the lake that is actually present in the water column. (This term, f_{WATER}, is discussed further below.) The annual flow volume rate will be estimated by multiplying the total area of the watershed, WA_L (presented previously under "***Load Due to Surface Runoff***"), by the average annual runoff, R (also presented previously).

The second term, (k_{WT}) (V_T) in the denominator of the model's overall mass balance equation, accounts for contaminant dissipation within the lake. It is the product of the lake volume, V_T, and the total first order total dissipation rate constant, k_{WT}. V_T will be derived by multiplying the average lake depth times WA_W, the surface area of Lake Greenwood (M^2; to be estimated from a topographic map showing Lake Greenwood). Data on lake depths will be attempted to be obtained from the State of Indiana.

The total dissipation rate constant, k_{WT}, includes fate and transformation processes affecting all of the chemical phases -- dissolved and sorbed chemical in the water column and in the benthic sediments. Water column and benthic degradation, and sediment burial will be considered:

$$\underset{(yr^{-1})}{k_{WT}} = (f_{WATER})\ (k_{GW}) + (f_{BENTH})\ (k_{GB}) + (f_{BENTH})\ (k_B)$$

Where:

k_{GW} = water column degradation rate constant $[(yr)^{-1}]$; when available, chemical-specific values will be obtained from the scientific literature or published water quality models; when not available, this rate constant will conservatively be equated to zero;

k_{GB} = benthic degradation rate constant $[(yr)^{-1}]$; when available, chemical-specific values will be obtained from the scientific literature or published water quality models; when not available, this rate constant will conservatively be equated to zero;

k_B = benthic burial rate constant [$(yr)^{-1}$], see discussion below;

f_{WATER} = fraction of total lake contaminant concentration that occurs in the water column (unitless), see discussion below;

f_{BENTH} = fraction of total lake contaminant concentration that occurs in the benthic sediment (unitless), see discussion below.

The benthic burial rate constant, k_B , will be estimated using Equation Nos. 9-4, 9-5, and 9-33 in the USEPA updated guidance manual for the evaluation of indirect exposure to combustor emissions (USEPA, 1993b). The remaining terms, f_{WATER} and f_{BENTH} , will be determined using the appropriate chemical state equations presented on pages 9-5 and 9-6 of this guidance document (USEPA, 1993b). These latter terms are calculated, in part, by the use of adsorption partition coefficients which describe quantitatively the partitioning of contaminants between sorbing material (such as suspended solids and bed sediments) and lake water in a sorbing material/water mixture, as described on pages 9-43 through 9-45 of the guidance document (USEPA, 1993b).

5.5 EXPOSURE POINT CONCENTRATIONS FOR ANTICIPATED RECEPTORS

The human receptors anticipated for inclusion in the risk assessment are assumed to be exposed to site chemicals from several sources and a number of exposure routes. The derivation of the exposure point concentrations of the chemicals of potential concern in relevant environmental media is summarized below. In general, the 95% upper confidence limit of the arithmetic mean of sample concentrations within each data set or the highest detected concentration in the data set, whichever is lower, is proposed as the media- and chemical-specific exposure concentration.

5.5.1 Base Personnel Under Scenario A

For the adult receptor, the exposure point concentrations for contaminants in air and those in soil will be determined as time-weighted average levels since this receptor's activities are presumed to be proportioned among time spent at home near Lake Greenwood and infrequent visits to each SWMU. The following equation will be used to calculate the time-weighted exposure point concentrations for the air and soil pathways:

$$EC = \sum_{i=1}^{n} \frac{(CC_i)\ (T_i)}{(TT)}$$

Where:

EC = exposure point concentration (media- and chemical-specific);
CC_i = contaminant concentration for area "i", where "n"= total number of SWMUs (or areas) contacted by the receptor;
T_i = time spent by receptor at SWMU (or area) "i";
TT = total time (hours/day or days/year).

For the toddler, the exposure point concentrations for contaminants in air will be the air dispersion modeling output for the area of the base housing near Lake Greenwood since the toddler is assumed to spend all of his/her time at home. Similarily, toddler contact with soil will be based on the average soil chemical levels derived using the algorithm presented previously in Section 5.4.2 for the soil accumulation of analytes related to dispersion and deposition (near Lake Greenwood) of contaminants present in the air emissions of the open burning/open detonation activities.

Adults and toddlers will also be exposed to potential contaminants while swimming in Lake Greenwood and by using this lake as their primary residential water source. The exposure point concentrations for this surface water body will be based on the output of the algorithm presented in Section 5.4.5 for the determination of surface water accumulation of analytes related to the air dispersion and depositon of particulate-bound contaminants.

5.5.2 SWMU Workers Under Scenario A

For the workers at each SWMU, the exposure point concentrations for contaminants in air will be determined as time-weighted average levels since this receptor's activities are presumed to be proportioned among time spent at various areas within the SWMU. The equation presented previously above (under Section 5.5.1) will be used to calculate the time-weighted exposure point concentrations for the air pathway.

The exposure point concentrations for contaminants in soil will be determined as area-weighted average levels since the worker's activities are presumed to be proportioned among various areas at each SWMU. The following equation will be used to calculate the area-weighted exposure point concentrations for the soil pathway:

$$\mathbf{EC} = \sum_{i=1}^{n} \frac{(CC_i)\ (A_i)}{(TA)}$$

Where:

EC = exposure point concentration (chemical-specific);
CC_i = contaminant concentration for area "i", where "n"= total number of areas contacted within the SWMU;
A_i = size (surface area) of area "i";
TA = total surface area of SWMU.

The exception to this approach for soil is at DR where two separate workers, an army worker and a navy worker, will be exposed to soil impacted by army and navy activities, respectively.

The exposure point concentrations for groundwater at ABG will be based on monitoring well data aggregated for the aquifer which supplies the current on-SWMU water supply well, and these data will be averaged only for those monitoring wells located within a reasonable, theoretical capture zone for the water supply well. Since water supply wells currently do not exist at the other SWMUs, groundwater is an incomplete exposure pathway at ORR and DR with respect to the current on-SWMU workers.

The exposure point concentrations for venison and turkey will be based on actual tissue levels (if available) or the output of the modeling algorithm presented previously in Section 5.4.4.1. The modeling inputs for this food pathway will include the (SWMU-specific) contaminant concentrations in soil based on averaging the soil analytical database available for samples collected across the entire SWMU. The modeling inputs for this food pathway will also include wildlife inhalation of contaminants in air, and these contaminant concentrations will be the air dispersion modeling output (isopleths) plotted over the entire area of each SWMU.

5.5.3 Off-Facility Residents Under Scenario A

For adults and toddlers, the exposure point concentrations for contaminants in air will be the air dispersion modeling output for the area of the Padanaram community. Similarily, receptor contact with soil will be based on the average soil chemical levels derived using the algorithm presented previously in Section 5.4.2 for the soil accumulation of analytes related to the dispersion and deposition of contaminants present in the air emissions of the open burning/open detonation activities.

Adults and toddlers will also be exposed to potential contaminants in ground water while ingesting drinking water (and through dermal contact while showering). The exposure

point concentrations for ground water will be based on monitoring well data averaged from the two wells placed at the furthest location downgradient from ABG and the Jeep Trail area, but on NAVSURFWARCENDIV property: the Beech Creek well 03B10 and the Alluvium well 03B02. The ground water exposure point concentrations of VOCs present will also be input into the shower model (Section 5.4.1) in order to estimate the air levels of VOCs inhaled while showering.

The off-facility residents are also assumed to be exposed to off-facility springs through ingestion of drinking water collected at these springs. This pathway will be evaluated as a sole source of drinking water (i.e., exposure to springs will neither be proportioned nor combined with exposure to ground water). The exposure point concentrations for the springs will be based on the analytical sampling data averaged from the two springs located along Little Sulphur Creek just south of NAVSURFWARCENDIV property: Spring 8 and Spring 10.

The exposure point concentrations of chemicals with the potential to bioaccumulate in food pathways will be the output of the algorithms presented previoiusly in Section 5.4.4. For venison and turkey, the exposure point concentrations will be based on actual tissue levels (if available) or the output of the modeling algorithm presented in Section 5.4.4.1. The modeling inputs for the food pathways will include the average chemical levels in soil derived using the algorithm presented previously in Section 5.4.2 (for the soil accumulation of analytes related to dispersion and deposition of contaminants present in the air emissions of the open burning/open detonation activities).

5.5.4 Park Visitors and Park Employees Under Scenario B

For these receptors at each SWMU, the exposure point concentrations for contaminants in soil will be determined by averaging the soil analytical database available for the entire SWMU.

The exposure point concentrations for groundwater at each SWMU will be based on monitoring well data aggregated separately for each aquifer, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well designed for a park. If the capture zone appears to be small in size relative to the total area of the SWMU and/or the current monitoring well field, then several theoretical capture zones (and well groupings) per aquifer will be used to calculate separate exposure point concentrations for various locations across the SWMU. In this case, the receptor doses related to the different well groupings will not be summed but will be carried through the risk characterization as distinct ground water exposure scenarios. If the capture zone appears to be large in size relative to the total

area of the SWMU and/or the current monitoring well field, then a single well grouping per aquifer, representing the average of the well data for the entire SWMU, will be used to calculate ground water exposure point concentrations.

The exposure point concentrations for creek surface water and sediment will be based on the creek-specific analytical sampling data. Surface water data will be grouped separately from sediment data. In addition, the media-specific data collected from Boggs Creek, from Turkey Creek and from Little Sulphur Creek will be grouped separately in order to calculate exposure point concentrations.

The park visitors and park employees associated with ABG are also assumed to be exposed to on-facility (off-SWMU) springs through incidental ingestion and dermal contact. The exposure point concentrations for these springs will be based on the analytical sampling data averaged from the three springs located along Little Sulphur Creek south of the Jeep Trail area: Springs A, B, and C.

The exposure point concentrations for venison and turkey will be based on actual tissue levels (if available) or on the output of the modeling algorithm presented previously in Section 5.4.4.1. The modeling inputs for this food pathway will include the (SWMU-specific) contaminant concentrations in soil based on averaging the soil analytical database available for samples collected across the entire SWMU.

5.5.5 On-SWMU Residents Under Scenario C

For future residents at each SWMU, the exposure point concentrations for contaminants in soil will be determined by averaging the soil analytical database available for the entire SWMU. In addition, the Jeep Trail area will be evaluated separately from ABG.

The exposure point concentrations for groundwater at each SWMU will be based on monitoring well data aggregated separately for each aquifer, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well designed for use by a single residence. If the capture zone appears to be small in size relative to the total area of the SWMU and/or the current monitoring well field, then several theoretical capture zones (and well groupings) per aquifer will be used to calculate separate exposure point concentrations for various locations across the SWMU. In this case, the receptor doses related to the different well groupings will not be summed but will be carried through the risk characterization as distinct ground water exposure scenarios. If the capture zone appears to be large in size relative to the total area of the SWMU and/or the current monitoring well field, then a single well grouping per aquifer, representing the average of the well data for the entire SWMU,

will be used to calculate ground water exposure point concentrations. As with soil, ground water at the Jeep Trail area will be evaluated separately from ground water at ABG.

The exposure point concentrations for creek surface water and sediment will be based on the creek-specific analytical sampling data. Surface water data will be grouped separately from sediment data. In addition, the media-specific data collected from Boggs Creek, from Turkey Creek and from Little Sulphur Creek will be grouped separately in order to calculate exposure point concentrations.

The future residents associated with ABG are also assumed to be exposed to on-facility (off-SWMU) springs through incidental ingestion and dermal contact. The exposure point concentrations for these springs will be based on the analytical sampling data averaged from the three springs located along Little Sulphur Creek south of the Jeep Trail area: Springs A, B, and C.

The exposure point concentrations of chemicals with the potential to bioaccumulate in food pathways will be the output of the algorithms presented previoiusly in Section 5.4.4. For venison and turkey, the exposure point concentrations will be based on actual tissue levels (if available) or on the output of the modeling algorithm presented in Section 5.4.4.1. The modeling inputs for the food pathways will include the (SWMU-specific) contaminant concentrations in soil based on averaging the soil analytical database available for samples collected across the entire SWMU.

5.6 HUMAN EXPOSURE DOSE ALGORITHMS

Once the exposure point concentrations of the chemicals of concern are calculated, these levels are translated into reasonably maximum exposure doses for the human receptor(s). This translation of environmental contamination levels into human doses of the chemicals of concern is made by using standard exposure assessment equations (USEPA, 1989a).

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where I = intake, the amount of chemical at the exchange boundary (mg/kg body weight/day); C = chemical concentration, the average concentration contacted over the exposure period (e.g., mg/liter water); and CR = contact rate, the amount of contaminated medium contacted per unit time or event (e.g., liters/day); EF = exposure frequency (describes how often exposure occurs (days/year)); ED = exposure duration (describes

how long exposure occurs (years)); BW = body weight (the average body weight of the receptor over the exposure period (kg)); and AT = averaging time (period over which exposure is averaged (days)).

Thus, the dose of a chemical that is received by an individual is dependent upon:

- The concentration of the chemical at the point of exposure.
- How often the individual comes into contact with the contaminated medium.
- How long the exposure occurs.
- The extent of contact that the individual has with the medium.
- The body weight of the receptor.

Because it is impossible to quantify each of these variables in the exposure assessment equation for every individual in a nearby population, various standard or default values/assumptions are commonly used in risk assessments. These assumptions underscore the reasonably maximally-exposed individual (MEI) approach.

Specific details of the exposure equations that Halliburton NUS Team recommends for use in this site-specific risk assessment, as well as the recommended value of each input parameter, are provided in the remainder of this section.

5.6.1 Inhalation of Contaminated Air

Emissions from the burning and detonation activities at ABG, ORR, and DR (Scenario A only) are expected to distribute throughout the air within the vicinity of each SWMU. Dispersion of volatile and particulate-bound chemicals is also anticipated to occur in the area of Lake Greenwood and beyond the boundaries of the facility (where off-facility residents reside). Thus, inhalation of contaminated air is a relevant exposure pathway in Current Use Scenario A for SWMU workers, base personnel/families, and off-facility, nearby residents. The equation recommended for calculating human exposure doses of chemicals of concern due to inhalation of volatile and particulate-bound chemicals is provided in Table 5-5, along with the values of the exposure variables recommended for use in this assessment for each receptor. The values proposed for use in this assessment to represent the parameters in this equation are explained in further detail below.

Contaminant Concentration in Air (CA)

These values will be the projected maximum ambient air levels of each chemical of potential concern at the specific receptor locations chosen in the risk assessment. These values are the outputs of the air dispersion CTO issued by NAVSURFWARCENDIV. For

TABLE 5-5

VARIABLE VALUES FOR INHALATION OF VAPOR-PHASE AND PARTICULATE-BOUND CHEMICALS[a]

Equation:

$$\text{Inhalation Dose (mg/kg-day)} = \frac{CA \times InR \times DF \times ET \times EF \times ED}{BW \times AT}$$

Where:

CA = contaminant level in air (mg/M^3)
InR = inhalation rate (m^3/hour)
DF = deposition fraction to deep lung (dimensionless) = 1.00 for VOCs (default value);
= 0.3 for particulates (Giacommeli - Maltoni et al., 1972)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-5 (Continued)

VARIABLE VALUES FOR INHALATION OF VAPOR-PHASE AND PARTICULATE-BOUND CHEMICALS[a]

Exposure variables:

	InR	ET	EF	ED	BW	AT	
	(m^3/hr)	(hr/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
CURRENT USE (Scenario A)							
SWMU Worker							
Adult	0.83	8	250 (ABG) 125 (ORR) 100 (Army worker at DR) 15 (Navy worker at DR)	20	70	25,550	7,300
Base Personnel/Families							
Adult	0.83	24	330 (at base housing)	4	70	25,550	1,460
Adult	0.83	8	20 (at the SWMUs)	4	70	25,550	1,460
Toddler	0.667	24	350	4	15	25,550	1,460
Off-Facility Residents							
Adult	0.83	24	350	64	70	25,550	23,360
Toddler	0.667	24	350	6	15	25,550	2,190

[a]See Section 5.6.1 for explanation of recommended exposure variables.

those instances in which a receptor enters more than one SWMU (or more than one area of contamination within a SWMU), the exposure point concentration will be modified to account for exposure at multiple locations. (See Section 5.5 for the explanation of how these exposure point concentrations will be derived.)

Inhalation Rate (InR)

The average inhalation rate of a receptor is dependent upon the age (or size), the sex, and the activity level of the individual. The value recommended for the inhalation rate of all adult receptors (<18 years) in this assessment is 0.83 m^3/hour (standard default factor presented in Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" (USEPA, 1991). For the toddler (ages 1 through 6), a value of 0.667 m^3/hour is recommended (USEPA, 1985).

Deposition Fraction (DF)

A volatile chemical will be assumed to be 100 percent available for absorption in the deep lung (e.g., DF = 1.0). Deposition of particulate matter in the respiratory system is a function of both the size of the particulate (aerodynamic diameter) in which the airborne chemical exists and the breathing rate of the individual (nose vs. mouth). According to Niinimaa et al (1981), mouth breathing in an adult begins to occur frequently when the ventilation rate exceeds 2.4 m^3/hr. As the assumed ventilation rates for the receptors of this assessment are below this level, only nose breathing applies.

The recommended value for the deposition fraction of particulates to the deep lung with nose breathing is 0.3 (Giacommeli-Maltoni et al., 1972). This value assumes uniform particle size distribution of particles less than or equal to 10 µm in size (i.e., the respirable fraction).

Exposure Time (ET)

The exposure time is the period of each day that the person is assumed to be present in the impact zone of the facility. For the SWMU workers, it is recommended that this term be 8 hours/day. For base personnel and their families (assumed to live on-facility), a conservative estimate of 24 hours/day is recommended. For nearby residents, 24 hours/day is also recommended. The adult base employee will be assumed to spend 8 hours at the SWMUs on days when contact occurs.

Exposure Frequency (EF)

The exposure frequency is the number of days per year that an individual comes into contact with the contaminated medium. According to NAVSURFWARCENDIV (1995), the following exposure frequencies are applicable for SWMU workers: ABG-250 d/yr; ORR-125 d/yr; DR-100 d/yr (army worker); 15 d/yr (navy worker). A total value of 350 days/year is recommended for base personnel/families and for nearby residents. Both of these values allow for 2 weeks of vacation. For the adult base personnel, 20 of the 350 exposure days will be assumed to occur at the SWMUs, and the remaining 330 days will occur at the base housing area.

Exposure Duration (ED)

The exposure duration is the number of years that an individual comes into contact with the contaminated medium. For adult SWMU workers, a period of 20 years is recommended. For base personnel and their families, a period of 4 years is recommended. For nearby neighbors, an exposure duration of 70 years (6 years as a toddler and 64 years as an adult) will be assumed.

Body Weight (BW)

The body weight term in the equation refers to the average weight of the receptor during the period of time that his/her exposure to site contaminants occurs. For the purposes of this assessment, we recommend the values suggested by the USEPA (1991): 70 kg for adults and 15 kg for toddlers.

Averaging Time (AT)

The averaging time is the time interval (in days) over which the health criterion is applicable. For cancer effects, this term is 25,550 days (70 years x 365 days/year) (USEPA, 1989). For non-cancer effects, this term is the number of years a receptor is exposed (exposure duration) multiplied by 365 days/year (USEPA, 1989). For SWMU workers, the non-cancer averaging time is 7300 days (20 years x 365 days). For base personnel and their families, the non-cancer averaging time is 1,460 days (4 years x 365 days). For nearby adult residents, this value is 23,360 days (64 years x 365 days). For nearby toddlers, this value is 2,190 days (6 years x 365 days/year).

5.6.2 Ingestion of Airborne Particulates Secondary to Inhalation

A fraction of the airborne particulates that are inhaled will also deposit in the upper airways, where through coughing they will reach the throat and then be swallowed. The equation to be used to calculate the human exposure dose due to ingestion of particulates secondary to inhalation is presented in Table 5-6, along with the recommended values for the exposure parameters. This pathway is relevant for SWMU workers, for base personnel and their families, and for off-facility residents (Scenario A only). Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Deposition Fraction (DF)

Assuming uniform distribution of particle size (less than or equal to 10 μm), the value suggested for fractional deposition of particles to the upper airways with nose breathing is 0.15 (Giacommeli-Maltoni et al., 1972).

5.6.3 Ingestion of Contaminated Soil

Pica behavior (toddlers) and work-related and gardening activities (adults) may expose human receptors to contaminated soil via incidental ingestion of this medium. The equation to be used to calculate the human exposure dose due to ingestion of contaminated soil is presented in Table 5-7, along with the recommended values for the exposure parameters. This pathway is relevant for all receptors (adults and toddlers) in all three exposure scenarios. Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Contaminant Concentration in Soil (CS)

The concentrations of chemicals of concern in soil relevant for this exposure pathway were described in Sections 4.2.3.1, 4.3.3.1, and 4.4.3.1. For those instances in which a single receptor has contact with soil at more than one SWMU (or more than one area of contamination within a SWMU), the exposure point concentration will be modified to account for exposure at multiple locations. (See Section 5.5 for an explanation of how these exposure point concentrations will be derived.)

TABLE 5-6

VARIABLE VALUES FOR INGESTION OF PARTICULATE-BOUND CHEMICALS SECONDARY TO INHALATION[a]

Equation:

$$\text{Fugitive Dust Ingestion Dose (mg/kg-day)} = \frac{CA \times InR \times DF \times ET \times EF \times ED}{BW \times AT}$$

Where:

CA = contaminant level in air (mg/M^3)
InR = inhalation rate (m^3/hour)
DF = deposition fraction of particulates to upper airways (unitless) = 0.15 (Giacommeli - Maltoni et al., 1972)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-6 (Continued)

VARIABLE VALUES FOR INGESTION OF PARTICULATE-BOUND CHEMICALS SECONDARY TO INHALATION[a]

Exposure variables:

	InR	ET	EF	ED	BW	AT	
	(m^3/hr)	(hr/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
CURRENT USE (Scenario A)							
SWMU Worker							
Adult	0.83	8	250 (ABG) 125 (ORR) 100 (Army worker at DR) 15 (Navy worker at DR)	20	70	25,550	7,300
Base Personnel/Families							
Adult	0.83	24	330 (at home)	4	70	25,550	1,460
Adult	0.83	8	20 (at the SWMUs)	4	70	25,550	1,460
Toddler	0.667	24	350	4	15	25,550	1,460
Off-Facility Residents							
Adult	0.83	24	350	64	70	25,550	23,360
Toddler	0.667	24	350	6	15	25,550	2,190

[a]See Section 5.6.2 for explanation of recommended exposure variables.

TABLE 5-7

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN SOIL[a]

Equation:

$$\text{Soil Ingestion Dose (mg/kg-day)} = \frac{CS \times IgR \times CF \times EF \times ED}{BW \times AT}$$

Where:

CS = contaminant level in soil (mg/kg)
IgR = ingestion rate (mg soil/day)
CF = conversion factor (10^{-6} kg/mg)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	IgR	EF	ED	BW	AT	
	(mg/d)	(d/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
CURRENT USE (Scenario A)						
SWMU Worker						
Adult	100	250 (ABG) 125 (ORR) 100 (Navy worker at DR) 15 (Army worker at DR)	20	70	25,550	7,300

TABLE 5-7 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN SOIL[a]

Exposure variables (cont'd):

	IgR	EF	ED	BW	AT	
	(mg/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
Base Personnel/Families						
Adult	100	124 (at base housing)	4	70	25,550	1,460
Adult	100	20 (at the SWMUs)	4	70	25,550	1,460
Toddler	200	144	4	15	25,550	1,460
Off-Facility Residents						
Adult	100	144	64	70	25,550	23,360
Toddler	200	144	6	15	25,550	2,190
FUTURE USE (Scenario B)						
Park/Natural Area Visitors						
Adult	100	108	20	70	25,550	7,300
Toddler	200	108	5	15	25,550	1,825

TABLE 5-7 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN SOIL[a]

Exposure variables (cont'd):

	IgR	EF	ED	BW	AT	
	(mg/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
Park/Natural Area Employees						
Adult	100	250	20	70	25,550	7,300
FUTURE USE (Scenario C)						
On-SWMU Residents						
Adult	100	144	64	70	25,550	23,360
Toddler	200	144	6	15	25,550	2,190

[a]See Section 5.6.3 for explanation of recommended exposure variables.

Ingestion Rate (IgR)

An adult worker (SWMU workers and park/natural area employees) will conservatively be assumed to consume 100 mg of soil per day. This is twice what is recommended for a receptor in a commercial/industrial setting (USEPA, 1991) due to the nature of the work done at the SWMUs and parks/natural areas. Soil consumption rates of 100 mg/day and 200 mg/day are recommended for other adult receptors and children, respectively (USEPA, 1991).

Exposure Frequency (EF)

Off-facility residents are conservatively assumed to have contact with contaminated off-facility soil 144 days a year (9 months a year, 4 days a week). This same value is recommended for base personnel and families and for future on-SWMU residents. Adult base personnel will be assumed to contact on-SWMU soil 20 days out of the total 144, and the remaining 124 will occur in the base housing area. SWMU workers will be assumed to come into contact with contaminated on-SWMU soil every working day (SWMU-specific exposure frequencies; see Section 5.6.1). Park visitors will conservatively be assumed to visit the park 3 days/week for 9 months a year, or 108 days/year. Park/natural area employees will be assumed to come into contact with contaminated on-SWMU soil every working day (250 days/year).

Exposure Duration (ED)

Off-facility residents are conservatively assumed to be exposed to contaminated off-facility soil for 64 years (adults) and 6 years (toddlers). Park visitors will conservatively be assumed to visit the park for 20 years. Future on-SWMU residents are assumed to live in the area for 70 years (64 as an adult and 6 as a toddler).

5.6.4 Dermal Contact with Contaminated Soil

The chemicals in contaminated soil also may be absorbed into the body of the human receptors through dermal contact with this medium. The equation to calculate human exposure dose due to dermal contact with contaminated soil is adapted from USEPA (1989a) and is provided in Table 5-8, with the recommended values for the exposure parameters. This pathway is relevant for all receptors (adults and toddlers). Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed:

TABLE 5-8

VARIABLE VALUES FOR DERMAL CONTACT WITH CHEMICALS IN SOIL[a]

Equation:

$$\text{Soil Dermal Contact Dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times EF \times ED \times ABS}{BW \times AT}$$

Where:

CS = contaminant level in soil (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area available for contact (cm^2/event)
AF = soil to skin adherence factor = 0.2 mg/cm^2 (USEPA, 1992)
EF = exposure frequency (events/year)
ED = exposure duration (years)
ABS = dermal absorption factor = 0.001 for inorganics and 0.01 for organics
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	SA (cm^2/event)	EF (events/yr)	ED (yrs)	BW (kg)	AT (days) Cancer	AT (days) Noncancer
CURRENT USE (Scenario A)						
SWMU Worker						
Adult	2490	250 (ABG) 125 (ORR) 100 (Army worker at DR) 15 (Navy worker at DR)	20	70	25,550	7,300

TABLE 5-8 (Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH CHEMICALS IN SOIL[a]

Exposure variables (cont'd):

	SA	EF	ED	BW	AT	
	(cm^2/event)	(events/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
Base Personnel & Families						
Adult	3510	124 (at base housing)	4	70	25,550	1,460
Adult	3510	20 (at the SWMUs)	4	70	25,550	1,460
Toddler	3580	144	4	15	25,550	1,460
Off-site Residents						
Adult	3510	144	64	70	25,550	23,360
Toddler	3580	144	6	15	25,550	2,190
FUTURE USE (Scenario B)						
Park/Natural Area Visitors						
Adult	3510	108	20	70	25,550	7,330
Toddler	3580	108	6	15	25,550	2,190

TABLE 5-8(Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH CHEMICALS IN SOIL[a]

Exposure variables (cont'd):

	SA	EF	ED	BW	AT	
	(cm^2/event)	(events/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
Park/Natural Area Employees						
Adult	2490	250	20	70	25,550	7,300
FUTURE USE (Scenario C)						
On-SWMU Residents						
Adult	3510	144	64	70	25,550	23,360
Toddler	3560	144	6	15	25,550	2,190

[a]See Section 5.6.4 for explanation of recommended exposure variables.

Skin Surface Area Available for Contact (SA)

The value used in the equation for the surface area of the adult worker's (SWMU worker and park/natural area employee) skin available for contact with soil is 2,490 cm^2/event, which corresponds to the maximum surface area of the hands and forearms measured in men (USEPA, 1989b). The value recommended for other adult receptors (base personnel, off-facility residents, and park visitors) is 3,510 cm^2/event (total surface area of arms and hands (USEPA, 1985). For toddlers, a value of 3,580 cm^2/event (total surface area of arms, hands, legs, and feet; USEPA 1985) is suggested.

Soil-to-skin Adherence Factor (AF)

The soil-to-skin adherence factor selected for the risk assessment is 0.2 mg/cm^2 (USEPA, 1992b).

Absorption Factor (ABS)

The absorption factor accounts for desorption of a chemical from the soil matrix and absorption of a chemical across the skin. For this risk assessment, organic chemicals will be assigned an absorption factor of 0.01 and inorganics will be assigned an absorption factor of 0.001 (USEPA, 1992b).

5.6.5 Ingestion of Contaminated Fruits and Vegetables

Consumption of contaminated home-grown fruits and vegetables may be a source of chemical exposure for the off-facility resident receptors and future on-SWMU residents. The equation proposed to calculate human exposure dose due to ingestion of contaminated fruits and vegetables is provided in Table 5-9, with the recommended values for the exposure parameters. Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Consumption Rate for Fruit/Vegetable "I" (CONV$_I$)

The consumptions rates for adults and toddlers that the Halliburton NUS Team recommends for use in the risk assessment are provided in Table 5-9. These are upper 95th percentile values as determined by Pao et al. (1982).

TABLE 5-9

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN VEGETABLES[a]

Equation:

$$\text{Fruit/Vegetable Ingestion Dose (mg/kg-day)} = \sum_{i=1}^{5} \frac{(CV_i \times CONV_i) \times CF \times FR \times ED}{BW \times AT}$$

Where:

CV_i = contaminant level in fruit/vegetable 'i' (mg/kg)
$CONV_i$ = consumption rate for fruit/vegetable 'i' (g/d)

	Potatoes	Tomatoes	Carrots	Beans/Peas	Lettuce
Adult	209	133	130	181	66
Toddler	123	67	85	104	29

CV = conversion factor (10^{-3} kg/g)
FR = fraction of fruit/vegetables that is homegrown (unitless) = 0.4 (USEPA, 1989a)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-9 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN VEGETABLES[a]

Exposure variables:

	EF	ED	BW	AT	
	(d/yr)	(yrs)	(kg)	(days)	
				Cancer	Noncancer
CURRENT USE (Scenario A)					
Off-Facility Residents					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190
FUTURE USE (Scenario C)					
On-SWMU Residents					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190

[a]See Section 5.6.5 for explanation of recommended exposure variables.

Fraction of Fruit/Vegetables that is Homegrown (FR)

A reasonable worst-case value for this parameter is 0.40 (USEPA, 1989a).

Exposure Frequency (EF)

The vegetable consumption rates provided in Table 5-9 have been averaged over an entire year. Therefore, the exposure frequency for fruit/vegetable ingestion for local residents is 350 days/year.

5.6.6 Ingestion of Contaminated Agricultural Foodstuffs

5.6.6.1 Ingestion of Contaminated Beef/Venison/Turkey

Ingestion of contaminated beef/venison/turkey may be a significant pathway of chemical exposure for human receptors in a rural area. Preliminary investigation indicates this may be a relevant pathway for the off-facility residents and SWMU workers (Scenario A), for park/natural area visitors/employees (Scenario B), and for future on-SWMU residents (Scenario C), in this risk assessment. The equation proposed to calculate human exposure dose due to ingestion of contaminated beef/venison is provided in Table 5-10, with the recommended values for the exposure parameters. Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed:

Contaminant Concentration in Beef/Venison/Turkey (CB)

The derivation of the concentrations of the chemicals of concern in beef/venison/turkey to be used in the risk assessment were described in Section 5.4.4.1.

Consumption Rate for Beef/Venison/Turkey (CONB)

The consumptions rates for beef for adults and toddlers that Halliburton NUS Team recommends for use in the risk assessment are provided in Table 5-10. These are upper 95th percentile values as determined by Pao et al. (1982). The consumption rates for venison and turkey for an adult hunter and his/her family will be estimated from site hunting data provided by NAVSURFWARCENDIV.

TABLE 5-10

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN BEEF/VENISON/TURKEY[a]

Equation:

$$\text{Beef/Venison/Turkey Ingestion Dose (mg/kg-day)} = \frac{CB \times CONB \times CF \times FR \times EF \times ED}{BW \times AT}$$

Where:

CB = contaminant level in beef/venison/turkey (mg/kg)
CONB = consumption rate for beef (g/d) = 199 g/day (adult) and 88 g/day (toddler)
= consumption rate for venison/turkey (g/d) = to be estimated from site hunting data
CF = conversion factor (10^{-3} kg/g)
FR = fraction of beef/venison/turkey from contaminated area (unitless) = 1.0 (default value)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-10 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN BEEF/VENISON/TURKEY[a]

Exposure variables:

	EF	ED	BW	AT	
	(d/yr)	(yrs)	(kg)	(days)	
				Cancer	Noncancer
CURRENT USE (Scenario A) and FUTURE USE (Scenarios B and C)					
Off-Facility Residents (Beef/Turkey/Venison) (Scenario A)					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190
SWMU Workers (Venison/Turkey) (Scenario A)					
Adult	350	20	70	25,550	7,300
Park/Natural Area Employees/Visitors (Venison/Turkey) (Scenario B)					
Adult	350	20	70	25,550	7,300
Toddler	350	6	15	25,550	2,190
On-SWMU Residents (Beef/Venison/Turkey) (Scenario C)					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190

[a]See Section 5.6.6.1 for explanation of recommended exposure variables.

Fraction of Beef that is Locally Raised (FR)

A default value of 1.00 is recommended for the local residents ingesting beef in this assessment. A value of 1.00 is also recommended for local hunters because the calculated consumption rates for venison and turkey will have already taken into consideration this factor.

Exposure Frequency (EF)

The beef consumption rates provided in Table 5-10 have been averaged over an entire year as will be the venison and turkey consumption rates. Therefore, the exposure frequency for beef/venison/turkey ingestion for local residents is 350 days/year.

5.6.6.2 Ingestion of Contaminated Milk

This pathway may also be a significant source of exposure to local residents (Scenario A) and future on-SWMU residents (Scenario C). The equation to calculate human exposure dose due to ingestion of contaminated milk is provided in Table 5-11, with the recommended values for the exposure parameters. Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed:

Contaminant Concentration in Milk (CM)

The derivation of the concentrations of the chemicals of concern in milk to be used in the risk assessment were described in Section 5.4.4.2.

Consumption Rate for Milk (CONM)

The consumptions rates for milk for adults and toddlers that the Halliburton NUS Team recommends for use in the risk assessment are provided in Table 5-11. These are upper 95th percentile values as determined by Pao et al. (1982).

Fraction of Milk that is Locally Produced (FR)

A default value of 1.00 is recommended for the local residents in this assessment.

TABLE 5-11

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN MILK[a]

Equation:

$$\text{Milk Ingestion Dose (mg/kg-day)} = \frac{CM \times CONM \times CF \times FR \times EF \times ED}{BW \times AT}$$

Where:

CM = contaminant level in milk (mg/kg)
CONM = consumption rate for milk (L/d) = 0.66 L/day (adult) and 0.81 L/day (toddler)
CF = conversion factor (1 kg≈ 1 L milk)
FR = fraction of milk that is locally produced (unitless) = 1.0 (default value)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-11 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN MILK[a]

Exposure variables:

	EF	ED	BW	AT	
	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
CURRENT USE (Scenario A)					
Off-Facility Residents					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190
FUTURE USE (Scenario C)					
On-SWMU Residents					
Adult	350	64	70	25,550	23,360
Toddler	350	6	15	25,550	2,190

[a]See Section 5.6.6.2 for explanation of recommended exposure variables.

Exposure Frequency (EF)

The milk consumption rates provided in Table 5-11 have been averaged over an entire year. Therefore, the exposure frequency for milk ingestion for local residents is 350 days/year.

5.6.7 Ingestion of Contaminated Household Water

Contaminated drinking water may be a source of chemical exposure for the human receptors in some locations. The equation to calculate human exposure dose due to ingestion of contaminated drinking water is provided in Table 5-12, with the recommended values for the exposure parameters. This pathway is relevant for on-SWMU workers who are reported to drink water from the on-SWMU production well at ABG, base personnel and their families, and off-facility residents (Scenario A), park visitors/employees (Future Use Scenario B), and on-SWMU residents (Future Use Scenario C). Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Contaminant Concentration in Groundwater (CGW)

The concentrations of the chemicals of concern in groundwater to be used in the risk assessment were discussed in Sections 4.2.3.4, 4.3.3.3, and 4.4.3.3.

Ingestion Rate (IgR)

The amount of production well water consumed by SWMU and park/natural area workers per day will conservatively be assumed to be 1 L. Current on- and off-facility residents and future on-SWMU residents will be assumed to consume 1 L (toddlers) and 2 L (adults) of contaminated water per day (USEPA, 1989a). Park visitors will conservatively be assumed to drink 1 L (adults) and 0.5 L (toddlers) of water per visit.

5.6.8 Dermal Contact with Contaminated Groundwater

Dermal contact with chemicals in groundwater represents another potential exposure route any time receptors shower or bathe. This pathway may be relevant for base personnel and their families and nearby residents (Scenario A) and future on-SWMU residents (Scenario C). The equation to calculate human exposure dose due to dermal contact with contaminated groundwater is provided in Table 5-13, along with the recommended values for the exposure parameters. Details of the derivation of these values are provided below.

TABLE 5-12

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN DRINKING WATER[a]

Equation:

$$\text{Drinking Water Ingestion Dose (mg/kg-day)} = \frac{CGW \times IgR \times EF \times ED}{BW \times AT}$$

Where:

CGW = contaminant level in groundwater (mg/L)
IgR = ingestion rate (L drinking water/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	IgR	EF	ED	BW	AT	
	(L/d)	(d/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
CURRENT USE (Scenario A)						
SWMU Worker						
Adult (ABG only)	1	250	20	70	25,550	7,300

TABLE 5-12 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN DRINKING WATER[a]

Exposure variables:

	IgR (L/d)	EF (d/yr)	ED (yrs)	BW (kg)	AT (days) Cancer	AT (days) Noncancer
Base Personnel & Families						
Adult	2	350	4	70	25,550	1,460
Toddler	1	350	4	15	25,550	1,460
Off-Facility Residents (Groundwater & Springs, ABG Only)						
Adult	2	350	64	70	25,550	23,360
Toddler	1	350	6	15	25,550	2,190
FUTURE USE (Scenario B)						
Park/Natural Area Visitors						
Adult	1	108	20	70	25,550	7,300
Toddler	0.5	108	6	15	25,550	2,190
Park/Natural Area Employee						
Adult	1	250	20	70	25,550	7,300

TABLE 5-12 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN DRINKING WATER[a]

Exposure variables:	IgR	EF	ED	BW	AT	
	(L/d)	(d/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
FUTURE USE (Scenario C)						
On-SWMU Residents						
Adult	2	350	64	70	25,550	23,360
Toddler	1	350	6	15	25,550	2,190

[a]See Section 5.6.7 for explanation of recommended exposure variables.

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TABLE 5-13

VARIABLE VALUES FOR DERMAL CONTACT WITH GROUNDWATER[a]

Equation:

$$\text{Ground Water Dermal Contact Dose (mg/kg-day)} = \frac{CGW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

CGW = contaminant level in groundwater (mg/L)
SA = skin surface area available for contact (cm^2)
PC = normalized chemical-specific dermal permeability constant (cm/hr)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = volumetric conversion factor for water (1 liter/1000 cm^3)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-13 (Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH GROUNDWATER[a]

Exposure variables:	SA	ET	EF	ED	BW	AT	
	(cm^2/event)	(hr/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
CURRENT USE (Scenario A)							
Off-Facility Residents (Groundwater and Springs, ABG Only)							
Adult	18,150	0.20	350	64	70	25,550	23,360
Toddler	7,200	0.20	180	6	15	25,550	2,190
Base Personnel & Families							
Adult	18,150	0.20	350	4	70	25,550	1,460
Toddler	7,200	0.20	180	4	15	25,550	1,460
FUTURE USE (Scenario C)							
On-SWMU Residents							
Adult	18,150	0.20	350	64	70	25,550	23,360
Toddler	7,200	0.20	180	6	15	25,550	2,190

[a]See Section 5.6.8 for explanation of recommended exposure variables.

Only those parameters unique to this pathway and/or not described previously are discussed.

Skin Surface Area Available for Contact (SA)

The area of skin in contact with contaminated water during showering/bathing is assumed to be the total body surface area of the individual. Based on a review of the published literature in this area, Halliburton NUS Team recommends the following 50th-percentile values (USEPA, 1989b): adult -18,150 cm^2; toddler - 7,200 cm^2.

Chemical-specific Normalized Dermal Permeability Constant (PC)

The estimation of exposure doses resulting from skin contact with groundwater requires the use of chemical-specific skin permeability constants. These are presented in cm/hr units. These skin penetration rates are not only a function of chemical property data but also of biological properties (e.g., skin thickness). Values for the permeability coefficients of many compounds are provided in Superfund Exposure Assessment Manual (SEAM) (USEPA, 1988). Dermal permeability coefficients for organic compounds can also be estimated using the chemical's K_{ow} value (Brown and Rossi, 1989).

Since the doses calculated using these dermal permeability constant (PC) values represent absorbed doses of each chemical through the skin, these PC factors need to be adjusted relative to the oral absorption of each chemical in order to normalize the dermal doses to the oral doses for risk characterization. This adjustment is made to be consistent with RAGS (USEPA, 1989a).

An appendix containing the derivation of the permeability constants for the chemicals evaluated in this exposure pathway and the adjusted PC values for these chemicals will be included in the risk assessment.

Exposure Time (ET)

The length of time of exposure in this pathway also depends upon the nature of the activity involved. Showering is typically modeled to occur for 0.20 hours per day (USEPA, 1989a).

Exposure Frequency (EF)

The frequency of dermal contact with water is also a function of the activity involved. For showering, adult exposure is typically modeled to occur every day, while bathing children

is modeled anywhere from every other day to 1-2 times per week. For this assessment, an exposure frequency of 180 days per year was selected for toddlers.

5.6.9 Inhalation of VOCs While Showering with Contaminated Household Water

Inhalation of VOCs while showering is a potential route of exposure in any risk assessment that involves the presence of these contaminants in residential water systems. The equation to calculate human exposure dose due to inhalation of VOCs while showering is provided in Table 5-14, with the recommended values for the exposure parameters. This pathway may be relevant for off-facility residents (adults and toddlers; Scenario A) and future on-SWMU residents (Scenario C). Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Contaminant Concentration in the Air in the Shower Stall (CA)

The calculation of the air concentrations of the volatile chemicals of concern were described in Section 5.4.1.

5.6.10 Incidental Ingestion of Contaminated Surface Water

Water ingested while swimming in contaminated surface waters may be a source of chemical exposure for base personnel and their families (Scenario A), park/natural area visitors/employees (Future Use Scenario B), and future on-SWMU residents (Scenario C).

The equation to calculate human exposure dose due to incidental ingestion of contaminated surface water is provided in Table 5-15, with the recommended values for the exposure parameters. Only those parameters unique to this pathway and/or not described previously are discussed. Since off-facility residents reportedly use the spring water for drinking water, oral exposure of these receptors to spring water will be estimated using the equation and exposure variables indicated in Table 5-12.

Contaminant Level in Surface Water (CSW)

The levels of contaminants to be used to quantify risk from exposure to surface water were discussed in Section 5.4.5.

TABLE 5-14

VARIABLE VALUES FOR INHALATION OF VOLATILE ORGANIC CHEMICALS WHILE SHOWERING[a]

Equation:

$$\text{Shower Inhalation Dose (mg/kg-day)} = \frac{CA \times InR \times DF \times ET \times EF \times ED}{BW \times AT}$$

Where:2

CA = contaminant level in air shower stall (mg/M^3)
InR = inhalation rate (M^3/hour)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

TABLE 5-14 (Continued)

VARIABLE VALUES FOR INHALATION OF VOLATILE ORGANIC CHEMICALS WHILE SHOWERING[a]

Exposure variables:

	InR	ET	EF	ED	BW	AT	
	(M^3/hr)	(hr/d)	(d/yr)	(yrs)	(kg)	(days) Cancer	Noncancer
CURRENT USE (Scenario A)							
Off-Facility Resident							
Adult	0.83	0.20	350	64	70	25,550	23,360
Toddler	0.667	0.20	180	6	15	25,550	2,190
FUTURE USE (Scenario C)							
On-SWMU Residents							
Adult	0.83	0.20	350	64	70	25,550	23,360
Toddler	0.667	0.20	180	6	15	25,550	2,190

[a]See Section 5.6.9 for explanation of recommended exposure variables.

TABLE 5-15

VARIABLE VALUES FOR INCIDENTAL INGESTION OF CHEMICALS IN SURFACE WATER[a]

Equation:

$$\text{Surface Water Ingestion Dose (mg/kg-day)} = \frac{CSW \times IgR \times ET \times EF \times ED}{BW \times AT}$$

Where:

CSW = contaminant level in surface water (mg/L)
IgR = ingestion rate (L surface water/hour)
ET = exposure time (hour/event)
EF = exposure frequency (events/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	IgR	ET	EF	ED	BW	AT	
	(L/hr)	(hr/event)	(events/yr)	(yrs)	(kg)	(days)	
						Cancer	Noncancer
CURRENT USE (Scenario A)							
Base Personnel/Families (Lake Greenwood)							
Adult	0.05	2.6	7	4	70	25,550	1,460
Toddler	0.05	2.6	7	4	15	25,550	1,460

TABLE 5-15 (Continued)

VARIABLE VALUES FOR INCIDENTAL INGESTION OF CHEMICALS IN SURFACE WATER[a]

Exposure variables (cont'd):

	IgR	ET	EF	ED	BW	AT	
	(L/hr)	(hr/event)	(events/yr)	(yrs)	(kg)	(days)	
						Cancer	Noncancer
Off-site Residents (Off-facility Springs)							
Adult	See Table 5-12 for exposure variables.						
Toddler							
FUTURE USE (Scenario C)							
Park/Natural Area Visitors (Creeks; Springs at ABG)							
Adult	0.05	2.6	7[b]	20	70	25,550	7,300
Toddler	0.05	2.6	7[b]	6	15	25,550	2,190
Park/Natural Area Employees (Creeks, Springs at ABG)							
Adult	0.05	1	50[b]	20	70	25,550	7,300
FUTURE USE (Scenario C)							
On-SWMU Residents (Creeks; Springs at ABG)							
Adult	0.05	2.6	7[b]	64	70	25,550	23,360
Toddler	0.05	2.6	7[b]	6	15	25,550	2,190

TABLE 5-15 (Continued)

VARIABLE VALUES FOR INCIDENTAL INGESTION OF CHEMICALS IN SURFACE WATER[a]

[a]See Section 5.6.10 for explanation of recommended exposure variables.
[b]At ABG burn pans area, half of the events will occur at Little Sulphur Creek and half will occur at the springs.

Ingestion Rate (InR)

The quantity of water consumed per hour while swimming is 0.05 L (USEPA, 1989a). For the purposes of the risk assessment, this will also be conservatively assumed to be the quantity that the park/natural area employee incidentally ingests per hour while working.

Exposure Time (ET)

An exposure time of 1 hour per event is suggested for the park/natural area employee. For the on-SWMU residents and park visitors, an exposure time of 2.6 hours is suggested.

Exposure Frequency (EF)

The average number of days each year that a person swims is seven (USEPA, 1989a). This is the value that is suggested for use in the risk assessment for quantifying exposure for on-SWMU residents and park/natural area visitors. The park/natural area employee will be assumed to come into contact with surface water at least one day each working week (50 days).

5.6.11 Dermal Contact with Contaminated Surface Water While Swimming

Human receptors may absorb chemicals through the skin while swimming or working in contaminated surface water. This pathway is relevant for base personnel/families (current use scenario) and all future use scenario receptors. The equation to calculate human exposure dose due to incidental ingestion of contaminated surface water is provided in Table 5-16, along with the recommended values for the exposure parameters. Only those parameters unique to this pathway and/or not described previously are discussed. Since off-facility residents reportedly bathe in the spring water, dermal exposure of these receptors to spring water will be estimated using the equation and exposure variables indicated in Table 5-13.

Skin Surface Area Available for Contact (SA)

For base personnel/families, park visitors, and on-SWMU residents, it will conservatively be assumed that the whole body surface area is available for contact with surface water. The whole-body surface areas of adults and toddlers to be used in this assessment are adult - 18,150 cm^2 and toddler -7,200 cm^2 (USEPA, 1989b). The park/natural area employee will be assumed to expose his feet, lower legs, hands, and forearms to surface water. The value suggested as the skin surface area of the park employee available for

TABLE 5-16

VARIABLE VALUES FOR DERMAL CONTACT WITH SURFACE WATER[a]

Equation:

$$\text{Drinking Water Dermal Contact Dose (mg/kg-day)} = \frac{CDW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

CSW = contaminant level in surface water (mg/L)
SA = skin surface area available for contact (cm^2)
PC = normalized chemical-specific dermal permeability constant (cm/hr)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
CF = volumetric conversion factor for water (1 liter/1000 cm^3)
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	SA	ET	EF	ED	BW	AT	
	(cm^2/event)	(hr/d)	(d/yr)	(yrs)	(kg)	(days)	
						Cancer	Noncancer
CURRENT USE (Scenario A)							
Base Personnel/Families (Lake Greenwood)							
Adult	18,150	2.6	7	4	70	25,550	1,460
Toddler	7,200	2.6	7	4	15	25,550	1,460

TABLE 5-16 (Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH SURFACE WATER[a]

Exposure variables:

	SA	ET	EF	ED	BW	AT	
	(cm^2/event)	(hr/d)	(d/yr)	(yrs)	(kg)	(days)	
						Cancer	Noncancer
Off-facility Residents (Off-facility springs)							
Adult	See Table 5-11 for exposure variables.						
Toddler							
FUTURE USE (Scenario C)							
Park/Natural Area Visitors (Creeks; Springs at ABG)							
Adult	18,150	2.6	7[b]	20	70	25,550	7,300
Toddler	7,200	2.6	7[b]	6	15	25,550	2,190
Park/Natural Employees (Creeks; Springs at ABG)							
Adult	7,010	1	50[b]	20	70	25,550	7,300

TABLE 5-16 (Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH SURFACE WATER[a]

Exposure variables:

	SA	ET	EF	ED	BW	AT	
	(cm^2/event)	(hr/d)	(d/yr)	(yrs)	(kg)	(days)	
FUTURE USE (Scenario C)						Cancer	Noncancer
On-SWMU Residents (Creeks; Springs at ABG)							
Adult	18,150	2.6	7[b]	64	70	25,550	23,360
Toddler	7,200	2.6	7[b]	6	15	25,550	2,190

[a]See Section 5.6.11 for explanation of recommended exposure variables.
[b]At ABG burn pans area, half of the events will take place at Little Sulphur Creek and half will take place at the springs.

contact is 7,010 cm^2 (the maximum surface area of the hands, forearms, legs, and feet measured in men (USEPA, 1989b)).

5.6.12 Ingestion of Contaminated Sediments

Receptors may also be exposed to contaminated sediments while swimming or working in contaminated surface waters. The equation to calculate human exposure dose due to ingestion of contaminated sediments is provided in Table 5-17, along with the recommended values for the exposure parameters. This pathway is relevant for receptors in both future use exposure scenarios. Details of the derivation of these values are provided below. Only those parameters unique to this pathway and/or not described previously are discussed.

Chemical Concentration in Sediment (CS)

The concentrations of the chemicals of concern in sediment to be used in the risk assessment were discussed in Sections 4.2.3.2, 4.3.3.2, and 4.4.3.2.

Ingestion Rate (IgR)

For the purposes of the risk assessment, sediment ingestion rates will be conservatively assumed to be one-half of the soil ingestion rates: 50 mg/day for adults and 100 mg/day for toddlers.

5.6.13 Dermal Contact with Contaminated Sediments

The equation to calculate human exposure dose due to dermal contact with contaminated sediments is provided in Table 5-18, along with the recommended values for the exposure parameters. This pathway is relevant for all receptors in both future use exposure scenarios. Only those parameters unique to this pathway and/or not described previously are discussed.

Skin Surface Available for Contact (SA)

The value suggested as the skin surface area of the park/natural area employee available for contact with sediment is 7,010 cm^2 (the maximum surface area of the hands, forearms, legs, and feet measured in men (USEPA, 1989b)). This same value is recommended for park/natural area visitors, and future on-SWMU residents. For toddlers, the value used for soil exposure (3,580 cm^2) is recommended.

TABLE 5-17

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN SEDIMENT[a]

Equation:

$$\text{Sediment Ingestion Dose (mg/kg-day)} = \frac{CS \times IgR \times CF \times EF \times ED}{BW \times AT}$$

Where:

CS = contaminant level in sediment (mg/kg)
IgR = ingestion rate (mg sediment/day)
CF = conversion factor (10^{-6} kg/mg)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	IgR	EF	ED	BW	AT	
	(mg/d)	(d/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
FUTURE USE (Scenario B)						
Park/Natural Area Visitors (Creeks)						
Adult	50	7[b]	20	70	25,550	7,300
Toddler	100	7[b]	6	15	25,550	2,190

TABLE 5-17 (Continued)

VARIABLE VALUES FOR INGESTION OF CHEMICALS IN SEDIMENT[a]

Exposure variables (cont'd):

	IgR (mg/d)	EF (d/yr)	ED (yrs)	BW (kg)	AT (days) Cancer	AT (days) Noncancer
Park/Natural Area Employees (Creeks)						
Adult	50	50[b]	20	70	25,550	7,300
FUTURE USE (Scenario C)						
On-SWMU Residents (Creeks)						
Adult	50	7[b]	64	70	25,550	23,360
Toddler	100	7[b]	6	15	25,550	2,190

[a]See Section 5.6.12 for explanation of recommended exposure variables.
[b]At ABG burn pans area, exposure frequency will be one-half of value indicated in table, as only half of the events will occur in Little Sulphur Creek (the other half occur at the springs).

TABLE 5-18

VARIABLE VALUES FOR DERMAL CONTACT WITH CHEMICALS IN SEDIMENT[a]

Equation:

$$\text{Sediment Dermal Contact Dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times EF \times ED \times ABS}{BW \times AT}$$

Where:

CS = contaminant level in sediment (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area available for contact (cm^2/event)
AF = sediment-to-skin adherence factor = 0.2 mg/cm^2
EF = exposure frequency (events/year)
ED = exposure duration (years)
ABS = dermal absorption factor = 0.001 for inorganics and 0.01 for organics
BW = body weight (kg)
AT = averaging time (days)

Exposure variables:

	SA	EF	ED	BW	AT	
	(cm^2/event)	(events/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
FUTURE USE (Scenario B)						
Park/Natural Area Visitors (Creeks)						
Adult	7010	7[b]	20	70	25,550	7,330
Toddler	3580	7[b]	6	15	25,550	2,190

TABLE 5-18 (Continued)

VARIABLE VALUES FOR DERMAL CONTACT WITH CHEMICALS IN SEDIMENT[a]

Exposure variables (cont'd):	SA	EF	ED	BW	AT	
	(cm^2/event)	(events/yr)	(yrs)	(kg)	(days)	
					Cancer	Noncancer
FUTURE USE (Scenario B)						
Park/Natural Area Employees (Creeks)						
Adult	7010	50[b]	20	70	25,550	7,300
FUTURE USE (Scenario C)						
On-SWMU Residents (Creeks)						
Adult	7010	7[b]	64	70	25,550	23,360
Toddler	3580	7[b]	6	15	25,550	2,190

[a]See Section 5.6.13 for explanation of recommended exposure variables.
[b]At ABG burn pans area, exposure frequency will be one-half of value indicated in table, as only half of the events will occur in Little Sulphur Creek (the other half occur at the springs).

Sediment-to-Skin Adherence Factor (AF)

The value recommended for the adherence of sediment to skin is the same as that for soil - 0.2 mg/cm^2 (USEPA, 1992b).

5.7 EVALUATION OF LEAD EXPOSURE

There currently are no subchronic or chronic health criteria (reference doses) published by the USEPA with which to compare receptor exposure doses to lead in the environment. Thus, the exposure assessment approach described in Section 5.5 above cannot be utilized for lead.

A recent OSWER directive (No. 9355.4-12) provides interim soil lead guidance for RCRA Corrective Action facilities. This guidance recommends a screening level for lead in soil for residential land use of 400 ppm. The Halliburton NUS Team recommends using the value of 400 ppm to screen RME lead soil concentrations for residential receptors (off-facility residents in Scenario A and future on-SWMU residents in Scenario C), since this lead concentration goal was calculated from the most recent version of USEPA's residential lead Uptake/Biokinetic Model.

For other receptors (SWMU workers and base personnel/families in Scenario A and park visitors/employees in Scenario B), it is proposed that oral and inhalation RFDs for lead be derived using regulatory standards (as described in Section 7.2.2).

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6.0 TOXICITY ASSESSMENT

6.1 INTRODUCTION

The toxicity assessment is the step in the risk assessment process in which the relationship between the dose of a chemical received and the incidence of adverse health effects in an exposed population is characterized. This characterization utilizes current scientific (toxicological) knowledge on each chemical of potential concern to the project, as well as governmental policies, to (a) characterize the nature and strength of the evidence of causation of chemical-induced health effects, and (b) quantitatively estimate the incidence of health effects in an exposed population as a function of chemical dose. Toxicity assessments are therefore critical components in risk assessments because they allow the exposure doses that are calculated in the exposure assessment section of the study to be translated into potential health risks to the various receptor populations.

The toxicity assessment will be composed of a qualitative description of the types of health effects associated with each chemical (abbreviated toxicity profile) and a quantitative description of the toxic potency of each chemical (health criteria).

6.2 ABBREVIATED TOXICITY PROFILES

An abbreviated toxicity profile will be prepared for each chemical of concern (i.e., the chemicals identified in the risk characterization section which are responsible for any calculated significant risks/hazards). These profiles will characterize the known acute and chronic toxic effects in humans for each of these chemicals for the inhalation, ingestion and dermal routes of exposure. Each profile will in particular discuss the studies that have been used in the development of the USEPA's health criteria for that chemical.

6.3 NON-CARCINOGENIC CHEMICALS OF CONCERN

Non-carcinogenic health effects may occur upon exposure to a dose of a chemical above its threshold. The reference dose of a chemical (RfD) is the toxicity value proposed by the USEPA to represent this threshold for regulatory purposes and thus is used to evaluate the potential for non-carcinogenic effects in exposed human receptor populations (USEPA, 1989a). RfDs are defined by the USEPA as estimates of daily exposure levels for the entire human population, including sensitive subpopulations, that are likely to be without appreciable deleterious effects. The unit of an RfD is mg chemical/kg body weight-day. Various types of RfDs are available depending on the exposure route (oral exposure to

water or food, or inhalation exposure to air), and the length of exposure being evaluated (chronic or subchronic).

The USEPA chronic RfDs are proposed for use as health criteria for assessing the health risk due to long-term exposure of the adult receptors to the emission substances associated with SWMU activities. Subchronic RfDs are applicable to exposures which occur over a time period of less than seven years (USEPA, 1989a). Subchronic RfDs are therefore proposed for the characterization of the non-carcinogenic risk to the toddler receptors in this risk assessment. A discussion of how these criteria will be used to calculate non-carcinogenic risks to these receptors is presented in Section 7.0, Risk Characterization.

Inhalation RfDs are proposed for use to estimate risk via the inhalation route of exposure. Oral RfDs are proposed for use to estimate risk for exposure pathways involving ingestion of the chemicals of potential concern. For systemic toxicants, the oral RfD will also be used for assessing risk from dermal exposure since there are no dermal values available in the technical literature or guidance. The primary source of the RfDs will be IRIS (USEPA, 1995). If an RfD is unavailable in Integrated Risk Information System (IRIS), Health Risk Assessment Summary Tables (HEAST) (USEPA, 1994a) will be used. For some chemicals, only the carcinogenic risk can be evaluated, as no RfD has been developed. When chemical-specific/route-specific toxicity values are not available from these sources for some of the chemicals of potential concern, a toxicologist at USEPA Region V will be consulted to obtain and/or receive approval of provisional toxicity values.

There are currently no USEPA health criteria for lead. As mentioned previously, the Halliburton NUS Team recommends comparing RME soil lead concentrations to the OSWER residential soil lead screening level of 400 ppm (USEPA, 1994b) to assess risk to off-facility residents (Scenario A) and future on-SWMU residents (Scenario C).

For assessing risk to other receptors (SWMU workers and base personnel/families in Scenario A and park visitors/employees in Scenario B), it is recommended that oral and inhalation RFDs for lead be derived using regulatory standards. An oral RFD for lead can be derived from the federal action level in drinking water of 15 µg/L, using the following equation:

$$\underset{(mg/kg\text{-}d)}{Oral\ RfD} = \frac{CGW \times IR}{BW}$$

where:

CGW = concentration of contaminant in groundwater (0.015 mg/L)
IR = ingestion rate (2 L/day for an adult)
BW = 70 kg (for an adult)

The calculated oral RfD for lead is 4.3E-04 mg/kg - d.

An inhalation RfD for lead can be derived from the federal ambient air quality standard for lead of 1.5 µg/M^3 using the following equation:

$$\underset{(mg/kg-d)}{Inhalation\ RfD} = \frac{IR \times RfC}{BW}$$

where:

IR = inhalation rate (20 M^3/d for an adult)
RfC = reference concentration (0.0015 mg/M^3)
BW = body weight (70 kg for an adult)

The calculated inhalation RfD for lead is 4.3E-04 mg/kg - d.

6.4 CARCINOGENIC CHEMICALS OF CONCERN

To estimate the lifetime (by convention 70 years) probability of human receptors contracting cancer as a result of their exposure to known or suspected carcinogens in the project database, USEPA carcinogen slope factors (SFs) are proposed. Slope factors are derived under the regulatory policy that assumes that a threshold for carcinogenicity does not exist. Laboratory studies cannot conduct, nor can epidemiological studies evaluate, dose-response experiments at low dose levels. Therefore, neither the non-threshold assumption nor the shape of the dose-response relationship at the desired regulatory risk levels can be experimentally determined at the present time. Consequently, the USEPA has promoted the use of mathematical models to extrapolate high-dose experimental data to low-dose outcomes.

The mathematical extrapolation model utilized today by the USEPA to calculate the 'slope' of the dose-response data in a cancer bioassay is the linearized multistage model (USEPA, 1989a). The 95 percent upper confidence limit of the slope of the line from this model is termed the carcinogen slope factor for the chemical. This carcinogen slope factor is

expressed as the lifetime cancer risk per mg chemical/kg body weight-day (USEPA, 1986). It should be clear, however, that the medical certainty of this or any other extrapolation model in use is unknown at the present time. However, the multistage model is viewed as conservative by design and consistent with the most current theory of the genotoxic mechanism of carcinogenicity.

In this baseline risk assessment, the cancer risk to the human receptors from exposure to the carcinogenic chemicals of potential concern at each SWMU will be calculated using these USEPA slope factors. IRIS (USEPA, 1995) will be the primary source for each slope factor. HEAST (USEPA, 1994a) will be used when no slope factor is available through IRIS. When chemical-specific/route-specific toxicity values are not available from these sources for some of the chemicals of potential concern, a toxicologist at USEPA Region V will be consulted to obtain and/or receive approval of provisional toxicity values.

Only those exposure pathways involving the routes of exposure for which the chemical is known or suspected to be carcinogenic will be evaluated. Inhalation slope factors will be used for the inhalation route of exposure, and oral slope factors will be used for ingestion exposure pathways and dermal exposure pathways, when appropriate. Section 7.0, Risk Characterization, provides details on how the USEPA slope factors will be used to assess risk.

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7.0 RISK CHARACTERIZATION

7.1 INTRODUCTION

The last step in the risk assessment process is risk characterization. It is in this step that the potential incidence of the human health risks associated with the project are determined. It is performed by integrating the exposure assessment and toxicity assessment databases. To characterize potential non-carcinogenic risks, comparisons will be made between project-specific exposure doses and toxicity criteria (subchronic and chronic RfDs). To characterize potential carcinogenic effects, probabilities that an individual might develop cancer due to a lifetime of exposure to site chemicals will be estimated by multiplying the project-specific exposure doses by toxicity criteria (SFs). Each of these numerical expressions of risk will then be accompanied by explanatory text interpreting the results.

7.2 SUBCHRONIC/CHRONIC HEALTH RISKS

7.2.1 Chemicals Other than Lead

By convention, the average daily exposure doses to human receptors over the specific time-frame of exposure are used for calculation of non-cancer health hazards (USEPA, 1989a). In this assessment, the following time frames will be assumed for each receptor:

Receptor	Time Frame of Exposure
SWMU Workers	20 years
Base Personnel/Families	
Adults	4 years
Toddlers	4 years
Off-SWMU Residents	
Adults	64 years
Toddlers	6 years
Park Visitors	
Adults	20 years
Toddlers	6 years

Park Employees	20 years
On-Facility Residents	
Adults	64 years
Toddlers	6 years

The non-cancer daily exposure doses calculated in the exposure assessment will be used to calculate hazard quotients (HQ) for each of the chemicals of potential concern possessing RfDs. Subchronic RfDs are appropriately used for exposures of less than 7 years; chronic RfDs are used for exposures longer than 7 years.

The hazard quotient approach assumes that there is a level of exposure to a chemical (e.g., RfD) below which it is unlikely for even sensitive individuals in a population to experience adverse health effects. Therefore, if the hazard quotient for a given substance is less than 1.00, the calculated site-specific exposure dose is less than the chemical's threshold dose, and it will therefore be concluded that, based on our current toxicological knowledge for the chemical, it is improbable that the chemical levels at each SWMU will induce non-carcinogenic health effects in the receptor population(s). A ratio equal to or greater than 1.00 will indicate the potential for adverse health effects in the modeled population, but not necessarily that they would occur.

When multiple non-carcinogenic chemical substances are evaluated for a population, a summation of all of the appropriate chemical-specific hazard quotients will be made (USEPA, 1986b). The same interpretation of this hazard index (HI), as described above for the hazard quotients, will then be used. If the hazard index for any receptor population is greater than 1.00, the chemicals will be segregated according to target organ/tissue and revised hazard indices will be determined before a risk description if forwarded.

7.2.2 Lead

There are currently no USEPA health criteria for lead. The Halliburton NUS Team recommends comparing RME soil lead concentrations to the OSWER soil lead screening level of 400 ppm (USEPA, 1994) to assess risk to off-facility residents (Scenario A) and future on-SWMU residents (Scenario C).

For assessing risk to other receptors (SWMU workers and base personnel/families in Scenario A and park visitors/employees in Scenario B), it is recommended that the oral and inhalation RfDs for lead derived using regulatory standards (as described in Section 6.3) be used. The calculated oral RfD for lead is 4.3E-04, and the calculated inhalation RfD for lead is 4.3E-04.

7.3 CARCINOGENIC HUMAN HEALTH RISK ANALYSIS

By convention, a 70-year exposure period is used to determine exposure doses to human receptors for carcinogenic risk calculations (USEPA, 1989a). In this assessment, the adult receptor exposure doses for the chemicals of potential concern (calculated in the exposure assessment) will be translated into cancer risks by the use of the following equation:

Lifetime Excess Cancer Risk	=	Estimated Pathway specific LADD (mg/kg-d)	X	Route-specific Slope Factor $(mg/kg\text{-}d)^{-1}$

where LADD = Lifetime Average Daily Dose (i.e., 70-year average exposure dose).

To assess the simultaneous exposure of a receptor population to multiple carcinogens from multiple exposure routes, all of the cancer risks calculated for a population will be summed (USEPA, 1986). The overall cancer risks associated with the project will then be compared to a de minimis lifetime cancer risk rate of 1.0 E-06 (USEPA, 1986) and to the Superfund remediation target risk range of 1.0E-06 to 1.0E-04.

7.4 UNCERTAINTY/SENSITIVITY ANALYSES

The subchronic and chronic health risks calculated in this assessment will be derived using a series of assumptions about the identity and quantity of contaminants in the environmental media associated with each of these SWMUs, their fate in the environment, the routes of receptor exposure, human behaviors that lead to chemical exposures, and the dose-response relationships underlying the health criteria. The major uncertainties pertaining to each of these areas will be reviewed in general in the uncertainty/sensitivity analysis section of the risk assessment.

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8.0 ECOLOGICAL RISK ASSESSMENT

8.1 INTRODUCTION

The Ecological Risk Assessment will evaluate the ecological risks potentially posed by the present levels of contamination in various NAVSURFWARCENDIV environmental media (soil, surface water, sediment, and air). The purposes of this component of this work plan are to: 1) review the existing site information to determine if additional data are required to perform an environmental risk assessment, 2) support a SAP including a QAPP and a HASP for that assessment, 3) specify the activities needed to gather the additional data, and 4) identify the risk assessment documents that will be submitted to the regulatory agencies for review, including the estimated dates for submittal.

8.1.1 Overview of the Risk Analysis Process

A quantitative baseline risk assessment will be conducted for the facility at Crane. The Ecological Risk Assessment will be based on existing Crane environmental contamination information such as described in the RCRA Facility Investigation, Phase III Ground Water Release Characterization Report (ABG) (Murphy, 1992), An Inventory of Natural Areas and Rare Plant Species at the Naval Weapons Support Center Crane, Indiana, (Jacquart and LeBlanc, 1987), The Bats of Crane Naval Weapons Support Center, Indiana, (Brack et al., 1987), Results of the Survey of Bird Species at the Naval Weapons Support Center, Crane, (Hengeveld, 1987), A Field Survey of Amphibians and Reptiles of Crane Naval Weapons Support Center, Martin County, Indiana, with Emphasis on Rare and Unusual Species, (Nelson et al., 1987), Final Report, Endangered Fish Survey of the Crane Naval Weapons Support Center, Martin County, Indiana, (ES&T, 1987), Installation Restoration Program - Corrective Actions - Draft Part 1 RFI Phase III Soils, (USACE, 1992), Soil Survey of Martin County, Indiana, (McElrath, 1988), Dye Trace of Beech Creek Aquifer, Ammunition Burning Ground, Naval Weapons Support Center Crane, Indiana, (Murphy and Ciocco, 1990), and other available environmental reports. This existing information will be supplemented with additional data obtained during the implementation of the Work Plan. Basic assumptions inherent to the baseline ecological risk assessment for the SWMUs at NAVSURFWARCENDIV include the continuing activity at each of the three sites (ABG, ORR, and DR).

8.1.2 Organization of Ecological Risk Assessment

The Ecological Risk Assessment will follow the guidelines provided in the RAGS Environmental Evaluation Manual (USEPA, 1989c). The ecological risk assessment, to be performed in conjunction with the Human Health Risk Assessment described earlier, will

be based on existing environmental information such as that described above. The Ecological Risk Assessment will consist of the same basic elements as the Human Health Risk Assessment, including toxicity assessment and risk characterization. The existing information describing the ecological setting of the ABG, ORR, and DR areas will be evaluated in conjunction with site-specific chemical data obtained during the implementation of this Work Plan. The Ecological Risk Assessment for the NAVSURFWARCENDIV will be based on the assumption of continued operation of the facilities for the normal operational life of the installation.

The fundamental elements of the ecological portion of the site risk assessment include:

- Hazard Identification: This includes the sources of contaminants, chemicals of concern, populations potentially exposed, and the place and duration of exposure.
- Ecological Exposure Assessment: This relates to the source and mechanism of release, media of concern, receptor points, and routes of exposure. An estimation of the exposure point concentrations of contaminants and their uptake is made.
- Toxicity Assessment: This involves an evaluation of known data concerning the individual contaminants and the concentration levels known to cause adverse effects in the biota. An evaluation (where possible) of the quantitative evidence for toxicity values for ecological species will be made.
- Ecological Risk Characterization: An estimate of the potential for adverse ecological effects to occur will be made. The uncertainty of the analysis and the available data will be addressed and the results of the study will be summarized.

8.2 HAZARD IDENTIFICATION

8.2.1 Conceptual Model of the Project

The Ecological Risk Assessment will consist of the same basic scenarios as in the human health evaluation. The existing information detailing the ecological setting of the three SWMUs will be evaluated in conjunction with site-specific chemical data obtained during the implementation of the work plan. However, for the ecological risk assessment, the three identified scenarios have been combined into two scenarios since the wildlife populations at the site are assumed to remain constant; only the site activities are expected to change. Therefore, only a current use scenario (i.e., burning continues indefinitely into the future) and a future use scenario (i.e., human intensive activities are discontinued) will be evaluated for the ecological risk assessment.

8.2.1.1 Site Contaminants and Environmental Media of Concern/Potential Exposure Pathways

Site Contaminants

At each of the three SWMUs the principal contaminants of concern include the explosives, propellants, oxidants, metals, flammable liquids, and other associated materials involved with the flashing, burning, detonating, or other thermal destruction practices carried out at each of the individual facilities. The site contaminants in addition to the feed stock products include the residues of the combustion process including the gases, particulates, and smoke and ash materials that have the potential for contamination of the ecological site environment and its surrounding areas. The specific contaminant evaluation will involve the identification of site contaminants in the various environmental media suspected to be contaminated, combined with a characterization of the contaminants of concern and their various transformation products, with particular reference to the properties of these materials known to or suspected to cause ecological damage.

Potential Exposure Pathways

Based on existing ecological information for the NAVSURFWARCENDIV facility there are potential terrestrial and aquatic exposure pathways for the release of contaminants from each of the three sites under evaluation. While the individual SWMUs are generally somewhat different in terms of the constituents that are disposed of at each site, for purposes of this ecological assessment, the contaminants are considered collectively and will be distinguished in the individual area descriptions as appropriate. The following section provides additional information concerning the contaminants of concern.

8.2.1.2 Selection of Chemicals of Concern to the Project

The individual contaminants of concern at the study sites that are of particular concern from an ecological perspective will be identified and summarized. Information on the physical/chemical properties, bioaccumulation potential, and other relevant characteristics of the contaminants will be used to evaluate the contaminants' likely persistence in the environment and the routes of chemical release of the individual contaminants to the environment. Physical/chemical information concerning the nature of the contaminants, along with available sampling and analytical data, will be used to determine contaminant concentrations in relevant media.

The contaminants of concern and their transformation products will be evaluated in terms of their known or suspected potential for causing ecological harm. Literature reviews will be conducted to evaluate the toxicity of contaminants of concern, with careful attention

directed to the specification of the effects of concern, such as mortality or reproductive failure and the duration of exposure (i.e., acute or chronic). Applicable or relevant and appropriate requirements (ARARs) will be identified for those contaminants that have established environmental criteria, and exceedances of those ARARs will be noted.

The maximum reasonable concentration of analytes will be used for the purposes of ecological screening. Doses corresponding to the maximum reasonable concentrations will be compared to an assessment factor of 0.01 of the LD_{50} for each contaminant (based on the Registry of Toxic Effects of Chemical Substances (RTECS) database maintained by the National Institute for Occupational Safety and Health (NIOSH). The LD_{50} value of 0.01 will be used for both the acute and the chronic toxicity level exposures.

8.3 EXPOSURE ASSESSMENT

The purpose of the ecological exposure assessment is to identify the environmental receptors, identify and evaluate potential current and future exposure pathways, and determine the extent of exposure under the site-specific current and future land use scenarios, using standard exposure assumptions presented in the document entitled Review of Ecological Risk Assessment Methods (USEPA, 1988), Selection Criteria for Mathematical Models Used in Exposure Assessments (USEPA, 1987) and Ecological Assessment of Hazardous Waste Sites (USEPA, 1989d). In addition, where more current evaluation and exposure assessment methodologies are available they will be incorporated into the assessment as applicable. Any potential proposed modifications to the standard exposure assumptions would be approved by the USEPA prior to using the modified assumptions in the Ecological Risk Assessment. In order to assure consistency with the exposure assumptions, Halliburton NUS Team will solicit any existing spreadsheet or other information developed by Region V that summarizes accepted exposure assumptions. The ecological exposure assessment process which will be conducted for the three SWMUs, including the ABG, ORR, and DR sites, at which contaminants of concern are present will be evaluated in the following three-step process:

1. Identify Potential Receptors

   - Characterize physical environment
   - Characterize potentially exposed populations
   - Characterize present and potential future land uses

2. Identify Exposure Pathways

   - Identify contaminated media

- Sources
- Releases
- Receiving media
- Fate and transport

- Identify exposure points for SWMUs (i.e., individual site or groups of related sites

- Identify exposure routes

- Identify exposure pathways associated with the greatest exposures

3. Quantify Exposure

- Determine exposure point concentration
- Determine contaminant intakes for pathway-specific exposures

The three SWMUs will be examined individually or collectively in groups of related sites, as appropriate. These individual sites or groups of related sites will constitute the "operable units" for the ecological exposure assessment.

8.3.1 Potential Ecological Receptors

The first step in the ecological exposure assessment (as identified above) is to identify the potential ecological receptors at the NAVSURFWARCENDIV. This will involve assessment of the NAVSURFWARCENDIV with respect to physical characteristics (e.g., climate, vegetation, geology, hydrology including surface and groundwater, soils). In addition, the locations of known ecological populations relative to the three study sites at NAVSURFWARCENDIV will be identified based on site evaluation and the collection of data from installation personnel, state, and federal sources. Based on current understanding of the program at NAVSURFWARCENDIV, it is assumed that the three SWMUs will have future land use restrictions for use as park, natural areas, or other non-intensive land uses which will not provide the same exposures to the human or ecological components of the environment that may possibly occur at the present time. Indigenous animals that could be used as indicator species for the study sites are listed in Table 8-1.

TABLE 8-1

INDIGENOUS ANIMAL INDICATOR SPECIES
RISK ASSESSMENT WORK PLAN

Mammal Species

Red Fox
Coyote
Bobcat
White-Tailed Deer
Mink
Muskrat
Cottontail Rabbit
Gray Squirrel
Fox Squirrel
Opossum
Raccoon
Eastern Mole
Indiana Bat
White-Footed Mouse
Deer Mouse
Shorttail Shrew
Striped Skunk
Long-Tailed Weasel
Woodchuck

Avifauna

Red Tailed Hawk
Broad-Winged Hawk
Red-Winged Blackbird
Lazuli Bunting
Carolina Chickadee
Mourning Dove
Wood Duck
Ruffed Grouse
Great Blue Heron
Belted Kingfisher
Mallard
Eastern Meadowlark
Barred Owl
Northern Bobwhite Quail
Field Sparrow
Wild Turkey
Pine Warbler
Hairy Woodpecker
Pileated Woodpecker
Marsh Wren
Bald Eagle
Turkey Vulture

Reptiles

Black Kingsnake
Northern Fence Lizard
Southern Black Racer
Five-Lined Skunk
Eastern Garter Snake
Snapping Turtle
Eastern Box Turtle
Midland Painted Turtle

Fish

Largemouth Bass
Bluegill
Flathead Catfish
Channel Catfish
White Crappie
Black Crappie
Blacknose Dace
Yellow Perch

TABLE 8-1 (Continued)

INDIGENOUS ANIMAL INDICATOR SPECIES
RISK ASSESSMENT WORK PLAN

Fish (continued)

Gizzard Shad
Common Shiner
Brook Silverside
White Sucker
Redear Sunfish
Green Sunfish
Warmouth
Black Bass

Insects

Terrestrial Species
Aquatic Species

Amphibians

Bullfrog
Striped Chorus Frog
Pickerel Frog
Southern Leopard Frog
Red Spotted Newt
Spring Peeper
Two-Lined Salamander
Spotted Salamander
Red-Backed Salamander
American Toad
Gray Treefrog

8.3.2 Exposure Pathways

8.3.2.1 Environmental Fate Characteristics of the Chemicals of Concern

The second step in the exposure assessment process is to identify the potential current and future exposure pathways. This process will require the identification of contaminant sources, the individual chemical release mechanisms, the receiving media, and the fate and transport characteristics of the contaminants of concern. The fundamental purpose of this portion of the ecological exposure analysis is to identify media that are receiving or potentially may receive site-generated contaminants.

Based on past experience, it is anticipated that some of the media, such as air, food, or game species, may reasonably be expected to function as contaminant migration pathways, even though site-specific exposure assessment data for these media are not currently available. In situations of this type, where possible and where applicable, USEPA models will be used to estimate the contaminant concentrations in the media for which actual monitoring data will not be available.

8.3.2.2 Exposure Point Locations for Receptors

Following the characterization of the potential receptors and the contaminated media, the contaminated exposure points will be identified by determining if and where any of the potentially exposed populations may come in contact with these media. This procedure will involve the integration of the results of the current and the potential future ecological receptors evaluation with the results obtained from the evaluation of the contaminated media. After determining the exposure points, the probable exposure pathways will be identified based on the media contaminated by site actions and the anticipated activities at the individual points of exposure.

Complete exposure pathways consisting of a source or chemical release from a source, an exposure point where the contaminant contact can occur, and an exposure route by which uptake can occur will then be determined for both the present and future conditions for each of the SWMUs. The exposure pathways expected to facilitate the greatest exposure will be identified for quantitative evaluation.

The soil ingestion exposure pathway will be evaluated. In addition to this exposure pathway, the surface water and groundwater pathways will be evaluated relative to the three sites under evaluation. It is possible that other exposure pathways such as the airborne route may represent a significant potential exposure route. At the three NAVSURFWARCENDIV sites, the proposed measurement endpoints are based on the bioavailability of contaminants of concern to the vegetation, and the indigenous animals

of the site environs and on the toxic response that ingestion of contaminated food materials would induce. One or several indicator species will be selected with regulatory agency concurrence. The principal ecological exposure pathways by which the indigenous plants and animals are exposed to contaminants from the various media are illustrated in Figures 8-1 and 8-2.

Subsequent to the initial screening, exposure via ingestion of soils, water, and vegetation will be evaluated for the indicator species. The concentration level to be evaluated is the reasonable maximum exposure (RME). This will be determined for the upper 95th percentile. As an example, for the NWSCC, eastern cottontail rabbits obtain food and water primarily from the herbaceous forage species of their habitat (some surface water consumption occurs but is not a major component of their diet). Therefore, the bioavailability of soil contaminants (for eastern cottontail) depends on the absorption of the contaminants by vegetation as well as the amount of soil ingested by the species during preening behavior. For organic contaminants, the amount absorbed can be estimated by calculating the chemical constituents' expected partitioning between grassy plants and soil. This calculation is accomplished through the use of the partitioning coefficient, Kow, and a regression equation developed by Travis and Arms (1988). [Note that any empirical equation used to quantify the movement of contaminants of concern from one medium to another, as noted by Travis and Arms (1988), will be referenced and justified as part of the ecological risk assessment.]

$$\log BCF_{veg} = 1.588 - 0.578 \log K_{ow}$$

where: BCF_{veg} is a vegetation-soil partitioning coefficient for grassy plants; and K_{ow} is the octanol-water partitioning coefficient available from USEPA's PHRED (Public Health Risk Evaluation Database).

The concentration of a specific organic contaminant in the grassy plant is calculated as the product of the concentration in soil and the chemical-specific vegetation-soil partitioning coefficient.

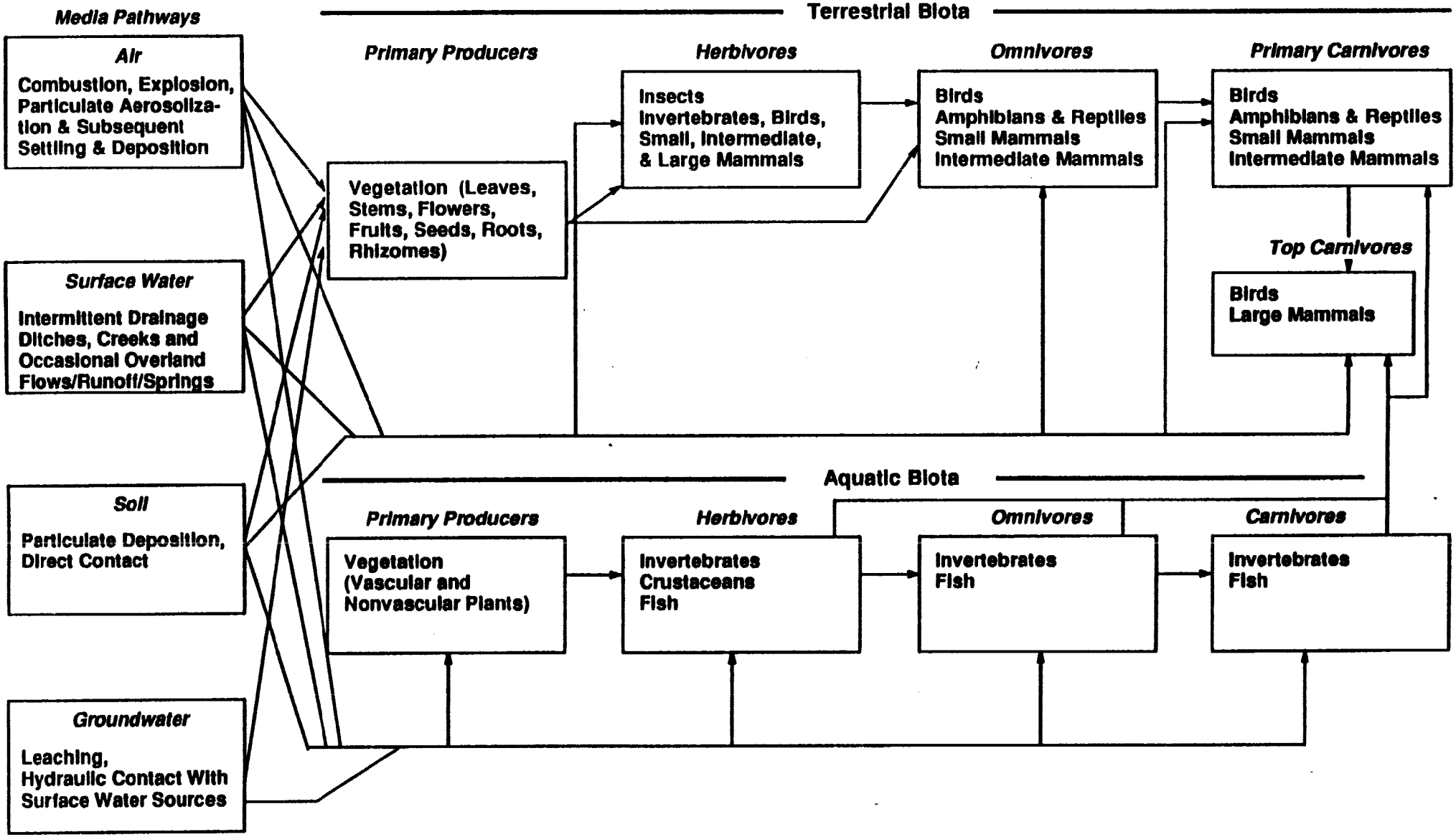
$$C_{veg} = C_{soil} \times BCF_{veg}$$

where C_{veg} = analyte concentration in the plant; and C_{soil} = analyte concentration in the soil.

The estimation of a species' exposure to contaminants of concern in vegetation requires information on the average weight of that species, the average daily intake of grassy plants by that species, and the feeding range of the individual species under evaluation. Efforts will be made to obtain this information from each of the individual sites to make the information as site-specific as is possible. At present, extremely limited amounts of

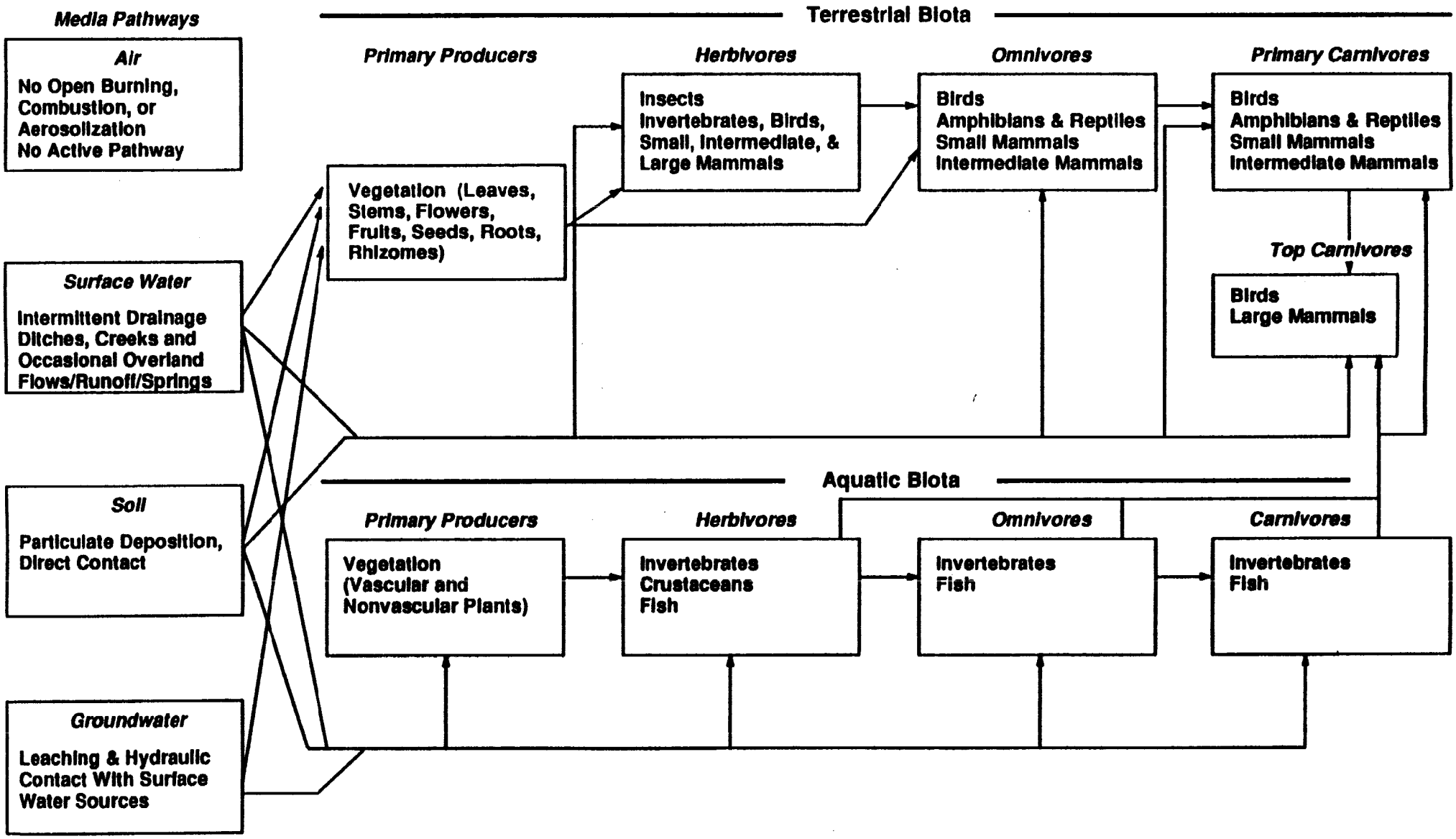
Figure 8-1

Ecological Risk Assessment (ERA) Conceptual Model (CM) – Ammunition Burning Ground (ABG), Old Rifle Range (ORR), and Demolition Range (DR) Current Use and Future Use Under Current Conditions CTO #76



Fi 8-2

ERACM – ABG, ORR, and DR
Future Use (Natural Area/Park Lands Use)
CTO #76



ecological information exist for the installation, and an even smaller amount of information is available for the three evaluation sites. Where possible, sources of information will be contacted or obtained to provide as large a database as possible.

The amount of contaminants of concern ingested via the soil, water, and vegetation at the individual sites will be compared with toxic dose information obtained from data for relevant receptors cited in the Registry of Toxic Effects of Chemical Substances (RTECS) database (NIOSH). If this information is not available, the toxicity criteria data will be sorted according to similar taxonomic groups (guilds), and a benchmark or average toxic dose for each group will be used. As an endpoint for these bioavailability doses, the 0.01 LD_{50} dose will be used where possible.

The bioconcentration factors for metal contaminants in vegetation cannot be calculated from their chemical or physical properties as is done commonly with various organic chemicals. Limited chemical data are available, however on concentrations of some metals in herbaceous plants as compared with metal element concentrations in soils. This information would be developed and presented in tabular form organized by individual metallic element, the soil concentration, the plant concentration, and individual element reference sources. As part of the metals evaluation, we propose to use the mean concentration of each metal in soil as a measurement of the central tendency rather than the median, because the mean considers the effects of outliers, thus affording greater protection for most sensitive ecological plant and wildlife species.

Indicator species in the specific context of the RAWP for NAVSURFWARCENDIV includes both terrestrial and aquatic species. An indicator species can be a single species, a group of species (guild), or a particular sensitive T&E species as required for this program. This use of the indicator species concept is useful in evaluation of the quantity, quality, and extent of habitat areas suitable for use as forage, cover concealment, and rearing areas for the wildlife of the site area. The degree to which impacts resulting from or projected to occur as a result of site activities can be extrapolated to the larger segment of the wildlife community depends largely on careful indicator species selection.

Indicator species are selected using two approaches: 1) selection of species to be used as indicator species consisting of those species with a high public interest, economic value, or similar criterion, and 2) selection of indicator species in order to provide a broader ecological perspective within or throughout a given ecotype. For this program in which it is important to increase the ecological perspective of an assessment, the following types of species were considered:

1. Species known to be sensitive to specific land use actions. The species selected using this approach serve as "bioindicators" or "early warning" species for the affected wildlife community.

2. Species that form a key role in a community due to their role in nutrient cycling or in energy flow.

3. Species that represent groups of species that utilize a common environmental resource (guilds). A representative species selected from the various guilds and predicted environmental impacts for the selected species can be extended with some degree of confidence to other guild members.

8.3.3 Quantitative Environmental Fate Analysis

The third step of the ecological exposure assessment is to determine the extent of exposure through quantitatively evaluating the exposure pathways expected to facilitate the greatest exposure. Accomplishment of this objective will involve quantifying estimates of exposure point concentrations and pathway-specific contaminant uptakes for the contaminants of concern. The estimates of exposure point concentrations will be developed using site-specific monitoring data and analytical models for pathways where contaminant transport must be simulated.

Standard exposure assumptions will be used to estimate the chemical-specific intakes for the exposure pathways selected for quantitative evaluation. Based on the review of existing site-related information coupled with the visual site inspection (November 18 to 20, 1992) exposures to contaminated soil via inhalation, dermal contact, or incidental ingestion, surface water contact or ingestion, or airborne particulate inhalation are considered to be the major current exposure pathways applicable to the three SWMUs at NAVSURFWARCENDIV. Exposures of the ecological receptors to contaminated groundwater are currently under consideration and may form another current exposure pathway based on information currently under development and evaluation. Potential agricultural pathways that might facilitate ecological exposure are not presently considered to be applicable, because agricultural activities are not currently conducted at locations that coincide with confirmed or suspected on-site contamination.

The major exposure pathways applicable to the three SWMUs at NAVSURFWARCENDIV include:

- Ecological exposure to contaminated soil via inhalation, dermal contact, or incidental ingestion.

- Ecological exposure to contaminated sediments via inhalation, dermal contact, or incidental ingestion.
- Ecological exposure to contaminated surface water via dermal contact or incidental ingestion.
- Ecological exposure to contaminated groundwater via dermal contact or incidental ingestion (possible pathway).
- Consumption of contaminated vegetation.
- Consumption of contaminated wildlife (predation).

For purposes of this exposure pathway analysis, exposure to contaminated soil and sediment is not considered to be a relevant future exposure route for sites where surface soil or sediment contamination has not been detected and is not expected to be present. In addition, exposure to contaminated groundwater is not considered to be a relevant future exposure route for sites in which contaminated groundwater has not been detected and is not expected to occur in the future.

The potential exposure pathways currently evaluated for the study sites at NAVSURFWARCENDIV will be reevaluated using the results obtained from the additional sampling and analysis to be conducted as part of this proposed evaluation program, in conjunction with additional information obtained on the physical characteristics of the site and potential receptors.

8.3.3.1 Air Dispersion Modeling of Analytes

Current investigations are being conducted through other CTOs regarding the questions associated with the airborne transport of contaminant materials from the SWMUs to other areas. Information as to isopleth concentrations of contaminants is not currently available but will be evaluated at such time as this information is made available for review and analysis.

8.3.3.2 Soil Concentrations of Analytes

Information concerning the presence of contaminants of concern in the soils of the ABG, ORR, and DR sites has been collected from some areas in the past. At present there is insufficient data available with which to determine the effects on the ecological portion of the environment. A soil sampling plan is included in the Sampling and Analysis Plan

portion of this Work Plan. A current plan of sampling for the parameters in Tables 9-2, 9-3, 9-4, and 9-6 is recommended as part of this effort.

8.3.3.3 Sediment Concentrations of Analytes

Very little sediment-related contaminant characterization has occurred in conjunction with the three study sites. Sediment in the stormwater sediment ponds near the ORR and the DR should be sampled where surface soils are carried into these water bodies and at the discharge end where these areas drain into the local streams. The transport of contaminants in the soils from the disposal sites could serve as a potentially significant pathway for exposure of aquatic biota to contaminants. The sediment samples should be systematically collected from the downgradient locations where this material accumulates. The constituents of concern for analysis include the parameters listed in Tables 9-2, 9-3, 9-4, and 9-6. The same sampling procedures to be used for collecting surface soil samples will be used for the collection of sediment samples.

8.3.3.4 Surface Water Concentrations of Analytes

In a manner similar to that noted above for the sediments, surface water sampling is needed to characterize the contaminants of concern to the biota of the site environs. The surface water sampling is important to determine what the aquatic biota will be exposed to and can potentially bioaccumulate. The surface water in the stormwater sediment ponds as well as the small creeks and streams passing through or along the SWMUs will be sampled at several points for the parameters listed in Tables 9-2, 9-3, 9-4, 9-6, and 9-7.

8.3.3.5 Fish Tissue Bioconcentration of Analytes

Because the accumulation of contaminants of concern in aquatic species can possibly lead to the potential for human ingestion as part of the food chain, it is important to sample fish tissue from the various ponds and streams near the study sites. As part of this analysis several distinct fish species will be sampled, if present, as possible. The bottom detritivores will be sampled. The carnivorous fish species will be sampled, and the herbivorous fish species will be sampled. The minimum sample size is 5 grams. By conducting this tissue sampling in the various trophic level groups, it should be possible to determine based on this information the various bioconcentration values associated with the major fish trophic levels. In this way, the different levels of contaminant bioconcentration can be quantitatively established. The fish species in the stormwater ponds as well as the small creeks and streams passing through or along the SWMUs and from control areas will be sampled at several points for the parameters listed in Tables 9-2, 9-3, 9-4, and 9-6.

8.3.3.6 Vegetation Bioconcentration of Analytes

Terrestrial vegetation represents the foundation of the food chain. As such, any uptake of contaminants of concern in the herbaceous vegetation or in the leaves, fruits, or nuts of plant species from the study area has the potential for transfer of contaminants through the ecological food chain. As a result of this relationship, vegetation will be collected from the three SWMU areas in the downwind and downgradient runoff directions, as well as some control samples collected from outside the area of influence of the demolition activities. This vegetation will be collected from plant species known to constitute dietary forage sources for various wildlife species (known to occur at the installation). The minimum sample size is 5 grams. In this manner, the first link in the terrestrial food chain will be evaluated for quantitative accumulation of contaminants of concern. The vegetation tissue in the vicinity of the SWMUs and from control areas will be sampled for the parameters listed in Tables 9-2, 9-3, 9-4, and 9-6.

8.3.3.7 Terrestrial Food Chain Bioaccumulation of Analytes

The terrestrial food chain will be evaluated for bioaccumulation of contaminants of concern using the same sampling rationale described for the fish and for the terrestrial vegetation. Representatives of the primary consumer wildlife groups will be collected and tissue samples will be taken for analysis of contaminant compound concentrations. Groups will be selected including primary consumers (i.e., small herbivorous species such as white-footed mouse, chipmunk or squirrel), omnivores (i.e., opossum, raccoon), or carnivores (i.e., short-tailed shrew, mink, and long-tailed weasel). Game species may be selected for analysis if the species can be obtained near the SWMUs. The minimum sample size is 5 grams. Game species are preferable sampling specimens because their relationship to the food chain is well established and may serve as a link to potential transfer of contaminants to the human food chain. The wildlife tissue in the vicinity of the SWMUs and from control areas will be sampled for the parameters listed in Tables 9-2, 9-3, 9-4, and 9-6.

8.4 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to qualitatively and quantitatively assess the toxicological hazards of the contaminants of concern as a function of the anticipated route of exposure (such as ingestion or inhalation). The toxicity assessment procedure follows the following steps:

1. Gather Toxicity Information

   - Qualitative
   - Quantitative

2. Determine Toxicity Values for Noncarcinogenic Effects

3. Determine Toxicity Values for Carcinogenic Effects

4. Determine Toxicity Values for Explosives for which Standard Toxicity Indices are Not Available

   - Review Literature
   - Review Structure/Activity Relationships
   - Consult with EPA Toxicologists

5. Summarize Toxicity Information

8.4.1 Abbreviated Toxicity Profiles

The qualitative toxicity assessment will include a discussion of published information concerning environmental toxicity for the contaminants of concern. A brief toxicity profile will be prepared for each contaminant of concern, summarizing documented adverse effects, dose/response information, routes of exposure, reliability of available data, and other readily available information. The quantitative toxicity assessment will involve identifying available quantitative indices of toxicity/carcinogenicity (e.g., mammal poisoning by nitrates). A reference dose (RfD) will be the quantitative index used in evaluating noncarcinogenic effects where available. The RfD represents the maximum acceptable uptake of non-carcinogens, where known for animal species. Frequently this information is unavailable or nonexistent for various wildlife species. Where such data are unavailable, reference to laboratory animal species, to be used as surrogates for the wildlife species, will be defined and explained.

Potential information sources for quantitative and/or qualitative toxicity data include the following:

- USEPA, Integrated Risk Information System (IRIS, 1993)
- USEPA, Health Effects Assessment Summary Tables (HEAST, 1989)
- USEPA, Public Health Risk Evaluation Database (PHREAD, 1989)
- USEPA Criteria Documents including;

- Drinking Water Criteria Documents
- Ambient Water Quality Criteria Documents
- Air Quality Criteria Documents
- Agency for Toxic Substances and Disease Registry, toxicity profiles

Due to the lack of toxicity data for many explosives-related chemicals, a detailed evaluation of recent sources describing health effects of explosives (e.g., Organic Explosives and Related Compounds: Environmental and Health Considerations; Burrows, et al., 1989) will be performed to identify relevant acceptable intakes or potency information for explosive-related compounds. For explosive compounds for which limited data are available, the structure/ activity relationships will be reviewed and evaluated to determine if toxicity data can be developed. Procedures may be developed to calculate acceptable daily intake (ADIs) values from LD_{50} data.

8.4.2 Environmental Benchmark Concentrations

The environmental benchmark concentrations for ecological evaluation will be established using the soil, sediment, surface water, and various tissue sample analytical results for the contaminants of concern. The benchmark concentrations will be established through the comparison of the baseline sampling results with the results obtained after review of the analytes and information concerning the 0.01 LD_{50} values for each contaminant, obtained from the literature. For various media, if contaminant concentrations are observed that exceed the 0.01 LD_{50} value for the selected indicator species, further evaluation of this information will be conducted. For this evaluation, the inclusion of control data to establish outside concentration levels is of high importance to the program. By obtaining background ambient concentrations from outside the area of influence of the combustion sites, it will be possible to determine if bioaccumulation is occurring for contaminants from the sites.

Chronic toxicity data or the 0.01 LD_{50} values will be used as appropriate. For use in this project at NAVSURFWARCENDIV, the 0.01 LD_{50} endpoint measure for comparison to the benchmark baseline concentration values is believed to be a good measurement endpoint as recommended by the USEPA in Public Health Risk Evaluation Database because it possesses all characteristics of a good measurement endpoint, including;

- Correspondence to an Assessment Endpoint - The ecological assessment endpoint is a reduction in abundance of indicator species populations at a site compared to the abundance of the same type of plant or animal species population in an ecologically similar, uncontaminated area. It is assumed that abundance will decrease under toxic stress. In addition to abundance, other indicators of population stress can be used such as indication of stunted growth.

- Readily Measured - Both explosive compounds and TCL compounds are readily measured in soils, sediments, water, and tissues.

- Appropriate to Temporal Dynamics - Because contaminant concentrations at the sites are not expected to change significantly in the soils, sediments, water, and tissues, they can be considered to be constant during the period of study.

- Low Natural Variability - The natural background concentrations of detected analytes in the various media are not expected to vary significantly during the current period of study.

- Diagnostic - The ecological measurement endpoints based on bioavailability and toxic response are obviously diagnostic of contaminant presence and its(their) effect(s).

- Broadly Applicable - The selected endpoints will be applicable to all sites and contaminants at the three sites at NAVSURFWARCENDIV.

- Standard - Contaminant concentrations will be measures by standard methods.

- Existing Data Series - Information on toxic doses of the potential contaminants in rabbits, rodents, and canids is readily available from the RTECS database, maintained by NIOSH.

In order to evaluate potential effects on aquatic systems on and adjacent to the site, Ambient Water Quality Criteria (AWQC) from the Clean Water Act developed for the protection of aquatic life (USEPA, 1986) will be used as the primary surface water criteria. The applicability of different AWQC depends on the intended use of the surface water. Specifically the criteria developed for freshwater, chronic exposure are considered the most applicable. If criteria are not available for freshwater chronic exposure, the criteria developed for freshwater acute exposure will be used for comparative purposes. If AWQC are unavailable, aquatic toxicity databases, such as the Aquatic Information Retrieval (ACQUIRE) database, and primary literature will be consulted to determine the relative toxicities of site contaminants found in surface waters.

Only limited data are available to evaluate the effects of contaminated sediment on aquatic life. The sediment data for the site may be compared with interim sediment quality criteria Interim Sediment Criteria Values for Nonpolar Hydrophobic Organic Contaminants (USEPA, 1988); Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria (USEPA, 1989); and

Technical Memorandum NOS OMA 52, The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program (NOAA, 1990).

8.5 RISK CHARACTERIZATION

8.5.1 Environmental Risk Analysis

For the ecological portion of this program, the population abundance (stress) of indicator species at sites within the NAVSURFWARCENDIV SWMUs and adjacent lands is the principal proposed basis for the ecological assessment endpoints. The specific species that will be used for these endpoints will be selected within USEPA guidance. The significance of species abundance depends on the role of the population within the studied ecosystem. As an example, small mammal species serve as prey for virtually all predators at NAVSURFWARCENDIV. For this program, an operational definition of the endpoint can be obtained by comparing the abundance of a particular species in an operational unit (by qualitatively or quantitatively identifying the NAVSURFWARCENDIV ecosystem in the vicinity of the SWMUs), as compared with the abundance of the species in similar but noncontaminated areas. A value for this latter abundance would be obtained by conducting parallel inventories within and outside of the SWMUs impact areas. The uncertainties associated with this comparative abundance approach will be discussed in the environmental assessment. USEPA concurrence will be sought in use of this abundance metric as an indication of ecological stress.

In practice, any noticeable (measurable) decrease in comparative abundance of indicator species could be assumed as the endpoint, after it has been determined that other ecological factors are not the primary causal factor contributing to this decrease. The species reduction (or other stress indicators) can be compared to the toxicity information obtained from the RTECS database and to the corresponding bioavailability of specific contaminants. Because small noncarnivorous mammals constitute the main diet item of predators at the NAVSURFWARCENDIV, ecological stress affecting their population can also be regarded as stress that will affect the predator population (through food chain relationships other than purely the bioaccumulation mechanism).

In addition to the indigenous wildlife and plant population, an evaluation of other potentially affected populations will also be conducted, with an emphasis placed on the rare, endangered, and threatened species. The potential effects on species that are of recreational or commercial importance will also be noted.

In the aquatic ecosystem of the streams and ponds near the ABG, ORR, and DR sites, two principal organism groups have been selected for analysis, including benthic

macroinvertebrates and fish species. Benthic macroinvertebrates were selected as one of the indicator organisms because in the sediments of the ponds and streams of the site area, they are essentially sessile (non-mobile) and thus serve as a bioindicator of water quality conditions occurring within the water column. In addition, their use as a bioindicator of water quality conditions can be measured on a yearly or seasonal basis. Fish were selected as an indicator organism because they represent all trophic levels from primary consumers through secondary and tertiary consumers.

The terrestrial ecosystem of the study area is comprised of a wide variety of wildlife types and forms including vegetation, birds, mammals, amphibians, and reptiles. Abundance information will be collected for these groups within and outside of the study area to determine based on species composition if there are any significant differences attributable to the activities at ABG, ORR, or the DR. In addition to the species abundance and diversity information to be collected, selected vegetation and wildlife species will be collected for quantitative tissue analysis to determine if there is evidence of bioaccumulation of contaminants of concern in the tissues of the wildlife and plants. This determination will be made to determine the plausibility of linkages and transfer of contaminants through the site ecological food chain.

8.5.2 Uncertainty/Sensitivity Analyses

Quantitative field measurements will be conducted in order to derive as accurate as possible species figures for the control and affected portions of the study areas. Where possible, specific measured areas will be censused for vegetation and small mammals. Where wildlife have higher mobility and increased home-range size, the measurement will use standard inventory/censusing techniques to obtain as representative a database as possible, within the constraints of time and budget for the program.

In the work product of this effort, the limitations of the ecological analysis and the underlying assumptions used in the development and execution of the program will be discussed in detail. This discussion will include enumeration of the limitations of the sampling data, the assumptions underlying the use of statistics in the data analysis, indices, and models where used, and an identification of other potential sources of error which could lead to uncertainty regarding an interpretation of the data generated from the program.

9.0 SAMPLING AND ANALYSIS PLAN

9.1 INTRODUCTION

This plan details the standard procedures to be followed for collecting samples for chemical and physical analyses at three SWMUs within NAVSURFWARCENDIV. The field investigation rationale and approach is detailed in Section 4.0 and summarized below in Section 9.2. Sections 9.3 through 9.9 detail the media-specific sampling plans including sample locations, equipment requirements, sample collection procedures, decontamination procedures, quality control protocols, and documentation requirements. Media-specific sampling plans integrate Standard Operating Procedures (SOPs) as included in Appendix A. Field documentation may include Rust E&I forms as presented in Appendix A. These forms may be used in lieu of, or in addition to these included in the SOPs.

9.2 SAMPLING APPROACH, RATIONALE, AND OBJECTIVES

Based upon potential primary contaminant sources and potential contaminant migration pathways and impacts for each SWMU, sampling needs specific to baseline human health and ecological risk assessment within each SWMU have been identified. Samples to be collected as part of the risk assessment are presented for each SWMU in Table 4-1, Table 4-4, Tables 4-12 through 4-14, and Tables 4-20, 4-21, and 4-26. These tables identify, by medium, the numbers and locations of samples to be collected, analytical parameters, and the rationale for sample collection. Sampling locations for each medium at the respective SWMUs are depicted on Figures 3-7 through 3-9, Figure 3-13, and Figure 3-16.

The tables in Section 4.0 demonstrate that the risk assessment investigative approach focuses on contaminant source characterization and the corresponding media impacts. The nature and extent of hazardous waste or constituents and their concentrations in the respective media serve as the basis for evaluating human health exposure and risk (Figures 4-1 through 4-3), as well as ecological exposure and risk (Figures 8-1 and 8-2). The risk assessment investigative approach incorporates the results of previous SWMU investigations including those completed as part of the federal portion of the RCRA Permit for NAVSURFWARCENDIV. Additionally, the objective of the risk assessment is to satisfy the requirements of 40 CFR Part 264 Subpart X, and comply with recommendations in the RAGS (December 1989), and the Corrective Action requirements as identified in the site's RCRA Part B permit.

The investigative sampling approach involves selection of sample locations based on data needs identified from previous investigations. Both composite and grab samples will be collected for most media. Grab samples are targeted at potential contaminant hot spots, coincident with areas displaying observable impacts (i.e., soil staining) or within those areas considered most likely impacted based on past or present operations (i.e., sumps).

In other instances, it is probable that the spatial variability of contaminants around the potential primary sources is limited, and therefore contaminant concentrations in individual subsamples will not reflect enough variability to effectively dilute the total composite concentration. For these reasons composite sampling is deemed appropriate for this investigation. Composite samples will be collected in conjunction with potential primary sources in an attempt to provide adequate source characterization, yet reduce the total number of samples collected and analyzed. Subsamples are targeted at the perimeters of potential primary sources (i.e. burn pans, surface impoundments). Composite grid sampling will be conducted for less well-defined potentially impacted areas (i.e., Army detonation area of the Demolition Range). The grid-based composites offer the best statistical sampling strategy for minimum bias while providing adequate site coverage over large areas.

It is proposed to use "control" surface soil samples previously collected and analyzed at the ABG (U.S. Army 1990) as representative of background conditions at the ABG. New background surface soil sample locations are proposed for the DR and ORR. Background soil sampling results will be evaluated separately for each SWMU. Surface and sediment samples collected within Little Sulphur, Turkey, and Boggs Creeks at the creeks' upstream or entry points to the respective SWMUs will be considered representative of SWMU background conditions. Background groundwater conditions may be established within existing or proposed upgradient monitoring wells, defined on the basis of water level measurements and proximity to potential primary contaminant sources. Media-specific background samples are identified in Section 4.0.

An ecological population survey will be conducted to fill a significant site-specific data need concerning the ecological relationships at, and affected by, the continued operation of the respective SWMUs. Macroinvertebrate fauna have historically been used to monitor the environmental conditions at a specific location. These organisms are able to reflect the previous water quality conditions because,

- They are relatively immobile.
- They have generally long life cycles.
- They contain many species ranging from tolerant to intolerant to many forms of pollution.

During the field program, samples of the macroinvertebrate fauna will be collected for analysis. A four-point approach to use of the macroinvertebrate community will be employed including:

1. Number of species.
2. Density (number per unit area).
3. Species diversity (Shannon-Weiner index).
4. The pollution tolerance of the individual species or groups.

The number of species present will be used to indicate the degree of water degradation. This method assumes that few species are unaffected by pollution. As a result, the community structure demonstrates an inverse relationship between the number of species and the pollution levels in which the species were found. However, the results are different for the number of individuals within a species. The number of individuals within a species will increase if the pollutant is organic and decrease if the pollutant is toxic.

Fish studies will involve both netting (seining) and electrofishing methods to census the fish fauna of the individual streams and creeks within and outside of the SWMU areas. Information obtained in this portion of the program will include the species observed and a measure of the relative abundance of the individual fish species identified. Information concerning the life stages of the species censused will also be obtained and recorded.

Subsequent to the ecological population surveys, vegetation and wildlife tissue samples will be collected to determine if any of the contaminants of concern are present in living tissue and represent potential sources for bioaccumulation of contaminant materials. This is important to the overall evaluation of the potential for transport of contaminants through the ecological food chain at and surrounding the individual SWMUs.

Sampling procedures, equipment, decontamination, and documentation will be consistent for each of the three SWMUs. Media-specific procedures are presented in the following sections for Surface (0 to 6 inches) Soil Sampling, Surface Water and Sediment Sampling, Monitoring Well Installation, Groundwater Sampling, Surface Water and Groundwater Hydraulic Characterization, Ecological Population Surveying, and Wildlife and Vegetation Tissue Sampling.

Prior to beginning any sampling or surveying activities, no one shall venture into any area which has not been cleared and designated safe by the Navy EOD or CAAA Unexploded Ordnance (UXO) Team. It is possible that some UXO may be present in the SWMUs to be sampled. Because of this, the Halliburton NUS Team shall work with UXO specialists from NAVSURFWARCENDIV using equipment capable of detecting ordnance in all areas where field activities are to be conducted. A magnetometer or other device determined

appropriate by the NAVSURFWARCENDIV UXO specialists, with borehole capability of at least 10 feet, shall be used to determine the presence/absence of subsurface UXO prior to drilling/subsurface sampling. Borehole monitoring shall be accomplished at 2-foot levels to a depth of at least 10 feet. If the geophysical equipment indicates a suspect UXO, an alternative drilling/subsurface sampling location shall be selected by the Halliburton NUS Team and SSO shall be immediately notified. Any unexploded ordnance shall be marked and access restricted in the immediate area. The NAVSURFWARCENDIV UXO Team shall be on-site with the drilling crew during the length of this project.

Because sampling locations are located in the active SWMUs, the SSO or FTL shall arrange SWMU access with Thomas Brent (NAVSURFWARCENDIV Point of Contact). Only after clearance has been obtained will sampling proceed with the NAVSURFWARCENDIV UXO Team. The NAVSURFWARCENDIV UXO Team shall clear each sampling location prior to sample collection. No one shall venture outside of the investigation area without NAVSURFWARCENDIV UXO Team clearance.

9.3 SURFACE SOIL SAMPLING

The purpose of this section is to identify the equipment and appropriate methods necessary to obtain surface (0-6 inches) soil samples at each SWMU. Surface soil samples will be collected to characterize potential releases to soil from primary sources, and subsequently evaluate risk to human and environmental receptors.

9.3.1 Sample Locations

The sample locations are described in Table 4-1, and shown on Figures 3-7 through 3-9, Figure 3-13, and Figure 3-16. Sample locations will be field-identified with lath or stakes prior to sampling. At the DR, surveyed sampling grids will be established in conjunction with the Army Detonation Area and Navy Detonation Area as shown on Figure 3-13. Surveyed sampling grids will also be established at the Target Area within the ORR as shown on Figure 3-13. Composite grid samples will be comprised of subsamples from each quadrant of the respective grid squares. Actual sampling locations will be accurately noted on sample log sheets with reference to survey coordinates.

9.3.2 Analytical Parameters

Surface soil samples will be analyzed using USEPA approved methods within the holding time parameters dictated by the QAPP (Appendix C). Soil samples will be analyzed for SVOCs, explosives, metals, and nitrite + nitrate (See SWMU-specific groups in Table 9-1). Specific compounds are listed on Tables 9-2 through 9-4. Surface soil samples at the ABG

TABLE 9-1

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC[2] LD/MS/MSD
SWMU #03/10 - AMMUNITION BURNING GROUND (and Old Jeep Trail)										
Soil		SVOC	IV	5	1	--	--	1	7	1
		Metals	IV	5	1	--	--	1	7	1
		Cyanide	IV	5	1	--	--	1	7	1
		Explosives	III	5	1	--	--	1	7	1
		Dioxin/Furan	III	3	1	1	--	1	6	1
Surface Water	Temp., pH, Specific Conductance		I	10	--	--	--	--	--	--
		VOC	IV	10	--	1	2	1	14	1
		SVOC	IV	10	--	1	--	1	12	1
		Metals[3]	IV	10	--	1	--	1	12	1
		Cyanide	IV	10	--	1	--	1	12	1
		Explosives	III	10	--	1	--	1	12	1
		COD	III	10	--	1	--	1	12	1
		TDS	III	10	--	1	--	1	12	1
		Sulfate	III	10	--	1	--	1	12	1
		Chloride	III	10	--	1	--	1	12	1
		Alkalinity	III	10	--	1	--	1	12	1
		NO_2+NO_3	III	10	--	1	--	1	12	1
Sediment		VOC	IV	5	1	--	1	1	8	1
		SVOC	IV	5	1	--	--	1	7	1
		Metals	IV	5	1	--	--	1	7	1
		Cyanide	IV	5	1	--	--	1	7	1
		Explosives	III	5	1	--	--	1	7	1
		NO_2+NO_3	III	5	1	--	--	1	7	1
Tissue		VOC	IV	25	--	--	2	3	30	1
		SVOC	IV	25	--	--	--	3	28	1
		Metals	IV	25	--	--	--	3	28	1
		Cyanide	IV	25	--	--	--	3	28	1
		Explosives	III	25	--	--	--	3	28	1
		NO_2+NO_3	III	25	--	--	--	3	28	1
Groundwater	Temp., pH, Specific Conductance		I	6	--	--	--	--	--	--
		VOC	IV	6	1	1	1	1	10	--
		SVOC	IV	6	1	1	--	1	9	--
		Metals[3]	IV	6	1	1	--	1	9	--

TABLE 9-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #03/10 - AMMUNITION BURNING GROUND (and Old Jeep Trail) (Continued)										
Groundwater (Continued)		Cyanide	IV	6	1	1	--	1	9	--
		Explosives	III	6	1	1	--	1	9	--
		COD	III	6	1	1	--	1	9	--
		TDS	III	6	1	1	--	1	9	--
		Sulfate	III	6	1	1	--	1	9	--
		Chloride	III	6	1	1	--	1	9	--
		Alkalinity	III	6	1	1	--	1	9	--
		NO_2+NO_3	III	6	1	1	--	1	9	--
SWMU #06/09 - DEMOLITION RANGE										
Soil		SVOC	IV	14	2	--	--	2	18	1
		Metals	IV	14	2	--	--	2	18	1
		Cyanide	IV	14	2	--	--	2	18	1
		Explosives	III	14	2	--	--	2	18	1
		Dioxin/Furan	III	3	1	--	--	--	4	--
Surface Water	Temp., pH, Specific Conductance		I	4	--	--	--	--	--	--
		VOC	IV	4	--	--	1	1	6	--
		SVOC	IV	4	--	--	--	1	5	--
		Metals(3)	IV	4	--	--	--	1	5	--
		Cyanide	IV	4	--	--	--	1	5	--
		Explosives	III	4	--	--	--	1	5	--
		Alkalinity	III	4	--	--	--	1	5	--
		COD	III	4	--	--	--	1	5	--
		TDS	III	4	--	--	--	1	5	--
		Chloride	III	4	--	--	--	1	5	--
		Sulfate	III	4	--	--	--	1	5	--
		NO_2+NO_3	III	4	--	--	--	1	5	--
Sediment		VOC	IV	4	--	--	1	--	5	--
		SVOC	IV	4	--	--	--	--	4	--
		Metals	IV	4	--	--	--	--	4	--
		Cyanide	IV	4	--	--	--	--	4	--
		Explosives	III	4	--	--	--	--	4	--
		NO_2+NO_3	III	4	--	--	--	--	4	--

TABLE 9-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #06/09 - DEMOLITION RANGE (Continued)										
Tissue		VOC	IV	25	--	--	2	3	30	2
		SVOC	IV	25	--	--	--	3	28	2
		Metals	IV	25	--	--	--	3	28	2
		Cyanide	IV	25	--	--	--	3	28	2
		Explosive	III	25	--	--	--	3	28	2
		NO_2+NO_3	III	25	--	--	--	3	28	2
Groundwater	Temp., pH, Specific Conductance		I	10	--	--	--	--	--	--
		VOC	IV	10	1	1	2	1	15	1
		SVOC	IV	10	1	1	--	1	13	1
		Metals(3)	IV	10	1	1	--	1	13	1
		Cyanide	IV	10	1	1	--	1	13	1
		Explosives	III	10	1	1	--	1	13	1
		COD	III	10	1	1	--	1	13	1
		TDS	III	10	1	1	--	1	13	1
		Chloride	III	10	1	1	--	1	13	1
		Sulfate	III	10	1	1	--	1	13	1
		Alkalinity	III	10	1	1	--	1	13	1
		NO_2+NO_3	III	10	1	1	--	1	13	1
SWMU #07/09 - OLD RIFLE RANGE										
Soil		SVOC	IV	6	1	--	--	--	7	--
		Metals	IV	6	1	--	--	--	7	--
		Cyanide	IV	6	1	--	--	--	7	--
		Explosives	III	6	1	--	--	--	7	--
		NO_2+NO_3	III	6	1	--	--	--	7	--
Surface Water	Temp., pH, Specific Conductance		I	2	--	--	--	--	--	--
		VOC	IV	2	--	1	1	--	4	--
		SVOC	IV	2	--	1	--	--	3	--
		Metals(3)	IV	2	--	1	--	--	3	--
		Cyanide	IV	2	--	1	--	--	3	--
		Explosives	III	2	--	1	--	--	3	--
		COD	III	2	--	1	--	--	3	--

TABLE 9-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #07/09 - OLD RIFLE RANGE (Continued)										
Surface Water (Continued)		TDS	III	2	--	1	--	--	3	--
		Sulfate	III	2	--	1	--	--	3	--
		Chloride	III	2	--	1	--	--	3	--
		Alkalinity	III	2	--	1	--	--	3	--
		NO_2+NO_3	III	2	--	1	--	--	3	--
Sediment		VOC	IV	2	--	--	1	1	4	--
		SVOC	IV	2	--	--	--	--	2	--
		Metals	IV	2	--	--	--	--	2	--
		Cyanide	IV	2	--	--	--	--	2	--
		Explosives	III	2	--	--	--	--	2	--
		NO_2+NO_2	III	2	--	--	--	--	2	--
Tissue		VOC	IV	25	--	--	2	2	29	1
		SVOC	IV	25	--	--	--	2	27	1
		Metals	IV	25	--	--	--	2	27	1
		Cyanide	IV	25	--	--	--	2	27	1
		Explosive	III	25	--	--	--	2	27	1
		NO_2+NO_3	III	25	--	--	--	2	27	1
Groundwater	Temp., pH, Specific Conductance		I	9	--	--	--	--	--	--
		VOC	IV	9	1	1	2	1	14	1
		SVOC	IV	9	1	1	--	1	12	1
		Metals(3)	IV	9	1	1	--	1	12	1
		Cyanide	IV	9	1	1	--	1	12	1
		Explosives	III	9	1	1	--	1	12	1
		COD	III	9	1	1	--	1	12	1
		TDS	III	9	1	1	--	1	12	1
		Sulfate	III	9	1	1	--	1	12	1
		Chloride	III	9	1	1	--	1	12	1
		Alkalinity	III	9	1	1	--	1	12	1
		NO_3+NO_2	III	9	1	1	--	1	12	1

TABLE 9-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

NOTES:

(1) Trip blanks will be provided at a frequency of one per cooler containing VOC samples (soil and water). The number of field blanks are based on two water sources. Rinsate blanks are collected at one per sampling method per day. Only samples obtained from every other day are analyzed. Field duplicates will be collected at a frequency of one per 10 samples collected. See Section 16.0 of Work Plan for event schedule.

(2) MS/MSD Samples are required for organic analysis. Samples shall be collected with extra sample volume at a frequency of one per 20 or fewer investigative samples per matrix. Triple the normal volume for aqueous collected for aqueous VOCs, SVOCs, explosives, and dioxin/furans. Double the normal volume for all other analysis.

(3) Metals and cyanide will be analyzed as total (unfiltered) samples.

FB - Field Blank
RB - Rinsate Blank
FD - Field Duplicate
LD - Laboratory Duplicate
MS - Matrix Spike
MSD - Matrix Spike Duplicate
TB - Trip Blank
SWMU - Solid Waste Management Unit
DQO - Data Quality Objective
QC - Quality Control
VOC - Volatile Organic Compound
SVOC - Semivolatile Organic Compound
COD - Chemical Oxygen Demand
TDS - Total Dissolved Solids
NO_3+ NO_2 - Nitrate Plus Nitrite

TABLE 9-2

SVOC LIST

Compound

Phenol
bis(2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene

1,2-Dichlorobenzene
2-Methylphenol
2,2'-oxybis-(1-Chloropropane)**
4-Methylphenol
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
N-Nitroso-di-n-dipropylamine

bis(2-Chloroethoxy) methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline

Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol

** Previously known by the name of bis(2-chloroisopropyl) ether.

TABLE 9-2 (Continued)

SVOC LIST

Compound	Compound
2,4,5-Trichlorophenol	Benzo(a)anthracene
2-Chloronaphthalene	Chrysene
2-Nitroanaline	bis(2-Ethylhexyl)phthalate
Dimethylphthalate	Di-n-Octylphthalate
	Benzo(b)fluoranthene
Acenaphthalene	Benzo(k)fluoranthene
2,6-Dinitrotoluene	Benzo(a)pyrene
3-Nitroaniline	Indeno(1,2,3-cd)pyrene
Acenaphthene	Dibenzo(a,h)anthracene
2,4-Dinitrophenol	Benzo(g,h,i)perylene
4-Nitrophenol	
Dibenzofuran	
2,4-Dinitrotoluene	
Diethylphthalate	
4-Chlorophenyl-phenyl ether	
Fluorene	
4-Nitroaniline	
4,6-Dinitro-2-methylphenol	
N-Nitrosodiphenylamine	
4-Bromophenyl-phenyl ether	
Hexachlorobenzene	
Pentachlorophenol	
Phenanthrene	
Anthracene	
Carbazole	
Di-n-butylphthalate	
Fluoranthene	
Pyrene	
Butylbenzylphthalate	
3,3-Dichlorobenzidine	

TABLE 9-3

EXPLOSIVES COMPOUND LIST

Explosives	Abbreviation
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX
1,3,5-Trinitrobenzene	TNB
1,3-Dinitrobenzene	DNB
Methyl-2,4,6-trinitrophenylnitramine	Tetryl
Nitrobenzene	NB
2,4,6-Trinitrotoluene	TNT
2,4-Dinitrotluene	24DNT
2,6-Dinitrotoluene	26DNT
o-Nitrotoluene	2NT
m-Nitrotoluene	3NT
p-Nitrotoluene	4NT

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TABLE 9-4

INORGANIC (METALS, CYANIDE) LIST

Analyte

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Tin*
Vanadium
Zinc
Cyanide

* Tin included for soil samples.

as well as background surface soil samples at the DR will be analyzed for dioxins (PCDD) and furans (PCDF) as listed in Table 9-8.

9.3.3 Equipment

The following equipment and material will be used during surface soil sampling:

1. Stainless steel hand trowels.
2. Water, distilled/deionized.
3. Isopropanol (decon spritz).
4. Five-gallon pail with cover to contain isopropanol rinses.
5. Cleaning brushes.
6. Stainless steel spoons.
7. Stainless steel putty knife.
8. Large stainless steel bowls.
9. Sample containers as indicated in Table 9-5.
10. Sample labels.
11. Lath/stakes.
12. Indelible pens.
13. Survey flagging.
14. Liquinox.
15. Shovel.
16. Camera and film.
17. Garbage bags.
18. Munsell Color Chart.

9.3.4 Procedures

Surface (0 to 6 inches) soil samples will include grab and composite samples collected consistent with Halliburton NUS SOP GH-1.3, Section 5.2 (Appendix A). Plant material or gravel will be cleared away with a shovel prior to surface soil sample collection. A decontaminated stainless steel hand trowel will be used to collect soil samples. Each sample will be classified according to the Unified Soil Classification System (USCS) and assigned a color according to a Munsell Soil Color Chart consistent with Halliburton NUS SOP GH-1.5 (Appendix A), and examined for obvious signs of contamination (staining, etc.). Subsamples collected for compositing will be placed in a stainless steel mixing bowl and stirred until a homogeneous mixture is obtained. The soil mixture will be divided into quadrants and small samples will be taken from each quadrant and placed in appropriate sample jars. Grab samples will be collected, described, and placed directly in appropriate sample jars. The containers and sample volumes required are listed in Table 9-5.

TABLE 9-5

SAMPLE CONTAINERS, VOLUMES, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
Soil/ Sediment	VOC	Two 60-ml septum-seal wide-mouth glass jars	4°C	14 days
	SVOC	One 8-oz. wide mouth glass jar	4°C	Extract in 7 days Analyze in 40 days
	Metals	One 8-oz. wide mouth glass jar	4°C	Mercury 28 days, All others 6 months
	Cyanide	One 8-oz. wide mouth glass jar	4°C	14 days
	Explosives	One 4-oz. wide mouth glass jar	4°C	Extract in 14 days Analyze in 40 days
	NO_2+NO_3	One 4-oz. wide mouth glass jar	4°C	28 days
	Dioxin, Furans	One 4-oz. wide mouth glass jar	4°C (Dark)	Extract in 30 days Analyze in 45 days after collection
Groundwater/ Surface Water	VOC	Two 40-ml septum-seal glass vial	1:1 HCl, pH <2, 4°C	14 days
	SVOC	Two 1-liter amber glass	4°C	Extract in 7 days Analyze in 40 days
	Metals	One 1-liter HDPE	1:1 HNO_3, pH <2, 4°C	Mercury 28 days, All others 6 months
	Cyanide	One 1-liter HDPE	NaOH, pH >12, 4°C	14 days

TABLE 9-5 (Continued)

SAMPLE CONTAINERS, VOLUMES, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
Groundwater/ Surface Water (Continued)	Explosives	Two 1-liter amber glass	4°C	Extract in 7 days Analyze in 40 days
	Chloride Sulfate Alkalinity TDS	One 1-liter HDPE	4°C	28 days 28 days 14 days 7 days
	COD NO_2+NO_3	One 1-liter HDPE	1:1 H_2SO_4, pH <2, 4°C	28 days
Tissue	VOC	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	14 days
	SVOC	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Extract in 7 days Analyze in 40 days
	Metals	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Mercury 28 days All others 6 months
	Cyanide	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	14 days

TABLE 9-5 (Continued)

SAMPLE CONTAINERS, VOLUMES, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
	Explosives	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Extract in 14 days Analyze in 40 days
	NO_2+NO_3	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	28 days

Note: HDPE = High Density Polyethylene

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9.3.5 Decontamination

Field sampling equipment contacting the soil sample will be decontaminated prior to use and between sample locations to avoid cross-contamination. The decontamination method is as follows:

1. Liquinox/water wash
2. Distilled or deionized water rinse
3. Isopropanol rinse
4. Distilled or deionized water rinse

Decontamination will include disposal of the samplers' gloves and other personal protective equipment which becomes grossly contaminated during sampling events. Decontamination practices, methods, and follow-up are addressed in Halliburton NUS SOP HS-02 (Appendix A).

9.3.6 Quality Control

Table 9-1 lists the samples needed for field quality control as detailed in the QAPP (Appendix C). Field duplicates will be collected at the same time and in the same manner as original samples.

Field documentation will undergo a daily internal QC review. Original field forms will be reviewed by the Site QC Officer for completeness.

9.3.7 Documentation

Soil sampling information and other observations made by the sampler during daily activities will be recorded on the appropriate field forms as included in Appendix A. This will include:

1. Daily Activities Reports and/or Daily Time Logs
2. Sample Log Sheets and/or Soils Data Forms
3. Sample Labels
4. Chain of Custody Records
5. Photographs of Sampling Locations

9.4 SURFACE WATER AND SEDIMENT SAMPLING

Single one-time surface water and sediment samples will be collected to evaluate potential contaminant impacts to surface water bodies and drainageways adjacent to, and within,

the SWMUs. At the ABG, surface water sampling will also include springs identified as being hydraulically connected to ABG (Murphy, 1992a).

9.4.1 Sample Locations

The sample locations are described in Tables 4-4 and 4-14 presented in Section 4.0 and shown on Figures 3-7 through 3-9, Figure 3-13, and Figure 3-16. Sample locations are within Little Sulphur Creek at the ABG, Boggs Creek at the DR, and Turkey Creek at the ORR. Additional sample locations include Springs A, B, C, 8, and 10. Actual sampling locations will be noted on sample log sheets with reference to permanent structures or other physical features.

9.4.2 Analytical Parameters

Surface water and sediment will be analyzed using USEPA approved methods and within holding time parameters dictated by the QAPP (Appendix C). Surface water samples will be analyzed in the field for specific conductance, pH, and temperature. Laboratory analysis will include VOCs, SVOCs, metals, cyanide, explosives, NO_2+NO_3, alkalinity, COD, SO_4, TDS, and chloride as summarized in Table 9-1. Sediment samples will be visually described in the field, and laboratory analysis will include VOCs, SVOCs, metals, cyanide, explosives, and NO_2+NO_3 as summarized in Table 9-1. In some cases, the parameters identified in Table 9-1 represent those currently lacking in the analytical database established during previous sampling and analysis. Specific compounds are listed in Tables 9-2 through 9-4, and Tables 9-6 and 9-7.

9.4.3 Equipment

The following equipment and materials will be used during surface water and sediment sampling:

1. Sample containers as indicated in Table 9-5.
2. Sampling tube/split-spoon/mud auger.
3. Isopropanol.
4. Five-gallon pail with cover (to contain isopropanol or soap wash water).
5. Alconox or liquinox soap.
6. Cleaning brushes.
7. Stainless steel bowls and spoons.
8. Chest waders.
9. pH meter.
10. Thermometer.
11. Indelible marking pens.

TABLE 9-6

VOC LIST

	Compound
1.	Chloromethane
2.	Bromomethane
3.	Vinyl Chloride
4.	Chloroethane
5.	Methylene Chloride
6.	Acetone
7.	Carbon Disulfide
8.	1,1-Dichloroethene
9.	1,1-Dichloroethane
10.	1,2-Dichloroethene (total)
11.	Chloroform
12.	1,2-Dichloroethane
13.	2-Butanone
14.	1,1,1-Trichloroethane
15.	Carbon Tetrachloride
16.	Bromodichloromethane
17.	1,2-Dichloropropane
18.	cis-1,3-Dichloropropene
19.	Trichloroethene
20.	Dibromochloromethane
21.	1,1,2-Trichloroethane
22.	Benzene
23.	trans-1,3-Dichloropropene
24.	Bromoform
25.	4-Methyl-2-pentanone
26.	2-Hexanone
27.	Tetrachloroethene
28.	Toluene
29.	1,1,2,2-Tetrachloroethane
30.	Chlorobenzene
31.	Ethyl benzene
32.	Styrene
33.	Xylenes (total)

TABLE 9-7

WATER QUALITY ANALYTE LIST

Analyte
Chemical Oxygen Demand (COD)
Total Dissolved Solids (TDS)
Alkalinity
Chloride (Cl)
Sulfate (SO_4)
Nitrite+Nitrate Nitrogen (NO_2+NO_3)

TABLE 9-8

DIOXIN/FURAN LIST

Compound

1. 2,3,7,8-Tetrachlorodibenzo-p-dioxin
2. 1,2,3,7,8-Pentachlorodibenzo-p-dioxin
3. 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin
4. 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin
5. 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin

6. 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin
7. 2,3,7,8-Tetrachlorodibenzofuran
8. 1,2,3,7,8-Pentachlorodibenzofuran
9. 2,3,4,7,8-Pentachlorodibenxofuran
10. 1,2,3,6,7,8-Hexachlorodibenzofuran

11. 1,2,3,7,8,9-Hexachlorodibenzofuran
12. 1,2,3,4,7,8-Hexachlorodibenzofuran
13. 2,3,4,6,7,8-Hexachlorodibenzofuran
14. 1,2,3,4,6,7,8-Heptachlorodibenzofuran
15. 1,2,3,4,7,8,9-Heptachlorodibenzofuran

16. 1,2,3,4,5,6,7,8-Octachlorodibenzo-p-dioxin
17. 1,2,3,4,5,6,7,8-Octachlorodibenzofuran

12. Paper towels.
13. Sample labels.
14. Sample log sheets.

9.4.4 Procedures

Surface water samples for this investigation consist of grab samples. Samples will be collected bankside where possible or by wading into shallow water where practical. Surface water samples will be collected by immersing the sample container in the body of water consistent with Halliburton NUS SOP SA-1.2, Section 5.3.5 (Appendix A). After sample collection, field measurements of specific conductance, pH, and temperature will be made and recorded on the surface water sample log sheet.

With the exception of macroinvertebrate surveys (Section 9.8.1.3), sediment samples for this investigation will consist of composite samples. Sediment samples collected from Little Sulphur, Boggs, and Turkey Creek will each be comprised of three subsamples. Sediment subsamples for use in compositing will coincide to each bank and the center of the creek bed. Sediment samples collected from the sedimentation ponds at the DR will each be comprised of five subsamples. The sediment subsamples will be collected from the perimeters of the ponds, within shallow water.

Surface water samples will be collected prior to sediment samples at each location. Sediment subsamples will be collected by wading into the creek in a manner which will minimize the stirring up of creek-bed sediment by approaching the subsampling location from the downstream direction. A stainless steel sampling tube or mud auger will be pushed or driven below the creek or pond bottom. After the sediment subsample is collected, it will be visually described with the appropriate data recorded on the sample log sheet. Subsamples collected for compositing will be handled according to procedures previously described for soil samples.

9.4.5 Decontamination

Field sampling equipment contacting the surface water or sediment sample will be decontaminated prior to use and between sample locations to avoid cross-contamination. The decontamination method is as follows:

1. Liquinox/water wash
2. Distilled or deionized water rinse
3. Isopropanol rinse
4. Distilled or deionized water rinse

Decontamination will include disposal of the samplers' gloves and other personal protective equipment which become grossly contaminated during sampling events. Decontamination practices, methods, and follow-up are addressed in Halliburton NUS SOP HS-02 (Appendix A).

9.4.6 Quality Control

Table 9-1 lists the samples needed for field quality control as detailed in the QAPP (Appendix C). Field duplicates will be collected at the same time and in the same manner as original samples.

Field documentation will undergo a daily internal QC review. Original field forms will be reviewed by the Site QC officer for completeness.

9.4.7 Documentation

Surface water and sediment sampling information and other observations made by the samplers during daily activities will be recorded on the appropriate field forms as included in Appendix A. This will include:

1. Sample Log Sheets (Surface Water and Sediment) and/or Surface Water/Sediment Data Forms
2. Daily Activities Reports and/or Daily Time Logs
3. Sample Labels
4. Chain of Custody Records

9.5 MONITORING WELL INSTALLATION

Groundwater monitoring well installation will include subsurface soil sampling and rock coring to allow characterization of subsurface stratigraphy and ensure placement of well screens within targeted aquifers at ORR. Monitoring wells will be installed within each borehole to provide hydrogeologic characterization as well as groundwater chemistry data useful in assessing risk to human and environmental receptors. The installation of groundwater monitoring wells is intended to compliment existing monitoring networks at each SWMU and to address risk assessment data needs not addressed during previous hydrogeologic investigations at the SWMUs.

9.5.1 Soil Boring and Well Locations

The locations of borings and wells are described in Table 4-21 and are shown on Figure 3-13 and Figure 3-16. The sample locations will be field identified prior to mobilization to the respective SWMUs. Field conditions may necessitate relocation of an identified well location, as approved by the Project Manager.

9.5.2 Equipment

Equipment and materials used during soil boring and well installation activities will include:

1. A fully-equipped drill rig capable of:

    a. Accomplishing soil boring to an approximate 55-foot depth using standard 4 1/4-inch hollow stem auger or wash rotary drilling techniques.
    b. Performing 2-inch and 3-inch (O.D.) continuous stainless steel and standard split-spoon sampling.
    c. Providing standard penetration test information for soils.
    d. Accomplishing rock coring (NX).
    e. Completing well installation.

2. Fiberglass tape of adequate length to measure depth of boring.
3. Electric water level indicator.
4. Tap water.
5. Munsell Soil Color Chart.
6. Boring logs.
7. Indelible marking pen and black ink pen.
8. Sample labels.
9. Photoionization/flame ionization detector.
10. Hard hat, safety glasses, and steel-toed boots.
11. Wooden core boxes.
12. Submersible pump or bailer.
13. Garbage bags.
14. Liquinox.
15. Atmospheric Monitoring Log.
16. pH, Conductivity Meter.
17. Thermometer.
18. Surge block

9.5.3 Procedures

9.5.3.1 Drilling and Sampling Procedures

Borings will be advanced using hollow stem auger or wash rotary techniques through unconsolidated soils to refusal (top of rock) consistent with Halliburton NUS Team SOP GH-1.4 (Appendix A). Soil borings/rock corings will be completed to anticipated depths as specified in Table 4-21. This will facilitate monitoring well installation within targeted aquifers. When soil borings cannot be continued using augers or rotary methods due to encountering bedrock, drilling and sampling will be performed using a diamond bit corer. Subsurface soil and rock will be collected utilizing split-spoon samplers or a diamond bit corer, respectively. In unconsolidated soils, split-spoon samplers will be advanced ahead of the augers with an all-terrain vehicle (ATV) or truck mounted drilling rig. The geologist will classify and log subsurface soils using USCS and a Munsell Soil Color Chart and maintain a complete soil boring log for each borehole consistent with Halliburton NUS SOP GH-1.5. The geologist will classify and log rock consistent with Halliburton NUS SOP GH-1.5 (Appendix A). Particular attention will be paid to noting and describing fractures, bedding planes, joints, and breaks as this may become critical for understanding contaminant transport. Rock cores will be taken and stored in core boxes.

In borings penetrating more than one aquifer, the upper aquifer will be sealed off before advancing the boring. Polyvinyl chloride (PVC) casing will be grouted a few feet into the aquitard stratum (usually shale) underlying the upper zone and allowed to set overnight. Downhole drilling equipment will be decontaminated before advancing into the next aquifer. In borings penetrating three aquifer zones, an 8-inch surface casing will be followed by 6-inch casing in the next deeper zone, and finally an open hole in the lower zone in which the 2-inch monitoring well casing and screen are set.

Atmospheric monitoring will be performed in the breathing zone for volatile organics with a flame or photoionization detector in accordance with the site-specific Health and Safety Plan (Appendix B). Instrumentation will be calibrated in accordance with manufacturers specifications. Monitoring equipment directives are included in Halliburton NUS SOP ME-01 (Appendix A), which addresses HNU PI-101 organic vapor meters, and Halliburton NUS SOP ME-02 (Appendix A), which addresses OVA 128 organic vapor analyzers.

9.5.3.2 Well Installation Procedures

Groundwater monitoring wells will be installed at all boring locations. Wells may be completed within either unconsolidated soils or bedrock consistent with Halliburton NUS SOP GH-1.7 (Appendix A). The minimum borehole diameter for well installation will be 3-7/8 inches. Monitoring wells less than 100-feet deep will be constructed of 2-inch (I.D.),

flush-threaded, Schedule 40 PVC riser and 0.010-inch slot screen. Monitoring wells greater than 100 feet deep will be constructed of Schedule 80 PVC riser and screen. For monitoring wells targeted to intersect the water table, 10-foot screens will be installed such that approximately 7 feet is below the water table and 3 feet is above the water table. Screened intervals may be adjusted in order to effectively monitor the targeted aquifer based on stratigraphic conditions encountered. Well installations targeted for deeper aquifers will be installed with 5-foot screens. Well construction materials will meet the criteria specified in Halliburton NUS SOP GH-1.7 (Appendix A).

Wells will be labeled with an indelible marker, and surveyed upon completion of the drilling program. Locations and elevations of the monitoring wells will be surveyed to State Plane coordinates and National Geodetic Vertical Datum (NGVD) respectively. Locations will be surveyed to the nearest 0.1 foot, and top of pipe and ground surface elevations will be surveyed to the nearest 0.01 foot.

Wells will be developed no sooner than 24 hours after completion of well construction, consistent with well development methods and procedures addressed in Halliburton NUS SOP GH-1.7 (Appendix A). Well development will consist of pumping the well using a submersible pump or bailer. Intermittent surging will be performed using a bailer or pump, if appropriate, to aid in removal of fine-grained material. Well development will continue until at least five well volumes have been removed and the water being removed from the well has the following characteristics:

- Water temperature is stabilized to $\pm 0.5°C$.
- pH is stabilized to ± 0.1 units.
- Conductivity is stabilized to ± 10 percent.

Field instruments will be calibrated before use according to operation manuals. The calibration results will be recorded on Equipment Calibration Logs and/or Instrument Calibration Logs as included in Appendix A.

9.5.4 Decontamination

To ensure that analytical chemical results reflect actual field conditions and concentrations, various equipment must be properly decontaminated. Upon arriving at the site and prior to initiation of the drilling program, drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined location at each SWMU. The drill rig and all boring and monitoring well construction equipment will be steam-cleaned prior to set-up at a location, between each monitoring well, and before leaving the SWMU. The use of various decontamination areas is critical because of the large size of

the investigation area. Decontamination of drill rigs and monitoring well materials is addressed in Halliburton NUS SOP GH-1.6 (Appendix A) and Section 13.0 of this RA WP.

9.5.5 Quality Control

Table 9-1 lists the samples needed for field quality control as detailed in the QAPP (Appendix C). Field duplicates will be collected at the same time and in the same manner as original samples.

Field documentation will undergo a daily internal QC review. Original field forms will be reviewed by the Site QC Officer for completeness.

9.5.6 Documentation

Subsurface sampling information and other observations made by the sampler during daily activities will be recorded on the appropriate field forms as included in Appendix A. This will include:

1. Daily Activities Reports and/or Daily Time Logs
2. Boring Logs and/or Soil Boring Log w/Atmospheric Monitoring
3. Monitoring Well Sheets (Overburden and Bedrock) and/or Monitoring Well Installation Diagram
4. Sample Labels
5. Chain of Custody Records
6. Groundwater Sample Log Sheets (Purge Data) and/or Well Development Forms
7. Air Monitoring Form and/or Atmospheric Monitoring Log

9.6 GROUNDWATER SAMPLING

9.6.1 Sampling Locations and Analytical Parameters

One round of groundwater sampling will be conducted from all newly installed and select existing monitoring wells at each SWMU. The monitoring wells to be sampled are specified on Tables 4-12, 4-13, 4-20, 4-21, and 4-26 within Section 4.0 and shown on Figures 3-7 through 3-9, Figure 3-13, and Figure 3-16. Groundwater samples will be analyzed for VOCs, SVOCs, explosives, metals, cyanide, chloride, sulfate, alkalinity, COD, TDS, and NO_2+NO_3 as summarized in Table 9-1.

9.6.2 Equipment

The following equipment will be used for groundwater sampling:

1. Keck pump.
2. Electric water level indicator or water level popper.
3. Field notebook.
4. Thermometer.
5. Conductivity meter.
6. pH meter and calibration buffer solutions.
7. Tap water, distilled or deionized water, and isopropanol.
8. Five-gallon pail with cover for collecting and storing isopropanol rinses.
9. Liquinox detergent.
10. Plastic sheeting.
11. Sample bottles and preservatives as listed in Table 9-5.
12. Bailer and rope.
13. Sample labels.
14. Groundwater sample log sheets.
15. Photoionization/flame ionization detector.
16. Calculator.
17. Pump decontamination tube and tray.
18. Garbage bags.

9.6.3 Procedures

Chemical sampling equipment will be transported into the field in clean plastic containers. Equipment removed from the containers will be placed upon clean plastic sheets in order to minimize contamination from ground surface. New sheeting will be used for each sampling location.

Groundwater sample acquisition will be consistent with Halliburton NUS SOP SA-1.1 (Appendix A). Prior to purging, the water level, the initial pH, conductivity, and temperature in the well will be measured. Monitoring wells will then be purged in order to collect samples representative of geochemical conditions. Prior to conducting purging procedures, static water levels in the wells will be measured and recorded. A minimum of five well volumes will then be removed from the monitoring wells through the use of a submersible pump or bailer. If well recharge rates are insufficient to conduct continuous pumping, the wells will be pumped dry, and a sample will be obtained soon after recharge.

Pumps used in the purging process will be fitted with a backflow check valve to prevent purge water from flowing back into the well. During the purging process, selected chemical and physical characteristics of the purge water will be monitored. These characteristics include visual turbidity, conductivity, pH, and temperature. Field meters will be calibrated according to the procedures in the manufacturer's operation manuals. Results of calibration will be recorded on Equipment Calibration Logs and/or Instrument Calibration

Logs as included Appendix A. Required purge volumes will be calculated consistent with Halliburton NUS SOP SA-1.1, Section 5.3 (Appendix A).

Groundwater samples will be collected from the monitoring wells following the purging process. Samples will be collected within 24 hours of well purging, with the exception of those wells where recovery from the purging process exceeds 24 hours. Groundwater samples will be collected using a submersible pump or bailer. Sample containers and preservatives to be used are listed in Table 9-5.

9.6.4 Decontamination

Decontamination procedures are detailed in Halliburton NUS SOP HS-02 (Appendix A). The Keck pump exterior will be cleaned between each use by: 1) a soap and water wash, 2) a tap water rinse, 3) an isopropanol rinse, and 4) two distilled or deionized water rinses. Five gallons of distilled or deionized water will then be pumped through the submersible pump before the next sample is collected. The soap and isopropanol rinses will be retained in closed containers for discharge to the base wastewater treatment system.

9.6.5 Quality Control

In order to verify the quality of the sampling process, sample, rinsate and field blanks and duplicates will be collected as listed in Table 9-1 and detailed in the QAPP (Appendix C). Field duplicates will be taken as the second sample collected consecutively from one well using the decontaminated submersible pump.

Field documentation will undergo a daily internal QC review. Original field forms will be reviewed by the Site QC Officer for completeness.

9.6.6 Documentation

Data collected and observations made during groundwater sampling will be recorded on the appropriate field forms as included in Appendix A. This will include:

1. Daily Activities Reports and/or Daily Time Logs
2. Groundwater Sample Log Sheet and/or Well Purging and Sample Collection Forms
3. Equipment Calibration Logs and/or Instrument Calibration Logs
4. Sample Labels
5. Chain of Custody Records

9.7 TISSUE SAMPLING PLANS

Vegetation and wildlife tissue samples will be collected to determine if the contaminants of concern are present in living tissue and represent potential sources for bioaccumulation of contaminant materials. This is important to the overall evaluation of the potential for transport of contaminants through the ecological food chain at and surrounding the individual SWMU sites. Tissue samples will be collected from vegetation and wildlife species located upgradient, at, and downgradient of the ABG, ORR, and DR sites. A maximum of 75 tissue samples, to include both aquatic and terrestrial tissue samples will be collected.

The wildlife tissue samples as currently planned will be one time sample acquisitions. The individual tissue sampling event is a "snapshot" of the site contaminant concentrations. Based on the immediate need to characterize the ecological exposure to contaminants, the program, as described, should provide adequate information for the purposes of characterization. For purposes of efficiency and cost effectiveness, the range of sample concentration variation obtained for the one sampling interval will be considered to be characteristic of "ambient" site conditions. Additional sampling events could be scheduled for this program but, at present, we do not anticipate this additional requirement.

9.7.1 Sample Locations

The physical locations as well as the number of samples collected will be determined based on the field work conducted as part of the Ecological Population Surveys described in Section 9.8. Since most of the ABG and the DR sites have been severely disturbed as a result of the demolition activities, sample sites adjacent to these areas will be used to obtain tissue samples. In addition, control sites outside the areas of influence of the three SWMUs will be selected for background tissue sample collection. The individual field sample locations will be identified prior to the sampling activity. Actual sampling locations will be noted on sample log sheets with reference to permanent structures or other physical features.

9.7.2 Equipment

The following sampling equipment and materials will be used during the surface vegetation and wildlife tissue sampling:

1. Glass sample containers.
2. Sterile disposable dissecting equipment.
3. Isopropanol.
4. Large plastic bags (1-2 mil thickness).

5. Five-gallon plastic pail with cover (for isopropanol or liquinox soap wash.
6. Liquinox soap.
7. Cleaning brushes.
8. Stainless steel trays and spoons.
9. Paper towels.
10. Indelible marking pens.
11. Sample labels.
12. Sample log sheets.
13. Disposable surgical aprons.
14. Sample collection bags and tags.
15. Tape recorder/tape.
16. Camera and film.

9.7.3 Procedures

Vegetation and wildlife tissue samples to be collected as part of the ecological exposure assessment investigation will consist of grab samples that will be located as close as possible to previously collected soil, sediment and water samples for cross referencing of data. The vegetation tissue samples will be collected by collecting herbaceous vegetation known to be a forage source for indigenous wildlife species. Samples will include foliage, fruits, and mast materials as appropriate to the season of sampling. The location and type of sample will be noted at the time of collection on the sample log sheet.

Wildlife tissue samples to be collected for this investigation will consist of grab samples. Aquatic samples will be limited to fish species representing various aquatic trophic levels. Fish will be obtained using either seining or electrofishing techniques to obtain samples which will be then bagged and immediately placed in ice coolers. Terrestrial wildlife tissue samples will be obtained from small mammals using live-trapping procedures. Animals selected for tissue analysis will be sacrificed in closed sample containers in a carbon dioxide rich atmosphere. After expiration, the animals will be bagged, labeled, and immediately placed on ice in coolers. Where possible, intermediate mammal species will be collected in the same manner and bagged, labeled, and placed on ice for shipment to the analytical laboratory. Large mammal species may consist of species which have been struck by vehicles at or near the individual SWMUs. Road kills coincidentally occurring during the course of the field program may be considered as candidates for tissue samples. Alternatively, large mammal (such as deer) tissue specimens may be obtained at the hunter check station on the installation if the animal was obtained near the individual SWMUs under study. Obtaining tissue from large mammals may present logistic or validation difficulties and will be evaluated further as part of this program.

For intermediate and large wildlife species, selective tissue removals may be required as part of the program. If required, removal of tissue such as liver, kidney or muscle tissue, (potential bioaccumulation sites) may be conducted. If required, this dissection and tissue removal will be conducted at the installation as soon as possible after obtaining the tissue, and the selected organs will be labeled and placed on ice for shipment under chain of custody to the analytical laboratory for analysis as summarized in Table 9-1.

9.7.4 Decontamination

All field sampling equipment contacting the vegetation or wildlife tissue materials will be decontaminated prior to use and between sample locations to avoid cross contamination. The decontamination method is as follows:

1. Liquinox wash
2. Distilled or deionized water rinse
3. Isopropanol rinse
4. Distilled or deionized water rinse

Decontamination will include the sampler's gloves and any other equipment or areas which become grossly contaminated during sampling events. Decontamination practices, methods, and follow-up are addressed in Halliburton NUS SOP HS-02 (Appendix A).

9.7.5 Quality Control

Table 9-1 lists the samples needed for field QC as detailed in the QAPP (Appendix C). Field duplicates will be collected at the same time and in the same manner as the original samples. Field duplicates will undergo a daily QC review after completion of the days' field activities. Original field forms will be reviewed by the Site QC officer for completeness.

9.7.6 Documentation

Both the surface water and the sediment sample information and any other observations made by the samplers during the daily activities will be recorded on the appropriate field forms as included in Appendix A. This may include:

1. Sample Log Sheets (Vegetation and Wildlife Tissue Samples)
2. Daily Activities Reports
3. Sample Labels
4. Chain of Custody Records
5. Photographs of Sample Locations

9.8 ECOLOGICAL POPULATION SURVEY PLANS

An ecological population survey of the three SWMUs is needed to fill a significant site specific data gap concerning the ecological relationships at, and affected by, the continued operation of the ABG, ORR, and the DR sites. The following ecological population survey plan is a general assessment of the aquatic and the terrestrial ecosystems in the area of the three SWMUs and the surrounding site environs.

9.8.1 Aquatic Survey

An aquatic survey will be conducted to characterize the macroinvertebrate and fish communities which could potentially be impacted by the continued operation of the ABG, ORR, and DR sites. Macroinvertebrate and fish species information will be collected.

9.8.1.1 Sample Locations

Macroinvertebrate and fish surveys will be conducted to evaluate water bodies and drainageways upgradient, at and downgradient of the ABG, ORR, and DR sites (three locations each, total nine macroinvertebrate stations). Current site conditions will be determined for sample locations established along Little Sulphur Creek and Springs A, B, and C (ABG), and along Turkey Creek and Boggs Creek in the vicinity of the ORR and the DR sites (Figures 3-7 through 3-9, and Figure 3-13). Three additional sampling stations outside of the influence of the ABG, ORR, and DR sites will be established for population and species survey comparisons.

Two samples will be collected from each of three stormwater runoff ponds draining the ORR and the DR sites. Two additional ponds will be sampled for use as background species information. Wherever possible, the macroinvertebrate sampling station will be located near the stations used for the surface water and sediment sampling stations.

The individual field sample locations will be identified prior to the sampling activity. Actual sampling locations will be noted on Sample Log sheets with reference to permanent structures or other physical features.

9.8.1.2 Equipment

The following sampling equipment and materials will be used during the surface macroinvertebrate and fish sampling:

1. Ponar or Eckman dredge.
2. D-frame kick net.

3. Plastic ziplock bags for sediment samples.
4. Sieves.
5. Chest waders/hip boots.
6. Square shovel.
7. Bucket auger/sample tube.
8. Munsell Color Charts.
9. Knife.
10. Lath and flagging.
11. Measuring tape.
12. Six foot folding ruler.
13. Hammer.
14. Camera and film.
15. Field notebook.
16. Macroinvertebrate taxonomic key.
17. Isopropanol (70%) preservative.
18. Plastic pail(s) with cover.
19. Freshwater fish keys.
20. Gill nets.
21. Seine nets.
22. Smith-Root Type IV Backpack electroshocker.
23. Sample jars.
24. Specimen labels.
25. Paper towels.
26. Decon solution.
27. Sample Log sheets.

9.8.1.3 Procedures

The macroinvertebrate samples will be collected just upstream from quantitative surface water and sediment sampling locations (Section 9.4) to exclude potential sampling disturbance when collecting the benthic samples.

Sediment materials will be collected using Ponar or Ekman Dredge, or alternatively will be collected using a decontaminated shovel from a 1/10 m^2 area of the bottom sediments for each of these locations. The collected sediments will be placed in plastic bags, labeled and 70 percent isopropanol will be added to each sample bag as a preservative. The samples will then be packaged with chain of custody documentation for shipment to the analytical laboratory for taxonomic determination of the species composition of the collected specimens.

Fish Survey

The fish fauna will be sampled at the same sampling stations used for the macroinvertebrate collection. However the time of sampling will be adjusted to occur after the macroinvertebrate samples are collected and at such time as the water body has had a chance to return to ambient (relatively undisturbed) site conditions. Where stream confirmation permits, upstream and downstream nets will be placed in the stream to compartmentalize the individual sampling segments. After the nets are placed, the field investigator will use the electrofishing backpack unit to collect the fish occurring within a given segment. The fish will be transferred to the plastic pail containing stream water and the individual species will be determined and counted. Any notable lesions or abnormalities which are observed will be noted at the time of the fish census activities.

Sampling and survey practices, methods, and follow-up are addressed in Halliburton NUS SOP SA-4.1 (Appendix A).

9.8.1.4 Decontamination

All field sampling equipment contacting the macroinvertebrate or fish sampling equipment will be decontaminated prior to use and between sample locations to avoid cross contamination. The decontamination method is as follows:

1. Liquinox wash.
2. Distilled or deionized water rinse.
3. Isopropanol rinse.
4. Distilled or deionized water rinse.

Decontamination will include the sampler's gloves and any other equipment or areas which become grossly contaminated during sampling events. Decontamination practices, methods, and follow-up are addressed in Halliburton NUS SOP HS-02 (Appendix A).

9.8.1.5 Data Evaluation

The macroinvertebrates collected during the stream and pond survey will be identified to the lowest practical taxon and the Shannon-Weiner index will be calculated to provide an estimate of the benthic macroinvertebrate species diversity.

The fish data collected as part of the survey program will be recorded and an indication of the individual species collected, the number per species, the location of collection and any additional observations concerning the fish fauna conditions will be made.

9.8.1.6 Quality Control

Field notebooks, field logs, field forms and any other field related sampling information will undergo a peer review as a quality control check on the results of the aquatic survey. Field notebooks, or a photocopy of them, field forms and photographs taken will be relinquished to the Project Manager for storage in secured project files. Macroinvertebrate and fish identification information will be reviewed by a second group member to verify their validity.

9.8.1.7 Documentation

Macroinvertebrate and fish fauna sampling locations will be recorded on a large scale site map. Photographs of the sampling site locations will be taken at the time of the field program. Information recorded in the field notebook will include:

- Type and location of macroinvertebrate communities sampled.
- Type and location of fish fauna communities sampled.
- Description of sediment characterization.
- Description of any noted bank communities.
- Hand drawn maps identifying approximate boundaries of sampled areas.
- Signs of wildlife use of the area.

A description of the field work will be recorded on daily time log forms.

Fish identifications, wherever possible, will be entered into the field notebook or, if there is a taxonomic question, the type specimen sample identification number will be noted and once the taxonomic issue is resolved, the field notebook will be updated and the identification noted as a subsequent entry to answer a previous unknown identification.

Both the surface water and the sediment sample information and any other observations made by the samplers during the daily activities will be recorded on the appropriate field forms as included in Appendix A. This may include:

1. Sample Log Sheets (Vegetation and Wildlife Tissue Samples).
2. Daily Activities Reports.
3. Sample Labels.
4. Chain of Custody Records.
5. Photographs of Sample Locations.

9.8.2 Terrestrial Survey

A terrestrial survey will be conducted to characterize the vegetation, avifauna, mammal, amphibian and reptile communities which could potentially be impacted by the continued operation of the ABG, ORR, and DR sites. The areas where the vegetation is surveyed will serve as the same area for collection of avifauna, mammal, amphibian and reptile species information.

9.8.2.1 Sample Locations

Since most of the ABG and the DR sites have been severely disturbed as a result of the demolition activities, sample sites adjacent to these areas will be used for ecological survey sampling. Control sites outside the areas of influence of the three SWMUs will also be selected for background ecological characterization. Field sample locations will be identified prior to the sampling activity. Actual sampling locations will be noted on sample log sheets with reference to permanent structures or other physical features.

At present, sampling locations north, east, south and west of the active SWMUs are being evaluated for field survey ecological investigations. Control areas outside of the influence of the ABG, ORR, and DR sites will be selected for ecological population and species survey comparisons. Control areas will be selected possessing the same dominant vegetation cover types to provide comparable population information.

9.8.2.2 Equipment

The following sampling equipment and materials will be used during the terrestrial sampling program:

1. Large scale site map.
2. Lath and flagging.
3. Hammer.
4. 100 foot measuring tape.
5. Compass.
6. Vegetation taxonomic keys.
7. Vegetation transect sampling forms.
8. Bird taxonomic keys.
9. Bird transect sampling forms.
10. Mammal taxonomic keys.
11. Mammal transect sampling forms.
12. Amphibian and Reptile taxonomic keys.
13. Amphibian and Reptile transect sampling forms.

14. Plant press.
15. Field notebook and pens.
16. Camera and film.
17. Hip boots or chest waders.
18. Binoculars.
19. Small and intermediate live traps.
20. Knife.
21. Spotlight.
22. Flashlight.
23. Sampling bags, plastic, zipper lock.
24. Indelible markers.
25. Sampling Labels.
26. Ice cooler with Ice.
27. Chain of custody forms.

9.8.2.3 Procedures

Vegetation Survey

A vegetation survey will be conducted in the dominant vegetation communities adjacent to each of the ABG, ORR, and DR sites. The vegetation survey locations will be marked with lath, stakes or engineering flagging. Vegetation strata to be sampled include the overstory, understory and herbaceous ground cover strata. The nested-plot technique will be used to sample the vegetation. Information including species presence, species density, species dominance and species importance value will be obtained from measurements made of each strata within the individual sampling areas. The information will be recorded in the site field notebook. In addition, a qualitative vegetation sampling area description sheet will be filled out for each of the sampling areas to provide additional information concerning the species presence or absence from each sampling area.

As part of the vegetation sampling, attention will be directed toward identifying observable indications of stressed vegetation from within the individual sampling areas. A key species which may serve as an indicator of airborne contaminant transport from the SWMUs is lichens. Both crustose and foliose lichens serve as differential integrators of heavy metals and other air toxic materials. The presence and condition of lichens within and outside the area of SWMU influence will be noted and may serve as an indicator of the extent of migration of contaminants off-site and their subsequent effects to the indigenous vegetation.

Avifauna

The avifauna of the individual SWMUs will be evaluated by using bird censusing techniques including a bird transect. This method involves walking the transect at dawn and at dusk on three consecutive days recording any birds observed or heard calling during that interval. As needed, a handheld tape recorder will be used to document the calls heard. At the completion of the bird transect survey, the recorded calls will be documented in the field notebook. Any calls not known will be retained and checked against known reference bird call tapes to determine the unknown species. Once identified, the identified former unknown species will be recorded with appropriate notation in the field notebook for future reference.

Mammals

Small mammal populations in the individual survey communities will be censused using live-traps placed in traplines. A total of 40 points will be used for a trapline with two livetraps set at each station. Station distances will be adjusted to assure that the small mammal trapping takes place within the same vegetation community. A total of three nights will be used for conducting the small mammal survey. Individual species will be observed, identifying the individual species captures, the sex of the animal and the reproductive condition of each animal caught will be recorded. This information will assist with the determination of the individual species abundance as well as the number of distinct species within the individual vegetation community censused. This survey will be conducted within and outside of the influence of the three SWMUs for comparison purposes.

Amphibians and Reptiles

Amphibian and reptile species will be censused by conducting a walk-over of the areas used for the vegetation, bird and mammal studies to provide consistent population information for these groups of organisms. By their very nature these species are covert in their habits and as a result, in addition to a walk-over survey species in this group will be noted when and where observed throughout the field program. In this way, the likelihood of encountering representative species from these groups is increased. Sampling and survey practices, methods, and follow-up are addressed in Halliburton NUS SOP SA-4.2 (Appendix A).

9.8.2.4 Decontamination

All field sampling equipment contacting the terrestrial samples will be decontaminated prior to use and between sample locations to avoid cross contamination. The decontamination method is as follows:

1. Liquinox wash.
2. Distilled or deionized water rinse.
3. Isopropanol rinse.
4. Distilled or deionized water rinse.

Decontamination will include the sampler's gloves and any other equipment or areas which become grossly contaminated during sampling events. Decontamination practices, methods, and follow-up are addressed in Halliburton NUS SOP HS-02 (Appendix A).

9.8.2.5 Data Evaluation

Field observations and habitat information gathered during the field investigation will be used to produce a community map for the survey area. A list of species identified for each community will be presented. Where endangered or threatened species have been identified as occurring in one of the sampled communities, the species habitat requirements for such species will be compared to the community maps and descriptive site information. Endangered or threatened species likely to be present in areas affected by the continuing demolition activities will be identified. The impact of the continuing operation of the SWMUs on the ecological components of the surrounding ecological communities will be assessed based on likely exposure pathways or identified pathways based on the vegetation and wildlife tissue analysis studies conducted as part of this program. A diagram defining the specific site-related ecological pathways will be developed based on the results of the field and analytical survey programs conducted as part of this study.

9.8.2.6 Quality Control

Field notebooks, field logs, field forms, and other field-related sampling information will undergo a peer review as a quality control check on the results of the aquatic survey. Field notebooks, or a photocopy of them, field forms, and photographs taken will be relinquished to the Project Manager for storage in secured project files. Field sampling data including habitat characterizations and individual area species list information will be reviewed by a second group member to verify their validity.

9.8.2.7 Documentation

Terrestrial vegetation survey sampling locations will be recorded on a large-scale site map. Photographs of the sampling site locations will be taken at the time of the field program. Information recorded in the field notebook will include:

- Plant species present in each sampled community.
- Relative density of the canopy understory and ground cover layers.
- Relative soil moisture.
- General topography.
- Observations of stressed vegetation.
- Signs of wildlife and area use by wildlife.
- Hand drawn maps of the general extent of each community.

Bird observations will be identified on a large-scale site map. Information recorded in the field notebooks will include:

- Species of birds observed, both audible and visual.
- Location of survey transect.
- Other signs of wildlife and area use.

Cassette tapes recorded as part of the survey will be included as part of the transect file information.

Mammal and amphibian/reptile observations will be identified on a large-scale site map. Information recorded in the field notebooks will include:

- Species observed, visual.
- Location of survey transect.
- Other signs of wildlife and area use.

General observations noted will include:

- Description of habitats characterization.
- Description of any noted endangered or threatened species.
- Description of any noted sensitive or ecologically unique communities.
- Hand drawn maps identifying approximate boundaries of sampled areas.
- Signs of wildlife use of the area.

A description of the field work will be recorded on Daily Activities Reports and/or Daily Time Logs.

Plant and wildlife identifications wherever possible will be entered into the field notebook or, if there is a taxonomic question, the type specimen sample identification number will be noted and once the taxonomic issue is resolved, the field notebook will be updated and the identification noted as a subsequent entry to answer a previous unknown identification.

Both the vegetation and wildlife sampling information and any other observations made by the samplers during the daily activities will be recorded on the appropriate field forms as included in Appendix A. This may include:

1. Sample Log Sheets (Vegetation and Wildlife Tissue Samples).
2. Daily Activities Reports.
3. Survey result field sheets (unique to species sampled).
4. Sample Labels.
5. Chain of Custody Records.
6. Photographs of Sample Locations.

9.8.2.8 Threatened and Endangered Species Surveys and Observations

As an integral portion of the ecological site survey work to be conducted at the ORR, the ABG and the DR, specific attention will be directed at the presence or absence of any state or federally listed threatened or endangered wildlife or plant species found to occur on-site. The field investigators will have with them in the field, lists of threatened and endangered (T&E) species known to occur on the facility. In addition, information concerning the taxonomic identification of protected species will be taken to the field to assist in the identification of any potential T&E species sitings. Where possible, field surveys in which a potential sensitive species is identified will include photographic documentation of species occurrence and notations as to location, time, and site conditions under which the observation was made. This information will be communicated to the NAVSURFWARCENDIV and to the responsible state or federal agency responsible for the individual species. Two specific surveys for T&E species will be conducted including survey work for the federally protected Indiana Bat (Myotis sodalis) and for the fanshell mussel (Cyprogenia stegaria) and the rough pigtoe mussel (Pleurobema plenum). Surveys for T&E species will be coordinated with the state representatives of the U.S. Fish and Wildlife Service. The Bald Eagle, a resident at the installation, will not be surveyed for since it is under intensive observation and surveillance by NAVSURFWARCENDIV installation wildlife resource specialists.

9.9 SURFACE WATER AND GROUNDWATER HYDRAULIC CHARACTERIZATION

9.9.1 Staff Gauge Installation

Staff gauges will be installed in Little Sulphur, Turkey, and Boggs Creeks to serve as surface water level measurement points. These points will serve as additional control when integrated with groundwater level measurements obtained from well installations.

9.9.1.1 Staff Gauge Locations

Staff gauges will be installed at locations shown on Figures 3-7 through 3-9, and Figure 3-13.

9.9.1.2 Equipment

The following equipment will be used for staff gauge installation:

1. Porcelain enameled steel staff gauges labeled in 0.1-foot increments.
2. Sledge hammer and/or post driver.
3. Chest waders.
4. Bracket fasteners, wire, nuts, and bolts.
5. Steel fence posts.
6. Camera and film.

9.9.1.3 Staff Gauge Installation Procedures

The staff gauges will consist of 2-1/2-inch wide steel staff gauges, finished with porcelain enamel, graduated to hundredths and marked at every foot and every tenth of a foot. The gauges will be located near midstream if accessible. The 3-1/2-foot gauge sections will be bolted to steel fence posts through grommeted holes and driven into place using a sledge hammer or post driver. Gauges will be placed to allow water levels to be read from the stream bank. The locations and top of gauge elevation for each gauge will be surveyed to tolerances specified for the groundwater monitoring wells. Surface water elevations will be recorded to the nearest 0.1-foot at the time of installation. Stream level measurements will be taken when groundwater levels are taken, so that groundwater and surface water levels can be integrated.

9.9.1.4 Decontamination

No decontamination of the staff gauge equipment is necessary.

9.9.1.5 Quality Control

Field documentation will undergo a daily internal QC review after completion of the days' field activities. Original field forms will be reviewed by the Site QC Officer for completeness.

9.9.1.6 Documentation

Data collected and observations made during the installation of staff gauges will be recorded on appropriate field forms as included in Appendix A. This will include:

1. Daily Activities Report and/or Daily Time Logs
2. Sample Log Sheets and/or Staff Gauge Information Forms
3. Photographs of staff gauge locations

9.9.2 Water Level Measurements

Water level measurements (Halliburton NUS SOP GH-2.5 (Appendix A)) will be taken after installation of the monitoring wells and after well development. One round of water level measurements will be collected from the newly installed and existing monitoring wells and from the surface water staff gauges. All water level measurements for a SWMU will be collected within a 24-hour period. Weather conditions at the time of measurement and well integrity will also be noted. Static water levels and well depths will be measured and recorded for the purpose of determining the groundwater flow directions and horizontal hydraulic gradients at the site. The water level surface will be measured using a popper or electric water level indicator. Each well will have a reference point (notch in the top of the protective outer casing) from which water level measurements will be taken. Measurements will be noted to the nearest 0.01-foot. A reference point elevation on the well and staff gauges will be established by survey with respect to the NGVD, with an accuracy of 0.01-foot. Water level measurements will be recorded on Groundwater Level Measurement Sheets and/or Water Elevations Forms as included in Appendix A.

9.10 FIELD SCHEDULE

The proposed field schedule is discussed in Section 16.0. The field schedule has been developed to accomplish the proposed field investigation using an efficient and cost-effective strategy. Mobilization, sampling sequences, and field team responsibilities have been planned to maximize efficiency of personnel use, pre-mobilization arrangements, and field data prerequisites. The actual scheduling of field work and work plan implementation is contingent on Navy and EPA approval of the work plan documents.

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10.0 SAMPLE IDENTIFICATION NUMBERS

Each sample will be identified using the system described below. These numbers will be used to complete required sample documentation including sample labels, sample tags, and Chain of Custody Records. Documentation will be completed following guidelines provided in Halliburton NUS SOP SA-6.1 (Appendix A). Each field sample identification number will consist of a project identifier, the year, SWMU number, sample matrix, sample location number, and collection depth as follows:

CR95-AABB-CC-DD

Where: CR = project identifier for Naval Surface Warfare Center, Crane Division
95 = 1995 Field Investigation

AA = SWMU:
- 03 = SWMU #03/10, Ammunition Burning Ground
- 06 = SWMU #06/09, Demolition Range
- 07 = SWMU #07/09, Old Rifle Range

BB = sample matrix:
- GW = Groundwater Sample
- SD = Sediment Sample
- SS = Soil Sample
- SW = Surface Water Sample
- VT = Vegetation Tissue
- WT = Wildlife Tissue

CC = sample location number (numbered sequentially within each SWMU). In the case of existing monitoring wells, existing well numbers/ nomenclature will be used.

DD = sample depth in feet:
- A = less than 2 feet below surface
- B = 2 to 4 feet
- C = 4 to 6 feet
- D = 6 to 8 feet
- etc.

Field duplicate, rinsate blank and field blank samples will be identified by noting a fictitious sample number. Trip blanks will be designated with "TB".

Examples of field sample identification numbers are as follows:

CR95-03SW01-01	NAVSURFWARCENDIV, 1995 Field Investigation, Surface Water Sample No. 1 from SWMU #03/10 (Ammunition Burning Ground).
CR95-06SS-A01-01	NAVSURFWARCENDIV, 1995 Field Investigation, Soil Sample No. 1 collected from 0-6 inches below the surface at SWMU #06/09 (Demolition Range).

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11.0 SAMPLE CUSTODY

The USEPA chain of custody protocols, as described in "National Enforcement Investigations Center (NEIC) Policies and Procedures," EPA-330/9-78-001-R, revised June 1985, will be followed. Custody is in three parts: sample collection, laboratory analysis, and final evidence files. Field evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. Custody procedures are outlined in Halliburton NUS SOP SA-6.1 (Appendix A) and the QAPP.

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12.0 SAMPLE HANDLING, PACKAGING, AND SHIPMENT

12.1 PACKAGING AND SHIPPING

Samples will be prepared consistent with Halliburton NUS SOP SA-6.2 (Appendix A), as detailed in Section 5.0 of the QAPP (Appendix C).

12.2 SHIPMENT COORDINATION

The FDC will notify the laboratories of sample shipments on the day of shipment. At that time the following information will be provided:

- FDC name and site office telephone number.
- Site name.
- Number(s) and matrix(ces).
- Carrier name and airbill number(s) for the shipment.
- Method of shipment (i.e., overnight).
- Date of shipment.
- Suspected hazards associated with the samples or site.
- Irregularities or anticipated problems with the samples, including special handling instruction or deviations from established sampling procedures or numbers of samples.
- Status of the sampling project (i.e., final shipment, update of future shipping schedule).

Sample shipments made after 5:00 p.m. EST will be called in at the start of business the next day (8:00 a.m. EST). Laboratories will be notified by 3:00 p.m. EST Friday concerning information about sample shipments being sent Friday intended for Saturday delivery/pickup.

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13.0 INVESTIGATION-DERIVED WASTE DISPOSAL

13.1 INTRODUCTION

Standard wastes generated during sampling activities include: drill cuttings, purge waters, decontamination fluids, personal protective equipment (PPE), disposable sampling equipment, plastic sheeting, and office wastes. Waste disposal procedures described below will be followed by on-site personnel.

13.2 WASTES FOR WASTEWATER TREATMENT PLANT

Equipment decontamination fluids containing isopropanol or soap detergents will be collected in covered 5-gallon pails and discharged to the base wastewater treatment plant upon approval.

13.3 WASTES FOR REFUSE HAULER

Wastes such as wastepaper and shipping boxes generated on-site from office-related activities will be staged for disposal by the base refuse hauler.

13.4 DISPOSABLE PERSONAL PROTECTIVE EQUIPMENT

Disposable PPE, disposable sampling equipment, and plastic sheeting will be collected in labeled plastic bags and placed in a designated NAVSURFWARCENDIV dumpster for Navy disposal.

13.5 DRILL CUTTINGS

Drill cuttings will be spread thinly on the ground surface around the soil borings and groundwater monitoring wells from which they originated.

13.6 PURGE WATER AND DECONTAMINATION WATER

Purge water derived from the development and sampling of groundwater monitoring wells will be discharged to the ground surface at the well location but at least 10 feet from the

well so as not to directly recharge the well. Decontamination water from the steam cleaning of drilling and sampling equipment not containing soap or isopropanol will be discharged to the ground surface adjacent to the sampling location. Steam cleaning will take place at least 25 feet away from sampling locations.

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14.0 FIELD MEASUREMENTS/SCREENING

14.1 FIELD MEASUREMENTS

Field measurements and screening data obtained during sample collection activities will be recorded as specified within Section 9.0.

14.2 CALIBRATION OF FIELD EQUIPMENT

Equipment to be used during the field sampling will be examined to determine that it is in an operable condition and will be calibrated at the beginning of each day of use. This includes checking the manufacturer's operating manual and the instructions for each instrument to ensure that all maintenance and operating requirements are being observed.

14.3 PREVENTIVE MAINTENANCE PROCEDURES/SCHEDULE

Field equipment will be maintained and calibrated according to manufacturer's specifications. Maintenance and calibration will be documented on Equipment Calibration Logs as specified in Halliburton NUS SOP SA-6.4 (Appendix A).

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15.0 DATA MANAGEMENT PLAN

15.1 FIELD MEASUREMENTS

Data from field measurements and sample collection activities will be appropriately recorded on field documentation forms as detailed in Section 9.0. If the field data are to be used in the project reports, they will be reduced or summarized and presented in the RA report.

15.2 LABORATORY DATA VALIDATION AND EVALUATION

Data reduction will be performed by the laboratory in accordance with the requirements of the laboratory-specific SOPs. Subsequent to receipt of data from the laboratory, data validation will be performed by the Halliburton NUS Team according to the USEPA National Functional Guidelines for Evaluating Laboratory Data (draft December 1990) and method-specific quality control criteria as applicable.

Diskette deliverables received from the laboratory will be utilized for data reporting. The diskettes will be uploaded to Oracle relational database software. Oracle applications software including Earth Science and Chemistry Database will be used to provide analysis of the data and for generation of report tables and figures. Report tables generated from Oracle are backchecked against hardcopy reports received from the laboratory to verify correctness of uploaded data. The laboratory will report organic, metals, and cyanide analytical data using Contract Laboratory Program (CLP) Statement of Work (SOW) March 1990 format and forms.

Data evaluation of validated analytical data will include data reduction and tabulation, statistical analysis, environmental fate and transport modeling, and mapping. The results will be incorporated into the RA report.

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16.0 SCHEDULE

1. Submit Internal Draft Risk Assessment Work Plan (RA WP) to Navy: February 23, 1993.

2. Receive comments from Navy: May 11, 1993.

3. Submit response to Navy comments: June 3, 1993.

4. Submit Draft RA WP to Navy/TRC/USEPA: June 25, 1993.

5. Discuss Draft RA WP with Navy/TRC/USEPA NAVSURFWARCENDIV: August 1993.

6. Receive comments from Navy/TRC/USEPA: June 21, 1994; March 30, 1995.

7. Submit responses to Navy/TRC/USEPA comments: September 8, 1994; May 25, 1995.

8. Submit Final RA WP to Navy/USEPA: July 12, 1995.

9. Receive USEPA approval of final RAWP: July 24, 1995.

10. Perform field work to gather additional data necessary to conduct and prepare Human Health and Ecological Risk Assessment (HHERA) (1 month): August 21 to September 21, 1995. NOTE: The Indiana Bat survey work will not be performed until May 15, 1996, due to U.S. Fish & Wildlife guidelines.

11 Laboratory turnaround of data (6 weeks): September 22 to November 3, 1995.

12. Submit Internal Draft HHERA (less Indiana Bat survey results) to Navy: February 9, 1996.

13. Receive comments from Navy: March 8, 1996.

14. Submit response to Navy comments: April 8, 1996.

*15. Submit Draft HHERA (less Indiana Bat survey results) to Navy/TRC/USEPA: May 1, 1996.

16. Receive comments from Navy/TRC/USEPA: August 1, 1996.

17. Submit response to Navy/TRC/USEPA comments: September 10, 1996.

*18. Submit Final HHERA to Navy/TRC/USEPA: October 22, 1996.

* Document to be submitted to USEPA by Navy.

NOTE: Items 10 through 18 are in CTO #229.

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APPENDIX A
TO WORK PLAN

HALLIBURTON NUS SOPs AND RUST E&I FIELD FORMS

HALLIBURTON NUS SOPs

GH-1.3	Soil and Rock Sampling
GH-1.4	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-1.6	Decontamination of Drilling Rigs and Monitoring Well Materials
GH-1.7	Groundwater Monitoring Point Installation
HS-02	Decontamination
ME-01	HNU PI-101 Organic Vapor Meter
ME-02	OVA 128 Organic Vapor Analyzer
SA-1.1	Groundwater Sample Acquisition
SA-1.2	Surface Water and Sediment Sampling
SA-4.1	Aquatic Ecological Inventory and Sampling
SA-4.2	Terrestrial Ecological Inventory and Sampling
SA-6.1	Sample Identification and Chain of Custody
SA-6.2	Sample Packaging and Shipping
SA-6.4	Remedial Investigation Forms
SA-6.5	Field Reports

RUST E&I FIELD FORMS

- Daily Time Log
- Soils Data Form
- Surface Water/Sediment Data Form
- Soil Boring Log w/Atmospheric Monitoring
- Rock Core Log
- Field Modification Form
- Field Modification Request Log
- Water Table Well Installation Diagram
- Piezometer Installation Diagram
- Well Development
- Well Purging and Sample Collection
- Water Elevation
- Staff Gauge Information Form
- Instrument Calibration Log
- Atmospheric Monitoring Log

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

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

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- ~~Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.~~
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- ~~Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).~~
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

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

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, ~~three~~ four 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

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

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

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

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

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

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

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

5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailigs, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.

- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.

- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

ATTACHMENT 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	$1\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1\frac{1}{2}$	$\frac{29}{32}$	1.470	905
EX, EXL, EWG, EWM	$1\frac{1}{2}$	$\frac{13}{16}$	1.470	845
AWT	$1\frac{7}{8}$	$1\frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	$1\frac{7}{8}$	$1\frac{3}{16}$	1.875	1.185
BWT	$2\frac{3}{8}$	$1\frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	$2\frac{3}{8}$	$1\frac{5}{8}$	2.345	1.655
NWT	3	$2\frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	$2\frac{1}{8}$	2.965	2.155
HWT	$3\frac{29}{32}$	$3\frac{3}{16}$	3.889	3.187
HWG	$3\frac{29}{32}$	3	3.889	3.000
$2\frac{3}{4} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{3}{4}$	3.840	2.690
$4 \times 5\frac{1}{2}$	$5\frac{1}{2}$	4	5.435	3.970
$6 \times 7\frac{3}{4}$	$7\frac{3}{4}$	6	7.655	5.970
AX Wire line 1/	$1\frac{7}{8}$	1	1.875	1.000
BX Wire line 1/	$2\frac{3}{8}$	$1\frac{7}{16}$	2.345	1.437
NX Wire line 1/	3	$1\frac{15}{16}$	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 254.
1/ Wire line dimensions and designations may vary according to manufacturer

ATTACHMENT 1
PAGE TWO

Size Designations			Casing coupling					Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

* For hole diameter approximation, assume $\frac{1}{32}$ inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.4.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equpment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.4.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g.,

to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer,the top of the cored interval contained within the box is in the upper left corner of the box,and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

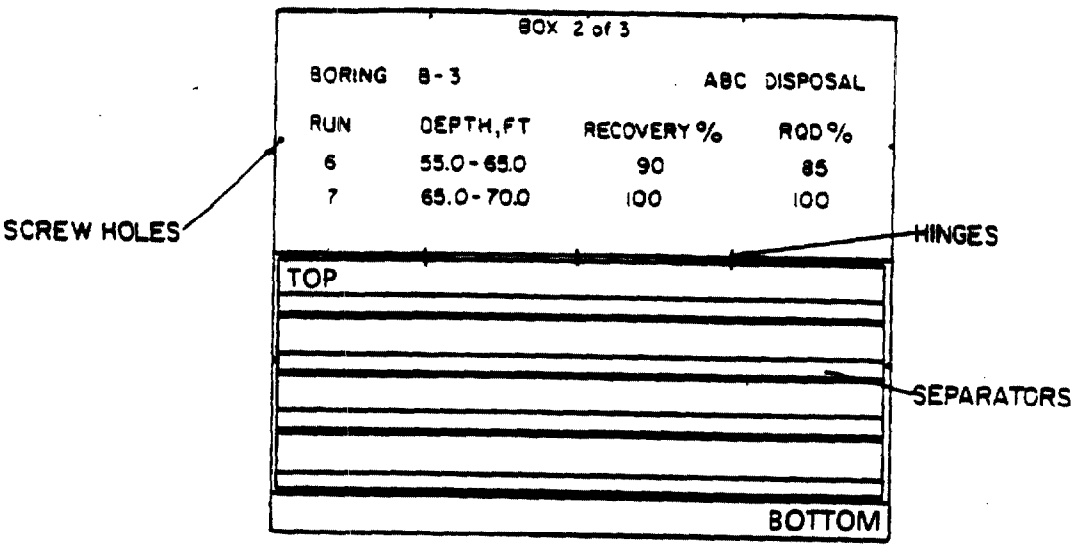
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

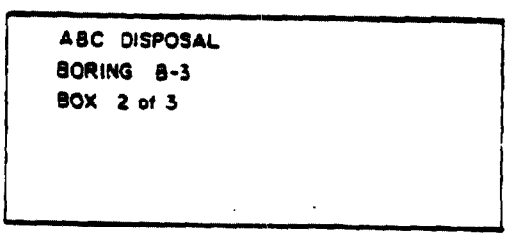
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

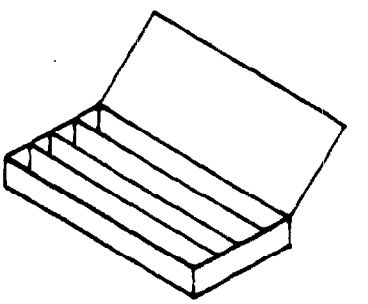
ATTACHMENT 2

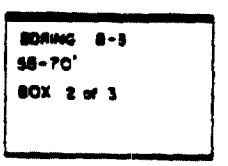


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

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7.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.4	Page 1 of 20
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK DRILLING METHODS		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to describe the methods, the sequence of operations and the equipment necessary to perform soil and rock borings.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that

logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative

methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injec d to keep down dust).
- The borehole diameter is large, to allow room for prop well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound

hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skille[illegible] operators.

- The cable-tool rig ca[illegible]erate satisfactorily in all formations, but is best suited for caving, boulder, c[illegible] or coa[illegible]avel type formations (e.g., glacial till) or formations with large cavities abo[illegible]e wat[illegible]le (such as limestones).

- When casing is used, [illegible] casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

- Split barrel (split spoon) or thin-wall tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required, such as use of a hollow stem auger.

- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.7 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2 to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations but has been used to install 3- to 4-inch diameter casings to 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.8 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the Work Plan. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:
  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."
- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.
- Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.
- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.
- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided

with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallo drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
Hollow-Stem Augers (Ref 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	-
	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	-
Thin Wall Tube Samplers (Ref 7)	-	2	1 7/8	-
	-	2 1/2	2 3/8	-
	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
	-	5	4 3/4	-
Drill Rods (Ref 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (in)
Driven External Coupled Extra Strong Steel* Casing (Ref 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D (in)	Coupling I.D. (in)
Flush Coupled Casing (Ref 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref 7)	EWM	1 1/2	7/8 **	
	AWM	1 7/8	1 1/8 **	
	BWM	2 3/8	1 5/8 **	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 X 3 7/8	3 7/8	2 11/16	
	4 X 5 1/2	5 1/2	3 15/16	
	6 X 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16 **	
	BQ (wireline)	2 23/64	1 7/16 **	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small diameter core (1 3/8") is not recommended.

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		Applicability EMG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

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NOTE: SEE ALSO Rust E&I Field Soil Boring Log Preparation Standard (Std. No. T.12.201)

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms and sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as (1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Munsell Soil Color Charts ~~shall not~~ will be used. ~~unless specified by the project manager.~~

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to ~~18~~ 9
Medium dense	10 ~~11~~ to ~~30~~ 29
Dense	30 ~~31~~ to ~~50~~ 49
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	3 ~~2~~ to 4	Easily penetrated several inches by thumb
Medium ~~stiff~~	0.50 to 1.0	5 ~~4~~ to 8	Can be penetrated several inches by thumb
~~Very~~ stiff	1.0 to 2.0	9 ~~8~~ to ~~15~~ 16	Readily indented by thumb
~~Hard~~ Very Stiff	2.0 to 4.0	17 ~~15~~ to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	Present but less than ~~0 - 10 percent~~ 5 percent
~~some~~ Few	5 - 10 ~~11 - 30~~ percent
~~and or adjective form of the soil type (e.g., "sandy")~~	~~31 - 50 percent~~
little	15 - 25 percent
some	30 - 45 percent
mostly	50 - 100 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to ~~four~~ three categories: dry, moist, and wet, ~~and saturated~~. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

[See ASTM D2488-84]

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types (USCS)
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

[See also Rust E&I soil description requirements.]

5.3 CLASSIFICATION OF ROCKS

[NOTE: See also Rust E&I Rock Coring Log Preparation (Std. No. T.12.236)]

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.
- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- ~~Rock type~~
- ~~Color~~
- ~~Bedding thickness~~
- ~~Hardness~~
- ~~Fracturing~~
- ~~Weathering~~
- Other characteristics

- Classification
- Lithologic modifiers
- Color
- Texture grain/crystal size
- Structure (bedding)
- Cementation
- Hardness
- Structure
- Degree of Weathering

- Solution or Void Condition
- Primary & Secondary estimated K
- Natural & induced core breaks
- RQD
- Primary & secondary porosity

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts ~~shall not~~ may be used ~~unless specified by the project manager~~.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

[See also Table 1, Rust E&I Std. No. T.12.236]

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.

- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, siliceous, hematitic)

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

5.5 BORING LOGS AND DOCUMENTATION [See also Rust E&I standards]

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to

provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

EXHIBIT 4-1

BORING LOG — **NUS CORPORATION**

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA: .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	GRAPHIC LOG OR ROCK CORE SCHEMATICS	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS
More than half of material is LARGER than No. 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>#4 Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand-clay mixtures.
SANDS 50%(+)<#4 Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE GRAINED SOILS
More than half of material is SMALLER than No. 200 sieve size

	FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)				GROUP SYMBOL	TYPICAL NAMES
	identification procedures on fraction smaller than No. 40 sieve size					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)			
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium		CL	Inorganic clays of low to medium plasticity gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight		OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High		CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

EXHIBIT 4-2

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X - NX (Conventional) Core (~2 1/8" O.D.)
Q - NQ (Wireline) Core (~1 7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▽ 12.6' Initial Level w/Date & Depth

12/18
▽ 12.6' Stabilized Level w/Date & Depth

D334901

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO: MW 3A
PROJECT NO.: 619 Y — DATE: 9-21-87 — DRILLER: B. GOLLIHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

	SAMPLE NO & TYPE/ RQD	DEPTH (FT) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR GRANULARITY USCS	REMARKS
	S-1	0.0	3/6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
		1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
		5.0								
	S-2	6.0	11/100/.5	0.8/1.0	5.5/6.0	M. SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
						TO				REFUSAL @ 6' 5.5 TOP OF DEC ROCK
						M. HARD				
										AUGERED TO 15' W/SOLID STEM AUG
										CUTTING MOIST @ ≈8' WATER @ 11'±
										WL @ 12:10 PM WAS ≈ 9' FROM G.S.
										SET 4" PVC CAS. @ 15.0'
9-21		15.0								
9-22						M. HARD	BRN GRAY	SILTY SHALE - FEW	VBR	SEVERAL 0 PPM
								QUARTZ PCS		Fe STAINED JOINTS ON CORE
										THRUOUT RUN. JOINTS AND BREAKS
										ARE HORIZ TO LO &. W/VUGS ON LOWER
		0.7/10.0	①	0%/0	7.0/10.0					PORTION 23 TO 25 OF CORE
		25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2" Φ SP SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A

PAGE 1 OF 3

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOULHUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

	SAMPLE NO & TYPE RQD	DEPTH (Ft) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO ∠ JNTS
								(SILTSTONE)		≈26 TO 27 2- VERT
								- FEW QUARTZ		JOINTS. IRON
								SEAMS		STAINS ON JNTS
										ROCK BECOMES AND
										BREAKS MORE LIKE
										A SILTSTONE WITH
										DEPTH.
	0/10.0	②	0%/0	8.7/10.0						
									BR	≈32 TO 33 FEW
										QUARTZ PIECES W/
									VBR	VUGS.
										SL. MICACEOUS
										VF QUARTZ GRAINS
										IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 · 2 VERT
										JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ
										PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR.
										@ 37± THIN CALCITE
										LAMINATIONS.
										WATER STAINED JNTS
									BR	THRUOUT RUN
										MORE SO 35-37±
	1.0/10.0	③	10%/0	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
									VBR	
		45.0								
										45.3 → 45.5 VERT
										JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS
										MORE CALCITE
										PRESENT

REMARKS _____

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

BORING LOG — NUS CORPORATION

PROJECT: HEBELKA SITE — BORING NO: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.)	BLOWS 6" OR ROD (ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%	10.0/10.0		M. HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	5	0%	1.8/10.0						
	65.0			66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	6	0%	1.3/10.0						
									POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS: AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE. AT 1:50 PM CORED HOLE TO 75' REAMED TWICE DUE TO RUNNING SAND (FRACTURE) AT ≈ 68'. REAMED 2ND TIME TO 81'. SET WELL 66'-76'.

BORING MW 3A

PAGE 3 OF 3

* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473 Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: S J CONTI — PENN - DRILL
WATER LEVEL DATA: 5.54' @ 8:50 AM 7-23-87 T-PVC — ACKER AD-II
(Date, Time & Conditions)

SAMPLE NO & TYPE OR RQD	DEPTH (ft) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	BOREHOLE OR USCS	REMARKS (HNU) HEAD SP
	0.0	5 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR-COAL, FELS		3/4 Φ FRAG - NEAR OLD
							TR-CC FRAG		RR. LINE.
							(FILL)		
	5.0					RED			
S-2		1 1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT-TR FRG TO	SM	MOIST TO WET (0PPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND ? 6" ±
									NUCLEONS 1.0X + NATURAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS. (GRAY)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		9 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	GM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 [illegible]	.9/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON FORD 8000 TRUCK

SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE
PROJECT NO.: 473Y
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)
DATE: 7-7-87
FIELD GEOLOGIST: S.J. CONTI
BORING NO.: MW013
DRILLER: E. EDWSON

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	SM	WET 0 PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST CHANGE IN
							TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
7/7	30.0					NTTD			CASING @ 28'
7/8 S-7		17 / 27	1.4/1.5		V. DENSE	BLUE GRAY	SILTY SAND - SOME GRAVEL	SM/	MOIST > WET (0 PPM)
	31.5	36					TR SS FRAG	GM	CONGLOMERATE IS FINE
							TR CLAY		GRAY & FRIABLE. SUBROUNDED GRAVEL
									NOT HAVE CLAY - BUT MAY BE SEMI-CONFINING.
	35.0								
S-8	35.3	30 / 50/4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET (0 PPM)
							SOME GRAVEL	GM	V. SL. TR CLAY - LESS THAN S-7
							TR SS FRAG		MORE FRAG. - MORE SAND THAN ABOVE.
	40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED
S-9		31 / 34	1.2/1.5		V. DENSE	GRN GRAY	SILTY SAND (FINE TO C.)	SM	HOLES TOGETHER WHEN MOIST → WET (0 PPM)
	41.5	24					SOME GRAVEL - TR	GM	LITTLE MORE CLAY THAN
							CLAY		S-8 SUBROUNDED GRAVEL
									VERY SLOW DRILLING 40-45 (RIG STALLS)
	45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
S-10		13 / 34	1.2/1.5		V. DENSE	GRN GRAY	SILTY SAND (FINE TO C.)	SM/	MOIST → WET (0 PPM)
	46.5	50					SOME GRAVEL - TR	GM	1" Ø SIZE - HOLES TO GETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASSIFICATION
									SLOW DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 @

BORING MW013

PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE
PROJECT NO.: 473Y
DATE: 7-8-87
BORING NO.: MW 013
DRILLER: B. ERICSSON
ELEVATION:
FIELD GEOLOGIST: SJ COUTU
WATER LEVEL DATA:
(Date, Time & Conditions)

	SAMPLE NO & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15/41	1.0/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	GM	MOIST - (OPPM)
		51.3	50/3				GRAY	TR CLAY	SM	PATCHES W/ PCS OF BLACK COAL/LIGNITE
										MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11/15	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (OPPM)
		56.5	26					SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE - SUB-ROUNDED GRAINS
										FIRST COHESIVE TYPE CLASSIF.
		60.0	40							
	S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SOME	SC	MOIST → WET (OPPM)
								GRAVEL	GW	NOT AS MUCH CLAY AS S-12 BUT VERY COHESIVE. SUBROUNDED GRAINS
										SET CAS. @ 66'.
		65.0								
7/13	S-14	65.8	37/50/3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR	SM	MOIST (OPPM)
								AND ROCK FRAG -	GW	MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" D SIZE
					68.0			TR. CLAY		COLOR CHANGE AT ≈68' MORE SAND PER DRILLER - BOTH OF SEMI CONF LAYER ?
							YELLOW BRN			
		70.0								
7/14	S-15		50/39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME	SC	MOIST → WET (OPPM)
		71.5	41					GRAVEL - TR	GC	1" MAX GRAVEL
								ROCK FRAG.		MORE GRAVEL @ 72' PER DRILLER

REMARKS: USING HOLLOW STEM TO ADVANCE BORING - WASHING OUT THRU AUGERS, WHEN NEEDED TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Φ STEEL CASING TO 66' - WILL DRILL BEHIND CASING AFTER GROUT SETS UP. S-14 @ 3:00 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW 013
PAGE 3 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO: MW013
PROJECT NO.: 437Y — DATE: 7-13-87 / 7-14-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ. CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth (ft.) OR SCR. SAT 75)	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-16	75.0	28 50 1.5	0.9/1.0		V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	SC	WET (OPPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTH OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" @ PC.
	80.0								NO SAMPLE @ 80' -
									DECIDED TO GO TO 85'
	85.0	50 .4	0.4/0.4		V. DENSE	GRAY ORANG. BRN	SILTY F. TO C. SAND - SOME	GW	WET (OPPM)
S-17	85.4			85			GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ~ 75' TO 85' IN THIS
									BORING.
							BOTM OF HOLE @ 85.0'		

REMARKS: S-17 @ 2:20 PM 7-14-87 - METHOD BEGINS 6" CASING SPUN 4" Ø - 5 7/8" OD. ADVANCE TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013

PAGE 4 OF 4

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved D. Senovich	

TABLE OF CONTENTS

SECTION

1.0 PURPOSE

2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental sample. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

FIELD SOIL BORING LOG PREPARATION STANDARD

1 INTRODUCTION

1.1 Purpose - This Standard establishes information to be collected and logging format to be used during the inspection of soil borings. This Standard is intended to establish consistency between logs and geologists thereby facilitating improved geological analysis, data presentation, and data base entry.

1.2 Application

1.2.1 This Standard applies to all soil boring inspection work.

1.2.2 This Standard applies to two versions of the Field Soil Boring Log - one with atmospheric monitoring and one without (Appendix A).

1.2.3 Underlined text in this Standard is policy.

- If a heading is underlined, the whole section, including subsections, is a policy. This paragraph is an example of policy since the controlling paragraph heading is underlined.

- Deviation from policy shall be allowed only in accordance with Technical Standard T.00.006 - *Policy for Deviation or Waivers from Technical Standards*.

1.2.4 Remaining text (not underlined) is guideline. Any deviation from guidelines requires approval from the Earth Science and Chemistry Discipline Manager.

1.3 Effective Date - This Standard shall be effective on the date listed as the origin date. (Revisions to this Standard shall be effective on the date listed as the revision date.)

1.4 Authority - The interpreting authority of this Standard is the Earth Science and Chemistry Discipline Manager.

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1.5 Distribution - Holders of Technical Standard Binder - Volumes 12D and 12E.

1.6 Glossary - All soil boring logs should contain approved soil descriptive terms. Descriptive terms and abbreviations to be used are presented in Table 1. Abbreviations should be used sparingly.

2 REQUIREMENTS

2.1 Personnel inspecting soil borings shall follow this technical standard using the Rust E&I Boring Log. An example of a completed log is provided in Appendix B, with descriptive terms and criteria for describing terms.

2.2 The enforcement of this Standard shall be in accordance with Technical Standard T.00.006 - Policy for Deviations of Waivers from Technical Standards.

2.3 Logging of soil borings shall be done in accordance with ASTM Standard D2488-6984, Recommended Practice for Description of Soils (Visual-Manual Procedure) and the procedures specified in Section 4.0.

2.4 Penetration tests and split spoon sampling shall be completed in accordance with ASTM Standard D1586-84, Penetration Test and Split-Barrel Sampling of Soils.

3 RESPONSIBILITIES

The Earth Science and Chemistry Discipline Manager, in cooperation with the Earth Science Group Manager, is responsible for the updating and quality control associated with this Standard.

4 PROCEDURES

4.1 General Instructions - The following should be completed before boring begins:

4.1.1 Complete all boring logs in black indelible ink. Pencil may be used when the logs will not be used as legal documents. Print clearly.

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4.1.2 Complete all general information on the top front and reverse of the boring log form (Appendix A) before drilling begins. General information includes the site name, project number, boring number, drilling method, personnel and companies completing the boring, and equipment to be used. A Borehole numbering system is established as outlined in T.12.202.

4.1.3 Set the depth scale in the "Depth in Feet" column. The boring log has a prepared scale with each full solid line representing one foot. Segments should never represent more than one foot. Record the depth in feet, at every fifth line (these lines are in bold print for easy recognition). Never include more than 20 feet per page.

4.2 Air Monitoring - When atmospheric monitoring is conducted, the appropriate version the Field Boring Log should be used. The Field Boring Log w/atmospheric monitoring includes several extra columns to facilitate recording of instrument readings. These columns are on the far right hand portion of the log and should include the time and instrument readings (photoionization detector, oxygen meter, etc.) for each corresponding depth interval.

4.3 Sampling Data - The following instructions should be used when completing the sampling data portion of the boring log (refer to Appendix B). The majority of this information can be completed prior to removing the sample from the borehole or opening the sampling device.

4.3.1 Interval - Record the sampling interval within this column (only included on Field Boring Log w/atmospheric monitoring).

4.3.2 Type - The sample type should be recorded in this column, i.e., SS=Split Spoon, ST=Shelby Tube, 5 ft CS=5 ft Continuous Sampler, etc.

4.3.3 Attempted - The column labeled "A" is for designating the interval over which sampling was attempted. Normal sample intervals are 18 or 24 inches. Hatchure the attempted sample interval in the "A" column.

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4.3.4 Recovered - The column labeled "R" is provided to record the amount of sample recovered. Hatchure the recovered sample length under this column. The length recovered is measured from the top of the attempted sample interval when less than full recovery is obtained.

4.3.5 Blow Counts - Record blow count information in the column labeled "B." The driller should provide blow counts for each 0.5-foot interval driven during sampling. When possible, count blow counts yourself rather than rely on the driller. Do not apply more than 50 blows for each 0.5-foot interval. If less than 0.5 feet was penetrated after 50 blows, write number of blow, slash "/", and the total length of penetration. Penetration will be recorded in tenths of feet.

4.3.6 The N value (Standard Penetration Resistance) is a representation of the geotechnical properties of the soil. The value is computed by adding the blow count values for the second and third 0.5-foot intervals. N values cannot be obtained if continuous soil core or Shelby tube sampling methods are used. Only a 140-pound hammer dropped 30 inches should be used to calculate N values. If a larger hammer weight is used, it should be recorded.

4.4 USCS Code

4.4.1 USCS - After extracting the sampling device from the borehole and opening the sampler, recovered soil should be classified and described. Procedures to be used to classify and describe soil are found in ASTM D2488 and ASTM D2487. The Unified Soil Classification System (USCS) flow charts utilized for soil classification are found in Appendix C. Please note that dual and borderline classifications are acceptable. However, use of these classifications should not be indiscriminate and must conform to ASTM D2488.

4.5 Soil Description - A general list of soil properties to be described is provided on the back of the boring log. Description of soil properties should be completed in the order outlined below. This order is specified to allow for easier data transfer between field and final logs and to provide a checklist to help ensure that at a minimum these components of the soil description are included.

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4.5.1 Soil

4.5.1.1 Consistency/Density - Based on the N value as identified in Table 1 and on the chart on the back of the boring log, list the consistency/density of the soil. Terms describing consistency are used to log cohesive soils (i.e. clays, silty clays, etc.). Terms describing density are used to log noncohesive soils (i.e. sands, gravels). Write the selected abbreviated consistency/ density modifiers selected in the far left corner of the first line of the sampled interval. Please note that the consistency/density designations and corresponding N values are an internal standard consistent with standard industry practice. Variations do exist. The most important consideration is accurate recording of the blow counts to facilitate interpretation by a geotechnical engineer.

4.5.1.2 Color - Color is the most obvious feature of the sample. A Munsell color chart is to be used to determine the appropriate color code (hue/chroma). Verbal description of color should precede the color code (i.e. dark reddish gray, 5 YR, 4/2).

4.5.1.3 Composition/USCS Description - Study the composition, physical properties, etc., of the sample and visually classify the soil. Assign a USCS group name using all capitals, and the USCS group symbol in the column provided according to ASTM D2488. Evaluate the primary and secondary components and list them by order of relative percent in the description of the soil. Indicate the percent term as follows: <5, trace, 5-10, few; 15-25, little; 30-45, some; >50, mostly. Optionally, the percentage of primary and secondary components may be noted within the lower right hand corner of the description as AA/BB/CC, where AA is the percentage of gravel, BB is the percentage of sand, and CC is the percentage of fines (clay and silt). Large particles should include a description of their physical shape (i.e., roundness or angularity) and mineral composition. These descriptions should be consistent with ASTM D2488 as noted on the back of the boring log. Use the texture and size abbreviations as follows:

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Name	Size Limits	Familiar Example
Boulder	≥305mm	Larger than basketball
Cobbles	76 mm - 305 mm	Grapefruit
Coarse gravel	19 mm - 76 mm	Orange or Lemon
Fine gravel	4.75 mm - 19 mm	Grape or pea
Coarse sand	2 mm - 4.75 mm	Rocksalt
Medium sand	0.42 mm - 2 mm	Sugar, table salt
Fine sand	0.075 - 0.42 mm	Powdered sugar
Fines	Less than 0.075 mm	

4.5.1.4 Moisture Content - Note the approximate moisture content of the sample. Terms used when describing moisture are dry, moist, and wet (water visible in voids). Consider the size of the soil pore space when estimating moisture content.

4.5.1.5 Plasticity - Plasticity attempts to quantify a soil's consistency with varying water content. Consult the techniques presented in ASTM Standard D2488-84, Techniques Used To Determine Plasticity. Fine grained, cohesive soil, will most likely display plasticity. Do not include plasticity for coarse grained soils. The modifying terms high, medium or low should be used with plasticity.

4.5.1.6 Cohesiveness - Cohesiveness relates how well a soil holds together. A soil should be described as cohesive or noncohesive.

4.5.1.7 Distinctive Features - Note distinctive features including texture, fabric, bedding, mottling, gleying, oxidation staining, varves, etc. Descriptive and modifying terms are included in Table 1.

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4.5.1.8 Depositional Environment - Based on the soil type and geologic setting, the geologist should identify the depositional environment in capital letters. For example, varves indicate lacustrine deposition, while sands and gravels are commonly found in an outwash or glacio-fluvial environment. Field evaluation of depositional environment aids in geological evaluation conducted later in the office. The formation name, member, etc., may be included if known.

4.6 Geologic Horizons, Depth to Changes in Strata

Subsurface materials should be represented in the "Graphic Log" column. Standard symbols contained in Appendix D should be used in the graphic log. In addition, the presence of fractures or thin layers may be drawn within this column.

Changes in geologic strata are important for geologic interpretations. It is important that strata changes be clearly and easily identified on the boring log. Identifying changes in geologic strata within a boring is a field responsibility. Strata changes should be recorded by a contact line at the appropriate depth extending across all columns. Major geologic units (based on depositional environment, etc.) should be indicated with a heavier line. When a change in strata occurs between two sequential but separated samples, the contact line shall be drawn one-half the distance between the samples, unless the actual depth is known based on drilling procedures.

4.7 Comments

4.7.1. Drilling Comments - Drilling Comments may include observations made by the driller or geologist which are not related to the sample description. Such comments may identify changes in the rate of boring advance, rocky or rough drilling, a fluid loss, or other potentially significant observations. These general comments should be recorded after the components of the soil description listed in Section 4.5. Professionalism should govern the nature of such comments as Field Boring Logs are often included as client submittals.

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4.7.2 Nature of potential contamination - In addition to stratigraphic characterization, comments may include observations related to the potential occurrence of soil contamination. If contamination is encountered, comments should identify discolored, odorous, or shiny (sheen) soil.

4.8 Water Level Readings - When groundwater is encountered while drilling, its depth should be noted along with the time and date. Stabilized water levels are to be recorded whenever possible. Spaces are provided for this at the top of the boring log. If a borehole is to be left open overnight, water level readings should be taken before leaving the site and prior to starting work the following day. Water level readings will be recorded on the first boring log page. Water elevations may be recorded on the Water Elevation form when more than three readings are obtained.

4.9 End of Boring - The end of the boring should be clearly identified at the appropriate depth with a double solid line extending across all columns. Beneath the solid double line the notation "EOB at X" will be added, where X is the total depth of the boring.

5 REFERENCE DOCUMENTS

5.1 Rust E&I Reference Documents

- T.00.006 - Policy for Deviations or Waivers From Technical Standards
- T.12.202 - Boring and Well Numbering

5.2 ASTM Standards

- ASTM D653-90 - Standard Terminology Relating to Soil, Rock, and Contained Fluids
- ASTM D1452-80 - Practice for Soil Investigation and Sampling by Auger Borings
- ASTM D1586-67 - Method of Penetration Test and Split Barrel Sampling of Soils
- ASTM D1587-83 - Method for Thin-Walled Tube Sampling of Soils

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- ASTM D2488-84 - Recommended Practice for Description of Soils (Visual Manual Procedure)

Approved by:

Thomas C. Leonhardt, P.E.
President and CEO

David L. Hargett, Ph.D.
Director, Corporate Disciplines Program

TS/SCIENTIF/12_201 E: 01/16/95

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TABLE 1
SOIL CHARACTERISTIC & DESCRIPTIVE TERMS

Colors - use only Munsell Soil Color Chart

Basic Material Types and Matrix Inclusions - Use ASTM-2488 abbreviations for normal grain sizes.

bedrock	cobbles	gravel
boulders	fill	sand
refuse		

Adjectives: large (lg), medium (md), small (sm); coarse (co), fine (f); inorganic, organic; calcareous; irregular

General Modifying and Descriptive Terms (not all inclusive)

with (w/)	lense	rock fragments
varved	alternate	with some
partings	seams	with scattered
trace (tr)	little	some
occasional	layers	and (&)
dry	nodular	banded
moist	wet	refusal
calcareous	fractured	jointed
leached	rootlets	concretions
iron staining	burrows	mottled

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TABLE 1
SOIL CHARACTERISTIC & DESCRIPTIVE TERMS

gleyed	water table	weathered
decomposed	cavity	vug (gy)
laminated		

Coarse Grained Soil Density

Designation	**N**
Very Loose (VL)	0-4
Loose (L)	5-9
Medium Dense (MD)	10-29
Dense (D)	30-49
Very Dense (VD)	50+

Coarse Grained Soils Modifying Terms (Angularity, Particle Shape)

Flat	well-graded	angular
Elongated	poorly-graded	subangular
		subrounded
		rounded

Fine Grained Soil Consistency

Designation	**N**
very soft (VS)	0-2
soft (S)	3-4
medium (M)	5-8

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TABLE 1 SOIL CHARACTERISTIC & DESCRIPTIVE TERMS	
stiff (ST)	9-16
very stiff (VST)	17-30
hard (H)	>30
Soil Structure Modifying Terms	
stratified	slickensided
laminated	lensed
fissured	homogenous
Note: Abbreviations should be used sparingly.	

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APPENDIX A

FIELD SOIL BORING LOGS

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RUST ENVIRONMENT & INFRASTRUCTURE

FIELD BORING LOG

BORING NO.

SITE: _____ PROJECT NO. _____

WATER LEVEL READINGS

DATE/TIME	WATER DEPTH	HOLE DEPTH	CASING DEPTH

DRILLING METHOD: _____

LOG BY: _____

FIRM/DRILLER: _____

PHYSICAL SETTING: _____

ABANDONMENT DATE: _____

ABANDONMENT METHOD: _____

GROUND SURFACE ELEV.: _____

COORDINATE TYPE: _____

NORTH: _____

EAST: _____

DATE/TIME START: _____

DATE/TIME COMPLETE: _____

WELL INSTALLATION DATE: _____

DEPTH IN FEET	SAMPLING DATA						GRAPHIC LOG	USCS	SOIL DESCRIPTION AND DRILLING COMMENTS
	B	N	A	R	NO.	T			

DGN :/usr/200312/sldlogs.dgn DATE:Tue Jun 15 11:52:28 1993 PWF :/200312/logs/sldlogs.prf

RUST ENVIRONMENT & INFRASTRUCTURE

FIELD BORING LOG
W/ATMOSPHERIC MONITORING

BORING NO.

SITE: _____ PROJECT NO. _____

WATER LEVEL READINGS

	DATE/TIME	WATER DEPTH	HOLE DEPTH	CASING DEPTH

DRILLING METHOD: _____

LOG BY: _____

FIRM/DRILLER: _____

PHYSICAL SETTING: _____

ABANDONMENT DATE: _____

ABANDONMENT METHOD: _____

GROUND SURFACE ELEV.: _____

COORDINATE TYPE: _____

NORTH: _____

EAST: _____

DATE/TIME START: _____

DATE/TIME COMPLETE: _____

WELL INSTALLATION DATE: _____

DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL DESCRIPTION AND DRILLING COMMENTS	SAMPLING DATA: S	N	A	R	SAMPLE TYPE	SAMPLE INTERVAL	AIR MONITORING: TIME	PID	O_2 / LEL

DGN: /usr/200312/fldlogs.dgn DATE: Tue Jan 15 11:52:28 1993 PDF: /usr/200312/logs/fldlogs.prf

APPENDIX B

COMPLETED FIELD BORING LOG EXAMPLE

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RUST ENVIRONMENT & INFRASTRUCTURE

FIELD BORING LOG W/ATMOSPHERIC MONITORING

BORING NO. B-101

SITE: NIMBY LANDFILL PROJECT NO. 17805.010

WATER LEVEL READINGS

DATE/TIME	WATER DEPTH	HOLE DEPTH	CASING DEPTH
12-25-93/0800	10'	18'	16'

DRILLING METHOD: 4 1/4" HSA w/continuous splitspoon sampling; 2" x 24" stainless steel splitspoons; CME 550 ATV

LOG BY: John DuRite

FIRM/DRILLER: Drilling R' Us / H. Reamer

PHYSICAL SETTING: Woodlot ~500' east of property boundary

ABANDONMENT DATE: 12-25-93

ABANDONMENT METHOD: Tremied bentonite slurry

GROUND SURFACE ELEV.: 770.2

COORDINATE TYPE: State Plane

NORTH: 1210.75

EAST: 800.50

DATE/TIME START: 12-25-93/0630

DATE/TIME COMPLETE: 12-25-93/0900

WELL INSTALLATION DATE: NA

DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL DESCRIPTION AND DRILLING COMMENTS	B	N	A	R	SAMPLE TYPE	SAMPLE INTERVAL	TIME	PID	O2/LEL
		OL/OH	Medium, dark brown, 10YR 4/3, ORGANIC SOIL	1				SS	0-2	0640	0.2	20.2
1		PT	W/SAND, moist low plasticity, noncohesive	3								
			Medium, very dark gray-brown, 10YR 3/2,	4								
2			PEAT, amorphous organic matter	3	7							
		ML	Stiff, gray, 2.5Y N5/0 to olive 5Y 5/2,	4				SS	2-4	0655	0.2	19
3			SILT, dry, low plasticity, noncohesive,	5								
			LOESS	5								
4				7	10							
		ML	Stiff, gray, 2.5Y N5/0, SILT WITH	5				SS	4-6	0705	0.1	20
5			SAND, dry to moist, nonplastic, noncohesive,	6								
			similar to above, LOESS	10								
6			00/15/85	9	16							
		SC	Medium Dense, brown, 7.5YR 5/3, CLAYEY	15				SS	6-8	0720	0.2	19.5
7			SAND, trace gravel, moist, noncohesive,	12								
			subangular to subrounded, fine to medium sand,	10								
8			TILL <5/75/20	16	22							
		CL	Very Stiff, dark brown, 10YR 4/4, SANDY	10				SS	8-10	0735	0.2	20
9			LEAN CLAY WITH GRAVEL, moist, noncohesive,	12								
			iron-stained, TILL	11								
10			15/20/65	13	23							
		GP/SP	Dense, reddish gray, 5YR 5/2, POORLY	20				SS	10-12	0755	0.2	20
11			GRADED GRAVEL/POORLY GRADED SAND, subrounded,	23								
			fine to coarse sand, fine gravel, moist to wet,	25								
12			noncohesive, OUTWASH 50/50/00	28	48							
		SP	Medium Dense, reddish brown, 5YR 5/3,	21				SS	12-14	0815	0.2	19
13			POORLY GRADED SAND WITH GRAVEL,	12								
			subangular fine to coarse sand, wet	13								
14			noncohesive, iron-stained, OUTWASH 15/85/00	14	25							
		GW	Loose, brown, 7.5YR 5/3, WELL GRADED	5				SS	14-16	0840	0.2	20
15			GRAVEL WITH SAND, subrounded to subangular	4								
			fine to coarse gravel with few rock fragments,	5								
16			primarily coarse sand, OUTWASH 75/20/<5	6	9							
		SW/SP	Medium Dense, light yellow brown, 10YR 6/4,	9				SS	16-18	0900	0.2	20.5
17			WELL/POORLY GRADED SAND, trace fines,	8								
			subrounded, medium to coarse sand, wet	10								
18			noncohesive, OUTWASH 00/95/<5	12	18							
19			EOB at 18'									
20												

DGN =/usr/200312/sldlogs.erd DATE=Tue Jun 15 11:52:28 1993 PRF = =/200312/logs/sldlogs.prf

APPENDIX C

FLOW CHARTS FOR IDENTIFYING FINE - AND COARSE - GRAINED SOIL (ASTM D2488)

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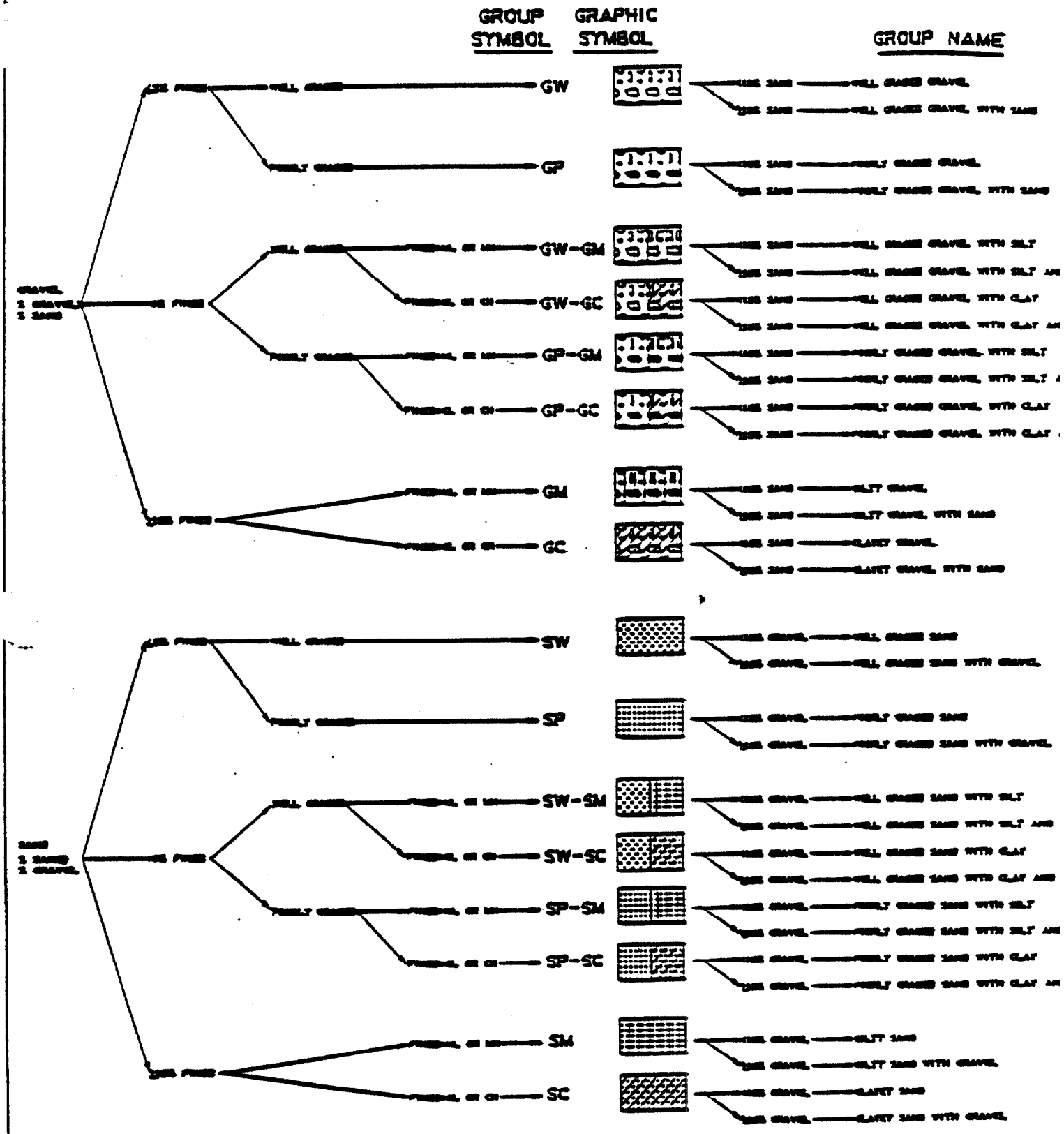
RUST ENVIRONMENT & INFRASTRUCTURE

COARSE GRAINED SOILS
UNIFIED SOIL CLASSIFICATION SYSTEM



DUAL SYMBOL

USED ONLY WHEN THE SOIL IS COARSE-GRAINED WITH 5% TO 12% FINES.

THE FIRST GROUP SYMBOL CORRESPONDS TO CLEAN SAND OR GRAVEL (SW, SP, GW, GP). THE SECOND SYMBOL CORRESPONDS TO SAND OR GRAVEL WITH FINES (SC, SM, GC, GM). EX.: GW-GC, WELL GRADED GRAVEL WITH C

BORDERLINE SYMBOL

A BORDERLINE SYMBOL MAY BE USED:

1) WHEN THE PERCENTAGE OF SAND AND PERCENTAGE OF GRAVEL ARE ABOUT THE SAME. EX.: GP/SP SC/GC, GM/SM

2) WHEN THE SOIL COULD BE EITHER WELL GRADED OR POORLY GRADED. EX.: GW/GP, SW/SP

RUST ENVIRONMENT & INFRASTRUCTURE

FINE GRAINED SOILS
UNIFIED SOIL CLASSIFICATION SYSTEM

GROUP AND GRAPHIC SYMBOL					GROUP NAME
CL	<30% PLUS NO. 200	<15% PLUS NO 200			LEAN CLAY
		15-25% PLUS NO 200	%SAND≥%GRAVEL		LEAN CLAY WITH SAND
			%SAND<%GRAVEL		LEAN CLAY WITH GRAVEL
	≥30% PLUS NO. 200	% SAND≥% OF GRAVEL		<15% GRAVEL	SANDY LEAN CLAY
				≥15% GRAVEL	SANDY LEAN CLAY WITH GRAVEL
		% SAND <% GRAVEL		<15% SAND	GRAVELLY LEAN CLAY
				≥15% SAND	GRAVELLY LEAN CLAY WITH SAND
ML	<30% PLUS NO. 200	<15% PLUS NO 200			SILT
		15-25% PLUS NO 200	%SAND≥%GRAVEL		SILT WITH SAND
			%SAND<%GRAVEL		SILT WITH GRAVEL
	≥30% PLUS NO. 200	% SAND≥% OF GRAVEL		<15% GRAVEL	SANDY SILT
				≥15% GRAVEL	SANDY SILT WITH GRAVEL
		% SAND <% GRAVEL		<15% SAND	GRAVELLY SILT
				≥15% SAND	GRAVELLY SILT WITH SAND
CH	<30% PLUS NO. 200	<15% PLUS NO 200			FAT CLAY
		15-25% PLUS NO 200	%SAND≥%GRAVEL		FAT CLAY WITH SAND
			%SAND<%GRAVEL		FAT CLAY WITH GRAVEL
	≥30% PLUS NO. 200	% SAND≥% OF GRAVEL		<15% GRAVEL	SANDY FAT CLAY
				≥15% GRAVEL	SANDY FAT CLAY WITH GRAVEL
		% SAND <% GRAVEL		<15% SAND	GRAVELLY FAT CLAY
				≥15% SAND	GRAVELLY FAT CLAY WITH SAND
MH	<30% PLUS NO. 200	<15% PLUS NO 200			ELASTIC SILT
		15-25% PLUS NO 200	%SAND≥%GRAVEL		ELASTIC SILT WITH SAND
			%SAND<%GRAVEL		ELASTIC SILT WITH GRAVEL
	≥30% PLUS NO. 200	% SAND≥% OF GRAVEL		<15% GRAVEL	SANDY ELASTIC SILT
				≥15% GRAVEL	SANDY ELASTIC SILT WITH GRAVE
		% SAND <% GRAVEL		<15% SAND	GRAVELLY ELASTIC SILT
				≥15% SAND	GRAVELLY ELASTIC SILT WITH SA
OL/OH	<30% PLUS NO. 200	<15% PLUS NO 200			ORGANIC SOIL
		15-25% PLUS NO 200	%SAND≥%GRAVEL		ORGANIC SOIL WITH SAND
			%SAND<%GRAVEL		ORGANIC SOIL WITH GRAVEL
	≥30% PLUS NO. 200	% SAND≥% OF GRAVEL		<15% GRAVEL	SANDY ORGANIC SOIL
				≥15% GRAVEL	SANDY ORGANIC SOIL WITH GRAVEL
		% SAND <% GRAVEL		<15% SAND	GRAVELLY ORGANIC SOIL
				≥15% SAND	GRAVELLY ORGANIC SOIL WITH SAN

BORDERLINE SYMBOL

A BORDERLINE SYMBOL MAY BE USED:

1) WHEN THE SOIL MAY FALL INTO ONE OF TWO POSSIBLE BASIC GROUPS: EX.: SC/CL, CL/CH.
2) WHEN THE PERCENTAGE OF FINE IS ESTIMATED BETWEEN 45% AND 55%, ONE SYMBOL SHOULD BE FOR A COARSE-GRAINED SOIL WITH FINES AND THE OTHER FOR A FINE GRAINED SOIL: EX.: GM/ML, SL/SC.
3) WHEN THE SOIL COULD BE EITHER A SILT OR A CLAY: EX.: CL/ML, SC/SM, CH/MH.
4) WHEN A FINE-GRAINED SOIL HAS PROPERTIES THAT INDICATE THAT IT IS AT THE BOUNDARY BETWEEN LOW COMPRESSIBILITY AND HIGH COMPRESSIBILITY: EX: CL/CH.

GROUP NAME FOR A BORDERLINE SOIL SHOULD BE THE FIRST SYMBOL EXCEPT FOR:

CL/CH	LEAN TO FAT CLAY
ML/CL	CLAYEY SILT
CL/ML	SILTY CLAY

- EVERY EFFORT SHOULD BE MADE TO FIRST PLACE THE SOIL INTO A SINGLE GROUP.

APPENDIX D

STANDARD GRAPHIC SYMBOLS FOR SOIL CLASSIFICATIONS

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USCS GRAPHIC STANDARDS

(ØL)
LOW PLASTICITY
ORGANIC SILT OR CLAY

(OH)
HIGH PLASTICITY
ORGANIC SILT OR CLAY

(CH)
HIGH PLASTICITY CLAY

PEAT

FILL

(CL)
LOW PLASTICITY CLAY

(CL-ML)
LOW PLASTICITY SILTY CLAY

(SC)
CLAYEY SAND

(MH)
ELASTIC SILT

(ML)
SILT

(SM)
SILTY SAND

(SP)
POORLY-GRADED SAND

(SW)
WELL-GRADED SAND

(SP-SC)
POORLY-GRADED
SAND WITH CLAY

(SP-SM)
POORLY-GRADED
SAND WITH SILT

(SW-SC)
WELL-GRADED
SAND WITH CLAY

(SW-SM)
WELL-GRADED
SAND WITH SILT

(GM)
SILTY GRAVEL

(GP)
POORLY GRADED GRAVEL

(GW)
WELL-GRADED GRAVEL

(GW-GM)
WELL-GRADED
GRAVEL WITH SILT

(GP-GC)
POORLY-GRADED
GRAVEL WITH CLAY

(GP-GM
POORLY -GRADED
GRAVEL WITH SILT

(GW-GC)
WELL-GRADED
GRAVEL WITH CLAY

ROCK CORING LOG PREPARATION

1 INTRODUCTION

1.1 Purpose - The purpose of this Standard is to establish the format and information to be collected during the inspection of rock borings for visual rock classification, hydrogeologic information, discontinuity information, and well installation data. This Standard establishes consistency between logs and loggers which improves geological analysis, data presentation, and data base entry.

1.2 Application

1.2.1 This Standard applies to all rock boring inspection work. It is primarily oriented toward diamond core drilling. However, it also establishes procedures to be followed when other types of rock drilling are being performed.

1.2.2 Underlined text in this Standard is Policy.

- If a heading is underlined, the whole section, including subsections, is a policy. This paragraph is an example of policy since the controlling paragraph heading is underlined.

- Deviation from policy shall be allowed only in accordance with Technical Standard T.00.006 - *Policy for Deviation or Waivers from Technical Standards.*

1.2.3 Remaining (not underlined) text is guideline. Any deviation from guidelines requires approval from the Earth Science and Chemistry Discipline Manager.

1.3 Effective Date - This Standard shall be effective on the date listed as the Origin Date. (Revisions to this Standard shall be effective on the Revision Date.)

1.4 Authority - The interpreting authority of this Standard is the Earth Science and Chemistry Discipline Manager

1.5 Distribution - Holders of Technical Standards Binder - Volumes 12D and 12E.

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1.6 Glossary - All rock boring logs shall contain the approved rock characteristic descriptions and abbreviations when used as presented in Table 1. Any other terms needed should be from an appropriate geologic dictionary or textbook.

2 REQUIREMENTS

2.1 Personnel assigned as field geologists on projects requiring rock coring shall be qualified by training and experience in rock classification and logging techniques. In addition, a general familiarity with drilling and coring procedures is required.

2.2 The personnel inspecting rock borings shall follow this Technical Standard. The rock boring log to be used is the Rust E&I Field Rock Coring Log. A completed example of this log is presented in Appendix A.

2.3 The enforcement of this Standard shall be in accordance with Technical Standard T.00.006 - Policy for Deviations or Waivers from Technical Standards.

2.4 The logging of rock borings shall be done in accordance with the following procedures under Section 4.0.

2.5 Diamond core drilling is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure. They are suitable for Standard physical properties tests and structural integrity determination.

2.5.1 Subsurface structural data which may be obtained are: occurrence of fractures (joints and faults) and weathered zones, bedding planes, and cavities. Some lineations and foliations may also be recorded.

2.5.2 This method is described in the context of obtaining data for hydrogeologic investigations, foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

2.5.3 Additional information obtainable during rock drilling work includes groundwater levels and permeability estimates. Piezometers or monitoring wells may be installed in the resulting coreholes.

2.5.4 Geophysical logging and packer tests may be performed in the coreholes to aid stratigraphic correlation and further quantify rock properties.

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2.6 Rock drilling methods other than diamond core drilling include mud rotary drilling, air rotary drilling, cable tool (churn) drilling, and air percussion drilling using surface drills or down-hole hammers. The information obtainable from these methods is limited to lithologic information from classification of cuttings and incomplete data concerning fractures and other discontinuities. Therefore, these methods should not be used for investigatory purposes. When these methods are used to drill boreholes in rock for other purposes such as well installation, the boreholes should be logged in accordance with the procedures in Section 4.5.

2.7 Because of the high cost of core drilling, it is essential to maximize core quality and recovery and to obtain the maximum amount of data available from the coring work consistent with project goals.

2.8 Rock drilling involves the use of hazardous equipment and this section does not purport to address all of the safety problems associated with the use of rock drilling rigs. See Section 3.4 of this document for further safety responsibility.

2.9 Implementation of this Standard may involve inspection around heavy equipment, potential exposure to hazardous materials through the use of equipment containing hazardous materials, or contact with hazardous materials/waste. These conditions may require site personnel to have health and safety training and equipment/site clearance. This Standard does not address all safety concerns. See Section 3.3, 3.4 and 3.5 of this Standard for safety responsibilities, and Section 5 for reference documents.

2.10 Criteria for Diamond Core Drill Use - If in doubt as to whether a diamond core drill rig is needed, the following shall be the criteria:

2.10.1 In accordance with Technical Standard T.12.225 - Penetration Test and Split-Barrel Sampling of Soils - a 1-inch (25.4 mm) or less penetration in 50 blows defines the formation unit as too hard for soil sampling techniques.

2.10.2 A diamond core drill rig may also be used based on other criteria established by the geologist or engineer.

3 RESPONSIBILITIES

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3.1 The Earth Science and Chemistry Discipline Manager is responsible for updating and quality control of this Standard. For geologic and hydrogeologic investigations, the Earth Science and Chemistry Discipline shall be responsible for QC. For geotechnical design projects, the Waste Management Discipline shall be responsible for QC.

3.2 The Earth Science and Chemistry or Waste Management Discipline Managers in cooperation with the Department Heads are responsible for assignment of a QC reviewer at project startup. The approach for investigating soil and rock shall be reviewed prior to initiating field activities.

3.3 The Project Manager is responsible for:

3.3.1 Consulting with their Region Environmental, Health and Safety Manager to establish appropriate health and safety practices and procedures during the subsurface investigation. Involvement of the REHSM is required when the potential exists for exposure to toxic/hazardous materials.

3.3.2 Ensuring that General Health and Safety Standards including T.00.020, T.00.021, and T.00.022 are followed.

3.3.3 Ensuring QC reviews are completed.

3.3.4 Preparing a Field Work Plan (prefield memo) which defines procedures and responsibilities on a project.

3.4 The Field Geologist is responsible for:

3.4.1 Observing and recording drilling procedures and activities.

3.4.2 Verifying that the work is performed so that core recovery and the quality of the core recovered are maximized and that Standards are implemented.

3.4.3 Logging and describing rock core samples.

3.4.4 Properly packaging, preserving, and identifying core samples.

3.4.5 Collection, maintenance, and return of all field, safety, and sampling equipment.

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3.5 On all sites requiring inspection around heavy equipment, the following minimum health and safety measures shall be followed:

3.5.1 Personnel shall wear a hard hat, safety glasses or goggles, and steel toe, steel shank boots.

3.5.2 A work zone shall be established around drill rigs. Where practical, a 25- to 30-foot radius around the rig shall be designated and delineate the work zone. Field geologists should avoid standing in this area except to collect samples. Personnel within the work zone must wear the above and have a portable eye wash unit, first aid kit, fire extinguisher, towels, and plastic garbage bags.

3.6 The Contractor is responsible for, and in charge of safety on all construction projects, including investigative projects where potential does not exist for exposure to toxic/hazardous materials. Refer to Policy No. 201 - Project Site Safety. The assignment of this responsibility is made clear in the contract documents and should be emphasized at the pre-drilling/construction conference. The field geologist is not a safety inspector or safety manager and shall not function in that capacity. Refer to Technical Standards T.11.100 and T.11.825.

3.7 It is the responsibility of the field geologist or project manager to approve any drilling mud or grouting techniques prior to their use in the borehole.

4 PROCEDURES

4.1 Core Drilling Procedures - Core drilling procedures are presented in ASTM Standard D2113, Section 6. A copy of this standard is included in Appendix B.

4.2 General procedures for transportation and storage of core containers are presented in Appendix B, Section 5. On a project-specific basis, the following additional procedures may be required when handling and packaging core:

4.2.1 Immediately after removal of the core from the barrel it should be placed in an examination tray. The field geologist shall tightly refit the ends of any pieces that have become separated and shall mark the full length of the core with two continuous and indelible lines of different color. These lines will serve as references for orienting core pieces as they are placed in core boxes and during later handling. After the core is marked, it shall be logged as described below. The

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drillers shall provide sufficient core trays so that the field geologist has sufficient time to perform this work without demands to give up a core tray to accommodate subsequent cores.

4.2.2 The core shall be photographed in the tray. When photographing the core, a reference scale, such as a tape or folding role, shall be placed adjacent to the core along with a color reference card and a card or core box lid labeled with the project number, boring number, run number, and depth.

4.2.3 Upon completion of logging the core shall be transferred to a core box either directly by or under the supervision of the field geologist, in accordance with the requirements of Appendix B, Section 5.

4.2.4 The core box must be labeled with the project name, number, boring number, depth of the core in the box, and box number. This information must be placed on the outside of the cover and on the outside left (as defined in ASTM D2113) end of the box. Core from different borings must not be combined in a single box. If it is necessary to break the core to fit it into the box, mark the break with an "H" using an indelible marker.

4.2.5 Before transporting, the lid of the core box must be securely fastened.

4.3 The list of data that needs to be included in the rock core log is presented in ASTM Standard No. D2113, Section 7 (Appendix B). The attached Field Rock Core Log (Appendix A) includes space to record all items listed in Section 7. The following procedures should be followed when preparing the log.

4.3.1 General Instructions

4.3.1.1 Complete all rock core logs in black indelible pen.

4.3.1.2 Complete all general information at the top of the rock core log form before drilling begins. This includes the site, project number, boring number, equipment descriptions, personnel, and date. Boring numbers are established as outlined in Standard T.12.202.

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4.3.1.3 Before work begins, set the depth scale in the "Depth in Feet" column. The boring log has a predivided scale with each line representing a maximum of 1-foot. Number depth in feet at each line. For investigations where detailed rock discontinuity data are needed, the depth scale may be adjusted (i.e. each line may be set to represent 0.5 foot).

4.3.2 Coring Data

4.3.2.1 Method - Designate the drilling method with an alpha code as follows:

AR = Air Rotary
CO = Coring
MR = Mud Rotary

4.3.2.2 Run Number and Length - Each time the core barrel or, in the case of wireline coring, the inner barrel is removed from the core hole it represents one run. Draw a horizontal line between runs in the columns headed "coring data". The runs should be numbered consecutively. Each run starts and ends at the core bit depth at the top and bottom of the run. The run length is the difference between the two. Run depths are best determined by measuring rod stick-up above the ground surface and subtracting this from the sum of the rod string length and core barrel length, including any adapters used. Most core barrels can hold slightly more than the nominal length. Beware of the driller who cores until the barrel is full and then says that the nominal length was drilled. In a deep hole, the cumulative error can be significant.

4.3.2.3 Recovery - Record total length of core recovered as a percentage of the run length. Darken the interval where the core loss occurred. If this cannot be identified, assume that the loss was from the bottom of the run. If core is lost from one run and later picked up by the next, it should be added to the run it was drilled rather than to the run it was recovered with.

4.3.2.4 MPF (Minutes Per Foot) - This is the time necessary to advance the core barrel per foot of advance. It may be averaged for the entire core run.

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4.3.2.5 Water Gain/Loss - Record any water loss in percent or gain in gpm during drilling.

4.3.2.6 RQD (Rock Quality Designation) - The sum of all core pieces longer than 4 inches (0.33 ft) divided by the run length times 100 percent. If the only fracture is a single fracture parallel to the core axis and the core is otherwise intact, count the core as intact.

4.3.2.7 Frac/Ft (Fractures per Foot) - Record the number of nonmechanical core separations for each 1-foot core interval. For highly fractured or disintegrated core, record as ">6" if more than six breaks are present.

4.3.3 Graphics - Show all discontinuities such as joints and bedding plane separations. Do not show mechanical breaks or core breaks made to fit the core into the box. Healed fractures should be shown as a dashed line.

4.3.4 Rock Type Code - Use the rock type alpha code corresponding to the graphic symbols from the chart on the back of the field rock core log from (Appendix A).

4.3.5 Rock Description - Use the following order of terms to describe rock: rock name, lithologic modifiers, color, texture (grain/crystal size), structure (bedding, foliation, etc), cementation, hardness, weathering, solution/voids/fracturing, porosity and other unique features. If small zones of soil are encountered, they should be described in accordance with Rust E&I Standard T.12.201 - Field Boring Log Preparation Standard.

4.3.5.1 Rock types are the general types listed on the back of the core log form (Appendix A) or Table 1. Additional types can be used on a project-specific basis but types should be Standardized among all geologists working on a project.

4.3.5.2 Modifications to the rock type are terms like "silty", "cherty", "fossilferous", or "vuggy", which describe gross structural or textural features which may be present. Mineralogic descriptions of clastic, igneous, or metamorphic rocks can be included here. Additional terms are listed in Table 1.

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4.3.5.3 Color, texture, weathering, grain size, and bedding: use the terms and their abbreviations as described on the back of the Field Rock Coring Log Form (Appendix A).

4.3.5.4 Structural Features - Describe any jointing, foliation, flow banding, bedding, lamination, sorting, and any other features. Describe any joint filling materials, their hardness and degree of filling, and the orientation of joints and bedding.

4.3.5.5 Formation - Note the formation name if it has been determined. Otherwise it can be added to the final boring log at a later date.

4.3.6 Comments - This column is to be used for observations made by the driller or geologist not related to sample description. Casing use should be recorded here as well as RPM for each run, if available, and observations concerning ease of drilling, rough drilling action, voids, mechanical breakdowns, and other events related to the drilling work. If water is encountered while drilling, the level at which it is detected may be noted here and clarified with the "water level readings" described below in 4.3.7.

4.3.7 Water Level Readings - When water is encountered while drilling, its depth should be noted along with the time and date. Spaces are provided for this at the top of the boring log. Readings should be taken periodically during drilling. If a borehole is to be left open overnight, water level readings should be taken before leaving the site and prior to starting work the following day. For each water level reading, note the hole depth and casing depth at the time of the measurement. Additional water level readings may be necessary and should be noted under "Drilling Data." All water level readings should be on the first page of a multipage log.

4.4 When more detailed discontinuity logging is needed, use the Rock Core Discontinuity Log Form in Appendix A.

4.5 When logging rock borings which are not cored, the Field Rock Core Log should still be used. Be sure to note the drilling method. It is recommended that jar samples of cuttings be taken at strata changes or at 5-foot minimum intervals. Number the samples consecutively in the "Run No." column. Lithology should be described in the "Rock Description" column in as much detail as possible. In air rotary or air percussion drilling,

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groundwater occurrences will be readily apparent and should be noted in the "Comments" column with the approximate GPM of water produced.

4.6 It is not recommended that diamond core drilling serve as the only means of subsurface site characterization when making engineering and environmental decisions. It should be used in combination with various other procedures including geological mapping, shallow drilling, and lab techniques as deemed pertinent to project goals and purposes.

5 REFERENCES

5.1 Rust E&I Reference Documents

- T.00.006 - Policy for Deviations or Waivers from Technical Standards
- T.00.020 - Hazardous Waste Safety Training
- T.00.021 - Employee Medical Surveillance Program
- T.00.022 - Preparation and Implementation of Site-specific Health and Safety Plans
- T.11.100 - Construction Site Safety
- T.11.825 - Safety Concerns During Environmental Construction Projects
- T.12.003 - Site Investigation Task Sequence and Description of Tasks
- T.12.006 - Standard RI/FS Work Plan Outline
- T.12.007 - Standard RI/FS Task Sequence Diagram
- T.12.012 - Standard Task Sequence Diagram for Environmental Assessments
- T.12.201 - Field Boring Log Preparation
- T.12.227 - Diamond Core Drilling for Site Investigation
- T.12.236 - Rock Coring Log Preparation
- T.12.702 - Preliminary Geomorphological Site Investigations from Indirect Sources of Information
- Policy No. 201 - Project Site Safety
- Corporate Health and Safety Program, Policies and General Standards Manual

5.2 ASTM Reference Documents

- ASTM D2113 - Diamond Core Drilling for Site Investigation

For a list of the applicable ASTM Standards see Appendix A, Section 2.

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5.3 Textbooks and Dictionaries

- Compton, Robert R., 1962, Manual of Field Geology, New York: John Wiley & Sons, Inc.
- Gary, M., McAfee, R., and Wolf, C.L., 1972, Glossary of Geology: Washington, D.C., American Geological Institute.

Approved by:

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TS/SCIENTIF/12_236 E: 01/12/95

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TABLE 1 ROCK CHARACTERISTIC TERMS	
Colors: Use Munsell Rock Color Chart	
Hardness	
V. Hard	Cannot scratch with knife
Hard	Difficult to scratch with knife
Medium	Scratched with knife
Soft	Easily scratched with knife
V. Soft	Scratched with fingernail
Weathering	
Fresh	(Rock is unstained, fractures are unstained)
Slight	(Rock mass is unstained, discontinuities are stained at surface)
Medium	(Discontinuities are stained, discoloration extends into rock)
High	(Rock thoroughly stained, may be softened, discontinuity surfaces thoroughly stained and may be crumbly)
Severe	(Rock consists of gravel-sized fragments which can be broken with fingers)

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TABLE 1
ROCK CHARACTERISTIC TERMS

Grain Size Use	
For standstone, limestone, dolomite, and igneous rocks, use "Fine" (F), "Medium" (M), and "Coarse" (C) corresponding to sand size classes.	
For coarser grained rock, use "Conglommeratic", "pegmatitic", "porphyritic", as appropriate.	
For finer grained rock, use "Waxy", "Amorphase", "Micritic", etc. as appropriate.	
[NOTE: Text is same as on "Field Rock Core Log - Instructions"]	
Structure (Bedding, foliation, etc.)	
For bedding, indicate range in tenths of feet.	
Rock Classifications (Note: More detailed rock classifications may be used as needed)	
sandstone	shale
limestone	conglomerate
dolomite	siltstone
coal	claystone
Breccia	chert
metamorphic	igneous
Modifying Terms	
fractured	jointed
concretions	mottled
moist	decomposed
vuggy	nodular
banded	fossiliferous

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TABLE 1
ROCK CHARACTERISTIC TERMS

calcareous	arenaceous
cherty	argillaecous
oolitic	arkosic
pyritized	bituminous
mineralized	carbonaceous
stylolitic	

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APPENDIX A

FIELD FORMS

Section A-1 - Field Rock Core Log

Section A-2 - Completed Field Rock Core Log Example

Section A-3 - Field Rock Core Discontinuity Log

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SECTION A-1

Field Rock Core Log
(Blank)

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RUST ENVIRONMENT & INFRASTRUCTURE

FIELD ROCK CORE LOG

Sheet 1 of _____

BORING NO. _____

SITE: _____ PROJECT NO. _____

WATER LEVEL READINGS

	DATE	TIME	DEPTH	CASING

DRILLING RIG: _____

CORE BARREL / BIT: _____

CASING USED: _____

LOGGED BY: _____

FIRM/DRILLER: _____

PHYSICAL SETTING: _____

ABANDONMENT DATE: _____

ABANDONMENT METHOD: _____

GROUND SURFACE ELEV: _____

COORDINATE/TYPE: _____

NORTH: _____

EAST: _____

DATE/TIME START: _____

DATE/TIME COMPLETE: _____

WELL INSTALLATION DATE: _____

Depth in Feet	CORING DATA							FRAC./ FT	GRAPHICS	ROCK TYPE CODE	ROCK DESCRIPTION	COMMENTS
	METHOD	RUN NO	LENGTH	% RECOVERY	MPF	%WATER GAIN/LOSS (GAL.)	% RQD					

&cont&

Tracking Cl. ...e. F_ROCKP1, 3/22/94

RUST ENVIRONMENT & INFRASTRUCTURE

FIELD ROCK CORE LOG

Sheet _____ of _____

BORING NO. _____

SITE: _____ PROJECT NO. _____

Depth in Feet	CORING DATA							FRAC./FT	GRAPHICS	ROCK TYPE CODE	ROCK DESCRIPTION	COMMENTS
	METHOD	RUN NO	LENGTH	% RECOVERY	MPF	%WATER GAIN/LOSS (GAL.)	% RQD					

&cont&

Tracking Code: 6 ACKFS. 3/8/94

SECTION A-2

Completed Field Rock Core Log
(Example)

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RUST ENVIRONMENT & INFRASTRUCTURE

FIELD ROCK CORE LOG

Sheet 1 of 5

BORING NO. B-101

SITE: NIMBY LANDFILL PROJECT NO. 17805.010

WATER LEVEL READINGS

DATE	TIME	DEPTH	CASING
02/18/94	1300	65	55

DRILLING RIG: CME 750
CORE BARREL / BIT: NQ wireline
CASING USED: 4-inch steel
LOGGED BY: JoAnn DuRite
FIRM/DRILLER: Drilling Inc. / H. Reamer
PHYSICAL SETTING: North fence line on nearly level topo high

ABANDONMENT DATE: 02/22/94
ABANDONMENT METHOD: High solids bentonite grout

GROUND SURFACE ELEV: 1250.6
COORDINATE/TYPE: State Plane
NORTH: 500.25
EAST: 800.50
DATE/TIME START: 02/18/94/0630
DATE/TIME COMPLETE: 02/22/94/1000
WELL INSTALLATION DATE: NA

Depth in Feet	METHOD	RUN NO	LENGTH	% RECOVERY	MPF	%WATER GAIN/LOSS (GAL.)	% RQD	FRAC./FT	GRAPHICS	ROCK TYPE CODE	ROCK DESCRIPTION	COMMENTS
1	CC	1	10	100%	3.4	90% loss	96%	2		DL	DOLOMITE, massive, white (10YR 8/1), fine grained, thick bedded, well cemented, hard, fresh, fractures mainly horizontal filled w/calcite, dolomite crystals, stained orange on fracture surfaces, low porosity.	±1200 RPM, Rod drop at 4.3 feet
2												
3												
4												
5												
6												
7												
8												
9												
10												
11	CO	2	5	85%	5.6	75% loss	82%	>6		DL	DOLOMITE, cherty, white to light gray (10YR 7/1 to 6/1), fine grained, thick bedded, well cemented, hard, fresh, voids filled w/clay, many chert nodules, moderate porosity.	±1700 RPM, Core barrel jammed in hole due to small pieces of chert
12												
13												
14												
15												
16	CO	3	10	92%	4.8	10% loss	43%	>6		SS	SANDSTONE, calcareous, light gray to white (2.5Y 7/6 to 2.5Y 8/0), very fine to medium grained, massive, moderatly to poorly cemented, soft, slightly weathered, one vug at the bottom of the core, coated with blue green mineralization.	±1500 RPM
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27	CO	4	10	100%	3.8	20% loss	98%	1		DL	DOLOMITE, oolitic, white (5Y 8/2), cryptograined, massive, well cemented, hard, moderatly weathered, vuggy throughout, vugs are 1-7mm in size, some with crystals	±1700 RPM Very little water loss, Drilled easy
28												
29												
30												

&cont&

SECTION A-3

Field Rock Core Discontinuity Log

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RUST ENVIRONMENT & INFRASTRUCTURE

Field Rock Core Discontinuity Log

Project:	Project No.:	Boring No.:
Driller/Firm:	Location Coordinates:	Elev. (App/Surv):
Logged By: _____ Date: _____	Boring Total Depth:	Run No.: _____ Depth: _____ To _____
Core Size/Drilling Method:		Log No.: _____ of _____

Coring Data									Rock Description									Discontinuity Description										
Run			Water	Rock Core					General				Fabric				Structure	Planes					Filling				Remarks	Depth
1	1	2	2	3	4	5	5	6	7	8	9	10	11	12	Vugs 13	Vugs 12	14	15	16	17	18	8	19	20	21	8	22		
Depth	Length	M.P.F.	Gain/Loss	Loss	Recovery		RQD	BPF	Type	Color	Hardness	Weathering	Grain Size	Fossils	Size	Quantity	Bedding	Joints	Graphic	Type	Orientation	Staining	Condition	Presence	Type	Color	Width		

APPENDIX B

ASTM STANDARD D2113

STANDARD PRACTICE FOR DIAMOND

CORE DRILLING FOR SITE INVESTIGATION

TS/SCIENTIF/12_236 E: 01/12/95

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Designation: D 2113 – 83 (Reapproved 1987)

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

This standard is issued under the fixed designation D 2113; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

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

2. Referenced Documents

2.1 *ASTM Standards:*

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

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

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

3. Significance and Use

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

4. Apparatus

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

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

4.3 *Core barrels*, as required:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.8 *Casings:*

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

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

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

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

4.9 *Drill Rods:*

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

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

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

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

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

TABLE 1 Core Bit Sizes

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

TABLE 2 Casing Sizes

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

TABLE 3 Drill Rods

Size Designation	Rod and Coupling Outside Diameter		Rod Inside Diameter		Coupling Bore, Threads		
	in.	mm	in.	mm	in.	mm	per in.
RW	1.09	27.7	0.72	18.2	0.41	10.3	4
EW	1.38	34.9	1.00	25.4	0.44	11.1	3
AW	1.72	43.6	1.34	34.1	0.63	15.8	3
BW	2.13	53.9	1.75	44.4	0.75	19.0	3
NW	2.63	66.6	2.25	57.1	1.38	34.9	3
HW	3.50	88.9	3.06	77.7	2.38	60.3	3

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

5. Transportation and Storage of Core Containers

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

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

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

6. Procedure

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

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

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

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

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

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

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

6.4 *Compatibility of Equipment:*

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

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

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

7. Boring Log

7.1 The boring log shall include the following:

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

..2 Elevation of the ground surface.

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

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

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

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

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

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

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

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

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

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

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

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

8. Precision and Bias

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

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

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

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

This standard is issued under the fixed designation D 2113; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

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

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

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

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

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

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

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

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

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

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

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

4.8 *Casings:*

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

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

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

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

4.9 *Drill Rods:*

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

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

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

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

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

TABLE 1 Core Bit Sizes

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

TABLE 2 Casing Sizes

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

TABLE 3 Drill Rods

Size Designation	Rod and Coupling Outside Diameter		Rod Inside Diameter		Coupling Bore, Threads		
	in.	mm	in.	mm	in.	mm	per in.
RW	1.09	27.7	0.72	18.2	0.41	10.3	4
EW	1.38	34.9	1.00	25.4	0.44	11.1	3
AW	1.72	43.6	1.34	34.1	0.63	15.8	3
BW	2.13	53.9	1.75	44.4	0.75	19.0	3
NW	2.63	66.6	2.25	57.1	1.38	34.9	3
HW	3.50	88.9	3.06	77.7	2.38	60.3	3

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

5. Transportation and Storage of Core Containers

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

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

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

6. Procedure

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

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

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

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

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

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

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

6.4 *Compatibility of Equipment:*

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

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

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

7. Boring Log

7.1 The boring log shall include the following:

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

7.1.2 Elevation of the ground surface.

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

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

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

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

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

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

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

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

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

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

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

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

8. Precision and Bias

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

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

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

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1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of

contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells.in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation;-risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. ~~Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout.~~ A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

"High solids" bentonite grout may be used.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout or high solids bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. this system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

7.0 RECORDS

[See also Rust E&I field forms]

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon®
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon®
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
Source: Barcelona et al., 1983
* Trademark of DuPont

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

* See also Attachment A.

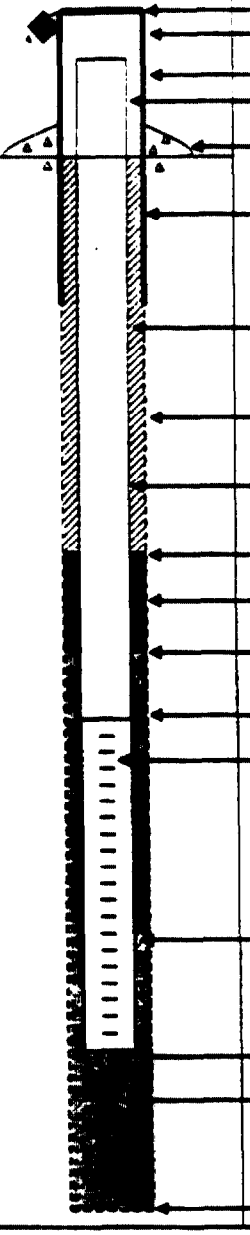
ATTACHMENT C

NUS CORPORATION
A Halliburton Company

BORING NO. _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE : _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

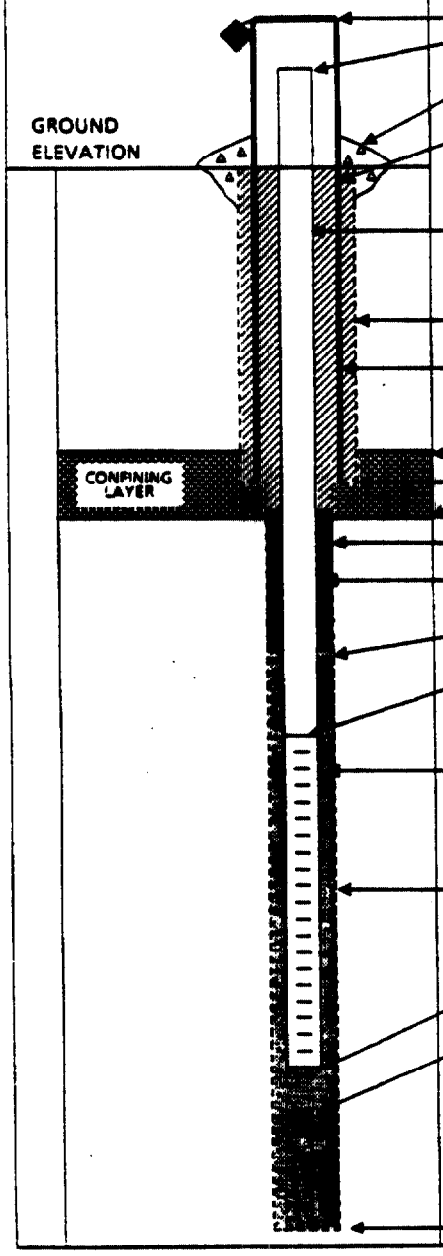
ATTACHMENT C
PAGE TWO

NUS CORPORATION

BORING NO : _____

CONFINING LAYER
MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF PERM. CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____

ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT. CONFINING LAYER: _____

ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____

TYPE OF SAND PACK: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE THREE

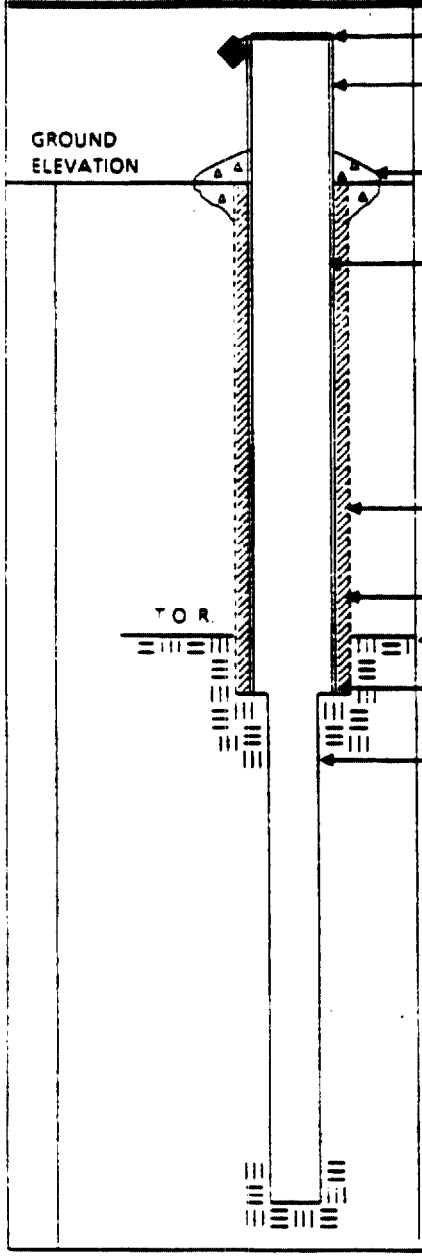
NUS CORPORATION
A Halliburton Company

BORING NO. _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____
TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:
_____
_____
_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:
_____
_____
_____

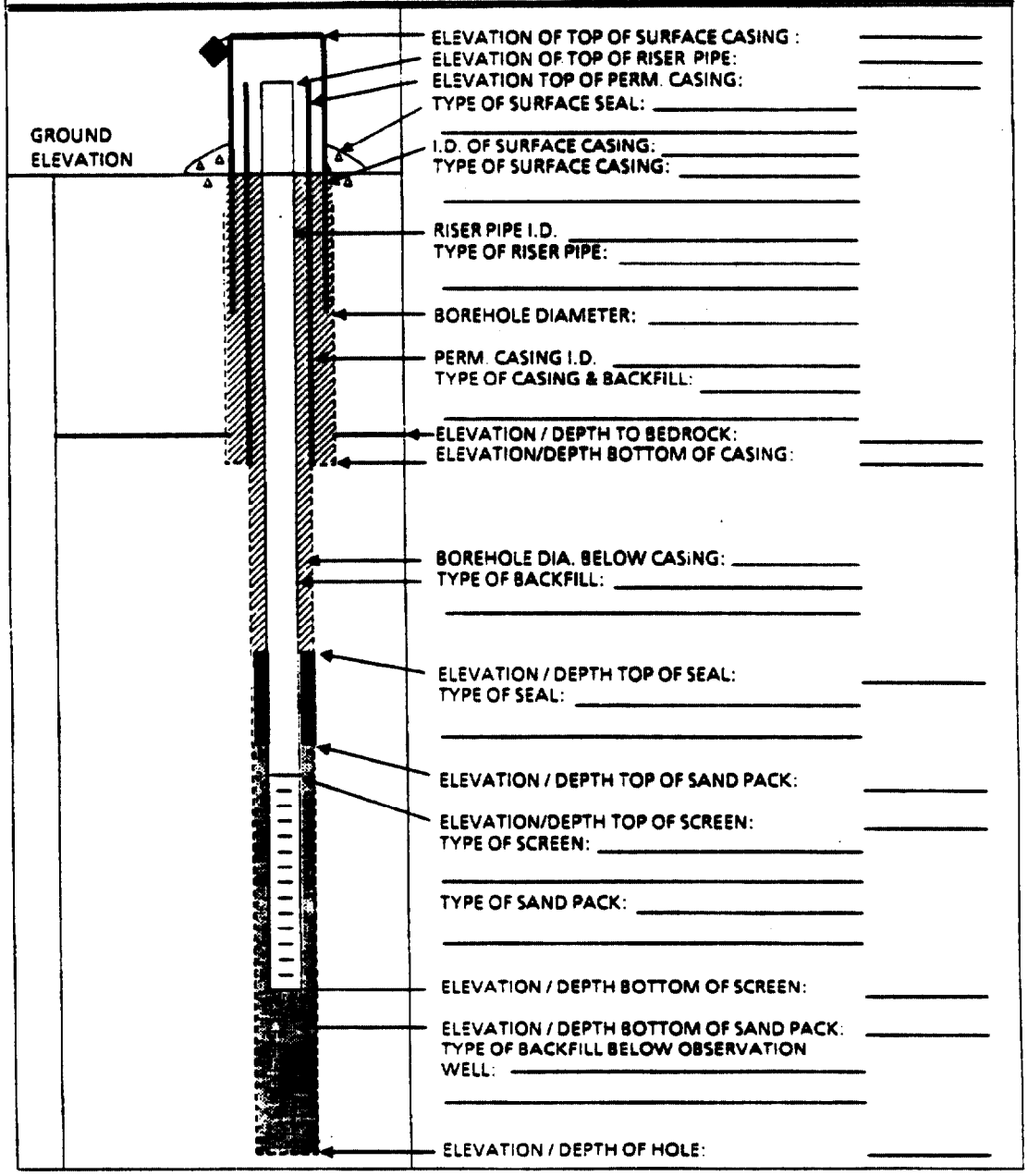
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



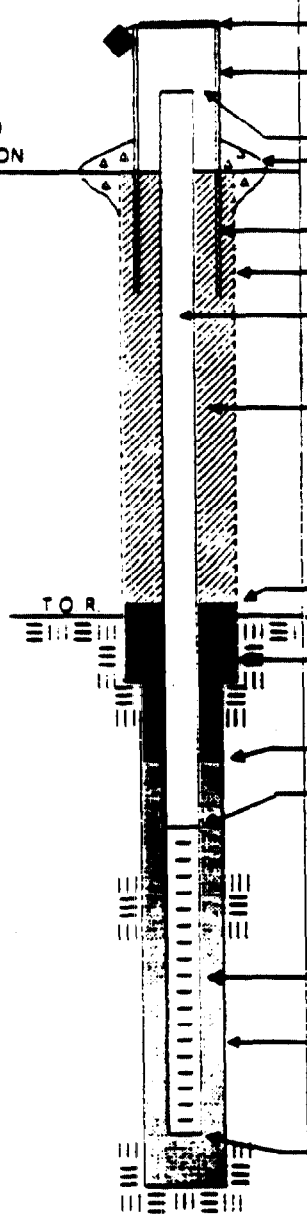
ATTACHMENT C
PAGE FIVE

NUS CORPORATION
A Halliburton Company

BORING NO _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____
STICK UP OF CASING ABOVE GROUND SURFACE: _____
ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
DIAMETER OF HOLE: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
ELEVATION / DEPTH TOP OF BEDROCK: _____
TYPE OF SEAL: _____
ELEVATION / DEPTH TOP OF SAND: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. SCREEN: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
CORE / REAM: _____
ELEVATION / DEPTH BOTTOM SCREEN: _____
ELEVATION / DEPTH BOTTOM OF HOLE: _____

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1.0 PURPOSE

To establish general decontamination procedures and guidelines for developing site and activity specific decontamination procedures.

2.0 SCOPE

Applies to all EMG activities where exposu: hazardous materials may occur.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Officer (OHSS) - The OHSS shall ensure that the site Health and Safety Officer (HSO) develops adequate decontamination procedures to prevent contamination of individuals or the environment beyond the exclusion zone.

Site Manager (SM) - The SM will ensure that sufficient information has been provided to the OHSS to prepare adequate decontamination procedures for inclusion in the site-specific Health and Safety Plan (HASP).

5.0 PROCEDURES

5.1 INTRODUCTION

Personnel responding to hazardous-substance incidents may become contaminated during the course of their work on a site. Protective clothing and respirators help prevent the wearer from becoming contaminated or inhaling contaminants, while good work practices help to reduce the contamination of protective clothing, instruments, and equipment.

Even with these safeguards, contamination may occur. Harmful materials can be transferred into clean areas, exposing unprotected personnel. In removing contaminated clothing, personnel may come in direct contact with and/or inhale the contaminants. To prevent such occurrences, contamination reduction and decontamination procedures must be developed and implemented. Such procedures must be in place before anyone enters a hazardous area and they must continue (modified as necessary) throughout the period of operation.

Decontamination involves physically removing contaminants and/or converting them chemically into innocuous substances. How extensive decontamination must be depends on a number of factors, the most important being the types of contaminants involved. The more harmful the contaminant, the more extensive and thorough decontamination must be. Combining decontamination, the correct donning of protective clothing, and the zoning of the site work areas minimizes cross-contamination from protective clothing to wearer, equipment to personnel, and one area to another. Only general guidance can be given on methods and techniques for decontamination. The exact procedure is determined by evaluating a number of factors specific to the incident.

The Health and Safety Officer (HSO) must exercise professional judgment in determining how the Contamination Reduction Corridor (CRC) will be organized and what decontaminants will be used. Factors that must be considered include: (1) the extent and type of hazard expected, (2) explosive

potential, (3) meteorological conditions, (4) topography, (5) levels of protection selected, and (6) availability of equipment and supplies.

5.2 PRELIMINARY CONCERNS

5.2.1 Initial Planning

The initial decontamination plan is based on the assumption that all personnel and equipment leaving the Exclusive Zone (area of potential contamination) are grossly contaminated. The plan includes a system for washing; rinsing; removal; and, when applicable; disposal of the protective clothing and equipment utilized. The washing and rinsing are done in combination with a sequential removal of equipment and clothing, starting at the first station with the most heavily contaminated article and progressing to the last station with the least contaminated article. Each piece of clothing or operation requires a separate decontamination station. These individual stations are to be spaced at about 3-foot intervals.

5.2.2 Contamination Avoidance

[See also Health & Safety Plan]

Contamination avoidance is the first and best method for preventing the transfer of contamination to personnel, or to uncontaminated areas. While planning site operations, methods are to be developed to prevent the contamination of personnel and equipment. Each person involved in site operations must regularly practice the basic methods, listed below, of contamination avoidance.

- Know the limitations of all protective equipment being used.
- Do not enter a contaminated area unless it is necessary to carry out a specific objective.
- When in a contaminated area, avoid touching anything unnecessarily.
- Walk around pools of liquids, discolored areas, or any area that shows evidence of possible contamination.
- Walk upwind of contamination, if possible.
- Do not sit or lean against anything in a contaminated area. In cases where you have to kneel (e.g., to take samples) use a plastic ground sheet.
- Before sampling any hazardous waste, read the label and manifest (if available) for all containers to determine as best you can the identity of the substance to be sampled and the potential contamination hazard. Be cautious - the label may not accurately reflect contents.
- While checking for waste contents, the field personnel should also check for potential incompatibility of wastes. These conditions might be caused by heat, fire, gas, and explosion; the contact of water and alkali metals; violent polymerization; or solubilization of toxic substances. Check waste containers for evidence of these conditions such as bulged drums, blistered paint, exploded drums, bubbles, dead vegetation, and melted or corroded surfaces.

- If at all possible, do not set sampling equipment directly on contaminated areas. Place equipment on a protective cover such as a ground cloth.

- Use the proper tools necessary to safely conduct the study.

In addition, it is necessary to plan for use of very specific methods to help reduce the potential for contamination transfer. For example, using remote sampling techniques, opening containers by nonmanual means, bagging monitoring instruments, using drum grapplers, watering down dusty areas, and avoiding areas of obvious contamination. All reduce the possibility of contamination and preclude a more elaborate decontamination procedure.

5.2.3 Site Organization

[See Health & Safety Plan]

An area within the Contamination Reduction Zone (see Attachment A) is designated the Contamination Reduction Corridor (CRC). The CRC controls access into and out of the Exclusive Zone and confines personnel decontamination activities to a limited area. The size of the corridor depends on the wind direction (up or side wind), number of stations in the decontamination procedure, the overall dimension of work control zones, and the amount of space available at the site. A corridor of 75 feet by 15 feet should be adequate for the most extensive decontamination. Whenever possible, it should be a straight path.

The CRC boundaries must be conspicuously marked, with entry and exit restricted. The far end is the hotline -- the boundary between the Exclusion Zone and the Contamination Reduction Zone. Personnel exiting the Exclusion Zone must go through the CRC. Anyone in the CRC must be wearing the appropriate protection designated for the decontamination crew. Another corridor may be required for the entrance and exit of heavy equipment needing decontamination. Within the CRC, distinct areas are set aside for the decontamination of personnel, portable field equipment, removed clothing, etc. These areas must be marked and restricted to those personnel wearing the appropriate protection. All activities within the corridor are confined to decontamination. The level of decontamination must be spelled out in the Site Health and Safety Plan (HASP).

Protective clothing, respirators, monitoring equipment, sampling supplies, and other equipment are all maintained outside of the CRC. Personnel dress into their protective equipment away from the CRC and enter the Exclusion Zone through a separate access control point at the hotline.

5.3 DECONTAMINATION GUIDANCE

The protection selected for a site study and the specific pieces of clothing worn in the Exclusive Zone dictate the items required and layout to the decontamination line. Different degrees of protection present different situations with respect to the type of decontamination procedure required. Attachments B-1, B-2, and B-3 outline the decontamination line organization for standard levels of protection; A, B, and C respectively.

The reason for leaving the Exclusion Zone determines the need for and extent of decontamination. Also, the time required for personnel decontamination must be ascertained and incorporated in the scheduling of site activities. A worker leaving the Exclusion Zone to pick up or drop off tools or instruments and immediately returning may not require full decontamination. A worker leaving to get a new air cylinder or change a respirator or canisters, however, would require some degree of decontamination. Personnel wearing self-contained breathing apparatuses must leave their work areas with sufficient air to walk to the CRC and go through decontamination. Individuals departing the CRC at breaktime, lunchtime, or the end of the day must be thoroughly decontaminated.

The type of decontamination equipment, materials, and supplies are generally selected on the basis of availability. The ease of equipment decontamination and disposability is also considered. Most equipment and supplies can be easily procured. Soft-bristle scrub brushes or long-handled brushes are used to remove contaminants. Buckets of water or garden sprayers are used for rinsing. Large galvanized wash tubs, stock tanks, or children's wading pools can also be used as containers for wash and rinse solutions. Large plastic garbage cans or similar containers lined with plastic bags are useful for the storage of contaminated clothing and equipment, and metal or plastic cans or drums are convenient for the temporary storage of contaminated liquids. Other gear includes paper or cloth towels for drying protective clothing and equipment. Heavy equipment such as bulldozers, trucks, backhoes, and drilling equipment are difficult to decontaminate. The methodology generally employed involves washing the equipment on a sloped concrete or plastic covered pad with a soapy water solution followed by a thorough water rinse. The wash and rinse solutions are applied through the use of a high pressure spray unit. Particular attention should be given to tires, scoop, and other components which directly contact the contaminated areas. Wipe test should be employed to determine the effectiveness of the decontamination procedure. The wash water must also be collected for proper disposal unless expressly waived by the governing agency.

Protective equipment, sampling tools, and other equipment are usually decontaminated by scrubbing with detergent water using a soft-bristle brush followed by rinsing with copious amounts of water. While this process may not be fully effective in removing some contaminants (in some cases, the contaminants may react with water), it is a relatively safe option compared to the use of a decontamination solution. The contaminant must be identified before a decontamination chemical is selected for use, as reactions of such a chemical with unidentified substances or mixtures may present additional hazard potentials. A decontamination solution must be selected in consultation with an experienced chemist. Some suggested decontaminating solutions are outlined in Attachment C.

Once decontamination procedures have been established, all personnel requiring decontamination must be given precise instructions and practice moving through the decontamination line. Progress through the decontamination line must be deliberate, organized, and exceptionally thorough to minimize hazard potentials for personal exposures and contamination transfer.

Decontamination station detail for various protection levels are outlined in Attachment D.

5.4 CLOSURE OF CRC

When the CRC is no longer needed, it must be closed down by the operators. All disposable items used and generated during the operation must be double-bagged and either contained on the site or removed to an approved off-site disposal facility. Decontamination and rinse solutions may be discarded on site if approved by regulatory agencies. Otherwise, they must be removed to an approved disposal facility. Reusable rubber clothing should be dried and prepared for future use. If gross contamination had occurred, additional decontamination or disposal of these items may be required. Cloth items must be bagged and removed from the site for final cleaning or disposal. All wash tubs, pails, containers, etc., must be thoroughly washed, rinsed, and dried to removal from the site.

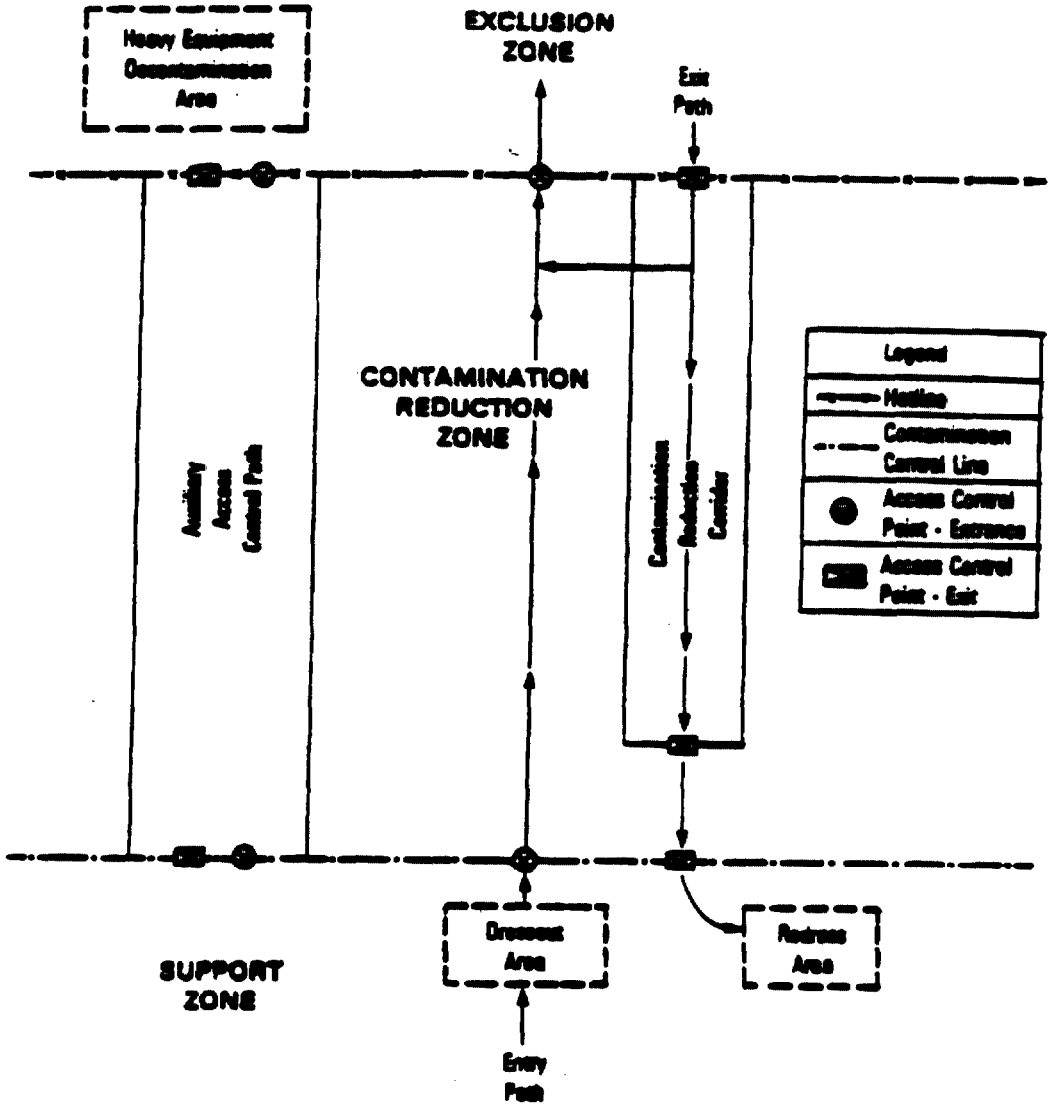
6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Contamination Reduction Zone Layout
Attachment B-1 - Decontamination Layout - Level A Protection
Attachment B-2 - DecontaminationLaytout - Level B Protection
Attachment B-3 - Decontamination Layout - Level C Protection
Attachment D - Suggested Decontaminating Solutions
Attachment D - Decontamination Station Detail (18 Sheets)

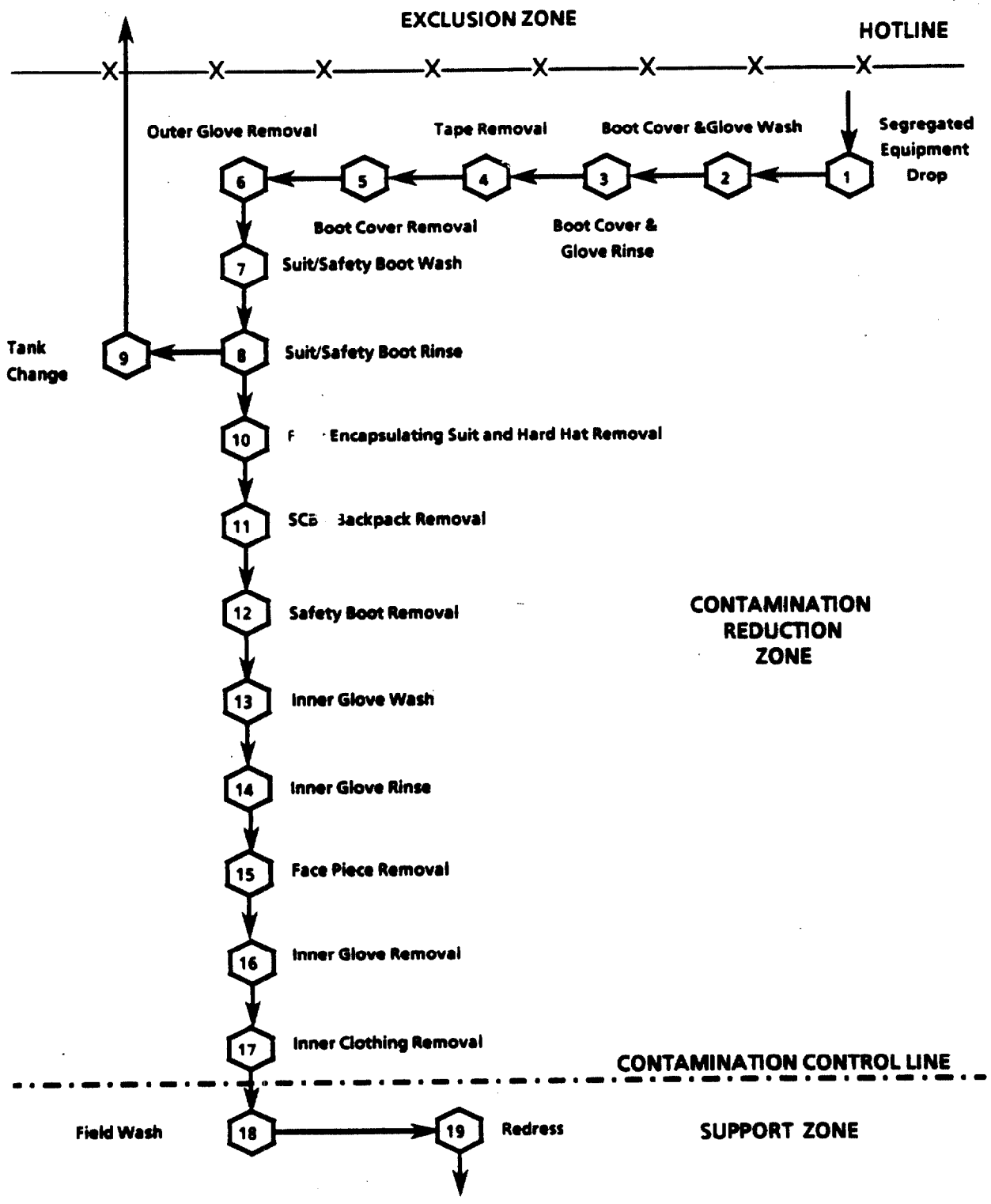
ATTACHMENT A



Contamination Reduction Zone Layout

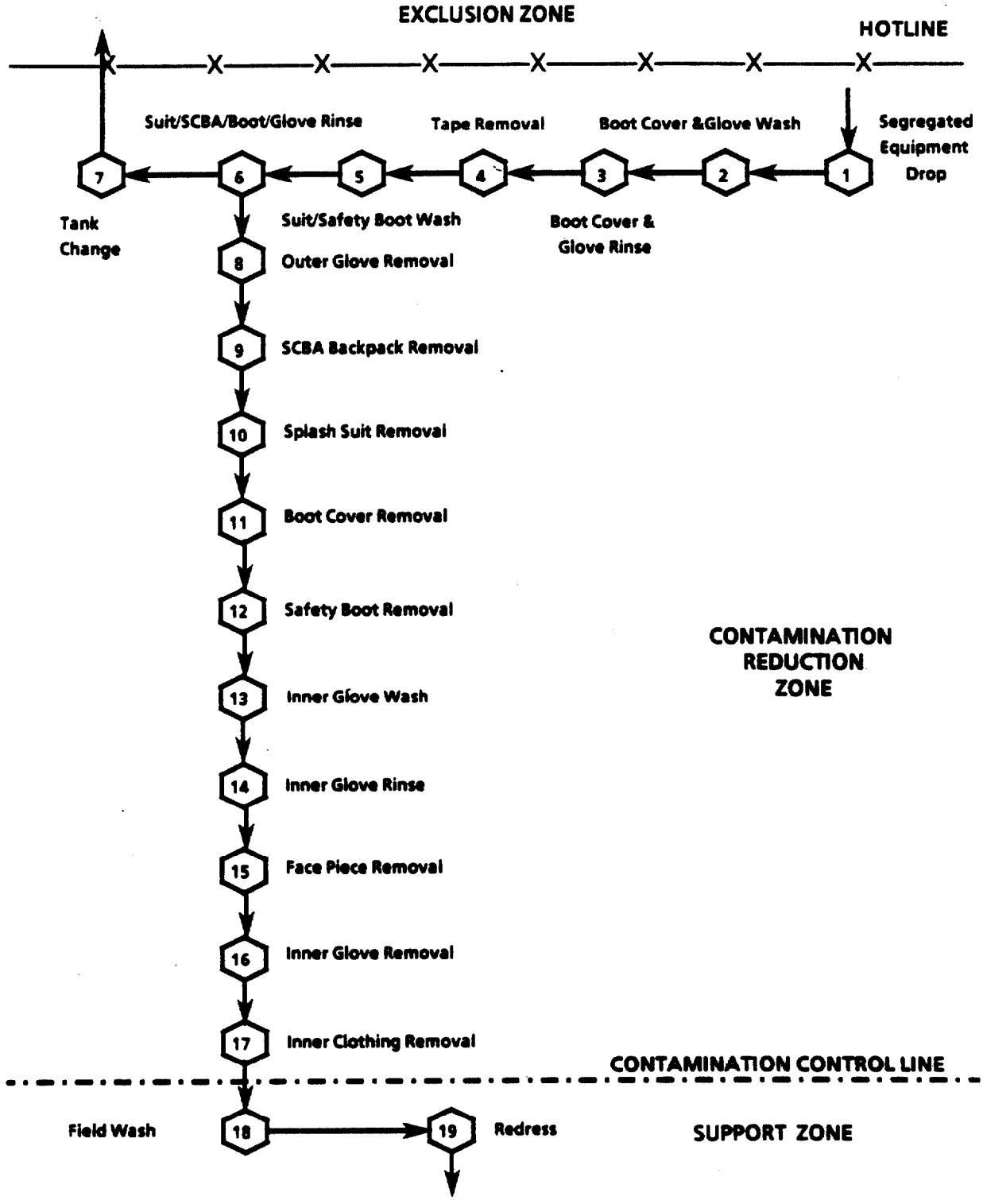
ATTACHMENT B-1

DECONTAMINATION LAYOUT - LEVEL A PROTECTION



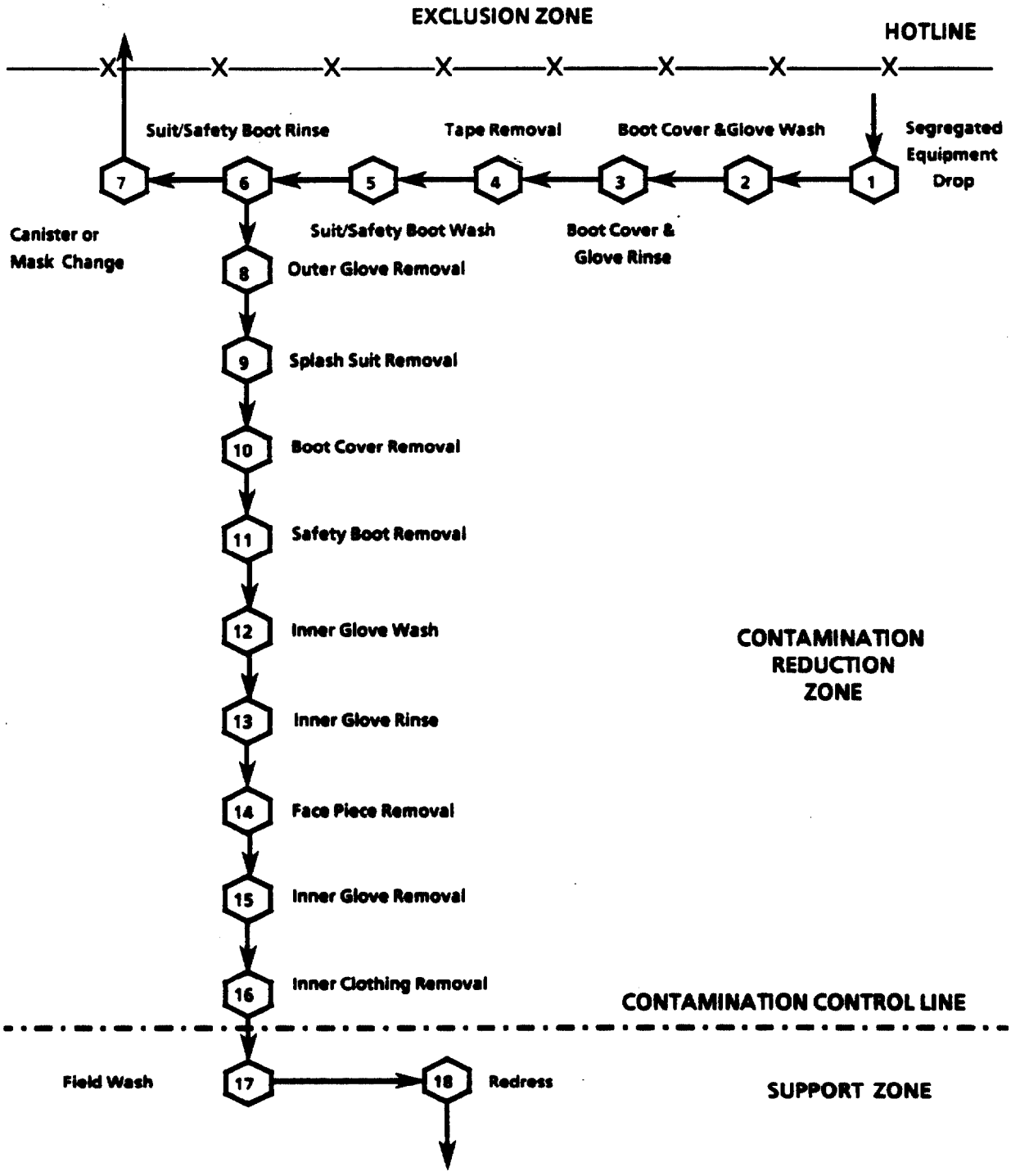
ATTACHMENT B-2

DECONTAMINATION LAYOUT - LEVEL B PROTECTION



ATTACHMENT B-3

DECONTAMINATION LAYOUT - LEVEL C PROTECTION



ATTACHMENT C

SUGGESTED DECONTAMINATING SOLUTIONS

Decon Solution	Mixing Solutions	Uses/Remarks
A. An aqueous solution containing a low-sudsing detergent.	Follow the mixing instructions written on the particular product label.	Generally has the widest range of use. Best choice on sites where contaminants are unknown or a wide range of contaminants exists.
B. An aqueous solution containing 5% sodium carbonate (NA_2CO_3) washing soda.	To ten gallons of water, add four pounds of sodium carbonate.	Decon solution of choice for base labile compounds such as the organophosphate pesticides. Effective in neutralizing inorganic acids. Since sodium carbonate is a water softening agent, this characteristic is an aid in physical removal of contaminants.
C. An aqueous solution containing 5% sodium bicarbonate ($NaHCO_3$) baking soda.	To ten gallons of water, add four pounds of sodium bicarbonate.	Sodium bicarbonate can be used to neutralize either base or acid contaminants. Good decon for base labile compounds.
D. An aqueous solution containing 2% trisodium phosphate (Na_3PO_4) TSP.	To ten gallons of water, add two pounds of trisodium phosphate.	See uses/remarks for Decon Solution B above.
E. An aqueous solution containing 10% calcium hypochlorite ($CaCl_2O_2$) HTH.	To ten gallons of water, add eight pounds of calcium hypochlorite.	Cyanide salts.
F. Ethylenediaminetetra-acetic acid (EDTA, versene, sesquesterene)	Commercial product, follow product label.	EDTA is a chelating agent and is decon of choice for heavy metal contaminants.
G. An aqueous solution containing 3 to 5% citric, tartaric, oxalic acids, of their respective sodium salts.	To ten gallons of water, add four pounds citric, tartaric or oxalic acid.	These compounds are chelating agents and are a decon of choice for heavy metal contaminants.

ATTACHMENT D

DECONTAMINATION STATION DETAIL

3A.1 Level A Decontamination

Equipment Worn

The full decontamination procedure outlined is for workers wearing Level A protection (with taped joints between gloves, boots, and suit). Such protection consist of

1. Fully encapsulating suit with integral boots and gloves
2. Self-contained breathing apparatus (SCBA)
3. Hard hat (optional)
4. Chemical-resistant boots with steel toe and shank
5. Boot covers
6. Inner and outer gloves

Procedure for Full Decontamination

Station 1: Segregated Equipment Drop

Deposit equipment used on the site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each drop area shall be designated for items suspected of being contaminated to different degrees. Segregation at the drop reduces the probability of cross-contamination.

Equipment necessary is

1. Containers of various sizes
2. Plastic liners
3. Plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water solution.

Equipment necessary is

1. Container (20 to 30 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE TWO

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Two or three long-handled, soft-bristle scrub brushes

Station 4: Tape Removal

Remove tape abound boots and gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool

Station 6: Outer -Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE THREE

Station 7: Suit/Safety Boot Wash

Thoroughly wash fully encapsulating suit and boots. Scrub suit and boots with long-handled, soft-bristle scrub brush and copious amounts of decon solution or detergent/water solution. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes

Station 8: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water solution using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Two or three long-handled, soft-bristle scrub brushes

Section 9: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, and joints taped. Worker then returns to duty.

Equipment necessary is

1. Air tanks
2. Tape
3. Boot covers
4. Gloves

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE FOUR

Station 10: Fully Encapsulating Suit and Hard Hat Removal

With assistance of helper, remove fully encapsulating suit and hard hat. Hang suits on rack or lay out on drop cloths.

Equipment necessary is

1. Rack
2. Drop cloths
3. Bench or stool

Station 11: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment necessary is a table.

Station 12: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool
4. Boot jack

Station 13: Inner-Glove Wash

Wash with decon solution or detergent/water solution that will not harm skin. Repeat as many times as necessary.

Equipment necessary is

1. Basin or bucket
2. Decon solution
3. Detergent/water solution
4. Small table

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE FIVE

Station 14: Inner-Glove Rinse

Rinse with water. Repeat as many times as necessary.

Equipment necessary is

1. Water
2. Basin or bucket
3. Small table

Station 15: Facepiece Removal

Remove facepiece. Deposit in container with plastic liner. Avoid touching face with fingers.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

Station 16: Inner-Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 17: Inner-Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off the site, since there is a possibility that small amounts of contaminants have been transferred in removing fully encapsulating suit.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE SIX

Station 18: Field Wash

Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shoer is not available.

Equipment necessary is

1. Water
2. Soap
3. Small table
4. Basin or bucket
5. Field Showers
6. Towels

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment necessary is

1. Tables
2. Chairs
3. Lockers
4. Clothes

Full Decontamination (Situation 1) and Three Modifications

The preceding description outlines each station that is included in a complete worst-case decontamination protocol. It is obvious that different sites will present different hazard levels and thus that site-specific modifications of this protocol will be required. The following table illustrates the modifications that can be made in response to a variety of conditions.

SIT*	STATION NUMBER																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
2	x	x	x	x	x	x	x	x	x										
3	x						x	x		x	x	x		x	x	x	x	x	
4	x						x	x	x										

*SIT- Situation Number

A TACH ENT D
CONT INATION STATION DETAIL
GE SE N

Situation 1: The individual entering the Contamination Reduction Corridor (CRC) is observed to be grossly contaminated, or extremely toxic substances are known or suspected to be present.

Situation 2: Some as Situation 1 except that individual needs new air tank and will return to Exclusion Zone

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves re not contaminated.

Situation 4: Same as situation 3 except that individual needs new air tank and will return to Exclusion Zone.

3A.2 Level B Decontamination

Equipment Worn

The full decontamination procedure outlined is for workers wearing Level B protection (with taped joints between gloves, boot, and suit). Such protection consists of

1. One-piece, hooded, chemical-resistant splash suit
2. Self-contained breathing apparatus
3. Hard hat
4. Chemical-resistant boots with steel toe and shank
5. Boot covers
6. Inner and outer gloves

Procedure for Full Decontamination

Station 1: Segregated Equipment Drop

Deposit equipment used on the site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment necessary is

1. Containers of various sizes
2. Plastic liners
3. Plastic drop cloths

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE EIGHT

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water solution.

Equipment necessary is

1. Container (20 to 30 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Two or three long-handled, soft-bristle scrub brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 5: Suit/Safety Boot Wash

Thoroughly wash chemical-resistant splash suit, SCBA, gloves, and safety boots. Scrub with long-handled, soft bristle scrub brush and copious amounts of decon solution or detergent/water solution.

Equipment necessary is

1. Container (30 to 50 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes
5. Small buckets
6. Sponges or cloths

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE NINE

Station 6: Suit/SCBA/Boot/Glove Rinse

Rinse off decon solution or detergent/water solution using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Small buckets
5. Two or three long-handled, soft-bristle scrub brushes
6. Sponges or cloths

Station 7: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer glove and boot covers donned, and joints taped. Worker returns to duty.

Equipment necessary is

1. Air tanks
2. Tape
3. Boot covers
4. Gloves

Station 8: Outer-Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 9: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment necessary is a table.

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE TEN

Station 10: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool

Station 11: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool

Station 12: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool
4. Boot jack

Station 13: Inner-Glove Wash

Wash inner gloves with decon solution or detergent/water solution that will not harm skin. Repeat as many times as necessary.

Equipment necessary is

1. Decon solution
2. Detergent/water solution
3. Basin or bucket
4. Small table

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE ELEVEN

Station 14: Inner-Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment necessary is

1. Water
2. Basin or bucket
3. Small table

Station 15: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

Station 16: Inner-Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 17: Inner-Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off the site since there is a possibility that small amounts of contaminants have been transferred in removing fully encapsulating suit.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE TWELVE

Station 18: Field Wash

Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment necessary is

1. Water
2. Soap
3. Small tables
4. Basins or buckets
5. Field showers

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment necessary is

1. Tables
2. Chairs
3. Lockers
4. Clothes

Full Decontamination (Situation 1) and Three Modifications

The preceding description outlines each station that is included in a complete worst-case decontamination protocol. It is obvious that different sites will present different hazard levels and thus that site-specific modifications of this protocol will be required. The following table illustrates the modifications that can be made in response to a variety of conditions.

SIT*	STATION NUMBER																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
2	x	x	x	x	x	x	x	x	x										
3	x						x	x		x	x	x			x	x	x	x	
4	x						x	x	x										

*SIT- Situation Number

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE THIRTEEN

Situation 1: The individual entering the CRC is observed to be grossly contaminated, or extremely toxic substances are known or suspected to be present.

Situation 2: Some as Situation 1 except that individual needs new air tank and will return to Exclusion Zone

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as situation 3 except that individual needs new air tank and will return to Exclusion Zone.

3A.3 Level C Decontamination

Equipment Worn

The full decontamination procedure outlined is for workers wearing Level C protection (with taped joints between gloves, boot, and suit). Such protection consists of

1. One-piece, hooded, chemical-resistant splash suit
2. Canister-equipped full-face mask
3. Hard hat
4. Chemical-resistant boots with steel toe and shank
5. Boot covers
6. Inner and outer gloves

Procedure for Full Decontamination

Station 1: Segregated Equipment Drop

Deposit equipment used on the site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment necessary is

1. Containers of various sizes
2. Plastic liners
3. Plastic drop cloths

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE FOURTEEN

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water solution.

Equipment necessary is

1. Container (20 to 30 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Two or three long-handled, soft-bristle scrub brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 5: Suit/Safety Boot Wash

Thoroughly wash splash suit and safety boots. Scrub with long-handled, soft bristle scrub brush and copious amounts of decon solution or detergent/water solution. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. Decon solution
3. Detergent/water solution
4. Two or three long-handled, soft-bristle scrub brushes

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE FIFTEEN

Station 6: Suit/SCBA/Boot/Glove Rinse

Rinse off decon solution or detergent/water solution using copious amounts of water. Repeat as many times as necessary.

Equipment necessary is

1. Container (30 to 50 gal)
2. High-pressure spray unit
3. Water
4. Two or three long-handled, soft-bristle scrub brushes

Station 7: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer glove and boot covers donned, and joints taped. Worker returns to duty.

Equipment necessary is

1. Canister (or mask)
2. Tape
3. Boot covers
4. Gloves

Station 8: Outer-Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 9: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Bench or stool
3. Plastic liner

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE SIXTEEN

Station 10: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool

Station 11: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners
3. Bench or stool
4. Boot jack

Station 12: Inner-Glove Wash

Wash inner gloves with decon solution or detergent/water solution that will not harm skin. Repeat as many times as necessary.

Equipment necessary is

1. Decon solution
2. Detergent/water solution
3. Basin or bucket

Station 13: Inner-Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment necessary is

1. Water
2. Basin or bucket
3. Small table

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE SEVENTEEN

Station 14: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit in container with plastic liner.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

Station 15: Inner-Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment necessary is

1. Container (20 to 30 gal)
2. Plastic liners

Station 16: Inner-Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off the site since there is a possibility that small amounts of contaminants have been transferred in removing fully encapsulating suit.

Equipment necessary is

1. Container (30 to 50 gal)
2. Plastic liners

Station 17: Field Wash

Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment necessary is

1. Water
2. Soap
3. Tables
4. Wash basins or buckets
5. Field showers

ATTACHMENT D
DECONTAMINATION STATION DETAIL
PAGE EIGHTEEN

Station 18: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment necessary is

1. Tables
2. Chairs
3. Lockers
4. Clothes

Full Decontamination (Situation 1) and Three Modifications

The preceding description outlines each station that is included in a complete worst-case decontamination protocol. It is obvious that different sites will present different hazard levels and thus that site-specific modifications of this protocol will be required. The following table illustrates the modifications that can be made in response to a variety of conditions.

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2	x	x	x	x	x	x	x	x	x										
3	x						x	x		x	x				x	x	x		
4	x						x	x	x										

*SIT- Situation Number

Situation 1: The individual entering the CRC is observed to be grossly contaminated, or extremely toxic substances are known or suspected to be present.

Situation 2: Some as Situation 1 except that individual needs new air tank and will return to Exclusion Zone.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as situation 3 except that individual needs new air tank and will return to Exclusion Zone.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number ME-01	Page 1 of 12
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Health and Safety	
Subject HNU PI-101 ORGANIC VAPOR METER		Approved D. Senovich	

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1.0 PURPOSE

To establish procedures for the use, maintenance, and calibration of the HNU PI-101 Organic Vapor Meter.

2.0 SCOPE

Applies to each usage of the HNU PI-101 photoionization detector by NUS/EMG personnel.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the HNU instrument. He/she shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he/she has been adequately trained and understands the operation and limitations of the instrument. He/she is further responsible to insure that the appropriate probe(s) have been selected for compounds to be found on site and that the instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The HNU System portable photoionizer detects the concentration of many organic gases as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. The molecule is transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively-charged ion and the free electron. The instrument measures this energy level.

5.2 INSTRUMENT CONFIGURATION

Three probes, each containing a different UV light source, are available for use with the HNU. Probe energies are 9.5, 10.2, and 11.7eV. All three detect many aromatic and large-molecule hydrocarbons. The 10.2 and 11.7eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2eV probe is the most useful for environmental response work, since it is more durable than the 11.7eV probe and detects more compounds than the 9.5eV probe.

5.3 CALIBRATION

The primary HNU calibration gas is benzene (or isobutylene, a benzene equivalent). The span potentiometer knob is adjusted for benzene calibration. A knob setting of zero increases the sensitivity to benzene approximately ten-fold. The instrument's response can be adjusted to give more accurate readings for specific gases and eliminate the necessity for calibration charts. Daily calibration is to be performed in accordance with Attachment G.

5.4 SPECIALIZED USES

While the HNU is used primarily as a qualitative instrument, it can also be used to detect certain contaminants or at least to narrow the range of possibilities. Noting instrument response to a contaminant source with different probes can eliminate some contaminants from consideration. For instance, a compound's ionizing potential may be such that the 9.5eV probe produces no response, but the 10.2 and 11.7eV probes do elicit a response. Also, HNU does not detect methane or hydrogen cyanide.

5.5 INSTRUMENT ADVANTAGES

The HNU is easy to use in comparison to many other types of monitoring instrumentation. Its range detection limit is also in the low parts per million range. Response time is rapid; the meter needle reaches 90 percent of the indicated concentration in 3 seconds for benzene. HNU can be zeroed in a contaminated atmosphere.

5.6 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Nonvolatile liquids, toxic solids, particulates, and many other toxic gases and vapors cannot be detected. Because the types of compounds that the HNU can detect is only a fraction of the chemicals possibly present at a field site, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower then the true concentration. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer of the gas-select-knob setting.

The instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

HNU Systems, Inc. Instruction Manual for Model PI 101 Photoionization Analyzer, 1975.

E. & E. FIT Operation and Field Manual: HNU Systems PI 101 Photoionization Detector and Century Systems (Foxboro) Model OVA-128 Organic Vapor Analyzer.

Personal Communication with Fran Connel, HNU Systems, Inc., January 4, 1984.

7.0 ATTACHMENTS

Attachment A - Start-up and Shutdown Procedures
Attachment B - Maintenance and Calibration Schedule
Attachment C - Calibration Procedure
Attachment D - Cleaning the UV Light Source Window
Attachment E - Cleaning the Ionization Chamber
Attachment F - Troubleshooting
Attachment G - Daily Calibration

ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

Start-up

1. Attach the probe to the readout unit. Match the alignment key, then twist the connector clockwise until a distinct locking is felt.

2. Turn the FUNCTION switch to the battery check position. Check to ensure that the indicator reads within or beyond the green battery arc on the scale plate. If the indicator is below the green arc, or if the red LED comes on, the battery must be charged prior to using.

3. To zero the instrument, turn the FUNCTION switch to the STANDBY position and rotate the ZERO POTENTIOMETER until the meter reads zero. Wait 15-20 seconds to ensure that the zero adjustment is stable. If not, then readjust.

4. Check to see that the SPAN POTENTIOMETER is set at the appropriate setting for the probe being used. Follow procedures in Attachment G in the performance of daily calibrations.

5. Set the FUNCTION switch to the desired ppm range.

6. Listen for the fan operation to verify fan function.

7. Check instrument with an organic point source (such as a magic marker) prior to usage to verify instrument function.

Shut Down

1. Turn FUNCTION switch to OFF.

2. Place the instrument on the charger.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

Function	Frequency
• Routine Calibration	Prior to each use*
• Factory Check-out and Calibration	Yearly or when malfunctioning
• Wipe Down Read-Out Unit	After each use
• Clean UV Light Source Window	Every month or as use and site conditions dictate
• Clean the Ionization Chamber	Monthly
• Recharge Battery	After each use

* In accordance with the specifications identified in Attachment G.

ATTACHMENT C

CALIBRATION PROCEDURE

Calibration Procedure 1

1. Run through start-up procedures as per Attachment 1.

2. Fill a sampling bag with HNU calibration gas of known contents.

3. Allow sample bag contents to be drawn into the probe and check response in ppm.

4. If the reading deviates ± 15 percent from the concentration of the calibration gas, the instrument requires maintenance.

5. Each office must develop a mechanism for the documentation of calibration results. This documentation includes:

   a. date inspected

   b. person who calibrated the instrument

   c. the instrument number (Serial number or Other ID number)

   d. the result of the calibration (ppm, probe ev, span pot setting)

   e. identification of the calibration gas (source, type, concentration)

Calibration Procedure 2 (for HNU Calibration Canisters Equipped with a Regulator)

1. Run through start up procedures as per Attachment 1.

2. Connect a sampling hose to the regulator outlet and the other end to the sampling probe of the HNU.

3. Crack the regulator valve.

4. Take reading after 5-10 seconds.

5. If the reading deviates ± 15 percent from the concentration of the calibration gas, the instrument requires maintenance.

6. Calibration documentation should be as in No. 5 above.

ATTACHMENT D

CLEANING THE UV LIGHT SOURCE WINDOW

1. Turn the FUNCTION switch to the OFF position and disconnect the sensor/probe from the Read Out/Control unit.

2. Remove the exhaust screw located near the base of the probe. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.

3. Loosen the screws on the top of the end cap and separate the end cap and ion chamber from the lamp housing, taking care that the lamp does not fall out of this housing.

4. Tilt the lamp housing with one hand over the opening, so that the lamp slides out of the housing into your hand.

5. The lamp window may now be cleaned with any of the following compounds using lens paper:

   a. HNU Cleaning Compound-All lamps except the 11.7 eV
   b. Carbon tetrachloride-All lamps except the 11.7 eV
   c. Methanol-All lamps

6. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

7. Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring. Do Not Overtighten.

8. Line up the pins on the base of the lamp housing with pins inside the probe shell and slide the housing assembly into the shell. It will only fit one way.

ATTACHMENT E

CLEANING THE IONIZATION CHAMBER

1. Turn the FUNCTION switch to the OFF position and disconnect the sensor/probe from the Read Out/Control unit.

2. Remove the exhaust screw located near the base of the probe. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.

3. Loosen the screws on the top of the end cap and separate the end cap and ion chamber from the lamp housing, taking care that the lamp does not fall out of this housing.

4. The ion chamber may now be cleaned according to the following sequence:

   a. acetone rinse with agitation (10 min.), then dry (preferably with oven at 100°C).

   b. methanol rinse with agitation (10 min.), then dry (preferably with oven at 100°C).

5. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

7. Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring. Do Not Overtighten.

8. Line up the pins on the base of the lamp housing with pins inside the probe shell and slide the housing assembly into the shell. It will only fit one way.

ATTACHMENT F

TROUBLESHOOTING

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).

   A. Broken meter movement.

      (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.

   B. Electrical connection to meter is broken.

      (1) Check all wires leading to meter and clean the contacts of quick-disconnects.

   C. Battery is completely dead.

      (1) Disconnect battery and check voltage with a volt-ohm meter.

   D. If none of the above solves the problem, consult the factory.

2. Meter responds in BATT CHK position, but reads zero or near zero for all others.

   A. Power supply defective.

      (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.

   B. Input transistor or amplifier has failed.

      (1) Rotate zero control; meter should deflect up/down, as control is turned.

      (2) Open probe. Both transistors should be fully seated in sockets.

   C. Input signal connection broken in probe or readout.

      (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.

      (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.

      (3) Check all wires in readout for solid connections.

ATTACHMENT G

DAILY CALIBRATION OF HNU PI-101

HNU PI-101 organic vapor meters are to be field calibrated at the beginning of each work day, prior to actual on site usage.

In order to accomplish this, HNUs assigned to jobs shall be accompanied with a calibration gas cylinder, an appropriate fitting, and a flexible connecting hose. The procedure for performing field calibration is as follows:

1. Connect the probe to the instrument and turn it on.
2. Attach the eight-inch extension to the probe.
3. Set the Span Potentiometer to the setting specified on the calibration cylinder.
4. Connect the cylinder fitting to the cylinder.
5. Connect the cylinder and the instrument together with the flexible tubing.
6. Open the cylinder valve and wait 15 seconds.
7. Instrument reading should coincide with the designed reading stated on the calibration cylinder label.
8. If item number 7 does not coincide, adjust the Span Potentiometer until the desired reading is achieved. Any such adjustments must be within the following limits:

Probe	Initial Span Pot. Setting	Maximum Acceptable Span Pot. Adjustment
9.5 eV	5.0	1.0
10.2 eV	9.8	8.5
11.7 eV	5.0	2.0

If these limits are exceeded, the sensitivity and accuracy of the instrument is hindered. At these points, the instruments are to be returned to the NUS Equipment Manager for inspection, necessary cleaning and maintenance, and recalibration.

The manufacturer also recommends that the lamp inside of the probe be checked twice per week (16 hours of use) and cleaned at least weekly. This involves removing any noticeable obstructions or contamination from the lamp by wiping it off with a clean, soft cloth being careful not to scratch the circular window.

ATTACHMENT G
DAILY CALIBRATION OF HNU PI-101
PAGE TWO

In using this instrument to protect NUS employees and subcontractors, it is imperative that it is accurately responding to airborne substances present at the work site. By implementing these procedures, this end will be better achieved.

Additionally, all calibration activities must be documented in field log books, instrument calibration log sheets, or equivalent. This information must include the date inspected, the person calibrating the instrument, the instrument serial or identification number, the probe lamp eV (9.5 , 10.2, or 11.7), identification of calibration gas (gas source stated on the cylinder label), the initial and final Span Potentiometer settings, and the instrument resultant reading. This information must be submitted to the Site Safety officer at the completion of the job.

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		Applicability EMG	
		Prepared Health and Safety	
Subject OVA 128 ORGANIC VAPOR ANALYZER		Approved D. Senovich	

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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 OBJECTIVE

To establish procedures for the use, maintenance, and calibration of the OVA 128 Vapor Analyzer.

2.0 SCOPE

Applies to each usage of the OVA instrument in implementation of the NUS/EMG Program.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the OVA. He shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he or she has been adequately trained, understands the operation of the OVA, and limitations of the instrument. He or she should also be sure that the instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The OVA operates in two different modes. In the survey mode, it can determine the approximate concentration of all detectable species in air. With the gas chromatograph option, individual components can be detected and measured independently, with some detection limits as low as a few parts per billion.

5.2 GAS CHROMATOGRAPH FUNCTION

In the Gas Chromatograph (GC) mode, a small sample of ambient air is injected into a chromatographic column and carried through the column by a stream of hydrogen gas. Contaminants with different chemical structures are retained on the column for different lengths of time (known as retention times) and, hence, are detected separately by the flame ionization detector. A strip chart recorder can be used to record the retention times, which are then compared to the retention times of a standard with known chemical constituents. The sample can be injected into the column either from the air-sampling hose or directly from a gas-tight syringe.

5.3 CALIBRATION

The OVA is internally calibrated to methane by the manufacturer. When measuring methane, it indicates the true concentration. In response to all other detectable compounds, however, the instrument reading may be higher or lower than the true concentration. Relative response ratios for substances other than methane are available. To interpret the readout correctly, it is necessary either to make calibration charts relating the instrument readings to the true concentrations or to adjust the instrument, so that it reads correctly. This second procedure is done by turning the 10-turn, gas-select knob, which adjusts the response of the instrument. The knob is normally set at 300 when calibrated

to methane. Secondary calibration to another gas is done by sampling a known concentration of the gas and adjusting the gas-select knob, until the instrument reading equals the true concentration.

5.4 LIMITATIONS

The OVA has an inherent limitation in that it can detect only organic molecules. Also, it should not be used at temperatures lower than about 40°F, because gases condense in the pump and column. It has no temperature control and, since retention times vary with ambient temperatures for a given column, absolute determinations of contaminants are difficult. Despite these limitations, the GC mode can often provide tentative information on the identity of contaminants in air without relying on costly, time-consuming laboratory analysis.

5.5 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected. Because the types of compounds that the OVA can potentially detect are only a fraction of the chemicals possibly present at an incident, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower than the true concentrations. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer or gas-select knob setting.

This instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

Century Systems (Foxboro). Service Procedures: Organic Vapor Analyzer; 128GC.

7.0 ATTACHMENTS

Attachment A - Start-up and Shutdown Procedures (2 Sheets)
Attachment B - Maintenance and Calibration Schedule
Attachment C - Calibration Procedure (2 Sheets)
Attachment D - Pump System Checkout
Attachment E - Burner Chamber Cleaning
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ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

START-UP

1. Connect the probe/read out connectors to the side-pack assembly.

2. Check battery condition and hydrogen supply.

3. For measurement taken as methane equivalent, check that the GAS SELECT Dial is set at 300.

4. Turn the electronics on by moving the INSR switch to the ON position and allow five (5) minutes for warm-up.

5. Set CALIBRATE switch to X10, use CALIBRATE knob to set indicator at 0.

6. Open the H_2 tank valve and the H_2 supply valve all the way. Check that the hydrogen supply gauge reads between 8.0 and 12.0 psig.

7. Turn the PUMP switch ON and check the flow system, according to the procedures in Attachment D.

8. Check that the BACKFLUSH and INJECT valves are in the UP position.

9. To light the flame, depress the igniter switch until a meter deflection is observed. The igniter switch may be depressed for up to five (5) seconds. Do not depress for longer than five (5) seconds, since it may burn out the igniter coil. If the instrument does not light, allow it to run several minutes and repeat ignition attempt.

10. Confirm OVA operational state by sniffing an organic source, such as a magic marker.

11. Establish a background level in a clean area, by using the charcoal scrubber (depress the sample inject valve) and recording measurements referenced to background.

12. Set the alarm level, if desired.

SHUT DOWN

1. Close H_2 supply valve and H_2 tank valve (Do Not Overtighten Valves).

2. Turn INSTR switch to OFF.

3. Wait until H_2 supply gauge indicates system is purged of H_2, then switch off pump.

4. Put instrument on electrical charger at completion of day's activities.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

• Check Particle Filters	Weekly or as-needed
• Check Quad Rings	Monthly or as-needed
• Clean Burner Chamber	Monthly or as-needed
• Secondary Calibration Check	Prior to project start-up
• Primary Calibration Check	Monthly or if secondary check is off by more than ± 10%
• Check Pumping System	Prior to project start-up
• Replace Charcoal	120 hours of use or when background readings are higher with the inject valve down than with the inject valve up, in a clean environment.
• Factory Service	At least annually

* Instruments which are not in service for extended periods of time need not meet the above schedule. However, they must be given a complete check-out prior to their first use addressing the above maintenance items.

ATTACHMENT C

CALIBRATION PROCEDURE

PRIMARY CALIBRATION

1. Remove instrument components from the instrument shell.

2. Turn on Electronics and Zero instrument on X10 scale. Gas select dial to 300.

3. Turn on Pump and Hydrogen. Ignite Flame. Go to Survey Mode.

4. Introduce a Methane Standard near 100 ppm.

5. Adjust R-32 Trimpot on Circuit Board to make meter read to standard.

6. Turn off hydrogen flame and adjust meter needle to read 40 ppm (calibrate @ X10) using the calibration adjust knobs.

7. Switch to X100 Scale. The meter should indicate 0.4 on the 1-10 meter markings (0.4 x 100 = 40 ppm). If the reading is off, adjust with R33 Trimpot.

8. Return to X10 Scale and adjust meter needle to 40 ppm with calibration adjust knob, if necessary.

9. At the X10 Scale, adjust meter to read 0.4 on the 1-10 meter markings using the calibration adjust. Switch to X1 scale. The meter should read 4 ppm. If the reading is off, adjust using the R-31 Trimpot.

SECONDARY CALIBRATION

1. Fill an air sampling bag with 100 ppm (Certified) methane calibration gas.

2. Connect the outlet of the air sampling bag to the air sampling line of the OVA.

3. Record the reading obtained off the meter onto the calibration record.

DOCUMENTATION

Each office shall develop a system, whereby the following calibration information is recorded.

a. Instrument calibrated (I.D. or Serial No.)

b. Date of calibration

c. Method of calibration

d. Results of the calibration

e. Identification of person who calibrated the instrument

f. Identification of the calibration gas (source, type, concentration, Lot No.)

ATTACHMENT D

PUMP SYSTEM CHECKOUT

1. With pump on hold unit upright and observe flow gauge.
2. Ball level significantly below a reading of 2 is inadequate flow.
3. Check connections at the sample hose.
4. Clean or replace particle filters, if flow is impaired or it is time for scheduled service.
5. Reassemble and retest flow.
6. If flow still inadequate, replace pump diaphragm and valves.
7. If flow normal, plug air intake. Pump should slow and stop.
8. If no noticeable change in pump, tighten fittings and retest.
9. If still no change, replace pump diaphragm and valves.
10. Document this function in the maintenance records.

ATTACHMENT E

BURNER CHAMBER CLEANING

1. Remove plastic exhaust port cover.
2. Unscrew exhaust port.
3. Use wire brush to clean burner tip and electrode. Use wood stick to clean Teflon.
4. Brush inside of exhaust port.
5. Blow out chamber with a gentle air flow.
6. Reassemble and test unit.
7. Document this function in the maintenance records.

ATTACHMENT F

QUAD RING SERVICE

1. Remove OVA guts from protective shell.
2. Remove clip ring from bottom of valve.
3. Unscrew nut from top of valve.
4. Gently pull valve shaft upward and free of housing.
5. Observe rings for signs of damage - replace as necessary.
6. Lightly grease rings with silicone grease.
7. Reassemble valve - do not pinch rings during shaft insertion.
8. Document this function in the maintenance records.

ATTACHMENT G

TROUBLESHOOTING

Indication	Possible Causes
• High Background Reading (More than 10 ppm)	1. Contaminated Hydrogen 2. Contaminated Sample Line
• Continual Flameout	1. Hydrogen Leak 2. Dirty Burner Chamber 3. Dirty Air Filters
• Low Air Flow	1. Dirty Air Filter 2. Pump Malfunction 3. Line Obstruction
• Flame Will Not Light	1. Low Battery 2. Ignitor Broken 3. Hydrogen Leak 4. Dirty Burner Chamber 5. Air Flow Restricted
• No Power to Pump	1. Low Battery 2. Short Circuit
• Hydrogen Leak (Instrument Not in Use)	1. Leak in Regulator 2. Leak in Valves

ATTACHMENT G
TROUBLESHOOTING
PAGE TWO

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).

   A. Broken meter movement.
      (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.

   B. Electrical connection to meter is broken.
      (1) Check all wires leading to meter and clean the contacts of quick-disconnects.

   C. Battery is completely dead.
      (1) Disconnect battery and check voltage with a volt-ohm meter.

   D. If none of the above solves the problem, consult the factory.

2. Meter responds in BATT CHK position, but reads zero or near zero for all others.

   A. Power supply defective.
      (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.

   B. Input transistor or amplifier has failed.
      (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.
      (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.
      (3) Check all wires in readout for solid connections.

ATTACHMENT H

SHIPPING

Since the OVA-128 contains hydrogen, it is subject to shipping restrictions.

As Personal Luggage

The OVA-128 can be taken on a plane as luggage, since a permit has been issued from the Department of Transportation to the manufacturer (Foxboro). Please refer to the original permit (Attachment 9) and the extended permit (Attachment 10).

Air Express

The following labels must be affixed to both sides of the OVA case when shipping OVA by Air Express.

- Danger - Peligro
- Flammable Gas
- Inside Container Complies with D.O.T. Regulations
- Hydrogen UN #1049
- Name and Address of Recipient

A hazardous air bill must be filled out. The following information is requested.

Proper Shipping Name	Hydrogen
Classification	Flammable Gas
I.D. No.	UN 1049
Net Quantity	75 Cubic Centimeters

In addition, the shipping's certification must be signed and marked CARGO AIRCRAFT ONLY.

ATTACHMENT I
D.O.T. EXEMPTION PERMIT

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

DRAFT

DOT-E 7607
(FIRST REVISION - CORRECTED COPY)

1. Century Systems Corporation, Arkansas City, Kansas, is hereby granted an exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer packages prescribed herein of a flammable gas for transportation in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the shipment of hydrogen in certain non-DOT specification cylinders as described in paragraph 7 below, and provides no relief from any regulation other than as specifically stated. Each of the following is hereby granted the status of a party to this exemption:

U.S. Department of Health, Education and Welfare, Rockville, Maryland - FTE-1.

2. BASIS. This exemption is based on Century Systems Corporation's application dated March 10, 1978, submitted in accordance with 49 CFR 107.105 and the public proceeding thereon. The granting of party status is based on the following application submitted in accordance with 49 CFR 107.111 and the public proceeding thereon:

The U.S. Department of Health, Education and Welfare's application dated March 13, 1978.

3. HAZARDOUS MATERIALS (Descriptor and class). Hydrogen, flammable gas.

4. PROPER SHIPPING NAME (49 CFR 172.101). Hydrogen.

5. REGULATION AFFECTED. 49 CFR 172.101, 173.3.

6. MODE OF TRANSPORTATION AUTHORIZED. Passenger-carrying aircraft.

7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification seamless stainless steel cylinder of not more than 7.22 cubic inch water capacity; each cylinder to be pressure tested to at least 4000 psig, and charged to not more than 2100 psig at 70°F. The cylinder is a component part of a portable gas chromatograph.

8. SPECIAL PROVISIONS.

a. Each device must be shipped in a strong outside packaging as prescribed in 49 CFR 173.301(h).

b. A copy of this exemption must be carried aboard each aircraft used to transport packages covered by this exemption.

c. The pilot in command must be advised when the gas chromatograph is placed on board the aircraft.

d. The gas chromatograph must be appropriately secured.

Continuation of 1st Rev. DOT-E 7607 corrected copy

DRAFT

9. REPORTING REQUIREMENTS. Any incident involving loss of contents from the package must be reported to the Office of Hazardous Materials Regulation as soon as practicable.

10. EXPIRATION DATE. May 1, 1980.

ued at Washington, D.C.:

9-7-78
(DATE)

Alan L. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: 3 of 3, FAA

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

DOT-E 7607
(PTE)

In accordance with 49 CFR 107.101 of the Department of Transportation (DOT) Hazardous Materials Regulations the party(s) listed below are granted the status of party to DOT-E 7607.

The expiration date of the exemption is March 31, 1983 for the party(s) listed below. This authorization forms part of the exemption and must be attached to it.

13 JUN 1980
(DATE)

ALAN L. ROBERTS
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Clayton Environmental Consultants, Inc. Southfield, Michigan	December 5, 1979
Foxboro Company Burlington, MA	March 24, 1980

ATTACHMENT J

D.O.T. EXEMPTION PERMIT EXTENSION

U.S. Department of Transportation
Research and Special Programs Administration

400 Seventh Street, S.W.
Washington, D.C. 20590

DOT-E 7607
(EXTENSION)

In accordance with 49 CFR 107.105 of the Department of Transportation (DOT) Hazardous Materials Regulations DOT-E 7607 is hereby extended by changing the expiration date in paragraph 10 from December 1, 1983 to September 1, 1985.

This extension applies only to party(s) listed below based on the application received in accordance with 49 CFR 107.105. All other terms of the exemption remain unchanged. This extension forms part of the exemption and must be attached to it.

J.R. Grothe for
Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

OCT 27 1983
(DATE)

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Foxboro Company South Norwalk, Ct.	September 16, 1983

ATTACHMENT K

HYDROGEN RECHARGING

1. High-grade hydrogen (99.999%) is required.
2. Connect the fill hose to the REFILL FITTING on the side Pack Assembly, with the FILL/BLEED valve in the OFF position.
3. Open H_2 supply bottle valve.
4. Place FILL/BLEED valve on fill hose in BLEED position momentarily to purge any air out of the system.
5. Crack the instrument TANK VALVE.
6. Open REFILL valve on instrument.
7. Place FILL/BLEED valve in FILL position until the instrument PRESSURE GAUGE equalizes with the H_2 SUPPLY BOTTLE PRESSURE GAUGE.
8. Shut REFILL valve, FILL/BLEED valve, and H_2 SUPPLY BOTTLE valve, in quick succession.
9. Turn FILL/BLEED valve to BLEED until hose pressure equalizes to atmospheric pressure.
10. Turn FILL/BLEED valve to FILL Position, then to BLEED position, then to OFF.
11. Close TANK on instrument.
12. Disconnect the FILL HOSE and replace protective nut on the REFILL FITTING.

ATTACHMENT L

PARTICLE FILTER SERVICING

There are two points in the air sampling line of the OVA where filters have been placed to keep particulates from entering the instrument. The location of these filters are indicated on the figure in Attachment M. The first filter is located in the probe assembly and the second filter (primary filter) is located on the side pack assembly. Cleaning procedures are as follows:

1. Detach the probe assembly from the readout assembly.

2. Disassemble the probe (the components unscrew).

3. The particle filter located within the probe can be cleaned by blowing air through the filter.

4. Reassemble the probe.

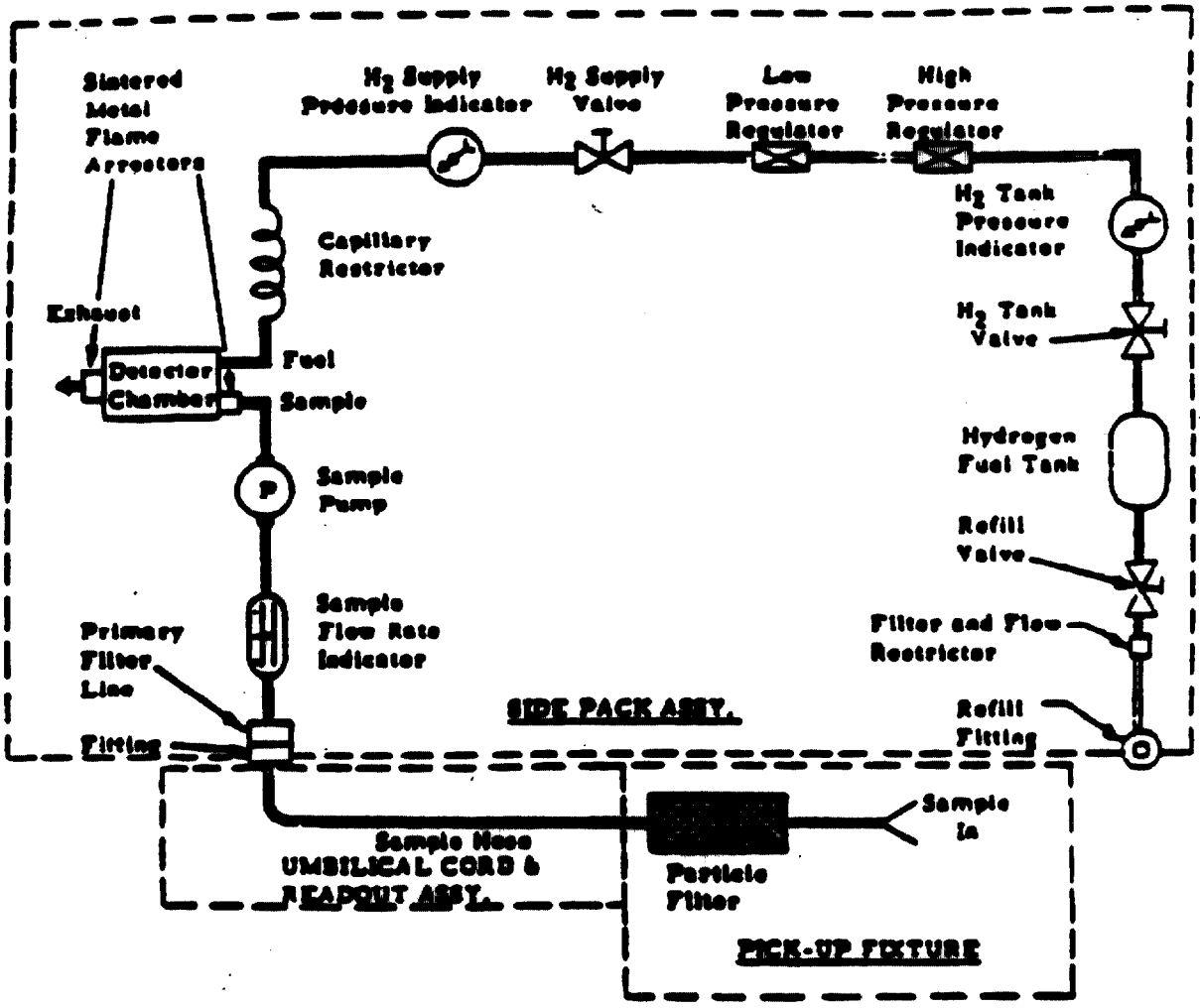
5. The primary filter, located behind the sample inlet connector on the side pack assembly, is accessed by removing the sample inlet connector with a thin-walled 7/16 inch socket wrench. Remove the filter and clean as above.

6. Reassemble the sample inlet fitting and filter to the side pack assembly.

7. Check sample flow rate.

ATTACHMENT M

FLOW DIAGRAM - GAS HANDLING SYSTEM



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		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

- Sample preservation requirements.

- Working schedule.

- List of team members.

- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer)

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

[See also QAPP]

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS [See QAPP]

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY [See QAPP]

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

U.S. EPA, 1980. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities. Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.

Johnson Division, UOP, Inc. 1975. Ground Water and Wells, A Reference Book for the Water Well Industry. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

Barcelona, M. J., J. P. Gibb and R. A. Miller, 1983. A guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. Manual of Ground Water Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Nielsen, D. M. and G. L. Yeates, 1985. A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells. Ground Water Monitoring Review 5:83-98.

7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page _____ of _____

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					

Signature(s):	Observations / Notes:
Type of Sample ☐ Low Concentration ☐ High Concentration ☐ Grab ☐ Composite ☐ Grab - Composite	

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-inch								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
2-inch								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
4-inch								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
6-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
8-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors available; must be primed
Gelsek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive displacement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1.75/60	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	999	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GasFilter Small Dia. Well Pump (#9500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thickness of "floating" contaminants
Q E D Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas, piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co.	Model 500 Vari Flow Pump	portable; peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selected, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton®, acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; optional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tole Devices Co.	Sampling Pump	portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials Abbreviations

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
SS	Stainless Steel
PC	Polycarbonate
EPDM	Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA	Not Applicable
AC	Alternating Current
DC	Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

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		Applicability EMG	
		Prepared Earth Sciences	
Subject SURFACE WATER AND SEDIMENT SAMPLING		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes methods and equipment commonly-used for collecting environmental samples of surface water and aquatic sediment for either on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.4), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

5.0 PROCEDURES

5.1 INTRODUCTION

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 DEFINING THE SAMPLING PROGRAM

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom [illegible] or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect an adsorption/desorption). The hydrologist developing the sampling plan must therefore, know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to be absorbed by particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 SURFACE WATER SAMPLE COLLECTION

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multipoint sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the water course taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the river's transports. The greater number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well-mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have as much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multiparameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e. when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1 to 5 foot increments coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- ~~Open tube~~
- Dip sampler
- ~~Hand pump~~
- ~~Kemmerer~~
- ~~Depth-Integrating Sampler~~

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for:

- Specific conductance
- Temperature
- pH (optional)
- Dissolved oxygen (optional)

as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

5.3.4.1 Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

5.3.4.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

5.3.4.3 Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. "Messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at 0.6 stream depth in a well-mixed stream.
- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken.
- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work from zones suspected of low contamination to zones of high contamination.
- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids are selected at random.
- Care should be taken to avoid excessive agitation of the water that results in the loss of volatile constituents.
- When obtaining samples in 40 ml septum vials for volatile organics, analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The bottle can be turned upside down to check for air bubbles.
- Do not sample at the surface, unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the month of the bottle facing upstream.

5.4 SEDIMENT SAMPLING

5.4.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations

of contaminants. The shape, flow pattern, bathometry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). It is therefore important to minimize the loss of low-density "fines" during any sampling process.

5.4.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

~~When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.~~

The following samplers may be used to collect bottom materials:

- Scoop sampler
- ~~Dredge samplers~~

5.4.2.1 Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

5.4.2.2 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

6.0 REFERENCES

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7.0 ATTACHMENTS

None.

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		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject AQUATIC ECOLOGICAL INVENTORY AND SAMPLING		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to present methodologies for surveying and sampling aquatic organisms at hazardous waste sites to determine potential impacts on organisms at higher trophic levels.

2.0 SCOPE

The methodologies presented in this procedure are appropriate for: identifying aspects of aquatic ecological communities which suggest impact due to hazardous waste contamination; identifying potential trophic pathways and transport mechanisms for substances of public health concern; and providing useful input to evaluation of the feasibility and risks of remedial design alternatives. Not all of the methodologies presented herein are appropriate for all sites because of health and safety constraints which must be factored into all field sampling and analysis plans incorporating the methodologies included in this guideline.

3.0 GLOSSARY

Benthos - Organisms living on, in, or attached to the bottom of a water body.

Cladocera - Water fleas, a suborder within the class comprising an important food for fish.

Community - An assemblage of plant or animal species which appear to occur together or a given area.

Ecosystem - The biotic community and abiotic environment associated with a particular area.

Ichthyoplankton - Fish eggs and fish larvae sufficiently large to be captured by a 505-micron mesh plankton net.

Macrophytes - Essentially larger aquatic plants, or all plants except microscopic plants or algae.

Macrozooplankton - Larval and post larval animal plankton sufficiently large to be captured by a 505-micron mesh plankton net.

Periphyton - Organisms attached or clinging to submerged stems, leaves, rocks or other surfaces projecting above the substrate.

Plankton - Organisms which float with the current and generally lack swimming capability.

Trophic Pathway - A pattern of energy and material transfer from primary producers through successive levels of consumer organisms, and ultimately, to decomposers.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that a senior ecologist prepares, reviews, and oversees implementation of project specific plans for projects where aquatic ecological inventorying and sampling are required, and that such plans conform to this procedure. The Site Manager is also responsible to assure that the plans are reviewed by the Health and Safety Officer for conformance with Health and Safety Guidelines.

5.0 PROCEDURES

5.1 PROGRAM DESIGN

The site-specific aquatic ecology field program is designed after the following tasks have been completed:

- Review and analysis of all available site-specific information.
- Review and understanding of program objectives.
- Review and understanding of the principles and procedures of each sampling and/or measurement method to be used (including review of specific equipment manuals).
- Consultation with the Site HSO (especially if there is a potential for sampling from a boat).

Program design will be dependent upon these factors and must be considered relevant to the type of environment being investigated (marine, estuarine, freshwater), in addition to program objectives. The sampling apparatus used for a specific project is dependent upon the type of environment since not all gear is applicable in all systems (e.g., electrofishing is ineffective in saline waters). Other considerations which may be relevant to sample survey design include:

- Emphasis on indicator species - focusing the sampling effort on certain species may be of use as a quick aid to identifying stress in the environment. Additionally, observations of high incidences of pathological disorders in fish (e.g., fin rot) provides information on the probability of stress in a particular area.
- Collection of specimens for tissue analysis - chemical contaminants are often concentrated from one trophic level to the next, especially for fat soluble materials. Identification of the main food chains present in the study area will be useful in establishing which organisms to concentrate on relative to tissue analysis studies of bioaccumulation.
- Incorporation of sampling - concurrent sampling of biota and the physical/chemical environment (e.g., water quality) is important for interpreting presence/absence/ abundance data on species observed.
- Inclusion of downstream (or upstream) sampling - offsite sampling locations may be necessary to establish far field effects of contaminants, downgradients in species composition and recovery rates as contaminants are dispersed and diluted, or determine if differences between onsite and offsite biota are significant, and upgradient or similar but uncontaminated systems as controls.
- Tidal fluctuations - estuarine and marine environments experience tidal variations, and therefore require sampling in inter- and sub-tidal zones as well as during ebb and flood tides, to properly characterize the area. Inter-tidal zones possess unique species (spartina, mussels) which present trophic pathways to both aquatic and terrestrial organisms. These species should be considered for tissue analyses for evaluating environmental fate, effects, and risks.
- Stream and lake cross-sections - depth and rate of flow vary, based on cross-section location.

The objectives of certain hazardous waste site ecological studies can be met with utilization of available information and qualitative methodologies comprising a General Field Survey. In these instances, program design can be accomplished by the field biologist with review by the senior project ecologist and the site HSO. At those sites where qualitative information or sample collection is deemed necessary, the field program should be designed with input from statistician. This is required not only to ensure usefulness of data collected, but also to optimize time spent in the field.

5.2 DATA RECORDING

Standard aquatic ecology field data sheets (Attachment A) should be used for General Field Surveys. These sheets should be pre-printed on weather resistant paper to ensure data preservation under adverse field conditions, and include (but not be limited to) the following:

- NUS Project Number, Site Name and Location
- Date and Time
- Recorder (Investigator)
- Station Location
- Sample description and/or sample number as appropriate.
- Weather conditions
- Record of any photographs taken

5.3 PRE-FIELD INVESTIGATION ANALYSES

Prior to the field effort, all relevant available information should be reviewed. This phase is particularly important for hazardous waste site studies because typically-employed field accessories such as binoculars or cameras are difficult to use in combination with personnel protection requirements (respirators, SCBA, etc.). At most sites, the quality and quantity of information obtained will be limited by the investigator's ability to identify aquatic organisms and habitat through a respirator mask and by stress incurred from working in protective clothing. Hence, there is a strong need to make maximum use of available information prior to field investigation. Pre-field investigation should include the following:

- Preliminary map depicting water bodies on-site or contained within drainage area that require investigation

- Access routes (paths, trails accommodating all terrain vehicles, etc.) as well as emergency egress routes and safety stations

- Existing background information on the study area including aquatic organisms that may be found, with emphasis on species which may be indicative of existing stress or contaminant vectors, from a public health standpoint.

Sources of information to be sought and consulted include the following:

- Aerial photography

- USGS topographic maps

- Observations and photographs obtained by previous investigators (e.g., FIT team or site reconnaissance survey)

- State field biologists

- Published literature on aquatic ecosystems occurring on or near the site
- Navigational and river maps, if applicable.
- Published references on materials and methods (e.g., References 1 and 2 or this guideline)
- State or federal endangered species specialists where appropriate.

5.4 FIELD PREPARATIONS

Complete any field-related activities that can be performed prior to actual conduct of the field study--this includes pre-labeling of sample containers, pre-recording certain information on data sheets (e.g., site and date), and preparing any anticipated sample preservatives to proper strength.

5.5 GENERAL FIELD SURVEY

The General Field Survey should rely largely on observational data obtained by the field biologist, utilizing a standard data sheet (sample shown in Attachment A) developed for each site. In some instances simple techniques such as dip netting, which utilize disposable nets, can be employed to provide qualitative information on species present, or for obtaining specimens for tissue analysis.

5.6 DETAILED FIELD SURVEY

A Detailed Field Survey should be performed where more specific information (e.g., species abundance and bottom composition) is needed and where safety levels permit more intensive types of sampling. This type of survey would normally be performed only at Level D or C sites. Data typically obtained from this survey can include:

- Water Quality
  - pH
  - Dissolved oxygen
  - Temperature
  - Conductivity or salinity
  - Transparency
- Flow
- Average width and depth
- Circulation
- Tidal stage
- Bottom Composition - sieved samples
- Invertebrates - grab samples, drift nets
- Plankton (phyto, zoo, ichthyo) - nets, pumps
- Canopy - percent cover
- Fish - electrofishing; seining; set nets; gill nets

Data typically obtained from this survey are recorded on the data sheet in Attachment B.

Health and safety considerations are in all cases a major part of designing a detailed field survey. Health and safety implications of field sampling techniques must be considered, as well as health risks to laboratory personnel performing any subsequent analyses.

5.7 QUANTITATIVE STUDIES

Quantitative estimates of species abundance may be difficult to obtain at some sites, due to health risks of the repeated sampling required for statistically-sound data. If after consideration of program objectives and site-specific health and safety conditions, a quantitative study is deemed necessary, a sampling and/or monitoring program can be designed. Frequency of sampling, as well as number of stations and samples per station, should be developed on the basis of statistical advice, the site ecologist's understanding of on-site conditions, and the Site HSO's review.

Data sheets similar to those employed for Detailed Field surveys should be used, (Attachment C) and lab sheets should be developed as appropriate.

5.8 SPECIFIC METHODS AND MATERIALS

The methods described below are standard and, where health and safety conditions permit, appropriate for use at hazardous waste sites.

5.8.1 Benthic Invertebrates

Benthic invertebrates live on or in the waterbody substrate. They can constitute an important component of food chains of fish species, and consequently may link sediment-contained pollutants with the human food chain. Benthic macroinvertebrate communities are often used as indicators of stress on aquatic composition and density is largely determined by substrate types and local environmental conditions.

Many methods have been employed for obtaining benthic samples. An ideal collection technique minimizes disturbance, minimizes time during which captured organisms can escape, and provides a defined volume. Sampling devices include hand-held corers, scoops, various grabs or dredges (Ponar, Peterson, Smith-McIntyre) the Surber sampler, and artificial monitoring substrates (e.g., Hester-Dendy Sampler). Major advantages and limitations are the following:

	Area Sampled	Advantages	Limitations
Peterson and Smith-McIntyre grabs	700cm^2	Will work in sand or gravel	Requires boat; unwieldy and heavy
Scoops	Variable	Simple	Non quantitative; may require hand immersion
Surber Sampler	1000cm^2	Semi-quantitative sample for streams appropriate for variety of substrates	Shallow water device (best when water 2' deep); requires hand immersion
Ponar Grab	500cm^2	Manageable, quantitative sample	Requires boat; limited to soft sediment

	Area Sampled	Advantages	Limitations
Artificial Substrate (e.g., Hester-Dendy Sampler)	Series of small plates or materials of fixed area	Does not require substrate extraction, simpler lab processing; quantitative estimate of species and individuals per area	Only samples the community which develops during sampling interval no measure of natural substrate
Hand Corer	Various, up to 10 cm diameter	Takes undisturbed, quantitative samples; easy to use and can be used in relatively coarse sediments	Cannot be used on hard substrates; unwieldy. Restricted to shallow water; may lose portion of sediment; requires hand immersion
Ponar Grab	500cm^2	Manageable, quantitative sample	Requires boat; limited to soft sediment

Grab samples are usually washed through sieves in the field to prevent the loss of small animals which die and decay rapidly. Choice of sieve size is usually based on sediment grain size, but it also determines the type and size of animals retained. The most commonly used mesh size for final sieving is 0.5 mm. The material retained by the sieve is preserved in 10 percent buffered formalin and labeled for laboratory analyses. Artificial substrates are removed from the array, bagged and preserved in total for lab picking and identification.

5.8.2 Plankton

Zooplankton

Zooplankton form a major food source for larval and adult fish as well as larger invertebrates. As they are typically microscopic, sampling procedures involve use of a net to strain them from the water. Nets are usually towed behind a boat, and fitted with flow meters (which measure volume of water filtered) if quantitative samples are required.

General procedures are:

- If metered, record start count (volume).
- Tow for approximately 5 minutes at 1-2 feet per second.
- If metered, record end count (volume).
- Empty contents of bucket into labeled sample container.
- Add preservative.

Nets are rinsed by splashing water through the net from the outside to concentrate collected material in a sample bucket. Contents of the bucket are then emptied into labeled jars containing 5% buffered formalin. The mesh of the bucket should also be rinsed from the outside in to ensure all collected material is transferred to the sample jar. Fresh water plankton should be preserved with sucrose/4% buffered formalin in order to preserve the cladocerans in a more easily identifiable form.

The primary variables involved in program design are (a) mesh size, (b) length of tow, (c) net diameter, (d) depth of tow, and (e) time of tow (day or night). Mesh sizes for environmental studies are relatively standard (202 micron) as are length of tow (5-10 minutes with minimum volume of

100 m^3). Nets are usually 0.5 or 1 meter diameter. Oblique tows sample all water depths and provide data representative of the entire water column.

Ichthyoplankton and Macrozooplankton

Ichthyoplankton and macrozooplankton include drifting organisms, typically fish eggs, larvae, and invertebrates of a size sufficient to be captured by a 505-micron mesh plankton net of 0.5 or 1 meter diameter.

Large mesh (505-micron) plankton nets with large mouths (0.5-1 m) are usually towed behind a boat, although they can be anchored in a current. In order to obtain comparable data for different times and locations, similar quantities of water need to be filtered. This is generally assured by using flow meters to measure the quantity of water passing through the nets. For density estimates, flow meters are mandatory.

Samples should be preserved with 10% formalin and placed in labeled vials. Sampling procedures are similar to those described for zooplankton.

Phytoplankton

Phytoplankton are aquatic plants that can occur as unicellular, colonial or filamentous forms. They are a primary food source for herbivorous zooplankton and fish. Typical sampling gear consists of either bottles (Kemerer, Van Dorn, Niskin or Nansen) or net sampling which is either towed through the water or water is pumped through. Nets can be used to selectively sample nanoplankton (<60 µm) or microplankton (<10 µm). Samples may be preserved with buffered formalin (40ml/100ml of sample) merthiolate (36ml/11 of sample) or 95% alcohol (50/50 mix of alcohol and sample).

5.8.3 Periphyton

Two standard procedures are available for documenting occurrence and estimating abundance of periphyton. If information on natural substrate is required, scrape periphyton off representative natural substrates such as rocks or logs, and place the collection in a sample vial with preservative. Sampling of natural substrates provides a more complete inventory of species occurrence and can be quantified by selecting replicate rocks from each station and scraping measured areas.

For situations where in-situ scraping may be precluded by health and safety constraints, or more rigorously quantifiable estimates of abundance may be required, artificial substrates can be employed. These usually consist of racks of microscope slides held on edge with the long axis parallel to the current. Such arrays are anchored in the water for periods of 1-3 months, depending on study objectives.

Substrates (either natural or artificial) are preserved in 3-5% buffered formalin. Each individual substrate is preserved in its own labeled vial. Substrates to be used for dry weight analysis do not have preservatives added. Vials should be of a size that will keep the slides from being scraped or bumped in transport.

5.8.4 Macrophytes

Macrophytes, (large aquatic plants) are important to any aquatic system as food, substrate for algae and invertebrates, and fish habitat. Mapping of large areas can be most efficiently done using aerial photographs. After delineation of macrophyte beds on the photographs, the areas should be verified

in the field. Spatial extent of the beds can then be determined using a planimeter. For smaller sites, the beds can be surveyed in the field.

5.8.5 Fish

Fish comprise an obvious and important part of the food chain for human beings as well as for wildlife such as waterfowl. The principal methods for sampling fish at hazardous waste sites will probably be seines, electroshocking, and gill netting.

Seines

Seine nets vary in length from 8 to 2,000 feet and in depth from 4 to 200 feet. The smaller seines (haul seines) are most frequently used for biological sampling in shallow water. Haul seines usually have a pole at each end and are drawn through the water by two people. Use of anything larger than 20 feet by 4 feet is not expected to be needed or practical at hazardous waste sites.

Entire reaches of streams can be sampled with a seine. One end of the seine is pulled along one shore while the other end is pulled (usually in the direction against the current) in a parallel fashion along the opposite shore. After a predetermined distance one end of the seine is worked to the opposite shore and the two ends beached.

Seining can also be employed to sample the shallow zones along lake, estuary, or stream banks. The technique is much the same as that described above except that one end is worked near shore and the other in deeper water. The offshore end should be slightly ahead of the nearshore end forming a "J." After a standard distance (25 feet is frequently used) to ensure comparability of different hauls (i.e., similar volumes of water scooped), the seine is beached.

Once beached, all fish in the net should be identified, counted, and measured (total length). If appropriate, reference specimens should be retained.

Haul seines are limited to use in water no more than waist deep. A clear shore for beaching should be chosen in advance. While seining the bottom the lead line should never come off the bottom and the float line should never go under the water. Substrate obstructions allow fish to escape under the net. Soft substrates allow the lead line to dig into the bottom making sampling difficult. Haul seines are selective for small, less mobile, fish.

Electroshocking

Electrofishing is used in freshwater sampling and can provide specimens for obtaining data on species composition, relative abundance, size distribution, or tissue chemistry.

Electroshocking involves producing an electric field between two electrodes immersed and placed in a water well or bucket in the water. Any fish entering the field are stunned which causes them to be captured with dipnets. After sampling, the fish should be measured, weighed, and identified or preserved in labeled bottles.

There are essentially two types of electrofishing equipment - those using AC current and those using DC current. With DC current fish are attracted to the anode, facilitating recovery by the sampler. The field produced using AC current has a larger effective range, but fish may be lost in turbid or swift waters, since they will not be attracted to the electrode. In addition there is a greater chance of killing the fish using AC.

If electrofishing by boat, move downstream at slow speeds especially when sampling deep pools or runs. Sample all habitats including bank areas. One person operates the boat and equipment, while another collects stunned fish from the bow of the boat with a net. Efficiency may be increased by having a second boat follow the electrofishing boat, to net any fish out of reach of the first.

If electrofishing on foot, the sampler wades upstream, taking care to sample all habitats. A second person follows to help net, carry the catch, or carry the cathode.

The electric current generated by shocking equipment (particularly AC devices) can cause serious injury to the user if safety precautions are not rigorously followed. Before field use, the investigator should become thoroughly familiar with the equipment manufacturer's instructions. Only devices with automatic cut-off (dead-man) switches should be used. Electroshocking crews should comprise three people, two samplers and an observer. Crew members entering the water or positioned on a boat must wear rubber boots and gloves. At least one member of the crew should be trained in First Aid and CPR (Cardiopulmonary Resuscitation).

Gill Nets

Gill nets are used in marine, estuarine and freshwater environments where fish movement is expected. Experimental gill nets typically measure 40 m in length and consist of a graded series of (five) 8 m panels with mesh sizes ranging from 19 mm to 62 mm square. Nets are set for a prescribed period of time (i.e., 24 hours). Captured fish are identified, enumerated, measured and weighed. (For onsite work, these nets should be considered expendable.)

Trawling

Trawls are nets used for sampling large deep water bodies, which may be present adjacent to a hazardous waste site. There are three basic trawl types: Try (permanent opening), otter (for demersel species), and mid-water (for various depths). Trawls are towed behind a boat against the prevailing surface current at a consistent speed and duration. Winches and booms are generallly needed to deploy and retrieve the nets. When retrieved, the cod end is opened and captured fish are identified, enumerated, measured, and weighed.

5.9 EQUIPMENT DECONTAMINATION, MAINTENANCE AND STORAGE

Proper decontamination, maintenance and storage procedures should be followed.

6.0 REFERENCES

American Public Health Association. 1981. Standard Methods, 15th Edition. American Public Health Association, Washington, D.C.

U.S. EPA, 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. (C.I. Wever, editor). U.S. EPA, Cincinnati, Ohio.

7.0 ATTACHMENTS

Attachment A - General Field Survey Data Sheets (3 Sheets)
Attachment B - Detailed Field Survey Data Sheet
Attachment C - Quantitative Study Data Sheets (2 sheets)

ATTACHMENT A
PAGE 1 OF 3

WATERBODY NAME OR DESCRIPTION
HYDROLOGY

ID

SITE NUMBER	
ON SITE	
OFF SITE	

FLOW (cfs)

DRY BED	(0)	
LOW	(1)	
MOD	(10)	
HIGH	(100)	
TIDAL	-	
N/A	-	

DEPTH (in)

DRY BED	(0)	
LOW	(6)	
MOD	(24)	
HIGH	(48)	
N/A	-	

SIZE (W') (Ac)

DRY BED	(0)	(0)	
LOW	(4)	(1)	
MOD	(12)	(5)	
HIGH	(25)	(10)	

SOURCE

GROUND/SPRINGS	
PRECIPITATION	
TRIBUTARY	
STORM SEWER	
SITE DRAINAGE	

ATTACHMENT A
PAGE 2 OF 3

WATERBODY NAME OR DESCRIPTION
WATERBODY

ID

SITE NUMBER
ON SITE
OFF SITE

MORPHOMETRY

CHANNELIZATION
POOLS
RIFFLES
CHUTES
MEANDERS

BANKS

EROSION/STABILITY
TREES
SHRUBS
GRASSES/WEEDS
MACROPHYTES

SUBSTRATE

CLAY
SILT/MUD
SAND
GRAVEL
COBBLE
RUBBLE

POLLUTION

COLOR/TURBID
DEBRIS/JUNK
OIL SLICKS
FOAM/SUDS
ODOR

ATTACHMENT A
PAGE 3 OF 3

WATERBODY NAME OR DESCRIPTION
LAND USE

ID

SITE NUMBER
ON SITE
ADJ TO SITE

OBSERVED LAND USES
UNDEVELOPED
RURAL
AGRICULTURAL
PARK
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
REFUSE
ABADONED

IMPACT
PRIMARILY PAST
SIGNIF CONT

PRESENT ECOL/FISH
NONE
LOW
HIGH

POTENTIAL ECOL/FISH
LOW
MOD
HIGH
COMMENT # (see sep sheet)
PHOTO #

PERIPHYTON
TYPE
PERCENT COVER

INVERTEBRATES
TYPES
R.A.

ATTACHMENT B

RECORD SHEET FOR DATA OBTAINED FROM DETAILED FIELD REVIEW

DETAILED FIELD SURVEY DATA SHEET

STREAM SURVEY — FISH COLLECTION

County: — T _____ R _____ Sec _____

STREAM — Township _____

Point of examination — Section No. — Description

GEAR USED — SMITH-ROOT TYPE VII ELECTROFISHER

Area covered

Immediate SHORE

TEMPERATURE--Air — Water

Weather (present and preceding)

WATER (Color, clarity, etc.)

AVERAGE WIDTH AND DEPTH — Current velocity

BOTTOM — pH

COVER — D.O.

VEGETATION — cond.

secchi

NATURAL FOOD

REMARKS

DATE — Time — Field No.

COLLECTOR

No.	GAME FISHES	Length	Weight	No.	FORAGE FISHES	Length	Weight
	Brook Trout						
	Brown Trout						
	Rainbow Trout						
	COARSE FISHES						

ATTACHMENT C (PAGE 1 OF 2)
RECORD SHEET FOR DATA OBTAINED FROM DETAILED FIELD SURVEYS

QUANTITATIVE STUDY DATA SHEET

__of__

Date:[ ][ ] / [ ][ ] / [ ][ ] Site:_____
mo day year

Station:[ ][ ][ ] Collectors:_____

Temperature: AIR (deg. C) [ ][ ][ ][.][ ] Vegetation:_____

WATER (deg. C) [ ][ ][ ][.][ ] _____

% Cover: [ ][ ][ ] Average Width and Depth:_____

_____

Secchi:[ ][ ][ ][.][ ] _____

pH: [ ][ ][.][ ] Field Calibration: [ ]

D.O. (mg/l): [ ][ ][.][ ] Field Calibration: [ ]

Conductivity (umhos):[ ][ ][ ][.][ ]

****POOL****

Width (m) [ ][ ][.][ ] % Periphyton Cover [ ][ ][ ]

	REP 1	REP 2	REP 3
Depth (cm):	[ ][ ][ ][.][ ] /	[ ][ ][ ][.][ ] /	[ ][ ][ ][.][ ]
Velocity (ft./sec.)	[ ][ ][.][ ]	[ ][ ][.][ ]	[ ][ ][.][ ]
SIEVES (kg)			
4 in. +	[ ][.][ ][ ]	[[.][ ][ ]	[ ][.][ ][ ]
No. 5	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 10	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 18	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 200	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
Benthos Bot.	[ ][ ][ ][ ][ ]	[ ][ ][ ][ ][ ]	[ ][ ][ ][ ][ ]

****RIFFLE****

Width (m) [ ][ ][.][ ] % Periphyton Cover [ ][ ][ ]

	REP 1	REP 2	REP 3
Depth (cm):	[ ][ ][ ][.][ ] /	[ ][ ][ ][.][ ] /	[ ][ ][ ][.][ ]
Velocity (ft./sec.)	[ ][ ][.][ ]	[ ][ ][.][ ]	[ ][ ][.][ ]
SIEVES (kg)			
4 in. +	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 5	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 10	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 18	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
No. 200	[ ][.][ ][ ]	[ ][.][ ][ ]	[ ][.][ ][ ]
Benthos Bot.	[ ][ ][ ][ ][ ]	[ ][ ][ ][ ][ ]	[ ][ ][ ][ ][ ]

REMARKS:_____

_____

_____

_____

_____

Reviewer: _____

ATTACHMENT C (PAGE 2 OF 2)
RECORD SHEET FOR DATA OBTAINED FROM DETAILED FIELD SURVEYS

QUANTITATIVE STUDY DATA SHEET (Cont'd)

SITE: _____
DATE: _____
STATION: _____

__of__
Periphytometer Installation: ( )( ) / ( )( ) / ( )( )
Periphytometer Removal: ( )( ) / ( )( ) / ( )( )

FISHERIES PROGRAM

Gear Used: Smith-Root Type VII Electrofisher
Time (24 hour clock) START: ( )( )( )( ) END: ( )( )( )( )

Species	Length (cm)	Weight (gm)	Bottle Number →
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
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( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )
( )( )( )( )( )	( )( )( ).( )	( )( )( )	( )( )( )( )( )( )

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		Applicability EMG	
		Prepared Earth Sciences	
Subject TERRESTRIAL ECOLOGICAL INVENTORY AND SAMPLING		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to present methodologies for surveying and sampling terrestrial vegetation and wildlife at hazardous waste sites.

2.0 SCOPE

The methodologies described in this procedure are appropriate for: identifying perturbations of terrestrial ecological communities which potentially relate to hazardous waste contamination; identifying potential transport mechanisms and food chain linkages for substances of public health concern; and providing the input to evaluate the feasibility and risks of remedial design alternatives. Methodologies presented herein cannot be assumed appropriate for all sites, because of site-specific health and safety constraints.

3.0 GLOSSARY

Community - Populations of plant and animal species which occur together over a given area.

Food Chain - The various pathways involved in transfer of food substances from the abiotic environment or from one organism or group of organisms to another organism or group of organisms.

Transport Mechanisms - The processes by which energy or substances move from one location to another. Can also refer to movement within an organism.

Wetlands - Areas of open shallow water or land vegetated by assemblages of plant species adapted to standing water, saturated soil or regular flooding. Methodological definition is presented in the January 10, 1989 "Federal Manual for Identifying and Delineating Jurisdictional Wetlands."

4.0 RESPONSIBILITIES

Site Manager - Responsible for ensuring that project-specific plans are reviewed by a qualified ecologist and the site Health and Safety Officer, and that plans and their implementation are in compliance with this guideline.

Project Biologist - Responsible for developing and implementing the sampling program, and interpreting the results of the program.

5.0 PROCEDURES

5.1 PROGRAM DESIGN

The site-specific terrestrial ecology field program will be part of the Field Sampling and Analysis Plan and should be designed after the following tasks have been completed:

- Determination by the Site Manager and project ecologist of the objectives of ecological field investigations;
- Review and analysis of all available site-specific information; and
- Consultation with the site Health and Safety Officer (HSO).

The objectives of most terrestrial ecology studies for hazardous waste site investigations can be met with utilization of available information and qualitative methodologies comprising a General Field Survey. In these instances, program design can be accomplished by the field biologist with review by the project ecologist and the HSO.

At those sites where quantitative information or sample collection is deemed necessary, the field program should be designed with input from a statistician. This is required not only to ensure usefulness of data collected, but also to minimize time spent in the field.

5.2 DATA RECORDING

Standard terrestrial ecology field data sheets (Attachment A identifies the types of forms needed to conduct quantitative plant sampling) should be used for General Field Surveys. In some instances (e.g., high winds or dense understory vegetation), compact bound water-resistant notebooks may be more appropriate. One page of each notebook should list all the information required to be recorded at each sampling or observation station, for reference while in the field.

Some investigations may require specially-designed data forms. These should include the following at a minimum:

- EPA Project Number, Site Name, and Location;
- Date and Time;
- Recorder (Investigator);
- Station location;
- Sample description and/or sample number, as appropriate;
- Weather conditions; and
- Record of any photographs taken.

5.3 PRE-FIELD INVESTIGATION ANALYSES

Prior to the field effort, all relevant available information should be reviewed. This phase is particularly important for hazardous waste site studies because typically employed field accessories such as binoculars, camera and field keys are difficult to use at sites of level C, B or A. At many sites, the quality and quantity of information obtained will be limited by the investigator's ability to identify plant and wildlife habitat features through a respirator mask. Hence, the pre-field investigation should include the following:

- Preliminary map or a listing of vegetation community types or wildlife habitat types likely to be encountered.

- Location of known important habitats or communities (e.g., wetlands, extensive undisturbed natural areas, and habitat for game species); and

- Access routes (paths, trails accommodating all terrain vehicles, etc.) as well as emergency egress routes and safety stations.

Sources of information to be sought and consulted should include, but are not limited to, the following:

- Aerial photography;
- USGS topographic maps;
- USGS County soil survey;
- Historical flood records and 100-year flood insurance maps;
- State wetland maps;
- Observations and photographs obtained by previous investigators (e.g., FIT team or site reconnaissance survey);
- County extension agents for wildlife and forestry data;
- State field biologists;
- Published literature on natural vegetation (e.g., Kuchler, 1964; Eyre, 1980; Braun, 1950); and
- State or federal endangered species specialists where appropriate.

5.4 GENERAL FIELD SURVEY

The General Field Survey comprises a series of observations and measurements recorded at plots located to achieve a representative sampling of the site and coverage of any known important areas. Standard quantitative data sheets (see Attachment A) should be compacted at each plot location; however, if time and cost is of a concern, then a qualitative study using site characterization sheets (Attachment B) may be an option.

Vegetation observations should include a listing of characteristic species by strata:

- Lower stratum includes dominant herbaceous species and those woody plants 50 cm (knee-high) or less high;
- Middle stratum includes woody plants higher than 50 cm and of stem diameter less than 2.5 cm;
- Lower canopy stratum includes woody plants with stems of diameter ranging from (2.5 cm to 10 cm) 1 inch to 4 inches at chest height; and
- Upper canopy stratum includes trees with stem diameter greater than 10 cm (4 inches).

Emphasis is on plant species which, because of their abundance appear to define a community type; are potentially part of the human food chain (e.g., berries and nuts); or are consumed by game species. Wetland communities warrant greater detail because they can constitute important wildlife habitat, particularly for waterfowl, and are likely sinks for water-borne contaminants. At a minimum, the field investigator should record sufficient data for applying in a qualitative manner the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands."

Observations relating to wildlife may also be recorded. In addition to actual sightings, observations includes tracks, dens, nests, scat, browsing signs, etc. Particular attention should be accorded to game species, which can constitute a link between contaminants and the human food chain. Important classes of game species to be considered include waterfowl, mourning dove, upland game birds, deer, rabbit and squirrel. Waterfowl, are of particular concern at hazardous waste sites since they can be abundant, are mobile, utilize wetland habitats serving as contaminant sinks, and can be heavily harvested for human consumption.

Observations of perturbations are important for interpreting cycling processes and identifying potential transport mechanisms. Typical observations of stress include:

- Bare soil resulting from erosion, flooding, vehicular use or toxicity;
- Occurrence of contaminant residues;
- Construction and other human induced disturbances;
- Fire;
- Heavy grazing or browsing;
- Unexplained mortality (e.g., standing dead tree boles); and
- Insect and disease damage

An inventory of selected areas adjacent to the site can greatly improve the usefulness of the General Field Survey. In some instances, off-site areas will support the same kinds of ecosystem occurring on-site, but in less disturbed states. Comparison of off-site with on-site ecosystems may provide some indication of the nature and degree of any on-site stresses. It is also important to identify and characterize possible off-site ecosystems that may serve as receptors for air-borne or water-borne contaminants originating on-site. An inventory of productive wildlife habitat in the region surrounding the site can provide a better estimate of potential wildlife usage of on-site areas by mobile species.

5.5 SPECIAL INVESTIGATIONS

At some hazardous waste sites it may be necessary to quantitatively estimate abundance of plant or animal species, or collect samples for chemical analysis. For these objectives, methodologies may have to meet statistical criteria as well as the site-specific health and safety considerations. Methodologies described below are standard, but not necessarily appropriate for all sites because of health and safety constraints. Selection of appropriate methodologies for quantitative studies at a particular site must include the involvement of an ecologist, statistician and health and safety specialist.

5.5.1 Abundance Estimates

Vegetation

Vegetation abundance may be measured in terms of stem density or cover. These measurements are obtained from nested plots, or quadrats; smaller-sized plots, used to sample the lower and middle strata, are contained ("nested") within larger plots used for sampling lower and upper canopy plants. Quadrat and nested sub-plot size may vary with sampling objectives.

Stem density is obtained by counting number of stems per plot. Cover is the percent of ground shaded by all the individuals of one species with the sun directly overhead, and may be estimated by eye to the nearest percent. Where more precise measures of cover of herbaceous and low shrubs is required, the point-frequency and line-intercept methods, respectively, may be considered.

Plots are regularly spaced along transects. Number of transects and number of plots will depend on floral diversity and objectives of program. Sampling adequacy can be based on species-area curves.

Wildlife

Determination of wildlife species occurrence and estimation of density require special techniques depending on species of interest, season, and site features. Standard methods for detecting presence of secretive species include, but are not limited to, the following:

- Live and snap trapping (small mammals);
- Pit trapping (small mammals, reptiles, and amphibians);
- Spot-light surveys (nocturnal species);
- Tape recordings and call counts (amphibians and birds);
- Mist netting (birds and bats);
- Berlese or Tullgren funnels (soil invertebrates); and
- Sweep netting (insects).

Use of most of these techniques is discussed in Schemnitz, (1980). For information on use of funnels for sampling soil invertebrates, consult Bender et al. (1972), and on sweep netting and insect sampling in general, consult Menhinick (1963) and Southwood (1966).

Traps should be set at roughly regular intervals along survey lines located in each of the habitat types to be sampled. Spacing and number of traps will depend on species, territory size, trapping efficiency, program objectives, and investigator's knowledge of species-specific behavior patterns. Spotlight searches and the playing of sound recordings are conducted at regular intervals along survey lines, with consideration for territory size and individual species behavior. Mist nets are located in areas likely to intercept low-flying birds; and likely locales can be selected based on feeding habits and site habitat features.

For most species, standard quantitative measures of wildlife density involve total counts, sample counts or mark-and-recapture. Assumptions and formulae for estimating population densities from these techniques are presented in Wildlife Management Techniques (Schemnitz, 1980), and White et al. (1982). Density estimates are time-specific, as populations of most animals fluctuate greatly from season-to-season and year-to-year.

5.5.2 Collecting Specimens for Chemical Analysis

The objectives of collecting plant and animal specimen for chemical analyses are to (1) identify occurrence of elevated concentrations of potential contaminants, (2) identify gradients of contaminant concentration, and/or (3) quantitatively determine concentrations in particular target species. For the latter two objectives a statistical approach will have to be developed to determine number of samples per tissue type, species, location, etc.

Selection of species for chemical analysis will depend on the program objectives, nature of suspected contaminants, and ecosystems occurring on-site. In most instances, species selected will either be a possible component of the human food chain, or a known bioaccumulator of the contaminant(s) of concern.

In developing a sampling plan and while collecting plant specimens, a number of factors have to be considered which influence concentrations of substances in vegetation. Concentrations may vary with height above ground, distance from plant perimeter, species, and plant tissue (e.g., leaf, root, current year stem, old growth stem and fruit). Many substances are relatively immobile in plants,

tending to accumulate at exterior surfaces where concentrations may be affected by rainfall washing and leaching. Soil factors can greatly influence substance availability for plant uptake and thus tissue concentrations.

After sampling design has been determined, consult with the analytical laboratory for proper containers and storage procedures. For most sampling efforts, zip-lock plastic bags will be adequate. Animal specimen should be stored in refrigerated containers and then frozen until laboratory analysis.

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7.0 ATTACHMENTS

Attachment A - Typical Terrestrial Ecology Field Data Sheet
Attachment B - Site Characterization

ATTACHMENT A

TYPICAL TERRESTRIAL ECOLOGY FIELD DATA SHEET

SITE: _____

INVESTIGATOR: _____ DATE: _____

SAMPLING LOCATE OR TRANSECT: _____

PLOT: _____

REVIEWED: _____

EACH QUANTITATIVE PLANT SAMPLING FORM SHOULD FEATURE ONE OF THE FOLLOWING:

- Upper Canopy (stem diameter > 10 cm): Listing at a minimum each individual by species and DBH (diameter at breast height)
- Lower Canopy (2.5 cm < stem diameter < 10 cm): Listing at a minimum each individual by species and DBH
- Middle Stratum (Height > 50 cm and stem diameter < 2.5 cm and woody vines): Listing at a minimum each species and percent cover.

  Lower Stratum (all herbs; woody spp. < 50 cm tall): Listing at a minimum each species and percent cover.

<u>NOTING</u>:

- Terrain features
- Disturbances
- Wildlife Observations
- Wetlands
- Etcetera

ATTACHMENT B

SITE CHARACTERIZATION

1. **General Information:**

Site ID Number: _____
County: _____
Section: _____
Watershed: _____
Date: _____
Observers: _____ _____
Air Photo Reference: _____
Photographs Taken: _____

2. **Topography and Soils:**

Elevation: _____ Slope Percent: _____
Slope Position: _____ Aspect: _____
Soils: _____

3. **Vegetation (Cover Classes(1)):**

		Tree Stratum	Shrub Stratum	Herb Stratum
Cover (%):				
Cover Type:				
Association:				
Average Height Dominants:				
Average DBH Dominants:				
Species Composition and Abundance:				
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				

ATTACHMENT B
SITE CHARACTERIZATION
PAGE TWO

3. **Vegetation (Cover Classes[1]) (CONTINUED):**

		Tree Stratum	Shrub Stratum	Herb Stratum
Cover (%):				
Cover Type:				
Association:				
Average Height Dominants:				
Average DBH Dominants:				
Species Composition and Abundance:				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

(1) Cover classes (midpoints): T < 1% none; 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

4. **Wildlife:**

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		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved D. Senovich	

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1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION [SEE WORKPLAN AND QAPP]

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration**: The expected concentration (i.e., low, medium, high).
- **Sample Type**: Grab or composite.
- **Preservation**: Type of preservation added and pH levels.
- **Analysis**: VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By**: Printed name of the sampler.
- **Case Number**: Case number assigned by the Sample Management Office.
- **Traffic Report Number**: Number obtained from the traffic report labels.
- **Remarks**: Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag [SEE QAPP]

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a w[illegible]e, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w[illegible]or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and i[illegible]ovided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la[illegible]atory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code**: Work Assignment Number.
- **Station Number**: The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year**: Same as Date on Sample Label.
- **Time**: Same as Time on Sample Label.
- **Designate - Comp/Grab**: Composite or grab sample.
- **Station Location**: Same as Station Location on Sample Label.
- **Samplers**: Same as Sampled By on Sample Label.
- **Preservative**: Yes or No.
- **Analyses**: Check appropriate box(es).

- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES [See also QAPP]

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the ~~sample log sheet and Chain-of-Custody Record exactly~~ Field Custody Card (See attached).

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment [See also QAPP]

Samples are accompanied by a Chain-of-Custody Record Form. ~~Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office~~. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- ~~Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.~~
- ~~Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.~~
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. ~~Custody seals are provided by ZPMO on an as-needed basis.~~
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

PROJECT NAME

SAMPLERS: *(Signature)*

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS							REMARKS

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks:	

ATTACHMENT B
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II
(Original is 8 by 10-1/2)

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY - REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08837

Name of Unit and Address				
Sample Number	Number of Containers	Description of Samples		
Person Assuming Responsibility for Samples			Time	Date

Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME	NO. OF CONTAINERS	REMARKS
SAMPLERS: (Signature)			

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS								REMARKS

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

D32401

ATTACHMENT D
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV
(Original is 8-1/2 by 14)

SEE Rust E&I form

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 4

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ NO.	PROJECT NAME					NO. OF CONTAINERS	Water/Wastewater	Soil/Sed.	Sldg/Waste	Misc.	REMARKS/TAG NUMBERS
SAMPLERS (Signature)											
STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION						

Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	Remarks
Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	

DISTRIBUTION: Original and Pink copies accompany sample shipment to laboratory. Pink copy retained by laboratory. Yellow copy retained by samplers. Blue copy extra copy as needed.

№ 4 3526

RUST ENVIRONMENT & INFRASTRUCTURE

Chain of Custody Record

Custody Seal #	RUST E&I Cooler #

Project Number	Project Name/Client

Sample Custodian: (Signature)

Item No.	Sample Description (Field ID Number)	Date	Time	Grab	Comp.	PID Reading (ppm)	Label Number	Analysis Required											Preservative Type	X-Field Filtered	Matrix: Sample Type: Soil	Groundwater	Surface Water	Sediment	Leachate	Sample Container: 40 mil VOA	120 mil VOA	8 oz	1 Litre Amber	1 Litre HDPE
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
10																														
11																														
12																														
13																														
14																														
15																														
16																														
17																														
18																														
19																														
20																														

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Disposed of by: (Signature)	Items:	Date/Time
Relinquished by: (Signature)	Date/Time	Received by: (Signature) [Laboratory]	Disposed of by: (Signature)	Items:	Date/Time

Send Lab Results To:	Remarks:	Check Delivery Method:	Laboratory Receiving Notes:
	Federal Express Airbill No.: Lab:	☐ Samples delivered in person ☐ Common carrier	Custody Seal Intact? Temp. of Shipping Container: Sample Condition:

FIELD CUSTODY CARD

Sample Number	Number of Bottles and Type	Depth	PID	Date	Time

Relinquished By _____ Date _____ Time _____

To _____

Relinquished By _____ Date _____ Time _____

To _____

EXAMPLE

ATTACHMENT E
SAMPLE LABEL

NUS Corporation PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

~~Case No.: _____ Traffic Report No.: _____~~

Remarks:

ACFILE: FORMS\BOTLABL

[See also Rust E&I sample label]

SAMPLE LABEL

RUST Environment & Infrastructure
4738 North 40th St., Sheboygan, WI 53082
Client:
Site:
001
Sample No: .
Analysis: .
Preservative: .
Date:___/___/___ Time:___:___ By:_____

ATTACHMENT F
SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Project Code

Station No.

Month/Day/Year

Time

Designate: Grab / Comp.

Station Location

Samplers (Signatures)

Preservative:
Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No. 3 60966

Lab Sample No.

EXAMPLE

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

CUSTODY SEAL

Date

Signature

[See also Rust E&I Custody Seal]

CUSTODY SEAL

RUST ENVIRONMENT & INFRASTRUCTURE

Custody Seal #

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.2	Page 1 of 12
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE PACKAGING AND SHIPPING		Approved D. Senovich	

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1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (>13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	[illegible]	CONTAINER NUMBERS	PIC	BURE
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-[illegible]	C	1	✓	
1	55 gal	450 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-[illegible]	—	2		✓
1	55 gal	250 lbs	x	Flammable liquid, n.o.s	Flammable liquid	55-[illegible]	B	3	✓	
1	16-A	12 lbs.	x	Bromine	Corrosive Material	55-[illegible]	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd _____

Shipment Date _____ Manifest No _____

Shipper Work Order _____

Service Order No _____

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NOTE: See also Rust E&I forms

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1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of.

3.0 GLOSSARY

Controlled Document - A consecutively-numbered form released by EPA for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

4.0 RESPONSIBILITIES

Field Operations Leader - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test forms (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 Sample Label

The sample label is a 2- by 4-inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1.

5.1.2 Sample Identification Tag

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

5.1.3 Chain-of-Custody Record Form

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in Zone 1 uses a

slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. Chain-of-custody record forms for Regions I, II, and IV are illustrated in SA-6.1 as well as procedures for filling out forms.

5.1.4 Chain-of-Custody Seal

Attachment B-4 is an example of a custody seal. The Custody seal is a 1- by 3-inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

5.1.5 Bottle Delivery Order (DO) Form

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

5.1.6 Repository Packing List (PL) Form

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

5.1.8 Sample Log Sheet

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

5.1.10 Traffic Report Label

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.

5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations
Attachment B-1 - Sample Label
Attachment B-2 - Sample Identification Tag
Attachment B-3 - Chain-of-Custody Record From, Region III
Attachment B-4 - Chain-of-Custody Seal
Attachment B-5 - CLP Sample Bottle Repository Order Form
Attachment B-6 - Repository Packing List Form
Attachment B-7 - Groundwater Sample Log Sheet Form
Attachment B-8 - Soil Sample Log Sheet Form
Attachment B-9 - Surface Water Sample Log Sheet Form
Attachment B-10 - Container Sample Log Sheet Form
Attachment B-11 - Organics Traffic Report Form
Attachment B-12 - Inorganics Traffic Report Form
Attachment B-13 - Traffic Report Labels
Attachment B-14 - Special Analytical Services (SAS) Packing List
Attachment B-15 - Dioxin Shipment Record Form
Attachment B-16 - Sample Shipping Log
Attachment C-1 - Groundwater Level Measurement Sheet
Attachment C-2 - Pumping Test Data Sheet
Attachment C-3 - Hydraulic Conductivity Testing Data Sheet
Attachment C-4 - Packer Testing Report Form
Attachment C-5 - Summary Log of Boring
Attachment C-6 - Overburden Monitoring Well Construction Sheet
Attachment C-7 - Confining Layer Monitoring Well Construction Sheet
Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet
Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-11 - Test Pit Log Form
Attachment D-1 - Equipment Calibration Log

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP Number	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
B-5	CLP Sample Bottle Repository Form	SA-6.6	Required
B-6	Repository Packing List Form	SA-6.6	Required
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
B-9	Surface Water Sample Log Sheet	SA-6.6	Required
B-10	Container Sample Log Sheet	SA-6.6	Required
B-11	Organics Traffic Report Form	SA-6.6	Controlled
B-12	Inorganics Traffic Report Form	SA-6.6	Controlled
B-13	Traffic Report Labels	SA-6.6	Controlled
B-14	Special Analytical Services (SAS) Packing List	SA-6.6	Required
B-15	Dioxin Shipment Record Form	SA-6.6	Required
B-16	Sample Shipping Log	SA-6.4	Required
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
C-2	Pumping Test Data Sheet	GH-2.3	Required
C-3	Hydaulic Conductivity Testing Data Sheet	GH-2.4	Required
C-4	Packer Testing Report Form	GH-2.2	Required
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
C-7	Confining Layer Monitoring Well Construction Sheet	GH-1.5	Required
C-8	Bedrock (Open Hole) Monitoring Well Construction Sheet	GH-1.5	Required
C-9	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-10	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-11	Test Pit Log	GH-1.8	Required
D-1	Equipment Calibration Log	----	Required

ATTACHMENT B-1

SAMPLE LABEL

PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

See SOP SA-6.1

ATTACHMENT B-2

SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signature)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No. 3 60966

Lab Sample No.

ATTACHMENT B-3

CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME					NO. OF CONTAINERS								REMARKS
SAMPLERS: (Signature)														
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION									

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

D334901

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

CUSTODY SEAL

Date

Signature

See SOP SA-6.1

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

REQUEST NO. _____

Date of Request: _____

Type of Request:
Routine [ ]
Fast Turnaround [ ] _____
Emergency [ ] _____
(Date/Time request called in)

From (Name): _____
Affiliation: _____
Telephone: _____
AR Signature: _____

TO: I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782/3095

Ship the following items for arrival by: _____ (Date)
(If applicable) Ship to arrive no earlier than: _____ (Date)

Item		Description	No. of Items Per Case	No. of Cases Requested
A	80-oz.	amber glass bottle	6	
B	40-ml	glass vial	72	
C	1-liter	polyethylene bottle	12	
D	120-ml	wide-mouth glass vial	12	
E	1-oz.	wide-mouth glass jar	12	
F	8-oz.	wide-mouth glass jar	12	
G	4-oz.	wide-mouth glass jar	12	
H	1-liter	amber glass bottle	12	
J	32-oz.	wide-mouth glass jar	12	
K	4-liter	amber glass bottle	4	
L	500-ml	polyethylene bottle	24	

Ship To: _____
(Provide street address) _____
Attention: _____
Call before delivery: _____
(Phone No.): _____

DISTRIBUTION: *White-Repository* *Yellow-Requestor* *Pink-SMO*

ATTACHMENT B-6

CLP SAMPLE BOTTLE REPOSITORY SUPERFUND PACKING LIST

REPOSITORY

I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782-3905

DELIVERY REQUEST NO. _____

Request date: _____

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: _____

DESTINATION (from Delivery Request)

Name: _____

Address: _____

_____

_____

Telephone No: _____

The materials listed below have been shipped as requested.

Date Shipped: _____

Mode of Shipment: _____

Shipment ID No: _____

Signature: _____

Type of Shipment: ___ Complete ___ Partial ___ Partial/Completes Request

Item No.	Description		No. of Cases Shipped	Lot Number(s)	QC Clearance Number(s)
A	80-oz	glass			
B	40-mL	glass			
C	1-L	poly			
D	120-mL	glass			
E	16-oz	glass			
F	8-oz	glass			
G	4-oz	glass			
H	1-L	glass			
J	32-oz	glass			
K	4-L	glass			
L	500-mL	poly			

AUTHORIZED REQUESTOR USE ONLY

Sign below and forward the yellow copy to the Sample Management Office (SMO) within 7 days of shipment receipt. Keep the pink copy for your file.

The above request was received by the designee, inspected, and accepted.

Date of Receipt: _____ Requestor Signature: _____

Send yellow copy to: USEPA Sample Management Office
P.O. Box 818
Alexandria, VA 22313

DISTRIBUTION: *White—Shipment Designee*
Blue—Shipping Contractor
Green—SMO
Yellow—Requestor (for return to SMO)
Pink—Requestor
Gold—Repository

ATTACHMENT B-7

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page ____ of ____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					
Signature(s):	Observations / Notes:				

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B-8

SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other _____

Page ____ of ____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

	Composite Sample Data		
Sample Method:	Sample	Time	Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			
Type of Sample ☐ Low Concentration ☐ High Concentration ☐ Grab ☐ Composite ☐ Grab - Composite			
	Sample Data		
	Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)	
Analysis:	Observations / Notes		

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B-9

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page ____ of ____

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Depth Sampled:				
Sample Date & Time:				
Sampled By:				
Signatures:				

Type of Sample

☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

ATTACHMENT B-10

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Container Data

Page ____ of ____
Case # ____
By ____

Project Site Name ____ Project Site Number ____
NUS Source No. ____ Source Location ____

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other ____ ____ ☐ Bag / Sack ☐ Tank ☐ Other ____ ____	Color ____ Condition ____ Markings ____ Vol. of Contents ____ Other ____

Disposition of Sample	Sample Description	Layer 1	Layer 2	Layer 3
☐ Container Sampled ☐ Container opened but not sampled. Reason ____ ____ Container not opened. Reason ____ ____	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	____	____	____
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
	% of Total Volume	____	____	____
	Other	____	____	____

	Type of Sample		
Monitor Reading:	☐ Low Concentration ☐ High Concentration		☐ Grab ☐ Composite ☐ Grab - Composite
Sample Method:			
Sample Date & Time:		Organic	Inorganic
	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-11

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE

CASE NO:

SAS NO: (IF APPLICABLE)

ORGANIC TRAFFIC REPORT

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER
NPLD O&M OTHER _____
NON-SUPERFUND—_____ PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

TRIPLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	SAMPLE DESCRIPTION ⑥ (FROM BOX 1) 1 2 3 4 5 6 7	CONCENTRATION ⑦ L - LOW/MED H - HIGH (SAS)	RAS ANALYSIS ⑧ VOLATILE	BASE/NEUT ACID	PESTICIDE /PCB's		SPECIAL HANDLING ⑨	STATION LOCATION ⑩

EPA Form 2075-7 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-12

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE

CASE NO:

SAS NO: (IF APPLICABLE)

INORGANIC TRAFFIC REPORT

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RFS RO RA ER NPLD O&M OTHER _____
NON-SUPERFUND— _____ PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN:

SAMPLING DATE: ④

BEGIN: END:

DATE SHIPPED: CARRIER: ⑤

AIRBILL NO:

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7 Ⓐ	CONCENTRATION L = LOW M = MED H = HIGH (SAS) Ⓑ	RAS ANALYSIS Ⓒ: TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS): pH	CHEMICAL INTEF	GRAVIMETRIC	SPECIAL HANDLING Ⓓ	STATION LOCATION Ⓔ

EPA Form 2075-6 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-13

TRAFFIC REPORT LABELS

MAB 342

C 6003

AC 865 · Soil/Sediment (VOA)

ATTACHMENT B-14

U.S. ENVIRONMENTAL PROTECTION AGENCY
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: 703/557-2490 - FTS/557-2090

SAS Number

SPECIAL ANALYTICAL SERVICE
PACKING LIST

Sampling Office:	Sampling Date(s):	Ship To:	For Lab Use Only
Sampling Contact: (name)	Date Shipped:		Date Samples Rec'd:
(phone)	Site Name/Code:	Attn:	Received By:

Sample Numbers	Sample Description i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

For Lab Use Only

White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy

ATTACHMENT B-15

USEPA Contract Laboratory Program
Sample Management Office
P O Box 818 Alexandria Virginia 22313
FTS 8-557-2490 703 557-2490

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

Site Name	Sampling Office	Ship To	FOR LAB USE ONLY Date Samples Rec'd
City & State	City & State		
EPA Site No	Sampling Contact (name)	Date Shipped	Received By
Latitude		Transfer To	Date Samples Rec'd
Longitude	Sampling Date		
Tier 1 2 3 4 5 6 7 (circle one)	Data Turnaround 15-Day ___ 30-Day ___	Date Shipped	Received By

SAMPLE NUMBERS	MATRIX: SOIL SEDIMENT	MATRIX: OTHER	DESCRIPTION: FIELD SAMPLE	DESCRIPTION: SAMPLE NO DUPLICATE	DESCRIPTION: SAMPLE NO SPIKE	DESCRIPTION: IN ORIG	DESCRIPTION: COMPOSITE SINGLE	DESCRIPTION: OTHER (SPECIFY)	ADD'L ANALYSIS: SPECIFY (SEE ORIG.)	FOR LAB USE: SAMPLE CONDITION ON RECEIPT

WHITE [illegible] YELLOW [illegible] Copy PINK [illegible] GOLD [illegible]

ATTACHMENT B-16

page___ of ___ EPA SAMPLE SHIPPING LOG FOR ALL SAMPLES SENT THROUGH THE CONTRACT LAB PROGRAM (12/85 version)

CASE#_____ SAS#_____ SITE NAME:_____

Site Leader:_____ EPA Project Officer:_____

Phone:

SAS REQUEST:(details required)

QC SAMPLE Info AND/OR COMMENTS	CONC. (low/med/high)	SAMPLE MATRIX (aq/sol)	TYPE OF REQUEST org.dio inor. SAS	SAMPLE TRAFFIC REPORT NUMBER	ORGANICS OR INORGANICS		DATA RECEIVED XX out -items not requested						LAB NAME	SAS REQUEST (itemize)	DATE SHIPPED	DATA REC'D
					LAB NAME	DATE SHIPPED	VOA	BNA	PEST	TCDD	METALS	CN				

ATTACHMENT C-1

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____
Project No.: _____
Personnel: _____
Date: _____

LOCATION

Municipality: _____
County: _____
State: _____
Street or Map Location (If Off-Site) _____

WEATHER CONDITIONS

Temperature Range: _____
Precipitation: _____
Barometric Pressure: _____

Equipment No.: _____
Equipment Name: _____
Latest Calibration Date: _____

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT C-2
PUMPING TEST DATA SHEET

PUMPING TEST DATA SHEET ***NUS CORPORATION***

PROJECT NAME: _____ MEASURED WELL: _____
PROJECT NO.: _____ DATE: _____ PUMPING WELL: _____
GEOLOGIST: _____ CHECKED: _____ TEST NO. _____
DISTANCE FROM PUMPING WELL(ft.)(r): _____ PUMP SETTING, FEET BELOW MONITORING POINT: _____
STATIC H_2O LEVEL (ft.)(s_o): _____ MONITORING POINT: _____
TIME PURGE START OR STOP (t_o): _____ ELEVATION OF MONITORING POINT (ft. above MSL) _____

TIME	(t) MIN. SINCE PUMP START OR STOP	WATER LEVEL MEASUREMENTS (ft.)			(s) DD Or RECOVERY (ft.)	PUMPING RATE (Q) GPM	REMARKS
		READING	CORRECTION	DTW			

ATTACHMENT C-3

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO. .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

ATTACHMENT C-4
PACKER TESTING REPORT FORM

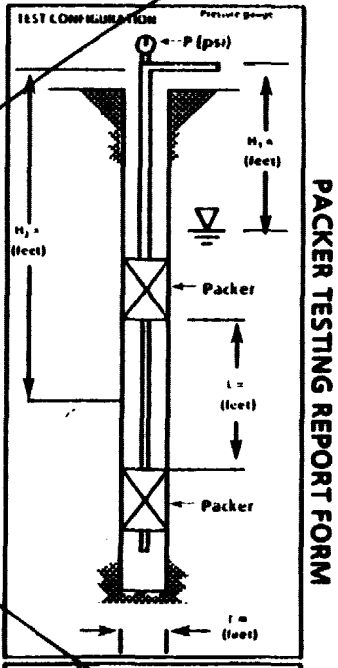
PACKER TEST REPORT

PROJECT: _____
BORING NO.: _____ CASING DEPTH: _____
TEST INTERVAL: _____

PROJECT NO.: _____ TEST NO: _____
CONTRACTOR: _____
BY: _____ CHECKED: _____

PAGE _____ OF _____
STATIC WATER LEVEL _____
PACKER PRESSURE _____

Flow Test					Calculated Results							
Pressure, P (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	H_2 = P(psi) × 2.31 (psi)	H_3* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp Q/H	K (cm/sec) = 9.67 × 10⁻⁷ × K (ft/yr)



* Length of test section in feet L	Cp (Standing Water Level)			
	1 ft	2 ft	5 ft	10 ft
1	31,000	40,000	25,000	23,000
2	15,000	18,000	13,000	15,000
5	9,000	9,000	8,000	8,000
10	6,000	6,000	6,000	5,000
10	5,000	5,000	5,000	5,000
15	4,000	3,000	3,000	3,000
20	3,000	3,000	3,000	2,000

CP = (1/(2 π L)) ln(L/r) (70,315.5)
7.48 Gallons = 1 ft³
1 psi = 2.31 ft head

* H_1 is used when the test length is below the water table
H_3 is used when the test length is above the water table

Remarks: _____

ATTACHMENT C-5

BORING LOG **NUS CORPORATION**

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA : .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR ROD	DEPTH (Ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	BORUSCOSCK	BORKESNESS	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

ATTACHMENT C-5 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS
More than half of material is LARGER than No 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50% or more of coarse fraction retained on No 4 sieve	CLEAN GRAVELS Little or no fines	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel sand mixtures, little or no fines
	GRAVELS WITH FINES Appreciable amount of fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures
SANDS 50% or more of coarse fraction passes No 4 sieve	CLEAN SANDS Little or no fines	Wide range in grain size and substantial amounts of all intermediate particle sizes	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS WITH FINES Appreciable amount of fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures

FINE GRAINED SOILS
More than half of material is SMALLER than No 200 sieve size

Identification procedures on fraction smaller than No 40 sieve size

	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

LEGEND

SOIL SAMPLES - TYPES

S 2" O.D. Split Barrel Sample
ST 3" O.D. Undisturbed Sample
O Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

N NX (Conventional) Core (~2 1/8" O.D.)
Q NQ (Wireline) Core (~1 7/8" O.D.)
Z Other Core Sizes, Specify in Remarks

WATER LEVELS

12/10
▽ 12.6' Initial Level ~Date & Depth

12/10
▽ 12.6' Stabilized Level ~Date & Depth

D334901

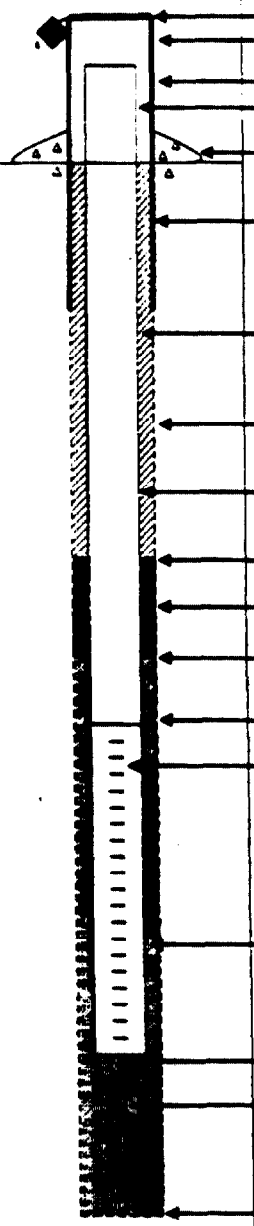
ATTACHMENT C-6

NUS CORPORATION
A Halliburton Company

BORING NO. _____

OVERBURDEN
MONITORING WELL SHEET

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-7

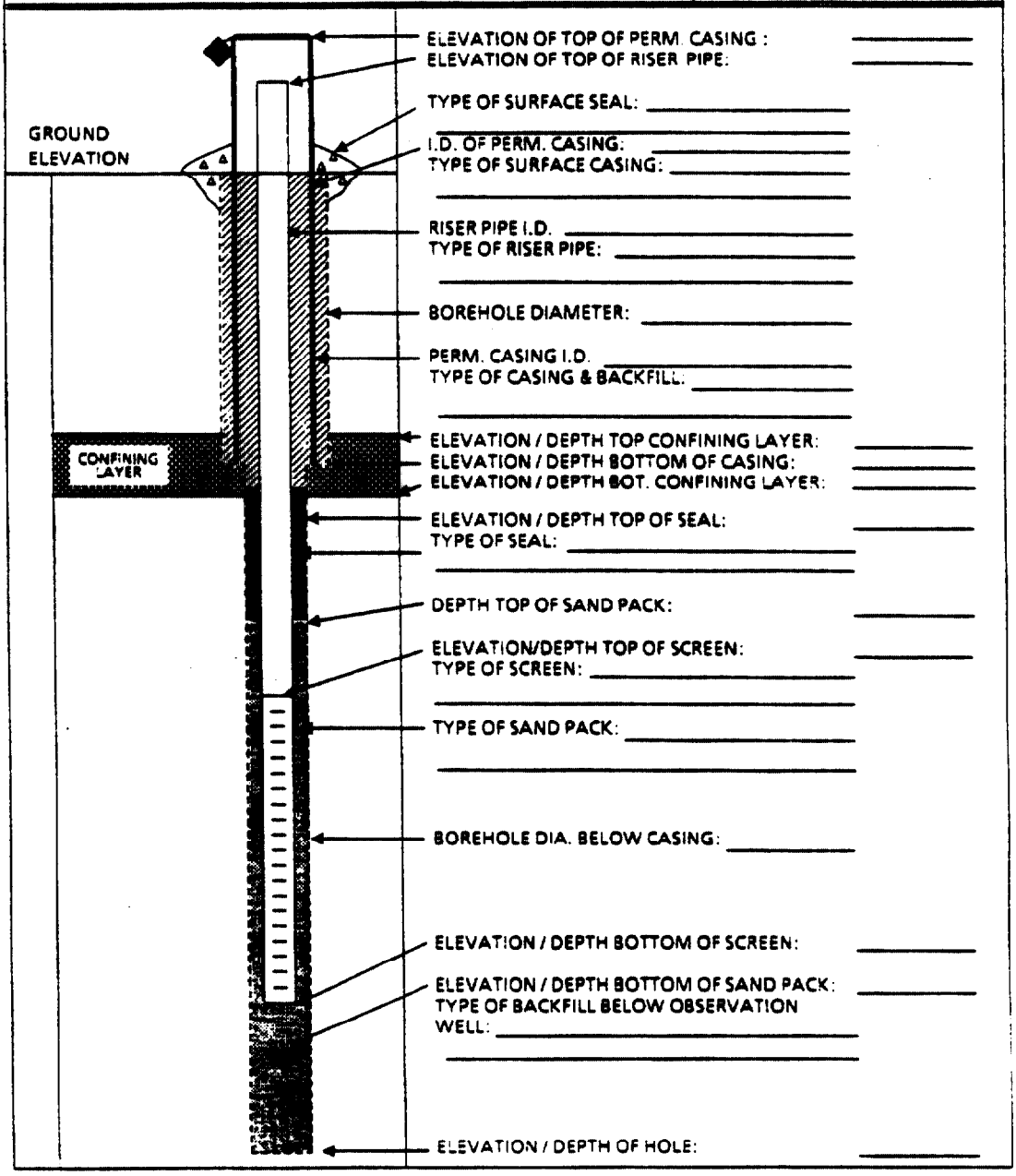
NUS CORPORATION

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

11-5-87

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ATTACHMENT C-8

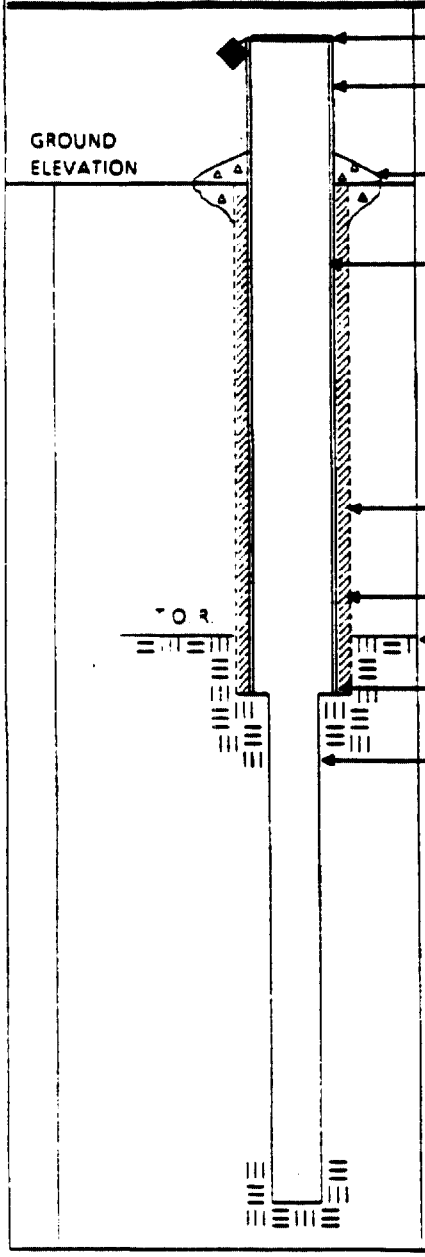
NUS CORPORATION
A Halliburton Company

BORING NO.: _____

BEDROCK MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

_____

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

_____

_____

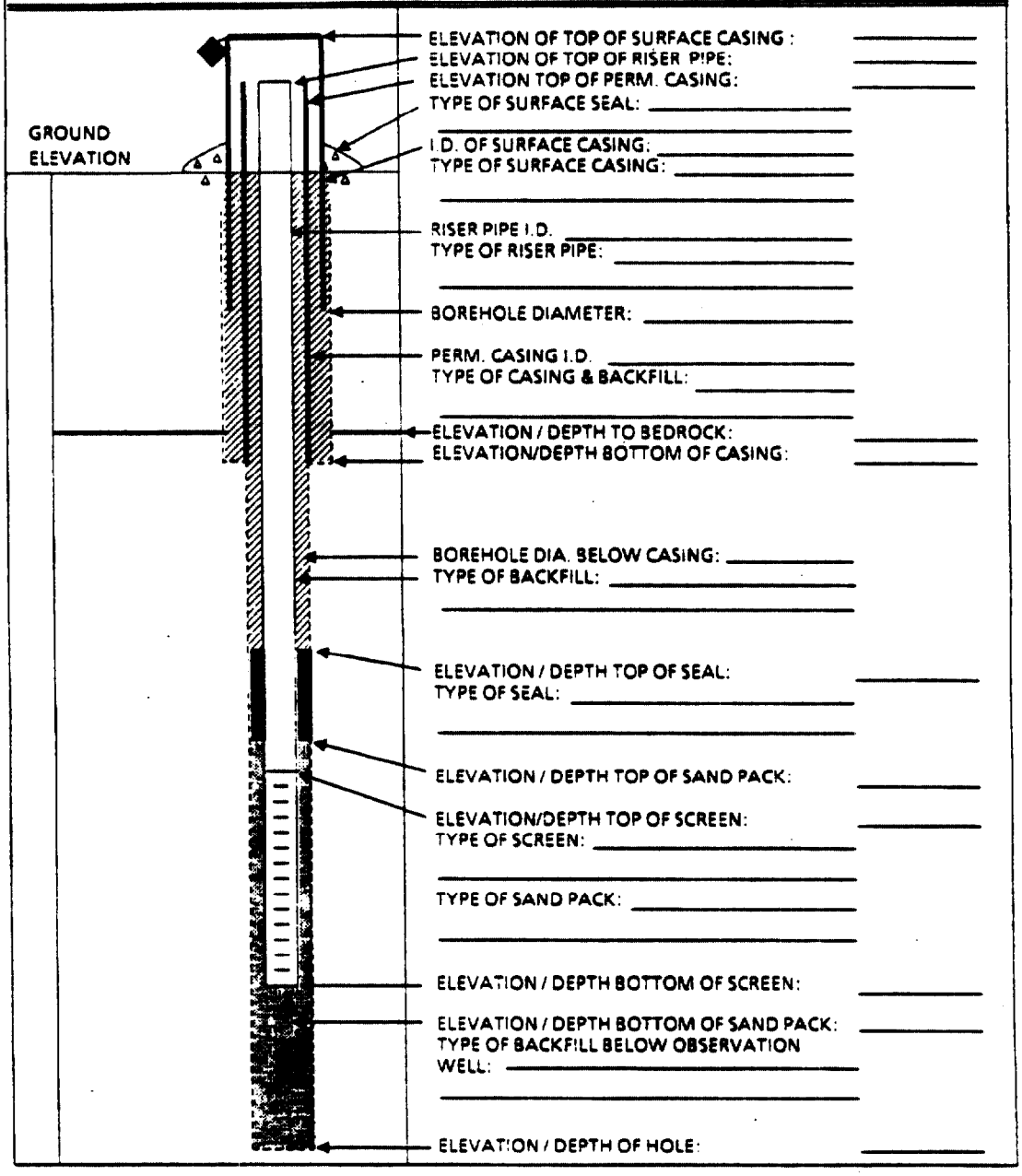
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-9

BORING NO : _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ATTACHMENT C-10

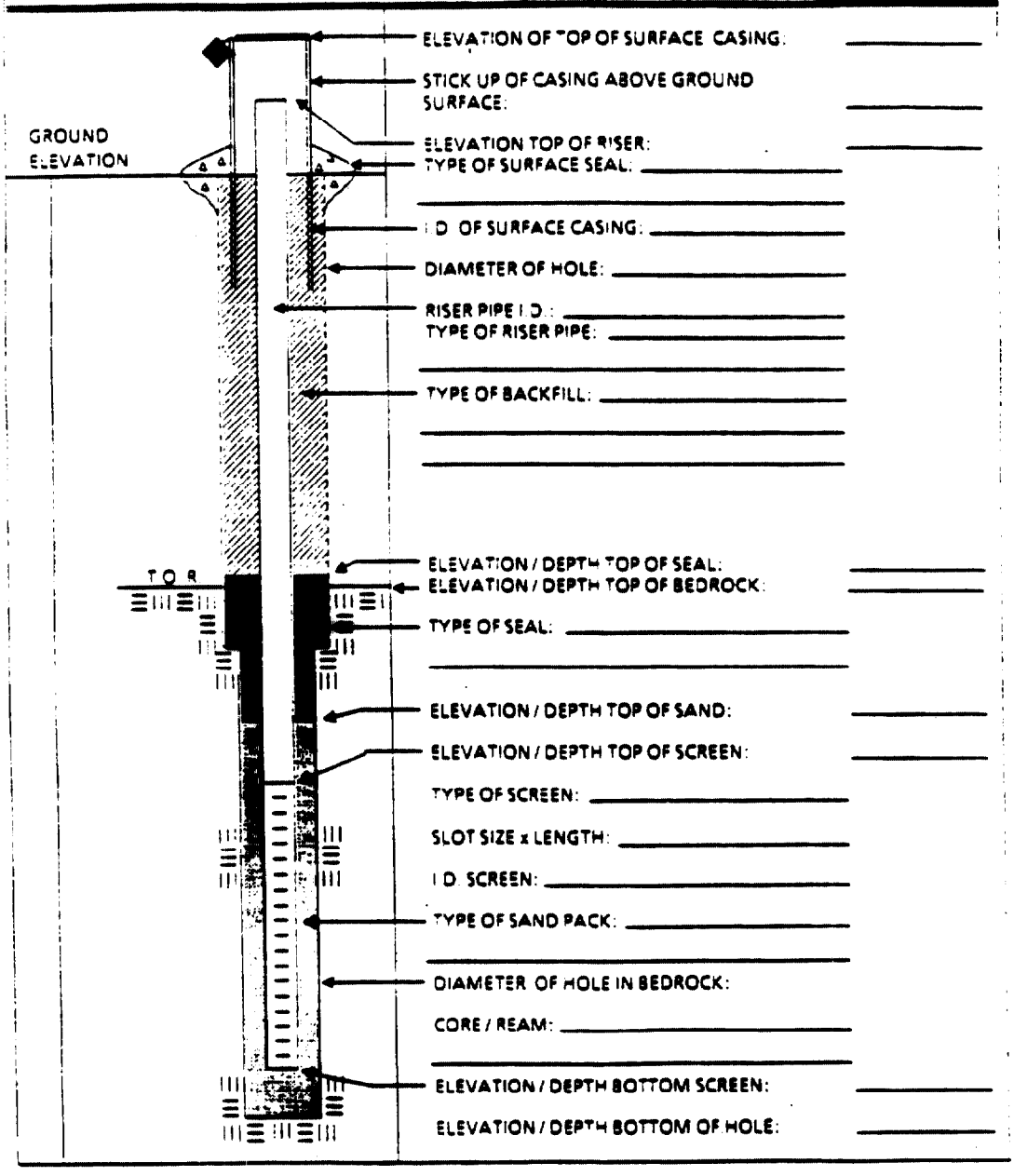
NUS CORPORATION
A Halliburton Company

BORING NO _____

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ATTACHMENT C-11

TEST PIT LOG ***NUS CORPORATION***

PROJECT: ..... TEST PIT NO.: .....

PROJECT NO.: ..... DATE: .....

LOCATION: .....

FIELD GEOLOGIST: .....

DEPTH (ft.)	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS .....

.....

.....

.....

PHOTO LOG ..... TEST PIT .....

.....

.....

.....

PAGE.....OF.....

ATTACHMENT D-1

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): _____

Manufacturer _____ Date Purchased _____

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.5	Page 1 of 7
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject FIELD REPORTS		Approved D. Senovich	

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5.3.3 Submittal and Approval

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1.0 PURPOSE

This procedure describes the periodic field reports which are required to be filled out during the conduct of Remedial Investigation (RI) field studies. These reports on the progress of field assignments are not to be confused with the forms associated with boring and well installation, sampling, sample custody and equipment maintenance described in Procedure SA-6.4.

These reports serve several purposes:

- To maintain a written record of major events/accomplishments/problems related to the field work.
- To allow ongoing monitoring of the actual progress of field tasks in comparison to the planned schedule, and to allow timely corrective action (if required).
- To inform Site Managers of progress/accomplishments for inclusion in The Monthly Project Tracking System.

2.0 SCOPE

The reports described herein are to be used during field investgiations, but do not replace or take precedence over project-specific or subcontractor-specific required reports. Additional reporting may particularly be required at enforcement-lead sites.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Field Operations Leader - responsible for assuring that the appropriate reports are completed in the required time-frame. Responsibilities for filling out individual reports are identified within the description of the reports (see below).

5.0 PROCEDURES

5.1 PROGRAM DESIGN

The primary means of recording onsite activities is the site logbook (see Procedure SA-6.3) and other field logbooks (e.g. geologists notebook, health and safety officer's logbook, sample logbooks). However, these logbooks and notebooks usually contain extremely detailed information which is required for data interpretation or documentation, but not for tracking and reporting of progress. Furthermore, the field logbooks remain onsite for extended periods of time and are thus not accessible for review by project management. The reports described in this procedure are, in essence, simplified summaries of the logbooks, which are designed to provide only the information needed by project management to keep informed of the progress of field activities.

5.2 DAILY ACTIVITIES REPORT

5.2.1 Description

The Daily Activities Report documents the activities and progress for each day's field work. This report is filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors (Attachment A is an example of a Daily Activities Report).

5.2.2 Responsibilities

It is the responsibility of the rig geologist to complete the report and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.2.3 Submittal and Approval

At the end of the shift, the rig geologist submits the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The reports are retained by the FOL for use in preparing the site logbook and weekly Field Summaries, and are submitted to the Site Manager weekly along with the Weekly Field Summary.

5.3 FIELD TRIP SUMMARY

5.3.1 Description

The Field Trip Summary is an abstract of the Site Logbook, summarizing the major activities onsite for a particular week or field cycle (e.g., 10 days). It should be organized on a day-by-day basis, and contain the following information at a minimum (see Attachment B):

- Date (week ending)
- Personnel onsite (contractor, subcontractors, visitors)
- Weather conditions encountered during the week
- Site activities
- Number and type of samples collected (including C.O.C. form numbers)
- Issues impacting progress of the project.

5.3.2 Responsibilities

The Field Operations Leader or responsible individual onsite if not the FOL (e.g., geophysics team leader, sampling team leader) is responsible for completing the Weekly Field Summary at the end of each week of ongoing site activity, or at the completion of an activity (if no further activity will take place during that week).

5.3.3 Submittal and Approval

The summary, along with Daily Activities Reports, Health & Safety Officer's Reports, and any other documentation, must be delivered or sent to the Site Manager at the end of each week.

The Field Trip Summary is an internal informational document and is not subject to project management review or approval.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Rig Shift Report
Attachment B - Field Trip Summary Report (2 pages)

ATTACHMENT A

DAILY ACTIVITIES RECORD - FIELD INVESTIGATION ***NUS CORPORATION***

PROJECT NAME: _____ PROJECT NO.: _____
CLIENT: _____ LOCATION: _____
DATE: _____ ARRIVAL TIME: _____ DEPARTURE TIME: _____
CONTRACTOR: _____ DRILLER: _____
BORING NO.: _____ NUS REPRESENTATIVE: _____

ITEM (1)	ORIGINAL QUANTITY (2) ESTIMATE	QUANTITY (2) TODAY	PREVIOUS TOTAL (2) QUANTITY	CUMULATIVE QUANTITY (2) TO DATE
1. Mobilization/Demobilization	Job			
2. Overburden Drilling/Sampling, minimum 6-inch	100 ft.			
3. Overburden Drilling, 10-inch	250 ft.			
4. Overburden Drilling 14-inch	450 ft.			
5. Bedrock Drilling 6-inch	530 ft.			
6. Bedrock Drilling 10-inch	650 ft.			
7. Bedrock Drilling 14-inch	150 ft.			
8. Temporary 6-inch Steel Casing	250 ft.			
9. Temporary 10-inch Steel Casing	200 ft.			
10. Temporary 14-inch Steel Casing	250 ft.			
11. Permanent 6-inch Steel Casing	1,250 ft.			
12. Permanent 10-inch Steel Casing	400 ft.			
13. PVC Well Construction/Installation	1,120 ft.			
14. Mine Void Sealing	8			
15. Boring Backfilling	NA			
16. Well Development	24 hrs.			
17. Test Borings	200 ft.			
18. Test Pit Excavation	50 hrs.			
19. Standby	20 hrs.			

COMMENTS: _____

(1) AS LISTED IN SPECS
(2) INCLUDE QUANTITY AND UNITS
(Ex. 20 ft., 6 hrs.)

APPROVED BY:

_____
NUS FIELD REPRESENTATIVE

_____
DRILLER OR REPRESENTATIVE

ATTACHMENT B
PAGE 1 OF 2
FIELD TRIP SUMMARY REPORT

SUNDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

MONDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

TUESDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

WEDNESDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

ATTACHMENT B
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

FRIDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

SATURDAY

Date: _____ Personnel: _____ _____

Weather: _____ Onsite: _____ _____

_____ _____

Site Activities: _____

_____

_____

_____

RUST ENVIRONMENT & INFRASTRUCTURE

Daily Time Log

Date: ____/____/____

Circle: Sun Mon Tue Wed Thu Fri Sat

Site: _____ Project No.: _____

Weather: _____

Task/Equipment: _____

Firm/Contractor's Personnel: _____ Hrs On–Site: _____

RUST's Personnel: _____ Hrs On–Site: _____

Site Visitors: _____

Time Log indicating work in progress, remarks:

0600 – 0630 _____

0630 – 0700 _____

0700 – 0730 _____

0730 – 0800 _____

0800 – 0830 _____

0830 – 0900 _____

0900 – 0930 _____

0930 – 1000 _____

1000 – 1030 _____

1030 – 1100 _____

1100 – 1130 _____

1130 – 1200 _____

1200 – 1230 _____

1230 – 1300 _____

1300 – 1330 _____

1330 – 1400 _____

1400 – 1430 _____

1430 – 1500 _____

1500 – 1530 _____

1530 – 1600 _____

1600 – 1630 _____

1630 – 1700 _____

1700 – 1730 _____

1730 – 1800 _____

Items requiring follow–up: _____

Summary of Daily Activities

Include items such as: boring numbers, footage drilled, well numbers, well construction, wells developed, samples and locations, problems, actions required, stand–by time, etc...

(1) _____

(2) _____

(3) _____

(4) _____

(5) _____

(6) _____

(7) _____

(8) _____

(9) _____

(10) _____

Stand–by time: _____ hrs.

Access delays: _____ hrs.

Actions required: _____

_____

_____

RUST ENVIRONMENT & INFRASTRUCTURE

Soils Data Form

Sheet _____ of _____

Site _____ Project Number _____

Date _____ Soil Sample Area _____

Time _____ Soil Subsample _____

Collectors _____

_____

Sample Depth _____

_____

_____

_____

Physical Description Of Subsampling Location: _____

_____

_____

_____

_____

_____

_____

Description Of Subsample: _____

_____

_____

_____

_____

_____

_____

Any Other Characteristics Of Note: _____

_____

_____

_____

_____

_____

_____

RUST ENVIRONMENT & INFRASTRUCTURE

Surface Water/Sediment Data Form

SURFACE WATER

Site _____

Date _____

Time _____

Collectors _____

_____

Sample Number [ ]

Sampling Equipment _____

_____

Project Number _____

Temperature _____

pH _____

Conductivity _____

Dissolved Oxygen _____

Turbidity: Low _____

Medium _____

High _____

Color: _____

Odor: _____

Water Depth: _____

Physical Description of Surface Water Sample Location: _____

_____

_____

_____

_____

SEDIMENT

Date _____

Time _____

Collectors _____

_____

Sample Number [ ]

Sampling Equipment _____

_____

Physical Description of Sediment Location: _____

_____

_____

_____

Physical Description of Sediment: _____

_____

_____

_____

Sheet ___ of ___

RUST ENVIRONMENT & INFRASTRUCTURE

FIELD BORING LOG W/ATMOSPHERIC MONITORING

BORING NO.

SITE: _____ PROJECT NO. _____

WATER LEVEL READINGS

DATE/TIME	WATER DEPTH	HOLE DEPTH	CASING DEPTH

DRILLING METHOD: _____

LOG BY: _____

FIRM/DRILLER: _____

PHYSICAL SETTING: _____

ABANDONMENT DATE: _____

ABANDONMENT METHOD: _____

GROUND SURFACE ELEV.: _____

COORDINATE TYPE: _____

NORTH: _____

EAST: _____

DATE/TIME START: _____

DATE/TIME COMPLETE: _____

WELL INSTALLATION DATE: _____

DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL DESCRIPTION AND DRILLING COMMENTS	SAMPLING DATA						AIR MONITORING		
				B	N	A	R	SAMPLE TYPE	SAMPLE INTERVAL	TIME	PID	O_2/LEL

DGN =/usr/200312/stdlogs.erd DATE=Tue Jun 15 11:52:28 1993 PRF = /usr/200312/logs/stdlogs.prf

GW | GP | GM | GC | SW | SP | SM | SC | ML | MH | CL | CH | OL | OH

PERCENTAGES OF GRAVEL, SAND AND FINES MAY BE STATED IN TERMS INDICATING A RANGE OF PERCENTAGES AS FOLLOWS:

TRACE	PARTICLES ARE PRESENT BUT EST. TO BE LESS THAN 5%
FEW	5 TO 10%
LITTLE	15 TO 25%
SOME	30 TO 45%
MOSTLY	50 TO 100%

STANDARD PENETRATION TEST CONSISTENCY OR DENSITY

FINE GRAINED

VERY SOFT (VS)	0-2
SOFT (S)	3-4
MEDIUM (M)	5-8
STIFF (ST)	9-16
VERY STIFF (VST)	17-30
HARD (H)	>30

COARSE GRAINED

VERY LOOSE (VL)	0-4
LOOSE (L)	5-9
MEDIUM DENSE (MD)	10-29
DENSE (D)	30-49
VERY DENSE (VD)	>50

CRITERIA FOR DESCRIBING ANGULARITY OF COARSE-GRAINED PARTICLES

DESCRIPTION	CRITERIA
ANGULAR	PARTICLES HAVE SHARP EDGES AND RELATIVELY PLANE SIDES WITH UNPOLISHED SURFACES
SUBANGULAR	PARTICLES ARE SIMILAR TO ANGULAR DESCRIPTION BUT HAVE ROUNDED EDGES
SUBROUNDED	PARTICLES HAVE NEARLY PLANE SIDES BUT HAVE WELL-ROUNDED CORNERS AND EDGES
ROUNDED	PARTICLES HAVE SMOOTHLY CURVED SIDES AND NO EDGES

CRITERIA FOR DESCRIBING MOISTURE CONDITION

DESCRIPTION	CRITERIA
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL IS BELOW WATER TABLE

ADDITIONAL DRILLING DATA

SPLIT TUBE SIZE _____ ID _____ OD
HAMMER WT. _____ lb _____ in drop
THIN WALL TUBE SIZE _____ OD
CASING USED _____ LF _____ Dia.
DRILL ROD SIZE _____
DRILL BIT TYPE _____ (a) _____ (b)
DRILL BIT SIZE _____ (a) _____ (b)
AUGER TYPE _____ OD
HOLLOW STEM AUGER _____ ID

SOIL DESCRIPTION REQUIREMENTS

(TO BE LISTED IN THIS ORDER WITH EACH ITEM SEPERATED BY A COMMA)

1 CONSISTENCY OR DENSITY (BASED ON N VALUE)
2 MUNSELL COLOR DESCRIPTION
3 MUNSELL HUE/CHROMA
4 USCS GROUP NAME (ALL CAPS)
5 GRAIN SIZE RANGE (FOR SAND & GRAVEL)
6 ROUNDNESS OR ANGULARITY (SAND & GRAVEL)
7 MOISTURE
8 PLASTICITY
9 COHESIVESS
10 DISTINCTIVE FEATURES
11 DEPOSITIONAL ENVIRONMENT
12 FORMATION/MEMBER (OPTIONAL, IF KNOWN-ALL CAPS)

NOTE: INCLUDE ESTIMATE OF GRAVEL, SAND, AND SILT AND CLAY PERCENTAGES IN LOWER RIGHT CORNER OF DESCRIPTION INTERVAL (SEE EXAMPLE BELOW)

CRITERIA FOR DESCRIBING STRUCTURE

STRATIFIED	ALTERNATING LAYERS OF VARYING MATERIAL OR COLOR WITH LAYERS AT LEAST 6MM THICK ;NOTE THICKNESS
LAMINATED	ALTERNATING LAYERS OF VARYING MATERIAL OR COLOR WITH THE LAYERS LESS THAN 6MM THICK; NOTE THICKNESS
FISSURED	BREAKS ALONG DEFINITE PLANES OF FRACTURE WITH LITTLE RESISTANCE TO FRACTURING
SLICKEN-SIDED	FRACTURE PLANES APPEAR POLISHED OR GLOSSY. SOMETIMES STRIATED
BLOCKY	COHESIVE SOIL THAT CAN BE BROKEN DOWN INTO SMALL ANGULAR LUMPS WHICH RESIST FURTHER BREAKDOWN
LENSED	INCLUSION OF SMALL POCKETS OF DIFFERENT SOILS SUCH AS SMALL LENSES OF SAND SCATTERED THROUGH A MASS OF CLAY; NOTE THICKNESS
HOMOGENEOUS	SAME COLOR AND APPEARANCE THROUGHOUT

CRITERIA FOR DESCRIBING PLASTICITY

NON-PLASTIC	A 1/2-IN (3MM) THREAD CANNOT BE ROLLED AT ANY WATER CONTENT
LOW	THE THREAD CAN BARELY BE ROLLED AND THE LUMP CANNOT BE FORMED WHEN DRIER THAN THE PLASTIC LIMIT
MEDIUM	THE THREAD IS EASY TO ROLL AND NOT MUCH TIME IS REQUIRED TO REACH THE PLASTIC LIMIT. THE THREAD CANNOT BE REROLLED AFTER REACHING THE PLASTIC LIMIT. THE LUMP CRUMBLES WHEN DRIER THAN THE PLASTIC LIMIT
HIGH	IT TAKES CONSIDERABLE TIME ROLLING AND KNEADING TO REACH THE PLASTIC LIMIT. THE THREAD CAN BE REROLLED SEVERAL TIMES AFTER REACHING THE PLASTIC LIMIT. THE LUMP CAN BE FORMED WITHOUT CRUMBLING WHEN DRIER THAN THE PLASTIC LIMIT

TYPICAL HOLLOW-STEM AUGER SIZES WITH SLIP-FIT, BOX AND PIN CONNECTIONS (AFTER CENTRAL MINE EQUIPMENT CO. 1987)

HOLLOW-STEM INSIDE DIAMETER (IN.)	FLIGHTING DIAMETER (IN.)	AUGER HEAD CUTTING DIAMETER (IN.)
2 1/4	5 5/8	6 1/4
2 3/4	6 1/8	6 3/4
3 1/4	6 5/8	7 1/4
3 3/4	7 1/8	7 3/4
4 1/4	7 5/8	8 1/4
6 1/4	9 5/8	10 1/4
8 1/4	11 5/8	12 1/2

SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

JAR METHOD - THE RELATIVE PERCENTAGE OF COARSE-AND FINE-GRAINED MATERIAL MAY BE ESTIMATED BY THOROUGHLY SHAKING A MIXTURE OF SOIL AND WATER IN A TEST TUBE OR JAR, AND THEN ALLOWING THE MIXTURE TO SETTLE. THE COARSE PARTICLES WILL FALL TO THE BOTTOM AND SUCCESSIVELY FINER PARTICLES WILL BE DEPOSITED WITH INCREASING TIME; THE SAND SIZES WILL FALL OUT OF SUSPENSION IN 20 TO 30 SEC. THE RELATIVE PROPORTIONS CAN BE ESTIMATED FROM THE RELATIVE VOLUME OF EACH SIZE SEPARATE. THIS METHOD SHOULD BE CORRELATED TO PARTICLE-SIZE LABORATORY DETERMINATIONS

VISUAL METHOD - MENTALLY VISUALIZE THE GRAVEL SIZE PARTICLES PLACED IN A SACK (OR OTHER CONTAINER) OR SACKS. THEN DO THE SAME WITH THE SAND SIZE PARTICLES AND THE FINES. THEN MENTALLY COMPARE THE NUMBER OF SACKS TO ESTIMATE THE PERCENTAGE OF PLUS NO. 4 SIEVE SIZE AND MINUS NO. 4 SIEVE SIZE PRESENT. THE PERCENTAGES OF SAND AND FINES IN THE MINUS SIEVE SIZE NO. 4 MATERIAL CAN THEN BE ESTIMATED FROM THE WASH TEST (X4.3)

WASH TEST- FOR RELATIVE PERCENTAGE OF SAND AND FINES. SELECT AND MOISTEN ENOUGH MINUS NO. 4 SIEVE SIZE MATERIAL TO FORM A 1-IN (25-MM) CUBE OF SOIL. CUT THE CUBE IN HALF, SET ONE HALF TO THE SIDE, AND PLACE THE OTHER HALF IN A SMALL DISH. WASH AND DECANT THE FINES OUT OF THE MATERIAL IN THE DISH UNTIL THE WASH WATER IS CLEAR AND THEN COMPARE THE TWO SAMPLES AND ESTIMATE THE PERCENTAGE OF SAND AND FINES. REMEMBER THAT THE PERCENTAGE IS BASED ON WEIGHT, NOT VOLUME. HOWEVER THE VOLUME COMPARSION WILL PROVIDE A REASONABLE INDICATION OF GRAIN SIZE PERCENTAGES.
X4.3.1 WHILE WASHING, IT MAY BE NECESSARY TO BREAK DOWN LUMPS OF FINES WITH THE FINGER TO GET THE CORRECT PERCENTAGES

IDENTIFICATION OF INORGANIC FINE-GRADED SOILS FROM MANUAL TESTS

SOIL SYMBOL	DRY STRENGTH	DILATANCY	TOUGHNESS
ML	NONE TO LOW	SLOW TO RAPID	LOW OR THREAD CANNOT BE FORMED
CL	MEDIUM TO HIGH	NONE TO SLOW	MEDIUM
MH	LOW TO MEDIUM	NONE TO SLOW	LOW TO MEDIUM
CH	HIGH TO VERYHIGH	NONE	HIGH

VOLUME OF SCHEDULE 40 PVC PIPE

DIAMETER	O.D.	I.D.	VOLUME GAL/LINEAR FT.
1 1/4"	1.66	1.38	0.08
2"	2.37	2.06	0.17
3"	3.50	3.06	0.38
4"	4.50	4.02	0.66
6"	6.62	6.06	1.50
8"	8.62	7.98	2.60
12"	12.75	11.93	5.81

VOLUME OF OPEN BOREHOLE AND ANNULUS BETWEEN CASING AND HOLE

HOLE DIAMETER	VOLUME GAL.	LIN. FT. CU. FT.	CASING DIA.	VOLUME GAL.	LIN. FT. CU. FT.	LBS/LIN. FT. SAND	PELLETS
7 1/4"	2.14	.29	1 1/4"	2.03	0.27	27	21
7 1/4"	2.14	.29	2"	1.91	0.26	26	20
7 3/4"	2.45	.33	2"	2.22	0.30	30	23
8 1/4"	2.78	.37	2"	2.55	0.34	34	26
10 1/4"	4.29	.57	2"	4.06	0.54	54	41
8 1/4"	2.78	.37	3"	2.28	0.30	30	23
10 1/4"	4.29	.57	3"	3.79	0.51	51	38
12 1/4"	6.13	.82	3"	5.62	0.75	75	57
8 1/4"	2.78	.37	4"	1.95	0.26	26	20
10 1/4"	4.29	.57	4"	3.46	0.46	46	35
12 1/4"	6.13	.82	4"	5.30	0.71	71	54
12 1/4"	6.13	.82	6"	4.33	0.58	58	44

MISCELLANEOUS DATA

1 CU. FT.= 7.5 GAL. (APPROX)
1 GALLON = .134 CU. FT. (APPROX)
1 CU. YD. = 202 GAL. (APPROX)
1 GALLON = .005 CU. YD. (APPROX)
1 GALLON OF WATER = 8.34 LBS. (APPROX)
1 CU. FT. OF FRESH WATER = 62.4 LBS. (APPROX)
PSI=.434 X THE HEIGHT OF THE WATER COLUMN IN FT.
FEET OF HEAD = PSI X 2.304
1 BARREL = 42 GALLONS (APPROX)
1 SACK OF SAND = 1 CU. FT AND APPROX 100 LBS.
1 SACK OF CEMENT = 1 CU. FT. AND APPROX 96 LBS.
1 PAIL OF BENTONITE PELLETS = 50 LBS. (APPROX)

EXAMPLE:

DEPTH IN FEET	SAMPLING DATA B	N	A	R	NO.	T	GRAPHIC LOG	USCS	SOIL DESCRIPTION AND DRILLING COMMENTS
	3				1	SS		SP	Loose, Yellowish brown, (10YR 5/6), POORLY GRADED SAND
1	4								WITH GRAVEL, fine to medium, subangular to subrounded,
	4								dry, iron-stained, LACUSTRINE
2	6	8							15/85/00

RUST ENVIRONMENT & INFRASTRUCTURE

FIELD ROCK CORE LOG

Sheet 1 of _____

BORING NO. _____

SITE: _____ PROJECT NO. _____

WATER LEVEL READINGS

	DATE	TIME	DEPTH	CASING

DRILLING RIG: _____

CORE BARREL / BIT: _____

CASING USED: _____

LOGGED BY: _____

FIRM/DRILLER: _____

PHYSICAL SETTING: _____

ABANDONMENT DATE: _____

ABANDONMENT METHOD: _____

GROUND SURFACE ELEV: _____

COORDINATE/TYPE: _____

NORTH: _____

EAST: _____

DATE/TIME START: _____

DATE/TIME COMPLETE: _____

WELL INSTALLATION DATE: _____

Depth in Feet	CORING DATA							FRAC./ FT	GRAPHICS	ROCK TYPE CODE	ROCK DESCRIPTION	COMMENTS
	METHOD	RUN NO	LENGTH	% RECOVERY	MPF	%WATER GAIN/LOSS (GAL.)	% RQD					

&cont&

Tracking Co Ids. F_ROCKP1, 3/22/94

RUST ENVIRONMENT & INFRASTRUCTURE

Field Modification Form
Item No. _____

Project: _____
Project No.: _____
Requested By: _____
Contract: _____

Description of Modification: _____

Reason for Modification: _____

Refer to: _____

Refer to Work Plan/QAPP Page and Paragraphs: _____

It is understood and mutually agreed that this form is to be used only to record minor modifications which do not increase or decrease the contract price or change the intent of a specific provision of the contract. Any modifications involving change to the Work Plan or QAPP documents must be approved by _____ prior to execution.

APPROVAL:

RUST E&I On-Site Representative

By: _____

Date: _____

_____ Representative

By: _____

Title: _____

Date: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Field Modification Request Log

Modification Number	Description	Date Submitted	Date Approved

RUST ENVIRONMENT & INFRASTRUCTURE

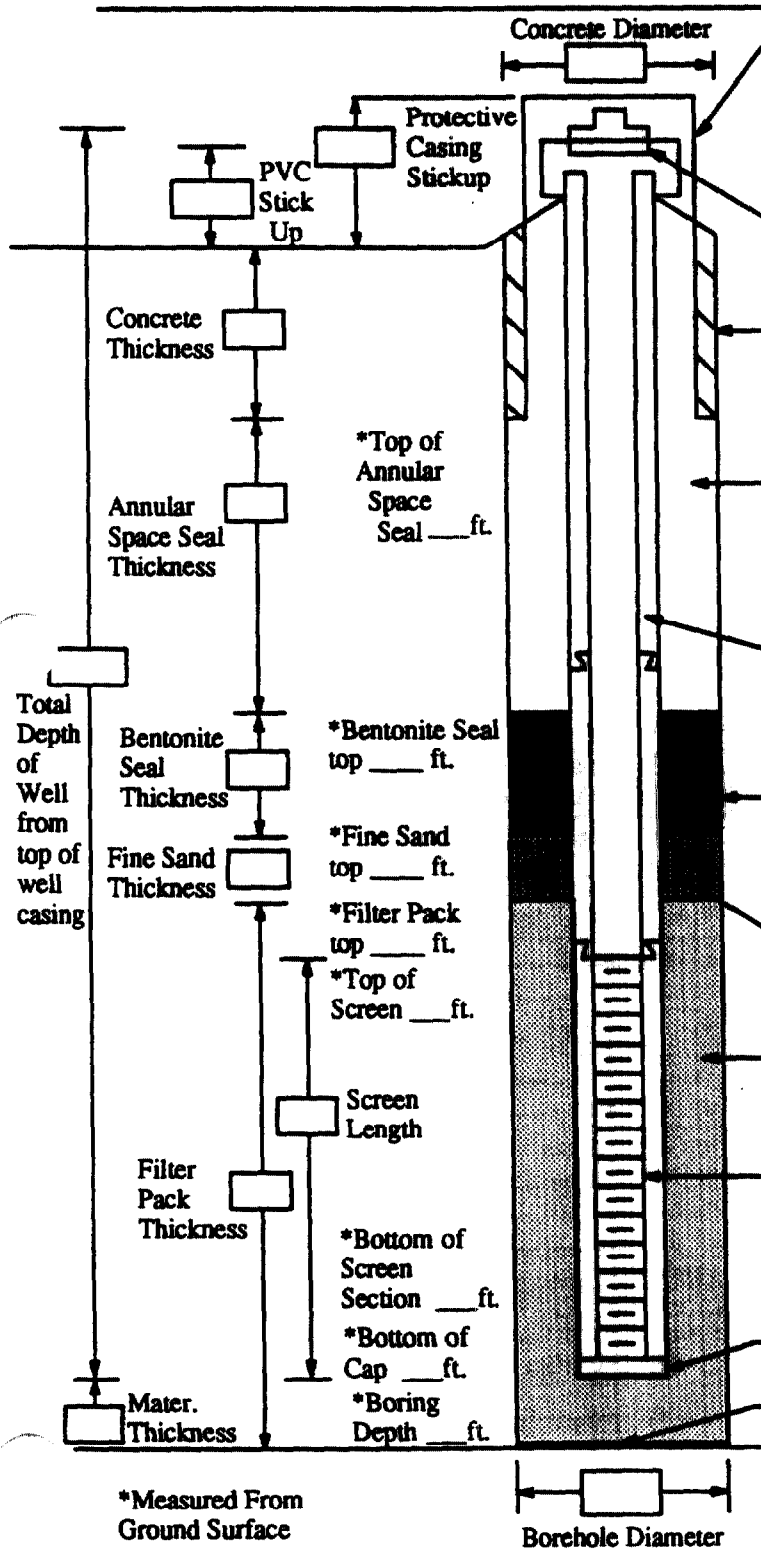
Water Table Well Installation Diagram

Site: _____ Date/Time Start: _____ Date/Time Finished: _____ Well No.: _____

Inspected by: _____ Driller Name: _____

Project No.: _____ Drilling Firm: _____

Survey Coordinates: _____ Ground Surface Elevation: _____



PROTECTIVE CASING

Type _____

Diameter _____ Locked _____ Key # _____

Length _____ Vented Yes/No

GUARD POSTS YES/NO

Type _____ Number _____

CAP OR PLUG Vented YES/NO Type _____

Material between protective casing and well casing

CONCRETE COLLAR YES/NO

Cement _____ lbs + Water _____ gal

Total Quantity _____ gal

Manufacturer _____

ANNULAR SPACE SEAL YES/NO

Type of Bentonite _____

Mix _____ lb bentonite + _____ gal H_2O

+ _____ lb cement

Total Quantity _____ gal Mud Wt _____ lbs/gal

WELL CASING Type _____ Schedule _____

OD _____ ID _____ Length/sec. _____

Flush threaded YES/NO Teflon Tape YES/NO

O-rings YES/NO Manufacturer _____

BENTONITE SEAL Manufacturer _____

Bentonite Type _____ Quantity _____ gal or lbs (Circle)

Hydrated _____ gal H_2O _____ Time

FINE SAND SEAL Material/Mesh size _____

Manufacturer _____

Product Name _____ # bags _____ Total lbs _____

FILTER PACK Material/Mesh size _____

Manufacturer _____

Product Name _____ # bags _____ Total lbs _____

SCREEN Slotted length _____

Type _____ Schedule _____

OD _____ ID _____ Length/sec _____

Slot size _____ No. slots/ft _____

Manufacturer _____

CAP OR PLUG Type _____ Length _____

MATERIAL BELOW WELL _____

*Measured From Ground Surface

WATER SOURCE _____

Notes: _____

RUST ENVIRONMENT & INFRASTRUCTURE

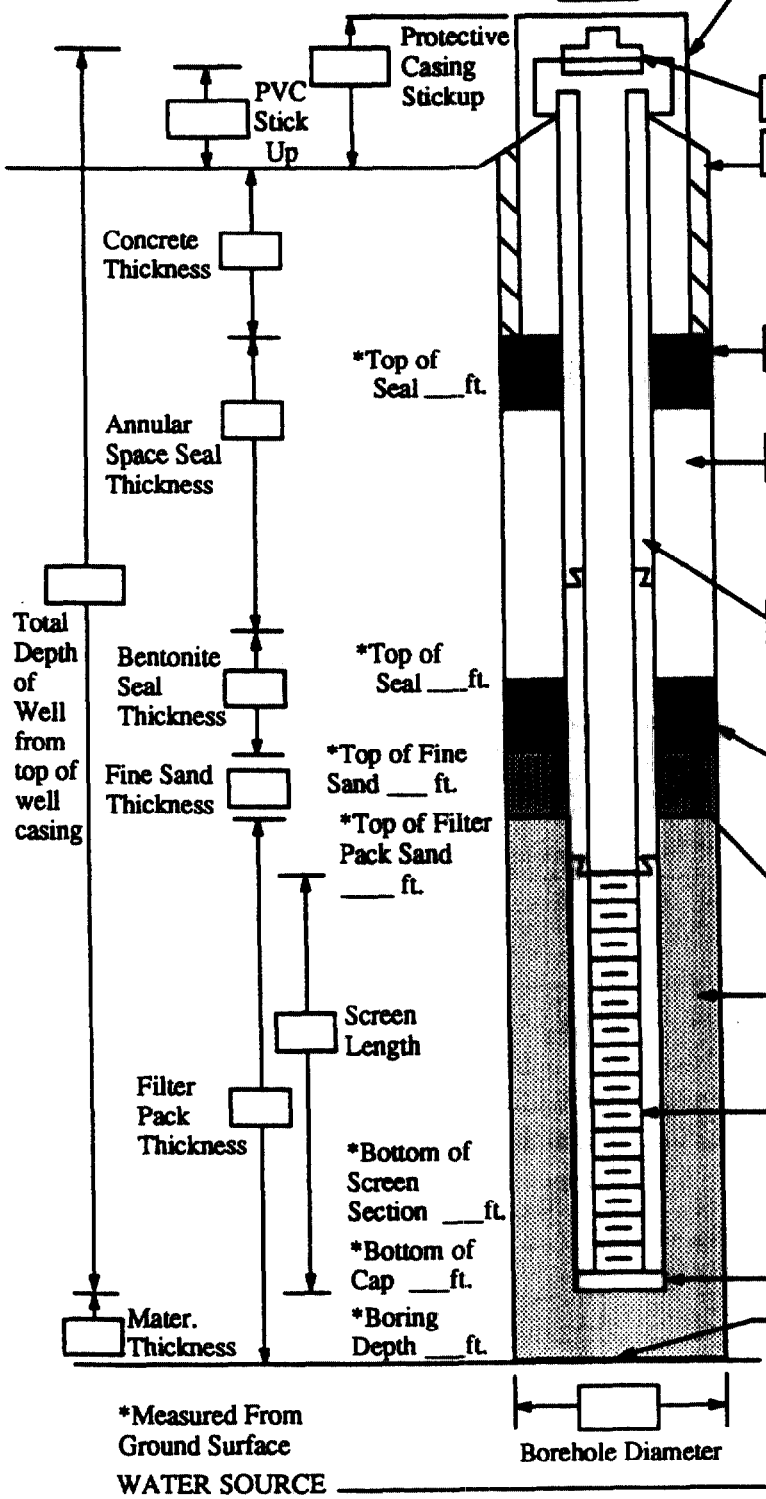
Piezometer Installation Diagram

Site: _____ Date/Time Start: _____ Date/Time Finished: _____ Well No.: _____

Inspected by: _____ Driller Name: _____

Project No.: _____ Drilling Firm: _____

Survey Coordinates: _____ Ground Surface Elevation: _____



PROTECTIVE CASING — **GUARD POSTS** YES/NO
Type _____ Number _____

Type _____
Diameter _____ Locked _____ Key # _____
Length _____ Vented Yes/No

CAP OR PLUG Vented YES/NO Type _____

CONCRETE COLLAR YES/NO
Cement _____ lbs + Water _____ gal
Total Quantity _____ gal
Manufacturer _____
Material between protective casing and well casing
_____

UPPER SEAL Manufacturer _____
Bentonite Type _____ Quantity _____ gal or lbs (Circle)
Hydrated _____ gal H_2O _____ Time

ANNULAR SPACE SEAL YES/NO
Type of Bentonite _____
Mix _____ lb bentonite + _____ gal H_2O
+ _____ lb concrete
Total Quantity _____ gal Mud Wt. _____ lbs/gal

WELL CASING Type _____ Schedule _____
OD _____ ID _____ Length/sec _____
Flush threaded YES/NO Teflon Tape YES/NO
O-rings YES/NO Manufacturer _____

LOWER SEAL Manufacturer _____
Bentonite Type _____ Quantity _____ gal or lbs (Circle)
Hydrated _____ gal H_2O _____ Time

FINE SAND SEAL Material/Mesh size _____
Manufacturer _____
Product Name _____ # bags _____ Total lbs _____

FILTER PACK Material/Mesh size _____
Manufacturer _____
Product Name _____ # bags _____ Total lbs _____

SCREEN Slotted length _____
Type _____ Schedule _____
OD _____ ID _____ Length/sec _____
Slot size _____ No. slots/ft _____
Manufacturer _____

CAP OR PLUG Type _____ Length _____

MATERIAL BELOW WELL _____
_____

*Measured From Ground Surface

WATER SOURCE _____

Notes: _____

RUST **Rust Environment & Infrastructure**

Well Development
(Must Have Well Construction Diagrams)

Well No. ( )

Date: ____/____/____
Mon. Tues. Weds. Thurs. Fri.

Site: _____

Weather: _____ Project No.: _____

Development Method: Pumped ☐ Bailed ☐ Other: _____

Pump Type: _____ Bailer Type: _____

Volume Calculation: _____

(D.T.B. – D.T.W. x vol./ft. = PVC/well volume) + (N* x H* x Annulus vol./ft.) = Total Well Volume
* (Wells that cannot be purged dry, 10x's the Total Well Volume must be purged)
(Wells that can be purged dry, slowly removing water, without surging until dry)

Time	Depth to Water (D.T.W.)	Depth to Bottom (D.T.B.)	Volume Removed (gal.)	pH	Cond.	Temp.	Color	Odor Y/N	Turbidity

Comments: _____

_____

_____

*N = porosity of filter pack
*H = length of filter pack or length of saturated filter pack (water level within screen length)
* = A 30–minute surge and purge before the 10x's the Total Well Volume

Annulus	vol./ft.
4"	0.42
6"	1.24
8"	2.38
10"	3.85

Inside Diameter	vol./ft.
1"	0.04
1.25"	0.06
2"	0.16
4"	0.65

HNu/PPM	LEL/%	O_2/%	H_2S/PPM	CO/PPM	

Signature: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Well Purging and Sample Collection

Project No.: _____ Well No. ( ) Site: _____

Purging Method: Pumped ☐ Bailed ☐ Other: _____

Pump Type: _____ Bailer Type: _____

Weather Conditions: _____

Volume Calculation: _____

(D.T.B. – D.T.W. x vol./ft. = Gals./well vol.)
(Gals./well vol. x 5 = Total Volume to be removed)

Gals./well vol.: _____

Time	Depth to Water (D.T.W.)	Depth to Bottom (D.T.B.)	Volume Removed (gal.)	pH	Cond.	Temp.	Color	Odor Y/N	Turbidity
		Sample Readings							

Comments: _____

Inside Diameter	vol./ft.
1"	0.04
1.25"	0.06
2"	0.16
4"	0.65

Field Blank Taken ☐ Time: _____

Well Duplicate ☐ No.: _____

Signature: _____

Date: ____/____/____

HNu/PPM	LEL/%	O_2/%	H_2S/PPM	CO/PPM	

RUST ENVIRONMENT & INFRASTRUCTURE

Water Elevation

PROJECT NO. _____ SITE _____

Well Number	Elevation Of Top Of Pipe	Depth To Water	Water Elevation	Depth To Bottom	Well Integrity				Comments
					Locked	Capped	Cracked	Obstruct	

Description Of Site _____

Soil Conditions _____

Weather _____ Temperature _____

Entered On Computer _____ Signature _____ Date _____

RUST ENVIRONMENT & INFRASTRUCTURE

Staff Gauge Information Form

Site: _____ Date: _____

By: _____ Project No.: _____

Staff Guage No. _____

Location: _____

Top of Pipe Elevation: _____

Date/Time: _____ Water Level: _____

Comments: _____

Staff Guage No. _____

Location: _____

Top of Pipe Elevation: _____

Date/Time: _____ Water Level: _____

Comments: _____

Staff Guage No. _____

Location: _____

Top of Pipe Elevation: _____

Date/Time: _____ Water Level: _____

Comments: _____

Staff Guage No. _____

Location: _____

Top of Pipe Elevation: _____

Date/Time: _____ Water Level: _____

Comments: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Instrument Calibration Log

INSTRUMENT: _____

Date Calibrated	Known Standard	Actual Instrument Reading	Adjustments Made	Calibrated By	Comments

COMMENTS: _____

RUST ENVIRONMENT & INFRASTRUCTURE

Atmospheric Monitoring Log
Field Health and Safety

Page _____ of _____
Date _____/_____/_____
Circle: Sun Mon Tue Wed Thu Fri Sat

Site: _____ Project No.: _____

Site Safety Officer: _____

Action Levels: D ☐ ⟶ C ☐ ⟶ B ☐ ⟶ (Stop work, call in for instructions)

(Check box and write in levels for upgrade)

Task/Equipment: _____

Weather: _____

Time	OVA PPM	HNu PPM	O_2 %	LEL %	H_2S PPM	Comments: Duration of Readings, Upgrades, Location, etc.

Additional Comments: _____

Signature: _____

APPENDIX B
TO WORK PLAN

HEALTH AND SAFETY PLAN

EPA ID NO. IN5 170 023 498

HEALTH AND SAFETY PLAN
RISK ASSESSMENT WORK PLAN
NAVAL SURFACE WARFARE CENTER CRANE DIVISION
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

Submitted to:
Department of the Navy
Southern Division
Naval Facilities Engineering Command
Code 185ND
2155 Eagle Drive
Charleston, South Carolina 29411-0068

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

Contract No. N62472-90-D-1298
Contract Task Order No. 0076

July 1995

REVIEWED BY:

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REGIONAL ENVIRONMENTAL
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RUST ENVIRONMENT & INFRASTRUCTURE
SHEBOYGAN, WISCONSIN
Under subcontract to Halliburton NUS

APPROVED BY:

Matthew M. Soltis
MATTHEW M. SOLTIS, CSP
HEALTH AND SAFETY MANAGER
HALLIBURTON NUS CORPORATION

HEALTH AND SAFETY PLAN
RISK ASSESSMENT WORK PLAN
NAVAL SURFACE WARFARE CENTER CRANE DIVISION
CRANE, INDIANA

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Reviewed by: Richard Tinsley Date: 6/27/95
Richard Tinsley, CSM
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Reviewed by: Matthew M. Soltis Date: 7-8-95
Matthew M. Soltis, CSP
CLEAN Health and Safety Manager
Halliburton NUS Corporation

D:\CTO7801\HASP1\COVER

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LIST OF ACRONYMS/ABBREVIATIONS

ABG	Ammunition Burning Ground
ACGIH	American Conference of Governmental Industrial Hygienists
BZ	Breathing Zone
CAAA	Crane Army Ammunition Activity
CEHSD	Corporate Environmental Health and Safety Director
CGI	Combustible Gas Indicator
CLEAN	Comprehensive Long-Term Environmental Action Navy
CPR	Cardiopulmonary Resuscitation
CRZ	Contamination Reduction Zone
DR	Demolition Range
EOD	Explosive Ordnane Department
EPA	Environmental Protection Agency
EZ	Exclusion Zone
FID	Flame Ionization Detector
HEPA	High Efficiency Particulate Air (Filter)
HSM	Health and Safety Manager
HASP	Health and Safety Plan
HR	Heart Rate
MSDS	Material Safety Data Sheet
MSHA	Mining Safety and Health Administration
NAVSURFWARCENDIV	Naval Surface Warfare Center, Crane Division
NIOSH	National Institute for Occupational Safety and Health
ORR	Old Rifle Range
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PEL	Permissible Exposure Limit
PID	Photoionization Detector
RA	Risk Assessment
SAP	Sampling and Analysis Plan
SCBA	Self-Contained Breathing Apparatus
SOP	Standard Operating Procedure
SSO	Site Health and Safety Officer
SWMU	Solid Waste Management Unit
SZ	Support Zone
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
UXO	Unexploded Ordnance
WBGT	Wet Bulb Globe Temperature (Index)
WP	Work Plan
WZ	Work Zone

1.0 GENERAL

This Site-Specific Health and Safety Plan (HASP) was prepared for the Risk Assessment (RA) Work Plan (WP) for the Ammunition Burning Ground (ABG), Demolition Range (DR), and the Old Rifle Range (ORR) at the Naval Surface Warfare Center Crane Division in Crane, Indiana (NAVSURFWARCENDIV), under Halliburton NUS Corporation Prime Contract No. N62472-90-D-1298 for the U.S. Navy, Southern Division, Charleston, South Carolina, in accordance with the regulatory requirements of 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response." In addition, the scope of work shall comply with and reflect the following applicable regulations and appropriate guidance publications, as a minimum:

- Federal Acquisition Regulation, F.A.R. Clause 52.236-13: Accident Prevention.
- U.S. Army Corps of Engineers (USACE), Safety and Health Requirements Manual, EM 385-1-1 (latest revision, 1987).
- Occupational Safety and Health Administration (OSHA), Construction Industry Standards, 29 CFR 1926, and General Industry Standards, 29 CFR 1910.
- NIOSH/OSHA/USCG/EPA, "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities," October 1985.
- Environmental Protection Agency (EPA) 40 CFR, Part 61, "National Emission Standards for Hazardous Air Pollutants; Asbestos NESHAP Revision; Final Rule," November 20, 1990.
- Other applicable Federal, State, and local safety and health requirements.

The purpose of this HASP is to summarize the project organization and responsibilities; establish standard operating procedures (SOPs) for preventing accidents, injuries, and illnesses; identify hazards; discuss the personal protective equipment that may be used; identify personnel health and safety training requirements; summarize the monitoring techniques; establish emergency procedures; describe the medical surveillance program; provide appropriate first aid equipment for site activities; provide for accident recordkeeping; and establish a schedule for safety inspections.

This HASP addresses those activities associated with the Sampling Analysis Plan (SAP) field activities identified in the RA WP to be conducted at NAVSURFWARCENDIV (Figure 1-1). Specifically, field investigation activities will be conducted at three Solid Waste Management Units (SWMUs), the ABG, DR, and the ORR (Figure 1-2).

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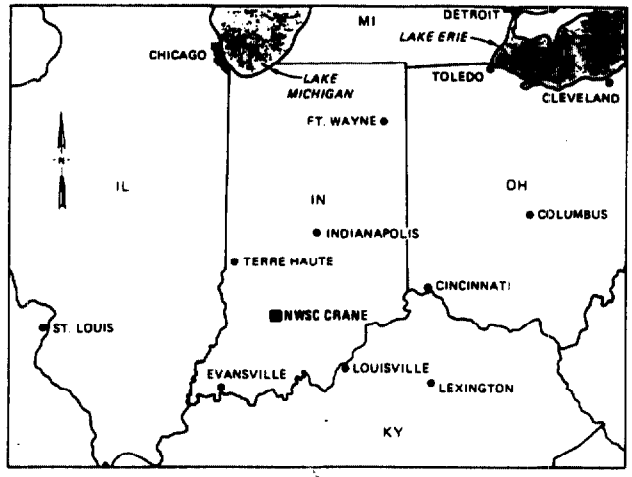
CLEAN CTO #0076

EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA HASP
JULY 1995



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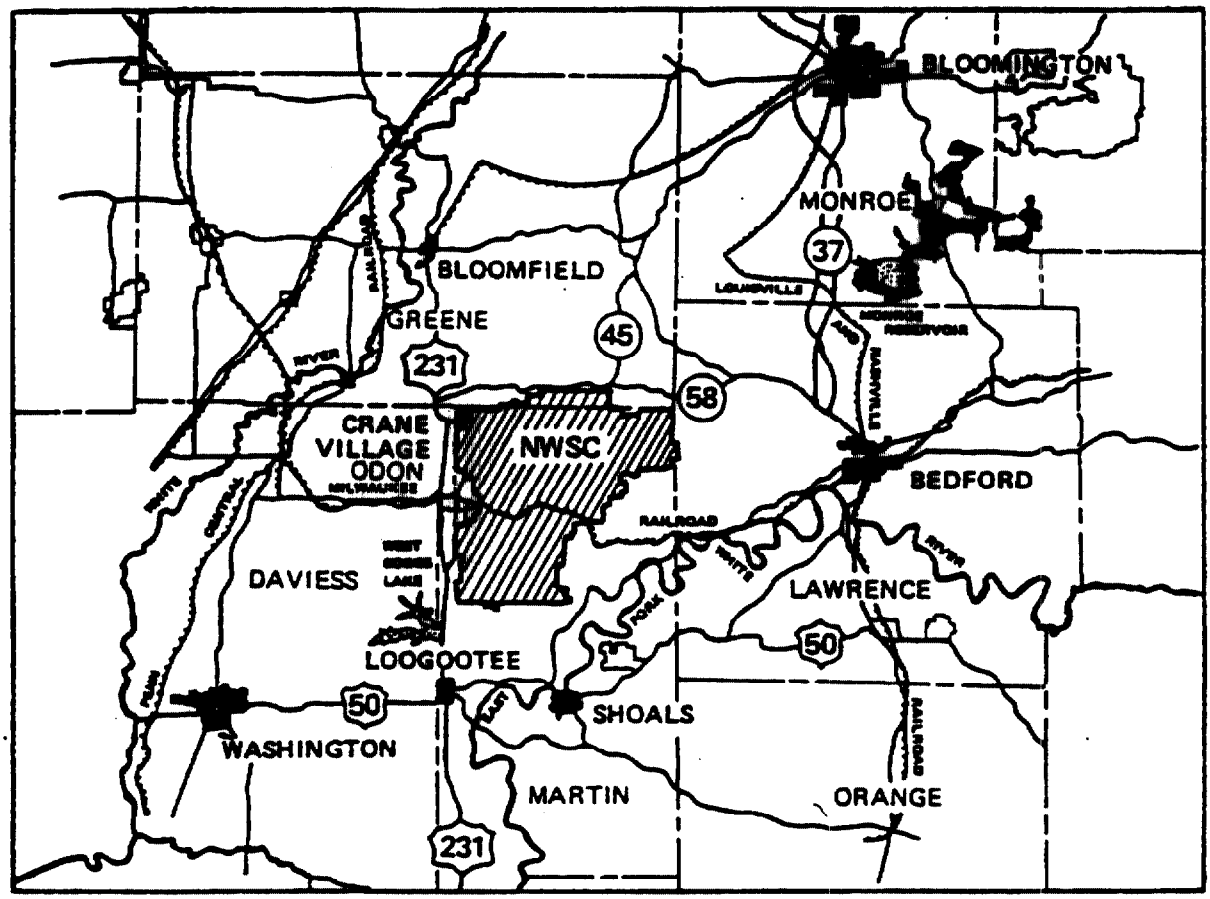

SOURCES: CHESAPEAKE DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, 1979 AND NAVAL ENERGY AND ENVIRONMENTAL SUPPORT AGENCY, 1983.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 1-1

20615

GENERAL LOCATION MAP
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

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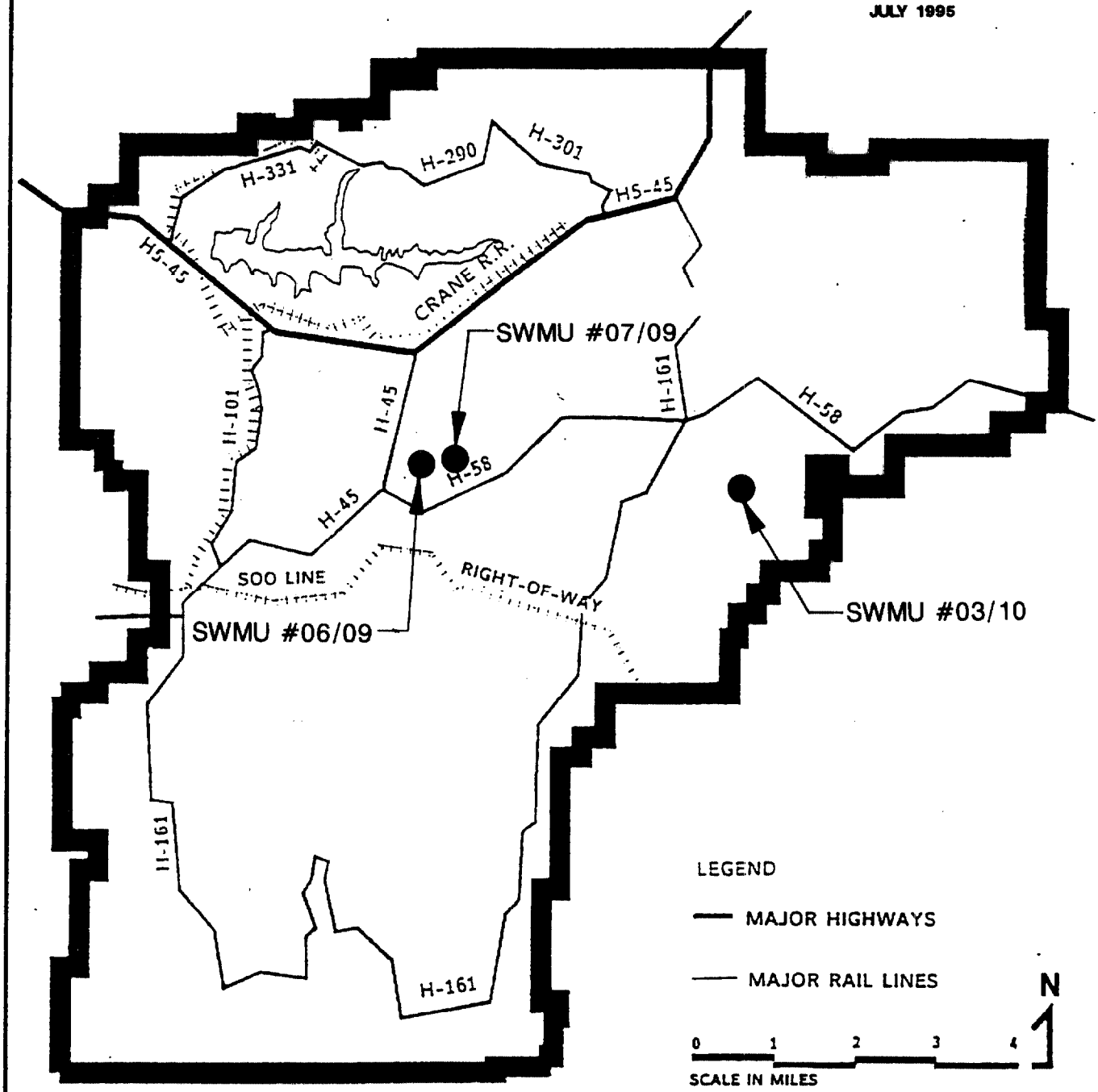
EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA HASP
JULY 1995



SWMU #03/10: AMMUNITION BURNING GROUNDS
SWMU #06/09: DEMOLITION RANGE
SWMU #07/09: OLD RIFLE RANGE

SOURCE: NORTHERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, NWSCC MASTER PLAN, 1986

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 1-2

SWMU - LOCATION MAP
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

This HASP will be implemented by the Rust Environment & Infrastructure (E&I) Regional Environmental Health and Safety Manager (REHSM), CLEAN Health and Safety Health Manager (CLEAN HSM), and the Site Health and Safety Officer (SSO) during site work. The SSO will be responsible for posting on-site the OSHA Job Safety and Health Protection poster.

Compliance with this HASP is required of all personnel who enter the sites. Assistance in implementing this HASP can be obtained from the REHSM and the CLEAN HSM.

The content of this HASP may change or undergo revision based upon additional information made available to health and safety personnel through monitoring results or due to changes in the technical scope of work. Any changes proposed must be approved by the REHSM and the CLEAN HSM. A HASP Field Modification Form is presented in Appendix C.

1.1 SCOPE OF WORK

- Surface Soil Sampling
- Surface Water/Sediment Sampling
- Soil Borings/Monitoring Well Installation
- Monitoring Well Development/Groundwater Sampling
- Surface Water and Groundwater Hydraulic Characterization
- Tissue Sampling

1.2 PROJECT PERSONNEL

Name/Firm	Title	Work Phone	Home Phone
Lorrie Ransome, Ph.D. Rust E&I	Designated Lead	414/458-8711	414/452-1368
Charles Zeal, P.E. Rust E&I	Project Manager	414/458-8711	414/459-7301
Pam Markelz	Corporate Env. Health and Safety Director	414/458-8711	414/457-4570
Richard Tinsley,CSM Rust E&I	Regional Env. Health and Safety Manager	708/955-6704	708/961-1361
David Richardson Rust E&I	Health and Safety	414/458-8711	414/459-9519

Name/Firm	Title	Work Phone	Home Phone
Rust E&I	On-Site Health and Safety Officer	(To be determined before field activities are initiated)	
Rust E&I	On-Site Health and Safety Officer (Alternate)	(To be determined before field activities are initiated)	

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2.0 ASSIGNMENT OF HASP RESPONSIBILITY

The following describes the health and safety designations and general responsibilities which will be implemented for field activities associated with the implementation of the RAWP.

2.1 CORPORATE HEALTH AND SAFETY MANAGER

The REHSM and the CLEAN HSM have overall responsibility for development and implementation of this HASP. The HSMs shall approve any changes to this HASP due to modification of procedures or newly proposed site activities.

The CEHSD will be responsible for the development of new company safety protocols and procedures necessary for field operations and will also be responsible for the resolution of any outstanding safety issues which arise during the site work. Health and safety-related duties and responsibilities will be assigned only to qualified individuals by the HSMs. Before personnel may work on-site, a current medical examination and acceptable health and safety training must be approved by the HSMs.

2.2 SITE SAFETY OFFICER

The HSMs shall direct the site health and safety efforts through an Assistant SSO as needed. The SSO will be responsible for implementing the HASP. The SSO may direct or participate in on-site activities as appropriate when this does not interfere with primary SSO responsibilities. The SSO has stop-work authorization which he/she will execute upon determination of an imminent safety hazard, emergency situation, or other potentially dangerous situations, such as detrimental weather conditions. Authorization to proceed with work will be issued by the HSMs in conjunction with the Project Manager. The Naval Explosive Ordnance Department (EOD) or Crane Army Ammunition Activity (CAAA) unexploded ordnance (UXO) expert also has stop-work authorization based on unexploded ordnance clearance activities.

2.3 SUBCONTRACTORS

Subcontracts will be issued for various tasks including soil boring and monitoring well installation. Other subcontracts may be issued for additional tasks, however, none are anticipated. Subcontractors shall comply with the requirements outlined in this HASP and in accordance with OSHA 29 CFR 1910 and 29 CFR 1926; but, in all cases, subcontractors shall be responsible for site safety related to or affected by their own field operations (i.e., heavy equipment operations).

3.0 SITE LOCATION AND DESCRIPTION

3.1 LOCATION

The NAVSURFWARCENDIV is located at Crane, Indiana, which is approximately 75 miles southwest of Indianapolis. NAVSURFWARCENDIV is an active facility and encompasses more than 100 square miles. Activities conducted at the NAVSURFWARCENDIV include the manufacture, testing, and disposal of off-specification and out of date military ordnance.

3.2 AMMUNITION BURNING GROUND (ABG)

Open burning at the ABG commenced in the 1940s. Generally, waste military energetic materials are now open burned in specially constructed burn pans or concrete pads. Currently, 27 burn pans are in operation at the ABG. Burns are typically carried out by pouring bulk propellants or energetic material into the pans to several inches in depth and remotely igniting.

Sludge burning pans are also in operation at the ABG. Sludge from various locations at the NAVSURFWARCENDIV are transported to the ABG and placed in the sludge burning pans, dewatered by gravity and an underdrain system, air dried to an optimum point, ignited, and burned in place.

Red phosphorus along with spent (burned) pyrotechnics are mixed with flammable solvents, fuel oil, and production scrap wood to be burned a second time to assure complete destruction before transporting off site for disposal.

The maximum amount of material burned per week is 490,000 pounds. The ABG covers approximately 20 acres.

Access to this area is restricted. All personnel must report to the ABG Control Building prior to any on-site activities for instructions and clearance.

3.3 DEMOLITION RANGE (DR)

High explosive waste munitions have been disposed of at the DR by detonation since the 1940s. The DR covers approximately 40 to 50 acres. From 1956 to 1960 as much as 10 tons per day were disposed. Munitions are palletized, double charged and buried to assure detonation.

Access to this area is restricted. All personnel must report to the DR Office located at the entrance of the site area. Mr. Luther Webster is the DR site manager and will be the NAVSURFWARCENDIV contact person for instructions and clearance prior to any on-site activities in this area.

The site is located on a ridge top with four sedimentation ponds located at the base of the ridge to capture surface runoff.

3.4 OLD RIFLE RANGE (ORR)

The ORR was originally used as a Marine rifle range. Today it is used for explosive treatment and disposal. The 10-acre site has been used for open burning/flashing since or before 1983. Small projectiles that has been defused are burned in large pans to eliminate any remaining residue. This operation is conducted twice to assure of waste destruction. Metals and soils are then segregated and containerized in roll-off boxes for disposal.

Access to this area is restricted. Clearance to this area shall be obtained through the DR officer (Mr. Luther Webster).

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4.0 HAZARD ASSESSMENT

4.1 WASTE DESCRIPTION/CHARACTERIZATION

The following chemical information is presented in order to identify the types of materials that may be encountered at the SWMUs. Detailed information on these materials was obtained from:

- ACGIH, Threshold Limit Values and Biological Exposure Indices for 1994-95.
- Hazardlines.
- Chemical Data Sheets.
- NIOSH Pocket Guide to Chemical Hazards - 1990.

The following is a list of chemicals and compounds that are potentially found on-site. Chemical Data Sheets and/or Hazardlines for each compound listed below, providing information such as the chemical's characteristics, health hazards, protection, exposure limits, and first aid procedures are presented in Appendix A. These chemicals include:

Ammonium Picrate	Diesel Fuel	Phosphorus
Arsenic	DNB	RDX
Barium	2,4 - DNT	Selenium
Benzene	2,6 - DNT	Silver
Black Powder	HMX	1,3,5-TNB
Cadmium	Lead	2,4,6-TNT
Chromium	Mercury	Trichloroethylene
Chromium Oxide	Nitroglycerin	

Waste Types: Liquid ___X___ Solid ___X___ Gas _____
Sludge ___X___ Semi-solid _____ Other _____

Characteristics: Corrosive _____ Flammable ___X___
Explosive ___X___ Volatile ___X___
Radioactive _____ Inert _____
Other Toxic

Exposure limits for the chemicals of potential concern are presented in Table 4-1 and the tasks, hazards, and control measures are shown in Table 4-2.

4.2 DEGREE OF HAZARD

On-site hazards include physical and chemical hazards. No radiological, biological, or laboratory wastes are suspected on-site.

TABLE 4-1

EXPOSURE LIMITS
NAVSURFWARCENDIV
CRANE, INDIANA

Compounds	PEL (mg/m^3)	TLV (mg/m^3)	STEL (mg/m^3)	IP	Odor Thresholds
Benzene	1 ppm	10 ppm	5 ppm	9.25	1.5-5 ppm
Trichloroethylene	50 ppm	50 ppm	537	9.47	20 ppm
Diesel Fuel	---	5	10[2]	---	---
Metals					
Arsenic	0.01	0.01	0.002[3]	---	---
Barium	0.5	0.5	---	---	---
Cadmium (dust)	0.005	0.01	---	---	---
Chromium (VI)	1.0	0.5	---	---	---
Chromium Oxide	0.5	0.5	---	---	---
Lead (dust)	0.05	0.15	---	---	---
Mercury[1]	0.05	0.05	0.03	---	---
Selenium	0.2	0.2	---	---	---
Silver (Soluble)	0.01	0.1	---	---	---
Explosive Compounds					
2,4,6-Trinitrotoluene	0.5	0.5	---	---	---
2,4-Dinitrotoluene	1.5	0.15	---	---	---
2,6-Dinitrotoluene	1.5	0.15	---	---	---
RDX	1.5	1.5	3[2]	---	---
HMX	---	---	---	---	---
1,3,5-Trinitrobenzene	---	---	---	---	---
Dinitrobenzene	1.0	1.0	---	---	---
Phosphorus	---	---	---	---	---
Ammonium Picrate	---	---	---	---	---
Nitroglycerin	---	0.05 ppm	0.1	---	---
Black Powder	---	---	---	---	---

TABLE 4-1 (Continued)

EXPOSURE LIMITS
NAVSURFWARCENDIV
CRANE, INDIANA

References:

American Conference of Governmental Hygienists (ACGIH) Threshold Limit Values (TLV) for 1993.
Hazard Lines 1992.
1989 Amended Permissible Exposure Limits (PELs), U.S. Department of Labor, OSHA.

IP - Ionization Potential.
STEL - Short-Term Exposure Limit.
PEL - Permissible Exposure Limit.
TLV - Threshold Limit Value.
PPM - Parts Per Million.
(1) - All forms except alkyl vapor.
(2) - This value is the ACGIH recommended 15-minute ceiling. An OSHA STEL value was not available for this compound.
(3) - This value is the NIOSH recommended 15-minute ceiling. An OSHA STEL value was not available for this compond.

TABLE 4-2

TASK SPECIFIC HAZARD ASSESSMENT TABLE
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

TASK	SITE	HAZARD	CONTROL MEASURES
Surface Water/Sediment Sampling	DR	Slip, Trip, Fall Dermal Contact	Flagging, Mark Hazards PPE, Harness, and Rope General Awareness
Soil Sampling	ABG ORR DR	Slip, Trip, Fall Dermal Contact Inhalation Thermal Stress Toxic/Explosive Atmosphere Explosive Devices	General Awareness Flagging, Access Controls PPE Respiratory Protection Work/Rest Cycles, Fluids Continuous Monitoring Work Closely With UXO Team
Soil Borings Well Installation/Groundwater Sample Collection	ABG ORR DR	Drill Rig (Heavy Equipment) Dermal Contact Inhalation Thermal Stress Toxic/Explosive Atmosphere Explosive Devices	Hard Hat, General Awareness Access Controls PPE Respiratory Protection Work/Rest Cycles, Fluids Continuous Monitoring Work Closely With UXO Team
Equipment Decontamination	ABG ORR DR	Dermal Contact Inhalation Thermal Stress Slip, Trip, Fall	PPE Respiratory Protection Work/Rest Cycles, Fluids Access Controls, General Awareness
Tissue Sampling	ABG ORR DR	Slip, Trip, Fall Dermal Contact	Flagging, Mark Hazards PPE, Harness and Rope General Awareness
Groundwater Hydraulic Characterization	ABG ORR DR	Dermal Contact Inhalation	Access Controls PPE, Respiratory Protection General Awareness
Surface Water Hydraulic Characterization	ABG ORR DR	Slip, Trip, Fall Dermal Contact	Flagging, Mark Hazards PPE, Harness and Rope General Awareness

4.2.1 Chemical Hazards

The contaminants of concern at the sites can affect the body if they are inhaled, come in contact with the eyes or skin, or are ingested. These compounds may be released during soil sampling, monitoring well installations, monitoring well development, and well sampling activities. The primary concern is for skin exposure to contaminated soils and potential inhalation of organic vapors or dust released during soil intrusive activities. Exposure to these substances by inhalation (in the Breathing Zone (BZ)) is not anticipated due to the relatively low levels found in the soil and water from previous studies.

Atmospheric monitoring, however, will be conducted during all phases of on-site field activities to determine the need for upgrading to appropriate levels of respiratory protection, as found in Section 9.2. Exposure by skin absorption is a low to moderate possibility, but can be prevented by use of proper protective equipment and good hygiene practices. Table 4-1 presents permissible exposure levels (PEL) for contaminants of concern.

4.2.2 Physical Hazards

Primary physical hazards at the site are those associated with drilling operations. Hazards that could be encountered during subsurface activities include falls and trips, injury from lifting heavy objects, falling objects, eye injuries, head injuries, and pinched or crushed hands and feet. Fire hazards may also be present due to the use of gasoline-powered heavy equipment, and the potential for explosive concentrations of vapors from flammable liquids in subsurface soils or volatile organic compounds associated with exposed wastes. During drilling operations, matting and planking may be needed around the drill rig to provide stability for the drill rig. The drilling contractor will make this decision. Also see Section 11.3 Safe Work Practices.

Depending on seasonal weather conditions, there is potential for workers on-site to be affected by heat stress or cold exposure. The SSO will monitor for heat stress or cold exposure in accordance with Section 12.7 of this HASP.

Soil boring activities and monitoring well installation provide potential for encountering buried hazards such as utilities. It shall be the subcontractor's responsibility to obtain "clearance" from the local utilities prior to initiating intrusive activities. Overhead electrical lines shall also be identified. If encountered, soil intrusive activities will be halted and the HSM's will be notified.

If dusty conditions exist during soil boring activities, the work zone area will be kept wet by spraying the work zone (WZ) with water to provide dust control.

Noise related to soil boring operations during soil boring and monitoring well installations is expected to be minimal; however as a precaution, hearing protection will be available.

Soil, sediment, and surface water sampling activities at the four sedimentation ponds exhibits the potential for slips and falls associated with wet surfaces and soft unstable sediment surfaces. The sampling does not represent any significant drowning hazard, however, a lifebelt and lanyard may be worn by the sampler as determined by the SSO.

4.2.3 Additional Precautions

It is possible that some unexploded ordnance (UXO) may be present in the SWMUs to be sampled. Because of this, the Halliburton NUS Team shall work with UXO specialists from NAVSURFWARCENDIV using equipment capable of detecting ordnance in all areas where field activities are to be conducted (Attachment B). A magnetometer, or other device determined appropriate by the NAVSURFWARCENDIV UXO specialists, with borehole capability of at least 10 feet, shall be used to determine the presence/absence of subsurface UXO prior to drilling/subsurface sampling. Borehole monitoring shall be accomplished at 2-foot levels to a depth of at least 10 feet. If the geophysical equipment indicates a suspect UXO, an alternative drilling/subsurface sampling location shall be selected by the Halliburton NUS Team and SSO shall be immediately notified. Any unexploded ordnance shall be marked and access restricted in the immediate area. The NAVSURFWARCENDIV UXO Team shall be on-site with the drilling crew during the length of this project.

Because sampling locations are located in the active SWMUs, the SSO shall arrange SWMU access with Thomas Brent (NAVSURFWARCENDIV Point of Contact). Only after clearance has been obtained will sampling proceed with the NAVSURFWARCENDIV UXO Team. The NAVSURFWARCENDIV UXO Team shall clear each sampling location prior to sample collection. No one shall venture outside of the investigation area without NAVSURFWARCENDIV UXO Team clearance.

4.2.4 Natural Hazards

Natural hazards such as weather, poisonous plants, bites from poisonous or disease-carrying animals and insects (i.e., snakes, ticks), cannot always be avoided. Refer to Section 12.0 for precautions and emergency procedures.

4.2.5 Confined Space Entry

Confined space entry is not anticipated for RA WP associated field activities and is, therefore, not addressed in this HASP. If confined space entry is necessary, work will be halted and the HSMs will be notified to prepare a plan before work continues.

4.2.6 Spill Containment

RA WP associated field activities are unlikely to require spill containment and are, therefore, not addressed in this HASP.

5.0 TRAINING REQUIREMENTS

5.1 BASIC TRAINING REQUIRED

Personnel who are required to work in areas where the potential for toxic exposure exists shall complete training and have site experience conforming to the requirements of 29 CFR 1910.120(e). In keeping with 29 CFR 1910.20, medical records and exposure records will be available to workers or his/her designated representative upon request.

Training includes a 40-hour course which describes procedures for working at hazardous waste sites. The procedures include a safety and health program, medical surveillance, decontamination, site characterization and analysis, protective clothing and monitoring equipment, site control work documentation, emergency response, engineering and administrative control to reduce exposure, and site safety evacuation procedures.

Contractors/subcontractors shall provide written documentation that these training/ experience requirements have been met. An example of a training documentation form is presented on Figure 5-1. Personnel shall also be trained in the contents of Appendix B, "Respiratory Protection Program."

5.2 SITE-SPECIFIC TRAINING

Site-specific training will be conducted by the SSO for on-site personnel and visitors to minimize exposure to potential of on-site hazards. Site-specific training will address the activities, procedures, monitoring, and equipment for the field operations at the ORR, DR, and ABG. This training will include identifying the names of personnel and alternate personnel responsible for site safety at the NAVSURFWARCENDIV.

In addition, this training at a minimum will include the following:

1. Site description and history.
2. Project activities, including coordination with other contractors.
3. Hazard evaluation.
4. On-site safety responsibilities.
5. Site control and work zones.
6. Personnel training.
7. Medical monitoring.
8. Atmospheric monitoring.
9. Personal protection, clothing, and equipment.
10. Decontamination procedures.
11. Emergency procedures.
12. Review of site-specific material safety data sheets (MSDSs).

FIGURE 5-1

OSHA TRAINING COMPLIANCE LETTER

Note: The following statements must be typed on company letterhead and signed by an officer of the company.

LOGO
XYZ CORPORATION
555 East 5th Street
Nowheresville, Kansas 55555

Month, day, year

(Project Manager)
Rust Environment & Infrastructure
4738 North 40th Street
Sheboygan, Wisconsin 53083

Subject: OSHA Compliance and Testing

Dear (Project Manager):

As an officer of XYZ Corporation, I hereby state that I am aware of the potential hazardous nature of the subject project. I also understand that it is our responsibility to comply with all applicable occupational safety and health regulations including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through 1910 and Parts 1926.

I also understand that Title 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response: Final Rule;" requires, but is not limited to, medical surveillance, for applicable employees, and appropriate level of training as required in paragraph (e) of 29 CFR 1910.120 for employees engaged in certain hazardous waste operations. I hereby state that I have reviewed these requirements; understand Title 29 of the CFR, Parts 1900 through 1910, and Part 1910, and Part 1926; and that XYZ Corporation and all of its employees who will perform work at the _____ site are in full compliance.

The following employees have had 40 hours of introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e) and have had 8 hours of refresher training as required by 29 CFR 1910.120(e)(8).

LIST EMPLOYEE NAMES, TYPE(S) OF TRAINING RECEIVED, AND DATES OF TRAINING HERE

Sincerely,

(Name of Company Officer)
Title

13. Safe work practices.
14. Other elements covered in this site-specific HASP.

This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safe operations. Training must include emergency preparedness, location of assembly areas, proper entry and exit procedures for exclusion zone (EZ), warning systems, location of emergency equipment, and route to the hospital.

5.3 SAFETY BRIEFINGS

Project personnel will be given briefings by the SSO on a daily or as-needed basis to further assist site personnel in conducting their activities safely. Briefings will be provided when new activities are to be conducted, changes in work practices must be implemented due to new information made available, or if site or environmental conditions change. Briefings will also be given to facilitate conformance with prescribed safety practices when performance deficiencies are identified during routine daily activities or as a result of safety audits.

5.4 SAFETY AUDITS

The REHSM, as necessary, will conduct regular safety audits of field operations and subcontractor performance to review for compliance with health and safety policies and procedures. Health and Safety audit findings will be documented and corrective action taken.

5.5 FIRST AID AND CPR

At least two individuals shall be trained and qualified to administer first aid and cardiopulmonary resuscitation (CPR).

The HSMs will identify the individuals possessing this training in order to ensure that emergency treatment is available during every workshift from a person qualified in first aid and CPR. These courses will be consistent with requirements of the American Red Cross and/or American Heart Association.

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6.0 MEDICAL SURVEILLANCE PROGRAM

All Rust E&I personnel and subcontractors performing field work at the NAVSURFWARCENDIV will be required to have passed a pre-assignment and/or periodic medical examination that is consistent with 29 CFR 1910.120(f) and 29 CFR 1926.58. Medical examinations shall be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine. A release for work will be confirmed by the CHSM before an employee can begin hazardous site activities.

Additional medical testing may be required by the CHSM in consultation with the company physician if an overt exposure or accident occurs, or if other site conditions warrant further medical surveillance.

Contractors/subcontractors will maintain the medical records for their own employees, but shall also provide the SSO with written documentation certifying that each employee at the site has met the requirements of the Medical Surveillance Program. This documentation will be provided before the first day of work for each employee assigned to the site. An example of a medical documentation form is presented on Figure 6-1. The pre-assignment and annual examinations are essentially the same in content and are the examining physician's discretion but generally include:

- An updated medical and occupational history
- A screening physical examination
- Blood and urine laboratory tests
- Chest X-ray
- Electrocardiogram
- Pulmonary function tests
- Audiometry
- Visual acuity test

At the end of employment or if deemed necessary after a employee's involvement in project-specific site work, he/she may have to complete a medical examination. This examination may be limited to obtaining an internal medical history of the period since the last full examination (consisting of medical history, physical examination, and laboratory tests).

6.1 EMERGENCY MEDICAL TREATMENT

Provisions for emergency medical treatment shall be integrated with the overall Site Emergency Plan (see Section 12.0) and shall include:

- At least two individuals per shift qualified to render first aid and CPR.

FIGURE 6-1

MEDICAL SURVEILLANCE LETTER

Note: The following statements must be typed on company letterhead and signed by an officer of the company.

LOGO
XYZ CORPORATION
555 East 5th Street
Nowheresville, Kansas 55555

Month, day, year

(Project Manager)
Rust Environment & Infrastructure
4738 North 40th Street
Sheboygan, Wisconsin 53083

Subject: OSHA Compliance and Testing

Dear (Project Manager):

As an officer of XYZ Corporation, I hereby state that the persons listed below participated in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations, Part 1910.120 entitled "Hazardous Waste Operations and Emergency Response: Final Rule." I further state that the persons listed below have had physical examinations under this program within the last 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear respiratory protection. I also state that, to my knowledge, no person listed below has any medical restrictions that would preclude him/her from performing their assigned activities at the _____ site.

LIST EMPLOYEE NAMES AND DATES OF MOST RECENT PHYSICAL EXAMS HERE

Should you have any questions, please contact me at 555/555-5555.

Sincerely,

(Name of Company Officer)
Title

D:\CTO7601\HASP1\FIGURES

- First aid kits in compliance with OSHA requirements and emergency first aid stations in the immediate work vicinity.

- Conspicuously posted phone numbers and procedures for contacting ambulance services, fire department, police, and medical facilities.

- Maps and directions to medical facilities (See Section 12.0).

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7.0 SITE CONTROL MEASURES

The purpose of the site control measures discussed in this section are to maintain order at the sites and to minimize chemical and physical hazards to on-site personnel, visitors, and the public. Site control zones will include an EZ, a contamination reduction zone (CRZ), and a support zone (SZ). In addition, temporary activity-specific WZs will be established at specific locations.

7.1 SITE ACCESS

Access to the NAVSURFWARCENDIV is controlled through the pass office located at the NAVSURFWARCENDIV Main Entrance on Hwy 45 (Bloomington Gate). A driver's license and proof of vehicle registration and insurance are required to obtain a pass. Once a pass has been acquired, access to the ABG, DR, and ORR are also controlled by checking in at each location.

7.2 EXCLUSION ZONE

The EZ is the area containing or suspected of containing contaminated materials. Since investigation activities will be conducted throughout the NAVSURFWARCENDIV, each investigative area boundary shall be delineated as the EZ.

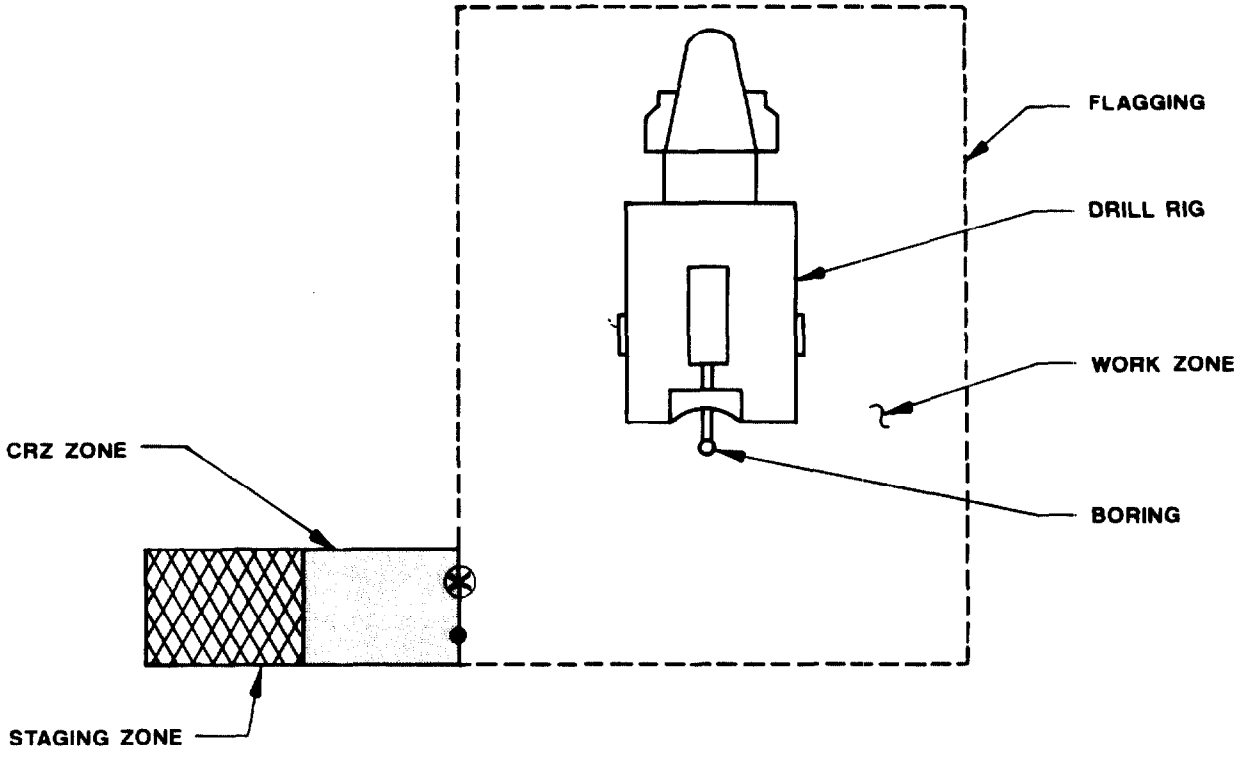
7.2.1 Work Zones

Temporary activity-specific WZs shall be established at each sampling activity. While completing soil borings and monitoring well installations the WZ shall be established and marked by safety rope or tape (see Figure 7-1). The WZ shall be a radius large enough to encompass the drill rig and allow sufficient space for safe work practices. A CRZ shall be placed at the WZ perimeter at an upwind location. A portable eye wash unit, fire extinguisher, towels, plastic garbage bags, decontamination supplies, and a first aid kit (sufficient to accommodate the field team) shall be placed in this CRZ. These supplies may be located in the vehicle parked adjacent to the WZ.

A temporary WZ shall be established at each sampling location where surface soil samples are to be collected. These WZ areas shall be established by laying about 5 square feet of plastic sheeting next to the sampling location for the placement of equipment and supplies. A portable eye wash, first aid kit (sufficient to accommodate the field team), towels, plastic garbage bags, fire extinguisher, and decontamination supplies are also required in this area, which may be located in the truck.

CLEAN CTO #0076

EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA HASP
JULY 1995



NOTES:

1. THE CRZ ZONE WILL CONTAIN:
   - PORTABLE EMERGENCY EYEWASH UNIT
   - FIRST AID KIT
   - FIRE EXTINGUISHER
   - TOWELS / WIPE CLOTHS
   - WATER FILLED TUB
   - 55-GALLON DRUM OR PLASTIC BAG
2. ⊗ ENTRY EXIT POINT
3. THE STAGING ZONE (IF APPLICABLE) WILL CONTAIN SUPPORT ZONE ACTIVITIES AND PERSONNEL TRANSPORT VEHICLES

SCALE: NTS

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 7-1
WORK ZONE LAYOUT
RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

7.3 PERSONNEL DECONTAMINATION

Personnel decontamination areas will be established on-site. Personnel will decontaminate and/or dispose of soiled protective clothing (i.e., disposable boots and gloves, etc.) in the CRZ established next to the temporary WZ. A fixed personnel decontamination area will be established adjacent to the fixed equipment decontamination pad where, after equipment decontamination, personnel can decontaminate and dispose of protective clothing and equipment before exiting the EZ. Refer to Section 10 for further decontamination procedures.

7.4 EQUIPMENT DECONTAMINATION PAD

To prevent off-site transport of contamination, the drill rig and associated equipment and vehicles will be decontaminated at a decontamination pad prior to exiting the EZ. This location will be selected by the SSO and Field Team Leader prior to start-up of field activities at the NAVSURFWARCENDIV. Drilling equipment (augers, rods, etc.) will be steam-cleaned at the decontamination pad as necessary. Decontamination liquids will be allowed to infiltrate into the soil. Refer to Section 10.0 for further decontamination procedures.

Sampling equipment such stainless steel hand augers, bowls, and spoons may be decontaminated at each sampling location. During decontamination, isopropanol rinses will be collected for later disposal at an approved NAVSURFWARCENDIV location. Other decontamination liquids will be allowed to infiltrate into the soil at each location. Refer to Section 10 for further decontamination procedures.

7.5 SUPPORT ZONE

The SZ is considered the uncontaminated area and will be identified by the SSO before field activities begin. It will contain the Command Post which will provide for team communications and emergency response. A mobile telephone will be located in this area. Appropriate sanitary facilities, safety, medical, and support equipment will be identified. No potentially contaminated personnel or materials are allowed in the SZ except for appropriately packaged/decontaminated and labelled samples.

7.6 SITE VISITORS

Visitors are required to report to the Field Team Leader and the SSO prior to accessing the sites, although none are anticipated. The SSO will document decisions regarding their access to the sites. If granted limited access, visitors must provide the SSO with documented compliance with Section 5.0 of this HASP, comply with other applicable

sections, and satisfy additional conditions placed on them as deemed appropriate by the SSO to ensure visitor safety. Visitors must sign in and out daily under the SSO's direction for the duration of their approved visit. Under no circumstances will visitors be allowed to interfere with, or participate in operations within the scope of the field investigation. All visitors shall be escorted throughout the sites by appropriately trained personnel.

As needed, the SSO will establish a designated Level D area as an observation point during intrusive activities. This designated area will be located to offer proximate viewing of site operations, and positioned such that visitors in no way may inhibit site access, logistics, or general operations. Further, the SSO will locate the viewing areas such that visitors present are at minimal risk of exposure to site hazards.

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8.0 PERSONAL PROTECTIVE EQUIPMENT

8.1 GENERAL

The level of protection to be worn by field personnel will be defined and controlled by the SSO. Personal protective equipment for general operations will be consistent with the requirements of 29 CFR 1910 Subpart I, "Personal Protective Equipment." Basic levels of protection for hazardous waste operations will be selected in accordance with the provisions of 29 CFR 1926.58(i), 29 CFR 1910.120(g)(3), "Personal Protective Equipment Selection," and Appendix A, "General Description and Discussion of the Levels of Protection and Protective Gear." Modification to basic protective equipment ensembles may be necessary for specific operations. In these cases, further definition will be provided by review of specific hazards, conditions, and proposed operational requirements, and by conducting air monitoring at the particular operation. Protection may be upgraded or downgraded, as deemed appropriate by the SSO and verified by the CHSM.

8.2 ANTICIPATED LEVELS OF PROTECTION FOR SITE OPERATIONS

• Surface Soil Sampling	Level D
• Surface Water/Sediment Sampling	Level D
• Monitoring Well Installation	Level D/C
• Monitoring Well Development/Groundwater Sampling	Level D/C
• Tissue Sampling	Level D
• Surface Water and Groundwater Hydraulic Characterization	Level D

Action levels used to determine the need to upgrade or downgrade the levels of protection are described in Section 9.2 of this HASP.

Level D personal protective clothing and equipment includes:

- Disposable Tyvek® or equivalent coveralls. (Polyethylene Coated Tyvek® required in sampling areas when splashing by contaminated soils or water is a possibility).
- Hardhat (when overhead hazards exist).
- Safety glasses or goggles.
- Steel toe, steel shank boots.

- Disposable latex gloves - required when handling and collecting soil, water, sediment, and tissue samples.
- Outer neoprene gloves - required when handling and collecting soil, water, sediment, and tissue samples.
- Disposable outer boots - required.
- Noise protection - as warranted.
- Lifebelt and lanyard - as warranted.

Level C protective clothing and equipment includes:

- Full-face air-purifying respirator National Institute for Occupational Safety and Health (NIOSH), Mining Safety and Health Administration (MSHA) approved fitted with acid gas/organic vapor/HEPA (High Efficiency Particulate Air filter) cartridges.
- Disposable Tyvek coveralls. (Polyethylene Coated Tyvek® required in sampling areas when splashing by contaminated soils or water is a possibility).
- Disposable latex inner gloves.
- Nitrile outer gloves.
- Hard hat (when overhead hazard exists).
- Steel toe, steel shank boots.
- Disposable outer boots.

Level B protective clothing and equipment includes the above Level C clothing with the addition of a self-contained breathing apparatus (SCBA) or supplied air-line respirator in place of an air-purifying respirator. If action levels are exceeded and based on evaluation of the conditions, and Level C protection is not sufficient and Level B respiratory protection is deemed necessary, work activities will be halted and arrangements for Level B equipment will be implemented.

The use and care of respiratory protection will be in accordance with the protocols described in Appendix B.

9.0 AIR MONITORING

9.1 GENERAL

It will be necessary to monitor the atmospheric conditions during on-site field sampling activities to determine the possible need to upgrade the personal protection of on-site workers. Atmosphere at the sample extraction point, soil cuttings, and fluids produced during drilling shall be monitored. In addition, air monitoring will be performed in the worker's BZ.

9.1.1 Soil Boring Operations/Monitoring Well Installations

Soil boring, and well installation activities will be initiated in Level D personal protection with the contingency to upgrade the level of protection based on the action levels.

Air monitoring will be performed at regular intervals throughout soil boring and well installation activities. A Flame Ionization Detector (FID) or Photoionization Detector (PID) shall be used to monitor the worker's BZ and the geologic samples upon retrieval. Drill cuttings and fluids produced during drilling shall also be monitored. Radiological hazards are not anticipated to be encountered in the testing areas.

9.1.2 Monitoring Well Development and Groundwater Sample Collection

Monitoring well development and groundwater sample collection activities shall be initiated in Level D personal protection with the contingency to upgrade the level of protection based on the action levels.

The PID/FID shall be used to continuously monitor the worker's BZ and the well casing. Prior to initiating development, testing, or sampling activities, the field team will stand upwind of the well casing and remove the well cap, stand back, and allow the well casing to vent for about 5 minutes. If action levels are not exceeded in the worker's BZ, development, testing, and/or sampling activities may proceed.

9.1.3 Soil Sampling

Soil sampling activities shall be initiated in Level D personal protection with the contingency to upgrade the level of protection based on the action levels.

Air monitoring of the worker's BZ shall be performed continuously during the sampling activities. An Organic Vapor Analyzer (OVA), FID, or HNu PID shall be used to monitor the BZ and the sampling extraction point.

9.1.4 Surface Water/Sediment Sample Collection

Surface water/sediment sampling activities shall be conducted in Level D protection. Atmospheric monitoring will be unnecessary because organic emissions are not anticipated due to the wet nature of the samples to be collected.

9.1.5 Tissue Sampling

Tissue sampling activities including netting of fish and trapping of small mammals shall be conducted in Level D protection. Atmospheric monitoring will be unnecessary because organic emissions are not anticipated due to the nature of the samples to be collected.

9.1.6 Surface Water and Groundwater Hydraulic Characterization

Surface water hydraulic characterization activities shall be conducted in Level D protection. Atmospheric monitoring will not be necessary because organic emissions are not anticipated due to the activities being performed in open surface water.

Personal protection, atmospheric monitoring, and well venting procedures as identified in 9.1.2 above shall be followed for groundwater hydraulic characterization activities.

9.2 ACTION LEVELS

Instrumentation will include a PID equipped with a 10.2 eV lamp and/or a Century OVA 128 FID. The action levels in this HASP will apply to site work during the duration of activities at the NAVSURFWARCENDIV.

Instrument	Action Levels	Level of Respiratory Protection/Action
PID/OVA	Continuous sustained readings to 1 ppm above background (typically to 0.2 ppm) in BZ	Level D
PID/OVA*	Continuous sustained readings of 1 ppm to 5 ppm above background	Level C (based on identification of contaminant)
PID/OVA	Continuous readings at 5 to 250 ppm above background in BZ	Level B (if applicable)

If visible dust is detected while working in Level D, upgrade to Level C respiratory protection is required. However, engineering controls, such as wetting the WZ area with water to control dust, will be implemented when feasible.

*In the event any action levels are exceeded, work activities shall be halted, and an attempt will be made to identify the contaminants present using colorimeter indicator tubes so that correct respiratory protection can be selected and action levels may be adjusted higher or more conservatively. The SSO shall notify the HSMs immediately prior to upgrading the level of respiratory protection.

9.3 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

9.3.1 Personal and Perimeter Monitoring

Personal and perimeter air monitoring will not be conducted unless Level D action levels are exceeded in the EZ. The determination to perform personal and perimeter air monitoring will be determined by the REHSM after discussions with SSO. If an air program is deemed necessary, work activities will be halted and a monitoring plan will be developed.

9.4 INSTRUMENT CALIBRATION AND MAINTENANCE

Instrument calibration and maintenance shall be performed according to manufacturer's specifications and documented on Field Instrument Calibration Logs. PID calibration shall be completed along with a FID calibration check on a daily basis.

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10.0 DECONTAMINATION PROCEDURES

The SSO shall determine the level of decontamination necessary based on the evaluation of specific work activities and the potential degree of contamination. Temporary CRZs shall be established at each sampling location.

10.1 EQUIPMENT

The drill rig, associated equipment, and vehicles will be decontaminated at a location on-site selected by the SSO prior to start-up of field activities in the EZ. Drilling equipment (augers, rods, etc.) will be steam-cleaned between sampling locations. These decontaminations will be performed on the ground away from the drilling location.

Non-disposable sampling equipment will be decontaminated before use, between samples, and before leaving the sampling location.

Equipment that cannot be immersed in soap solution and water will be wiped clean and rinsed with distilled water.

10.2 PERSONNEL

Personnel will perform decontamination in the personal decontamination area. Decontamination of personnel in Level D will consist of removal and disposal of coveralls (when worn) disposable boots, and gloves. Decontamination of personnel using Level C protective equipment will consist of:

- Washing boots, waders, or other non-disposable protective equipment, (i.e., hard hat, safety glasses/goggles, etc.) suspected of being contaminated using soap solution followed by potable or distilled water rinse.
- Removal and disposal of boot covers and waders if worn.
- Removal and disposal of coveralls.
- Removal and disposal of outer gloves.
- Removal, cleaning, and storage of respiratory equipment.
- Removal and disposal of inner gloves.

10.3 CONTAMINATION PREVENTION

One of the most important aspects of decontamination is the prevention of contamination. Good contamination prevention should minimize worker exposure and help ensure valid sample results by precluding cross-contamination. Procedures for contamination avoidance include:

Personnel

- Know the limitations of all personal protective equipment being used.
- Do not walk through areas of obvious or known contamination.
- Do not handle or touch contaminated materials directly. Do not sit or lean on potentially contaminated surfaces.
- Make sure all personal protective equipment has no cuts or tears prior to donning.
- Fasten all closures on suits, covering with tape, if necessary.
- Particular care should be taken to protect any skin injuries.
- Stay upwind of airborne contaminants.
- Do not carry cigarettes, gum, food, or candy into contaminated areas.
- On-site personnel are encouraged to shower at the end of their work day.

Sampling/Monitoring

- Cover instruments with clear plastic, leaving openings for sampling ports, and sensor points.
- Bag sample containers prior to placement of sample material into containers.

Heavy Equipment

- Care should be taken to limit the surface area of equipment that comes into contact with contamination.

General

- If contaminated tools are to be placed on noncontaminated equipment for transport to the decontamination pad, plastic should be used to keep the equipment clean.

- Spoils from sampling work should be placed so as not to be in the expected paths of individuals.

10.4 DISPOSAL PROCEDURES

Waste materials and other field equipment/supplies shall be handled in such a way as to preclude the potential for spreading contamination, creating a sanitary hazard, or causing litter to be left on-base. See Section 13.0 of the Risk Assessment Work Plan for details regarding investigation-derived waste disposal procedures.

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11.0 GENERAL SAFE WORK PRACTICES AND COMMUNICATIONS

11.1 SAFETY EQUIPMENT

Basic emergency and first aid equipment will be available at the SZ and/or the CRZ, as appropriate. This shall include communications equipment, first aid kit (sufficient to accommodate field team), emergency eye wash, and other safety-related equipment. Fire extinguishers will be provided, inspected, and available on-site.

11.2 COMMUNICATIONS

Walkie-Talkies - Hand-held units shall be used as much as possible by field teams for communication between downrange operations and the Command Post base-station.

Telephones - A mobile telephone will be located in the Command Post area in the SZ for communication with emergency support services/facilities.

Hand Signals - Hand signals will be used by downrange field teams in conjunction with the buddy system. These signals are very important when working with heavy equipment. They shall be known by the entire field team before operations commence and reviewed during site-specific training.

Signal	Meaning
• Hand gripping throat	Out of air; can't breathe
• Grip partner's wrist	Leave area immediately; no debate
• Hands on top of head	Need assistance
• Thumbs up	OK; I'm all right; I understand
• Thumbs down	No; negative

11.3 SAFE WORK PRACTICES

The following safe work practices will be implemented during site operations:

- Only properly trained and equipped personnel will be allowed to work in potentially contaminated areas.

- The number of personnel and equipment in the sampling areas will be kept to a minimum, consistent with safe site operations.

- Workers shall adhere to the "buddy system" while working downrange and in designated EZs. Radio contact shall be maintained between pairs on-site in order to assist each other in case of emergencies.

- Workers shall not exit EZs until soiled equipment and clothing have been removed and decontaminated or properly disposed of.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer, ingestion, and inhalation of potentially contaminated materials is prohibited.

- As necessary, personnel will thoroughly wash their hands and faces upon leaving the investigation areas.

- Contact with potentially contaminated materials and surfaces shall be avoided. Personnel shall comply with contamination control measures.

- Personnel with facial hair or other facepiece seal obstructions will not be permitted to work where respirators are required.

- Work shall only be conducted if adequate illumination is provided, i.e., visual observation is not impaired due to loss of daylight conditions.

Drilling

While the drilling subcontractor is responsible for safe means and methods of operating their drill rigs, (refer to Section 2.3 of this HASP), personnel working near drill rig operations shall be aware of the following safe work practices:

- Drillers shall inform personnel working with drill rig activities, (i.e., soil boring operations) as to the location of the emergency stop device.

- No drilling within 20 feet in any direction of overhead power lines will be permitted. The locations of all underground utilities must be identified and marked prior to initiating any subsurface activities.

- In the event the drill rig would come in contact with an electrical source, do not touch any part of the equipment or attempt to enter or leave it. Do not touch any person who may be in contact with electrical current. If rescue is attempted, only use a dry, clean rope or unpainted wooden pole.

- Personnel must develop hand signals with equipment operators.

- A remote sampling device must be used to sample drill cutting if the tools are rotating or if the tools are readily capable of rotating. Samplers must not reach into or near the rotating equipment. If personnel must work near any tools which could rotate, the driller must shut down the rig prior to initiating such work.

- Drillers, helpers, and samplers must secure all loose clothing when in the vicinity of drilling operations.

- "All" compressed gas cylinders must be stored and used in an upright position, properly secured and protected from damage, and segregated and labeled as empty, full, or in use.

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12.0 EMERGENCY PREPAREDNESS

12.1 EMERGENCY COORDINATOR

The Site Emergency Coordinator shall be the SSO. The SSO shall implement the emergency action plan as outlined in 29 CFR 1910.38. Although the following six items are typically more applicable to operating facilities, they will be implemented to the extent possible when applicable.

- Emergency escape procedures and routes.
- Procedures for those remaining for critical operations (this will not apply).
- Procedures to account for employees after evacuation.
- Rescue and medical duties.
- Preferred means of reporting fires and emergencies.
- Names, job titles, or departments to contact for additional information of duties outlined in this HASP.

12.2 EMERGENCY SERVICES CONTACTS

The Site Emergency Coordinator (SSO) shall verify appropriate emergency contacts and will make contact with them before beginning work on-site. The Site Emergency Coordinator (SSO) will inform the emergency contacts about the nature and duration of work expected on the base and the type of contaminants and possible health or safety effects of emergencies involving these contaminants. Also at this time, the Site Emergency Coordinator (SSO) and the emergency response units shall make arrangements to handle any emergencies that might be anticipated.

EMERGENCY PHONE NUMBERS:

Police Department:	3300 NAVSURFWARCENDIV Base
Fire Department:	3300 NAVSURFWARCENDIV Base
Hospital:	Bloomington Hospital
Hospital Address:	601 West Second Street Bloomington, IN 812/336-9515
Ambulance:	Base 3300 Hospital - 812/336-9515

National Response Center:	1-800-424-8802
Poison Control Center:	1-800-942-5969
REHSM:	Richard Tinsley 708-955-6600 (work) 708-961-1361 (home)
SSO:	To be determined before field activities begin

HOSPITAL ROUTE:

A hospital route map and written description depicting the route to the hospital from the investigation area is presented on Figure 12-1.

Once the SZ is established, and before field activity start-up, the Site Emergency Coordinator (SSO) shall drive the route to the hospital, post directions and/or a map to the hospital, and set up the first aid station including a 10-pound Type A/B/C fire extinguisher.

12.3 IMPLEMENTATION

The Site Emergency Coordinator (SSO) shall implement the emergency action procedures whenever conditions at the site warrant such action. The Site Emergency Coordinator (SSO) will be responsible for coordinating the evacuation, emergency treatment, and emergency transport of site personnel as necessary, and for notification of emergency response units and the appropriate management staff. In the event an evacuation is necessary, the SSO will take a role count at the designated gathering location with the use of the daily sign in and out sheet. The following conditions may require implementation of emergency action procedures:

- Fire or explosion on-site.
- Serious personal injury.
- Release of hazardous materials, including gases or vapors at levels greater than the maximum use concentrations of respirators.
- Unsafe working conditions, such as inclement weather.

12.4 FIRE OR EXPLOSION

If an actual fire or explosion has taken place, emergency steps will include 1) evacuation of work area and venting, and 2) notification of the fire department and other appropriate emergency response groups if necessary.

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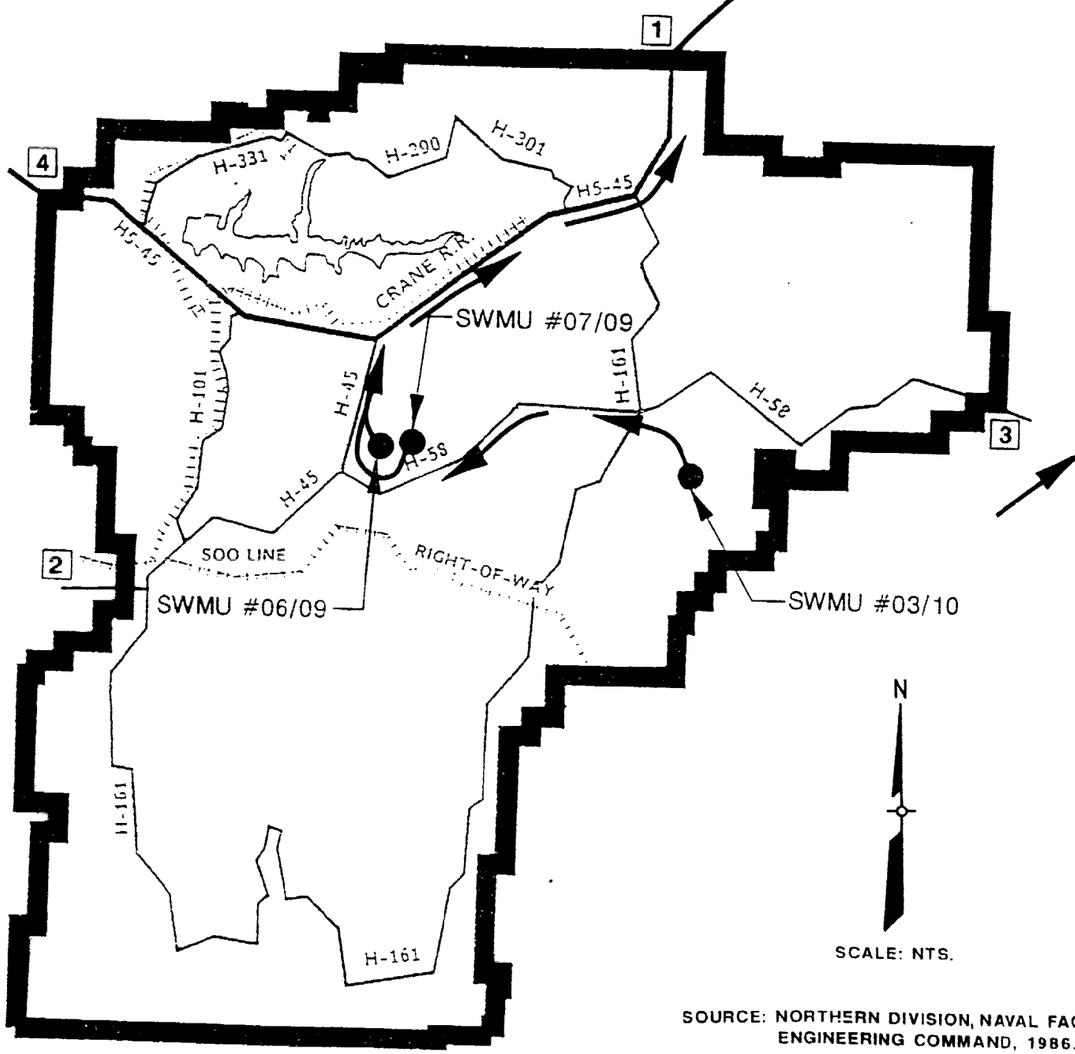
ROUTE TO BLOOMINGTON HOSPITAL

★ EXIT BASE ON H5-45 THROUGH THE BLOOMINGTON GATE; FOLLOW HWY 45 NORTH TO BLOOMINGTON AT HWY 45 AND HWY 37; CONTINUE GOING STRAIGHT OVER THE OVERPASS (BLOOMFIELD RD.); FOLLOW BLOOMFIELD RD. NORTH WHICH TURNS INTO 2ND. STREET; FOLLOW 2ND. STREET AND HOSPITAL IS ON YOUR RIGHT (601 WEST 2ND. STREET).



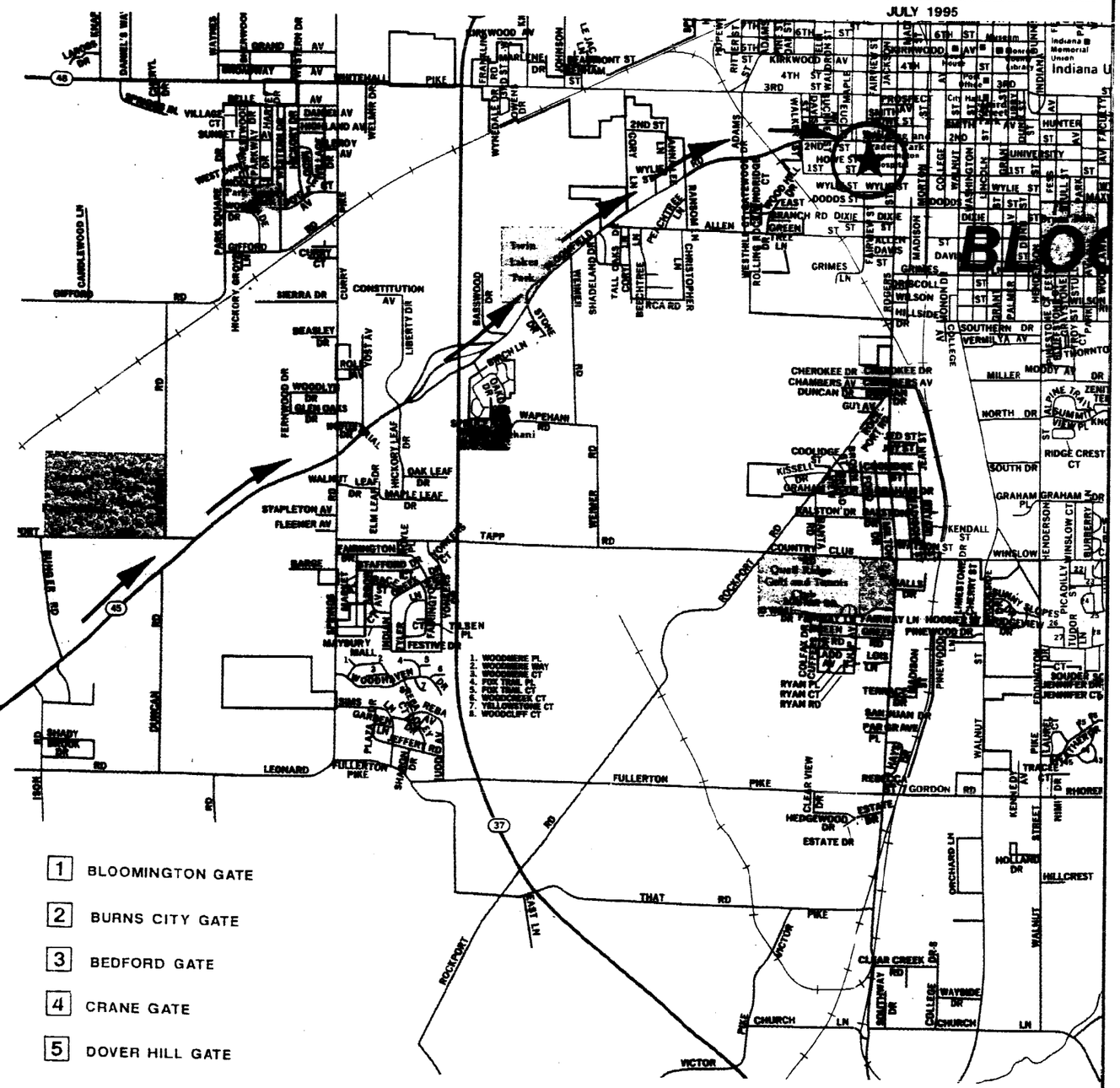
1 BLOOMINGTON GATE

2 BURNS CITY GATE

3 BEDFORD GATE

4 CRANE GATE

5 DOVER HILL GATE



SOURCE: NORTHERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, 1986.

MERCHANT MAP SHEET GUIDE AND INDEX, 1992.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 12-1

HOSPITAL ROUTE MAP

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

12.5 PERSONAL INJURY

Emergency first aid will be administered on-site as appropriate. Then the individual will be decontaminated if possible, depending on the severity of the injury, and transported to the nearest medical facility if needed.

12.6 OVERT CHEMICAL EXPOSURE

Typical response procedures include:

SKIN CONTACT:	Use copious amounts of soap and water. Wash/rinse affected area thoroughly, then provide appropriate medical attention. Eye wash will be provided on-site at the CRZ and/or SZ. Eyes should be rinsed for 15 minutes upon chemical contamination.
INHALATION:	Move to fresh air and/or, if necessary, decontaminate/transport to hospital.
INGESTION:	Decontaminate and transport to emergency medical facility.
PUNCTURE WOUND OR LACERATION:	Decontaminate and transport to emergency medical facility. The SSO will provide medical data sheets to medical personnel as requested.

12.7 ADVERSE WEATHER CONDITIONS

In the event of adverse weather conditions, the SSO will determine if work can continue without endangering the health and safety of field workers. Some items to be considered before determining if work should continue are:

- Potential for heat stress and heat-related injuries.
- Potential for cold stress and cold-related injuries.
- Treacherous weather-related working conditions.
- Limited visibility.
- Potential for electrical storms.

12.7.1 Heat Stress

The SSO shall visually monitor personnel to note for signs of heat stress. Field personnel will also be instructed to observe for symptoms of heat stress and methods on how to control it. One or more of the following control measures can be used to help control heat stress:

- Provide adequate liquids to replace lost body fluids. Personnel must replace water and salt lost from sweating. Personnel must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.
- Replacement fluids can be commercial mixes such as Gatorade®.
- Establish a work regime that will provide adequate rest periods for cooling down. This may require additional shifts of workers.
- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments.
- Breaks are to be taken in a cool rest area (77°F is best).
- Personnel shall remove impermeable protective garments during rest periods.
- Personnel shall not be assigned other tasks during rest periods.
- Personnel shall be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress.

The heat stress of personnel on-site may be monitored utilizing biological monitoring or the Wet Bulb Globe Temperature Index (WBGT) technique when workers are not wearing protective coveralls (i.e., Tyvek®). This method will require the use of a heat stress monitoring device.

One of the following biological monitoring procedures shall be followed when the workplace temperature is 70°F or above.

- Heart rate (HR) shall be measured by the pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 10 minutes (or 33 percent), while the length of rest period stays the same. If the pulse rate is 100 beats/minute at the beginning of the next rest period, the following work cycle should be shortened by

33 percent. The length of the initial work period will be determined by using the table below.

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUES

Work-Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous Work	80.0°F	80.0°F	77.0°F
75% Work - 25% Rest, Each Hour	87.0°F	82.4°F	78.6°F
50% Work - 50% Rest, Each Hour	88.5°F	85.0°F	82.2°F
25% Work - 75% Rest, Each Hour	90.0°F	88.0°F	86.0°F

- Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature at the beginning of the rest period should not exceed 99°F. If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the oral temperature exceeds 99.7°F at the beginning of the next rest period, the following work cycle shall be further shortened by 33 percent. OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with the oral temperature above 99°F.

12.7.2 Cold Exposure

If field activities occur during a period when temperatures average below freezing, the following guidelines will be followed.

Persons working outdoors in temperatures at or below freezing may be subject to frostbite. Extreme cold for a short time may cause severe injury to the surface of the body, or result in profound generalized cooling of the body core, resulting in coma and death. Areas of the body which have high surface area-to-volume ratio such as fingers, toes, and ears are the most susceptible.

Two factors influence the development of a cold injury; ambient temperature and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in

combination with low temperature. For instance, 10°F with a 15-mile per hour (mph) wind is equivalent to chilling still air to -18°F.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration-soaked.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: Characterized by sudden blanching or whitening of skin.
- Superficial frostbite: Skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- Deep frostbite: Tissue is cold, pale, and solid; extremely serious injury.

Prevention of frostbite is vital. Keep the extremities warm. Wear insulated clothing as part of one's protective gear during extremely cold conditions. Check for symptoms of frostbite at every break. The onset is painless and gradual--you may never know you have been injured until it is too late.

To administer first aid for frostbite, bring the victim indoors and rewarm the areas quickly in water between 39°C and 41°C (102°F to 105°F). Give a warm drink--not coffee, tea, or alcohol. The victim should not smoke. Keep the frozen parts in warm water or covered with warm clothes for 30 minutes, even though the tissue will be very painful as it thaws. Then elevate the injured area and protect it from injury. Do not allow blisters to be broken. Use sterile, soft, dry material to cover the injured areas. Keep victim warm and get immediate medical care.

After thawing, the victim should try to move the injured areas a little, but no more than can be done alone (without help).

- Do not rub the frostbitten part (this may cause gangrene).
- Do not use ice, snow, gasoline, or anything cold on frostbite.
- Do not use heat lamps or hot water bottles to rewarm the frostbitten area.
- Do not place the body part near a hot stove.

Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages: 1) shivering; 2) apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F;

3) unconsciousness, glassy stare, slow pulse, and slow respiratory rate; 4) freezing of the extremities; and, finally, 5) death.

Effects arising from cold exposure will be minimized by providing workers with insulated clothing when the equivalent chill temperature is less than 30°F as defined and presented in the ACGIH booklet in Table 5. Furthermore, field activities will generally be curtailed or halted if the equivalent chill temperature is below -20°F. The ultimate responsibility for delaying work at a site due to inclement weather rests with the SSO.

12.8 POISON IVY

If personnel come in contact with poison ivy, the individual should immediately wash the affected area with Ivy Cleaner provided in the first aid kit. If a rash develops, it should be treated at a medical facility as soon as possible.

12.9 SNAKES AND TICKS

12.9.1 Snake Bite Prevention and First Aid

On project sites, precautions against the possible presence of snakes should be taken when walking through overgrown vegetation and when moving debris (i.e. lumber, scrap metal, etc.). If someone is bitten by a snake, and the snake bite occurs in a location that is within a 1-hour drive of a medical facility, a conservative approach is safest. Keeping the victim quiet, lying or sitting, and reassuring him/her is all that is required. He/she should be transported safely (no speeding) to the nearest medical facility. For the reassurance of both the victim and the first aider, a snake bite is not nearly as dangerous as popular mythology would suggest. In North America, death from snake bite to healthy adults is very rare. Many bites, even from known poisonous snakes, do not result in a significant amount of venom being injected. Even when significant envenom occurs, symptoms develop slowly over many hours and can be controlled with appropriate treatment. Field treatments advised against include ice, cutting and suction around the wound, and tourniquets. Studies indicate that ice leads to increased tissue destruction. Cutting and sucking out the wound can be shown to offer some help if it is done with the correct technique and equipment and if the victim has received a large dose of venom. In light of the damage that can be done, the risk of such a procedure is too high. It is best to transport the person immediately to a medical facility.

12.9.2 Tick Bite Prevention and First Aid

Routinely check for ticks after being outdoors. Remove ticks as soon as possible before they embed. To minimize exposure, wear light-colored clothing so ticks can be detected.

Tuck pants into boots or socks and wear longsleeved shirts. Apply tick/insect repellent to clothing.

When a tick is found embedded, remove it by grasping it with a tweezers as close to the skin as possible and gently pull it straight out. Do not twist or jerk the tick because the head may remain embedded. Once the tick is removed, wash the bite area and your hands with soap and water and apply an antiseptic to the bite. Save the tick in a jar labeled with the date and the place where the tick was acquired. A physician may find this information and the tick specimen helpful in diagnosis if an infection results.

12.10 ACCIDENT/INJURY REPORTING AND RECORDKEEPING

The SSO shall maintain logs and reports covering health and safety aspects of the project throughout the duration of work activities. In the event of an on-site accident resulting in an exposure or injury, the SSO shall immediately complete an Accident/Injury Report form and send a copy to the Rust E&I CHSM. In the event of an accident or injury, the Rust E&I CHSM and Project Manager shall notify the Navy. The SSO shall be responsible for maintaining on-site, the routinely completed records and forms listed in Section 14.0 of this HASP.

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13.0 AUTHORIZATIONS AND FIELD TEAM REVIEW

13.1 AUTHORIZED PERSONNEL

Personnel entering the NAVSURFWARCENDIV investigation areas while field activities are being conducted must be authorized by the HSMs. Authorization will involve completion of appropriate training courses and medical examination requirements as required by OSHA 29 CFR 1910.120, current fit-testing and review and sign-off of this HASP. All personnel must be escorted by appropriately trained personnel, and check in with the Field Team Leader at the Command Post.

PERSONNEL AUTHORIZED TO PERFORM WORK ON-SITE:

1. David Richardson
2. Charles Zeal
3. Jeff Maletzke
4. Rob Stenson
5. Personnel Authorized by the Rust E&I REHSM and the CLEAN HSM

OTHER PERSONNEL AUTHORIZED TO ENTER SITE:

1. U.S. Navy Representatives
2. CAAA Representatives
3. Halliburton NUS Personnel
4. Subcontractor Personnel

13.2 FIELD TEAM REVIEW

Each field team member shall sign this section after site-specific training is completed and before being permitted to work on site.

I have read and understand this Health and Safety Plan. I will comply with the provisions contained therein.

Site/Project: **CONTRACT TASK ORDER NO. 0076**
NAVAL SURFACE WARFARE CENTER CRANE DIVISION
CRANE, INDIANA

Name Printed	Signature	Date

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14.0 RECORDKEEPING

The following records and reports will be established and kept as appropriate for the activities associated with implementing the RA WP.

- Accident/Incident Reports
- Daily Sign In/Sign Out Log
- Air Monitoring Records
- Sample Chain of Custody Form
- Personnel Training Certificates
- Site-Safety Orientation Log
- Health and Safety Audit Reports
- Instrumentation Calibration Logs
- Material Safety Data Sheets/Chemical Data Sheets/Hazardlines
- Medical Data Sheets (to be sent with injured personnel to hospital)
- Medical Examination Reports (Physician's Written Opinion)
- Respirator Fit Test Records
- Respirator Inspection Records
- Job Exposure Report

A blank Medical Data Sheet is included as the next page of this document. A Medical Data Sheet will be completed for each person working at the site.

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MEDICAL DATA SHEET

Project Name/Location: _____

Employee Name: _____ Home Telephone: _____

Address: _____
_____
_____

Birthdate: _____ Height: _____ Weight: _____

Drug and Other Allergies: _____
_____
_____
_____
_____

Notable Medical Conditions/Medical Restrictions: _____
_____
_____
_____
_____
_____
_____

Do You Wear Contact Lenses? _____ Yes _____ No
Dentures? _____ Yes _____ No

Are you using any medications? _____ Yes _____ No Please list:
_____
_____
_____

Emergency Contact: _____ Relationship: _____
Address: _____ Phone: ( )_____
_____

Personal Physician: _____ Phone: ( )_____
Address: _____
_____

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APPENDIX A
TO HEALTH AND SAFETY PLAN

CHEMICAL DATA SHEETS/HAZARDLINES

..PRINT A;

D003 RE-ENTER PARAGRAPH SELECTION...INVALID CODE WAS A;_:

ENTER DOCUMENT SELECTION._: ,,PRINT ALL/DOC=1

02 INVALID...ENTER DOCUMENT SELECTION (DOC=)._: ..PRINT ALL/DOC=1

1
AN ACCESSION NUMBER: 185. 9212.
CN CHEMICAL NAME: **AMMONIUM PICRATE.**
SY SYNONYMS: AMMONIUM PICRONITRATE. OBELINE PICRATE. PICRIC ACID, AMMONIUM SALT. PICRATE OF AMMONIA. AMMONIUM CARBAZOATE. UN 0004. PICRATOL. 2,4,6-TRINITROPHENOL, AMMONIUM SALT. EXPLOSIVE D. RCRA P009. AMMONIUM PICRATE, DRY.
RN CAS NUMBER: 131-74-8.

REG. TOXIC NUMBER: BS3855000.

CHEMICAL FORMULA: C6H6N4O7.

PD
PHYSICAL DESCRIPTION:
YELLOW CRYSTALS.

MOL WT:	246.16
BOILING PT:	EXPLODES AT 793 F
SOLUBILITY:	1%
FLASH PT:	EXPLOSIVE
VAPOR PRES:	NOT AVAILABLE
MELT PT:	DECOMPOSES
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	
SPEC GRAVITY:	1.7
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
NO OCCUPATIONAL EXPOSURE LIMITS ESTABLISHED BY OSHA, ACGIH OR NIOSH
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: AMMONIUM PICRATE IS A SKIN, EYE AND MUCOUS MEMBRANE IRRITANT, AND IS A SKIN SENSITIZER. THERE IS INSUFFICIENT DATA TO FULLY QUANTIFY THE TOXICITY. EXPOSURE MAY RESULT IN NAUSEA, ABDOMINAL PAIN, YELLOW STAINING OF THE SKIN, CONVULSIONS AND DEATH.

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED
YELLOW CRYSTALS.
IC
INCOMPATIBILITIES:
SULFURYL CHLORIDE. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC.
CL
CLOTHING:

PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).

WEAR EYE PROTECTION TO PREVENT:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, REMOVE CLOTHING AND DO NOT WEAR AGAIN UNTIL SUBSTANCE HAS BEEN REMOVED FROM CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
NO SPECIFIC; ADVISE:
- DUST AND MIST RESPIRATOR
- AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER

HIGH LEVELS
- TYPE 'C' SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE WITH A FULL FACE-PIECE, HELMET, OR HOOD OPERATED IN CONTINUOUS-FLOW MODE
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS. 53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
NO INFORMATION AVAILABLE FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS": ADVISE: GENERAL MEDICAL HISTORY.

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
SKIN.

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). RHINITIS, INFLAMMATION OF NASAL MUCOSA (SC0236).
SENSITIZATION, ALLERGIC REACTION (SC0148);
DERMATITIS, INFLAMMATION OF SKIN (SC0044). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046).
ABDOMINAL, SECTION BETWEEN THORAX AND PELVIS (SC0750);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). OLIGURIA, DECREASED URINATION (SC0323). ANURIA, COMPLETE LACK OF URINATION (SC0304).
SKIN, COVERING OF BODY (SC0174);
YELLOW DISCOLORATION, ABNORMAL PIGMENTATION OF TISSUE (SC0383). PRURITIS SEVERE ITCHING (SC0558).
SKIN, COVERING OF BODY (SC0174);
ERUPTION, A RASH OR LESION (SC0602). STUPOR, LETHARGY, UNCONSCIOUSNESS (SC0214). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034).
CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). BITTER TASTE, DISAGREEABLE TASTE (SC0503).

FA

FIRST AID.

(1 OF 6)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 6)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 6)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 6)
IF THIS SUBSTANCE IS INGESTED AND IF THE PERSON IS CONSCIOUS AND NOT CONVULSING, INDUCE EMESIS BY GIVING SYRUP OF IPECAC (KEEPING THE HEAD BELOW THE HIPS TO PREVENT ASPIRATION), FOLLOWED BY WATER. REPEAT IN 20 MINUTES IF NOT EFFECTIVE INITIALLY. IN PATIENTS WITH DEPRESSED RESPIRATION OR IF EMESIS IS NOT PRODUCED, PERFORM GASTRIC LAVAGE CAUTIOUSLY (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GASTRIC LAVAGE SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

(5 OF 6)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE

REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 6)
ACTIVATED CHARCOAL - GIVE ACTIVATED CHARCOAL WITHIN THE FIRST FEW MINUTES OF POISONING. GIVE PORTIONS EQUIVALENT TO ABOUT 5 ML FOR EACH KILOGRAM OF BODY WEIGHT, ORALLY OR BY GASTRIC LAVAGE. REMOVE BY SUCTION OR EMESIS, AND REPEAT THE PROCEDURE UNTIL A TOTAL OF 100 GM OF CHARCOAL HAS BEEN INTRODUCED AND RECOVERED. EACH GRAM OF ACTIVATED CHARCOAL WILL ADSORB 100-1000 MG OF POISON. DO NOT MIX CHARCOAL WITH OTHER AGENTS TO INCREASE PALATABILITY. GASTRIC LAVAGE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
NONE IN COMMON USE.

RS

REGULATORY STATUS.

(1 OF 28)
****
FEDERAL REGULATION

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1

AN ACCESSION NUMBER: 271. 9211.
CN CHEMICAL NAME: ARSENIC, SOLID.
SYNONYMS: UN 1558. ARSENIC. COLLOIDAL ARSENIC. ARSENIC BLACK. GREY
SENIC. METALLIC ARSENIC. ARSENIC, METALLIC. ARSENICALS. ARSENIC-75.
STCC 4923207.
RN CAS NUMBER: 7440-38-2.

REG. TOXIC NUMBER: CG0525000.

CHEMICAL FORMULA: AS.

D

PHYSICAL DESCRIPTION:
SILVER-GRAY BRITTLE, CRYSTALLINE SOLID WITH AN ODOR OF GARLIC.

MOL WT:	74.92
BOILING PT:	SUBLIMES AT 1135 F
SOLUBILITY:	INSOLUBLE
FLASH PT:	NONCOMBUSTIBLE SOLID
VAPOR PRES:	NOT AVAILABLE
MELT PT:	1503 F AT 28 ATM
UEL IN AIR:	NONCOMBUSTIBLE
LEL IN AIR:	NONCOMBUSTIBLE
MEC IN AIR:	
SPEC GRAVITY:	5.6 - 5.9
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:	.

L

RMISSABLE EXPOSURE:
UG(AS)/M3 OSHA TWA
200 UG(AS)/M3 ACGIH TWA
2 UG(AS)/M3 NIOSH RECOMMENDED 15 MINUTE CEILING
HUMAN SUFFICIENT EVIDENCE FOR CARCINOGENICITY (IARC GROUP-1 ARSENICS)
ANIMAL LIMITED EVIDENCE FOR CARCINOGENICITY (IARC GROUP-1 ARSENICS)
OSHA CARCINOGEN; KNOWN HUMAN CARCINOGEN (NTP)
HUMAN CARCINOGEN (EPA - CATEGORY A)
TUMORIGENIC DATA (RTECS)
REPRODUCTIVE EFFECTS DATA (RTECS)
MUTAGENIC DATA (RTECS)
SURVEILLANCE INDEX CLASSIFICATION I: HIGH HEALTH HAZARD POTENTIAL
CERCLA HAZARD RATING - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 -
PERSISTENCE 3
TOXICOLOGY: ARSENIC IS AN EYE, SKIN AND MUCOUS MEMBRANE IRRITANT AND
A SKIN SENSITIZER. IT IS MODERATELY TOXIC BY INGESTION. ARSENIC IS A
NEUROTOXIN. POISONING MAY AFFECT THE HEART, LIVER, KIDNEYS, AND THE
HEMATOPOIETIC, GASTROINTESTINAL AND ENDOCRINE SYSTEMS. CHRONIC EXPOSURE
TO ARSENIC COMPOUNDS MAY CAUSE GENERALIZED MUSCULAR WEAKNESS,
BRONZING OF THE SKIN, MEE'S LINES IN THE FINGERNAILS AND A FEELING
OF PINS AND NEEDLES IN THE EXTREMITIES. EVIDENCE FOR CARCINOGENICITY
OF ARSENIC COMPOUNDS IN ANIMALS IS CONSIDERED LIMITED. THERE IS
SUFFICIENT EVIDENCE THAT SKIN CANCER IS CAUSALLY ASSOCIATED WITH
EXPOSURE TO INORGANIC ARSENIC COMPOUNDS IN THE OCCUPATIONAL
ENVIRONMENT. THE RISK OF LUNG CANCER INCREASED 4 TO 12 TIMES IN
CERTAIN SMELTER WORKERS WHO INHALED HIGH LEVELS OF ARSENIC TRIOXIDE.
WEVER, THE INFLUENCE OF OTHER CONSTITUENTS OF THE WORKING
ENVIRONMENT CANNOT BE EXCLUDED. CASE REPORTS HAVE SUGGESTED AN
ASSOCIATION BETWEEN EXPOSURE TO ARSENIC COMPOUNDS AND LIVER TUMORS
AND BLOOD DISEASES.
THE THRESHOLD LIMIT VALUE WAS SET ON THE PROBABILITY THAT SOME
ARSENIC COMPOUNDS, OR THE METAL ITSELF, IS CHRONICALLY LESS TOXIC THAN
ARSENIC TRIOXIDE.

ORL-MAN TDLO: 7857 MG/KG/55Y ORL-RAT LD50: 763 MG/KG
ORL-MUS LD50: 145 MG/KG IPR-MUS LD50: 46,200 MG/KG
IPR-GPG LDLO: 10 MG/KG SCU-GPG LDLO: 300 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
100 MG(AS)/M3 POTENTIAL
CARCINOGENNIOSH
SILVER-GRAY BRITTLE, CRYSTALLI.

:C

INCOMPATIBILITIES:
ARSENIC, SOLID: BROMATES: REACT VIGOROUSLY. CHLORATES: REACT VIGOROUSLY. FLUORINE: REACTS VIGOROUSLY. LITHIUM: REACTS VIGOROUSLY. POTASSIUM: REACTS VIGOROUSLY: HYDROGEN GAS: REACTS VIGOROUSLY. OXIDIZING MATERIALS: REACT VIGOROUSLY. ACIDS: REACT VIGOROUSLY. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC.

:L

CLOTHING:
29CFR1910.1018 INORGANIC ARSENIC WHERE THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC EXISTS, AND FOR ALL WORKERS WORKING IN REGULATED AREAS, THE EMPLOYER SHALL PROVIDE AT NO COST TO THE EMPLOYEE AND ASSURE THAT EMPLOYEES USE APPROPRIATE AND CLEAN PROTECTIVE WORK CLOTHING AND EQUIPMENT SUCH AS, BUT NOT LIMITED TO: COVERALLS OR SIMILAR FULL-BODY WORK CLOTHING; GLOVES, AND SHOES OR COVERLETS; FACE SHIELDS OR VENTED GOGGLES WHEN NECESSARY TO PREVENT EYE IRRITATION, WHICH COMPLY WITH THE REQUIREMENTS OF 29CFR1910.133(A) (2)-(A)(6); AND IMPERVIOUS CLOTHING FOR EMPLOYEES SUBJECT TO EXPOSURE TO ARSENIC TRICHLORIDE. THE EMPLOYER SHALL PROVIDE THE PROTECTIVE CLOTHING IN A FRESHLY LAUNDERED AND DRY CONDITION AT LEAST WEEKLY, AND DAILY IF THE EMPLOYEE WORKS IN AREAS WHERE EXPOSURES ARE OVER 100 UG/M3 OF INORGANIC ARSENIC OR IN AREAS WHERE MORE FREQUENT WASHING IS NEEDED TO PREVENT SKIN IRRITATION. THE EMPLOYER SHALL REPAIR OR REPLACE THE PROTECTIVE CLOTHING AND EQUIPMENT NEEDED TO MAINTAIN THEIR EFFECTIVENESS. THE EMPLOYER SHALL ASSURE THAT CONTAMINATED PROTECTIVE CLOTHING TO BE CLEANED, LAUNDERED, OR DISPOSED OF, IS PLACED IN A CLOSED CONTAINER IN THE CHANGE-ROOM WHICH PREVENTS DISPERSION OF INORGANIC ARSENIC OUTSIDE THE CONTAINER. THE EMPLOYER SHALL INFORM IN WRITING ANY PERSON WHO CLEANS OR LAUNDERS CLOTHING OF THE POTENTIALLY HARMFUL EFFECTS INCLUDING THE CARCINOGENIC EFFECTS OF EXPOSURE TO INORGANIC ARSENIC.

WEAR EYE PROTECTION TO PREVENT:
29CFR1910.1018 INORGANIC ARSENIC FACE SHIELDS OR VENTED GOGGLES WHEN NECESSARY TO PREVENT EYE IRRITATION, WHICH COMPLY WITH THE REQUIREMENTS OF 29CFR1910.133(A)(2)-(A)(6).
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THERE IS ANY POSSIBILITY OF THIS SOLID CONTACTING THE EYES.

EMPLOYEE SHOULD WASH:
29CFR1910.1018 INORGANIC ARSENIC THE EMPLOYER SHALL ASSURE THAT EMPLOYEES WORKING IN THE REGULATED AREA OF SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM EXPOSURE TO INORGANIC ARSENIC WASH THEIR HANDS AND FACE PRIOR TO EATING. THE EMPLOYER SHALL ASSURE THAT EMPLOYEES WORKING IN REGULATED AREAS OR SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC SHOWER AT THE END OF THE WORK SHIFT. FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINGES FOR CHEMICAL

PROMPTLY WASHED WITH SOAP AND WATER. WORKERS WHO HANDLE INORGANIC ARSENIC SHOULD WASH THEIR FACES, HANDS, AND FOREARMS THOROUGHLY WITH SOAP AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
29CFR1910.1018 INORGANIC ARSENIC THE EMPLOYERS SHALL PROVIDE FOR EMPLOYEES WORKING IN REGULATED AREAS OR SUBJECT TO THE POSSIBILITY OF SKIN OR EYE IRRITATION FROM INORGANIC ARSENIC, CLEAN CHANGE ROOMS EQUIPPED WITH STORAGE FACILITIES FOR STREET CLOTHES AND SEPARATE STORAGE FACILITIES FOR PROTECTIVE CLOTHING AND EQUIPMENT IN ACCORDANCE WITH 29CFR1910.141(E). FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS": EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
29CFR1910.1018 INORGANIC ARSENIC EMPLOYERS SHALL ASSURE THAT ALL PROTECTIVE CLOTHING IS REMOVED AT THE COMPLETION OF A WORK SHIFT ONLY IN APPROPRIATE CHANGE ROOMS. THE EMPLOYER SHALL PROHIBIT THE REMOVAL OF INORGANIC ARSENIC FROM PROTECTIVE CLOTHING OR EQUIPMENT BY BLOWING OR SHAKING. FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FROM CHEMICAL HAZARDS": CLOTHING WHICH IS CONTAMINATED WITH INORGANIC ARSENIC SHOULD BE REMOVED IMMEDIATELY AND PLACED IN SEALED CONTAINERS FOR STORAGE UNTIL IS CAN BE DISCARDED OR UNTIL PROVISION IS MADE FOR THE REMOVAL OF INORGANIC ARSENIC FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF TH BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
SEND BACK AREA EXCEDED.

MS

MEDICAL SURVEILLANCE:
29CFR1910.1018 THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REQUIRES EMPLOYERS TO PROVIDE A MEDICAL SURVEILLANCE PROGRAM FOR EMPLOYEES WHO ARE OR MAY BE EXPOSED TO LEVELS OF INORGANIC ARSENIC ABOVE THE ACTION LEVEL FOR AT LEAST 30 DAYS PER YEAR (WHICH WOULD INCLUDE AMONG OTHERS, ALL EMPLOYEES, WHO WORK IN REGULATED AREAS). EXAMINATIONS ARE ALSO TO BE PROVIDED TO ALL EMPLOYEES WHO HAVE HAD 10 YEARS OR MORE EXPOSURE ABOVE THE ACTION LEVEL FOR MORE THAN 30 DAYS PER YEAR WHILE WORKING FOR THE PRESENT OR PREDECESSOR EMPLOYER THOUGH THEY MAY NO LONGER BE EXPOSED ABOVE THE LEVEL. THIS MEDICAL SURVEILLANCE PROGRAM SHALL CONSIST OF: (1) AN INITIAL MEDICAL EXAMINATION INCLUDING: (A) WORK AND MEDICAL HISTORY (1) SMOKING HISTORY (2) PRESENCE AND DEGREE OF RESPIRATORY SYMPTOMS (B) A 14" BY 17" POSTERIOR-ANTERIOR CHEST X-RAY AND AN INTERNATIONAL LABOR OFFICE UICC/CINCINNATI (ILO U/C) RATING (C) A NASAL AND SKIN EXAM (D) A SPUTUM CYTOLOGY EXAM (E) OTHER EXAMS WHICH THE PHYSICIAN BELIEVES APPROPRIATE BECAUSE OF THE EMPLOYEE'S EXPOSURE TO INORGANIC ARSENIC OR BECAUSE OF REQUIRED RESPIRATOR USE (2) PERIODIC EXAMINATION (A) ANNUAL EXAMS FOR THOSE EMPLOYEES 45 YEARS OF AGE OR LESS WITH FEWER THAN 10 YEARS EMPLOYMENT WHERE EMPLOYEE EXPOSURE EXCEEDS THE ACTION LEVEL INCLUDING: (1) MEDICAL HISTORY UPDATE (2) NO SPUTUM CYTOLOGY (B) SEMI-ANNUAL EXAMS FOR OTHER COVERED EMPLOYEES INCLUDING: (1) ALL TESTS IN INITIAL EXAM (2) MEDICAL HISTORY UPDATE (3) ADDITIONAL EXAMINATIONS (A) LATERAL AND OBLIQUE X-RAYS (B) PULMONARY FUNCTION (C) PALPATION OF SUPERFICIAL LYMPH NODES AND COMPLETE BLOOD COUNT FOR WORKERS EXPOSED TO

EMPLOYEE FOR ANY REASON DEVELOPS SIGN AND SYMPTOMS COMMONLY ASSOCIATED WITH EXPOSURE TO INORGANIC ARSENIC THE EMPLOYER SHALL PROVIDE AN APPROPRIATE EXAM.
OTHER MEDICAL SURVEILLANCE RECOMMENDED: 40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
ATTENTION TO SMOKING, ALCOHOL, MEDICATION, AND EXPOSURE TO CARCINOGENS.
FOOD AND DRUG ADMINISTRATION (FDA) SURVEILLANCE INDEX CLASSIFICATION (SIC) - CLASS I: HIGH HEALTH/TOXICITY HAZARD. THIS HAZARD POTENTIAL WARRANTS IMMEDIATE INCLUSION OF THIS SUBSTANCE IN MEDICAL MONITORING PROGRAM ON A CONTINUOUS BASIS.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
ATTENTION TO SMOKING, ALCOHOL, MEDICATION, AND EXPOSURE TO CARCINOGENS.
NOTICE OF INTENT TO ESTABLISH ACGIH BIOLOGICAL EXPOSURE INDICIES FOR ARSENIC AND SOLUBLE COMPOUNDS INCLUDING ARSINE: 50 UG/G CREATININE INORGANIC ARSENIC METABOLITES IN URINE / TIMING-END OF WORKWEEK.

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
RESPIRATORY SYSTEM. SKIN. EYES. LYMPHATIC SYSTEM. CENTRAL NERVOUS SYSTEM. MUCOUS MEMBRANES. KIDNEYS. LIVER. BLOOD. PERIPHERAL NERVOUS SYSTEM.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
SENSITIZATION, ALLERGIC REACTION (SC0148). FROTHY SPUTUM, FOAMY MIXTURE OF SALIVA AND MUCOUS (SC0627). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). LASSITUDE, A SENSE OF WEARINESS (SC0098). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). GIDDINESS, FRIVOLOUS, DIZZINESS (SC0071). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). WEAKNESS, LACK OF STRENGTH (SC0167). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046).
EXTREMITIES, ARMS OR LEGS (SC0062);
MYALGIA, MUSCLE PAIN OR TENDERNESS (SC0526). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). ANOREXIA, DIMINISHED APPETITE (SC0006).
CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). CORYZA, HEAD COLD (SC0431).
PERFORATION, OPENING IN HOLLOW ORGAN OR VISCUS (SC0127);
NASAL, PERTAINING TO THE NOSE (SC0114).
SEPTUM, WALL DIVIDING 2 CAVITIES OF NOSE (SC0202).
SKIN, COVERING OF BODY (SC0174).
LESIONS, DISCONTINUITY OF TISSUE (SC0416). PALMAR AND PLANTAR HYPERKERATOSIS, GROWTHS ON HANDS & SOLES OF FEET (SC0266). ALOPECIA, BALDNESS (SC0201). PERIPHERAL NEURITIS, INFLAMED NERVES OF EXTREMITIES (SC0129). BRONZING OF THE SKIN, GOLDEN-YELLOW SKIN PIGMENTATION (SC0126). KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094).
PHOTOPHOBIA, INTOLERANCE TO LIGHT (SC0131). DYSPHAGIA, DIFFICULTY IN SWALLOWING (SC0325). METALLIC TASTE, TASTE RESEMBLING METAL IN MOUTH (SC0216). THROMBOCYTOPENIA, DECREASE IN BLOOD PLATELETS (SC0329). BONE

POLYNEURITIS, INFLAMMATION OF MANY NERVES (SC0624). PARESTHESIA, ABNORMAL SENSATION WITHOUT CAUSE (SC0125). ANESTHESIA, LOSS OF SENSATION (SC0005). CIRRHOSIS, PROGRESSIVE DISEASE OF LIVER (SC0027). APLASTIC ANEMIA, ANEMIA FROM BONE MARROW DAMAGE (SC0285). ATAXIA, MUSCULAR INCOORDINATION (SC0013). TREMORS, TREMBLING, SHAKING (SC0197). CONFUSION, IN A BEWILDERED STATE (SC0030). INCOORDINATION, LACK OF COORDINATION (SC0085). FEVER, BODY TEMPERATURE ABOVE NORMAL (SC0067). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). WRIST DROP, WRIST WILL NOT EXTEND (SC0208). BRITTLE FINGERNAILS, FINGERNAILS CRACKING AND SLOUGHING (SC0225). CARDIAC, PERTAINING TO HEART (SC0023);
FAILURE, LOSS OF FUNCTION (SC0386). LIVER DAMAGE, INJURY TO THE LIVER (SC0221).
SKIN, COVERING OF BODY (SC0174);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).
LUNG, RESPIRATORY ORGAN (SC0377);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
INGESTED ARSENIC: REMOVE INGESTED ARSENIC BY GASTRIC LAVAGE OR EMESIS. FOLLOW WITH A SALINE CATHARTIC. MAINTAIN BLOOD PRESSURE, AIRWAY AND GIVE OXYGEN IF RESPIRATION IS DEPRESSED. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS IF VICTIM IS UNCONSCIOUS. GET MEDICAL ATTENTION IMMEDIATELY. ANTIDOTE: GIVE DIMERCAPROL, 3 MG/KG (OR 0.3 ML/KG) EVERY 4 HOURS FOR 2 DAYS AND THEN 2 MG/KG EVERY 2 HOURS FOR A TOTAL OF 10 DAYS. DIMERCAPROLIS AVAILABLE AS A 10% SOLUTION IN OIL FOR INTRAMUSCULAR ADMINISTRATION. NEXT, GIVE PENICILLAMINE, UP TO 100 MG/KG/DAY (MAXIMUM 1 G/DAY) DIVIDED INTO 4 DOSES FOR NO LONGER THAN 1 WEEK. IF A LONGER ADMINISTRATION PERIOD IS WARRENTED, DOSAGE SHOULD NOT EXCEED 40 MG/KG/DAY. GIVE THE DRUG ORALLY HALF AND HOUR BEFORE MEALS. (DREISBACH, HANDBOOKOF POISONING, 12TH ED.). ADMINISTRATION OF GASTRIC LAVAGE, OXYGEN AND/OR ANTIDOTE SHOULD BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 5)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH,

MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

T

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
URINE ARSENIC AS EXPOSURE INDEX.
ARSENIC IN HAIR AND NAILS AS EXPOSURE INDEX.
14" X 17" POST-ANTERIOR X-RAY.

Y FUNCTION.

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NTER DOCUMENT SELECTION._: 7440-28-0

002 INVALID...ENTER DOCUMENT SELECTION (DOC=)._: 7440-28-0

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1

N ACCESSION NUMBER: 271. 9211.
:N CHEMICAL NAME: ARSENIC, SOLID.
:Y SYNONYMS: UN 1558. ARSENIC. COLLOIDAL ARSENIC. ARSENIC BLACK. GREY ARSENIC. METALLIC ARSENIC. ARSENIC, METALLIC. ARSENICALS. ARSENIC-75. STCC 4923207.
:N CAS NUMBER: 7440-38-2.

REG. TOXIC NUMBER: CG0525000.

CHEMICAL FORMULA: AS.

'D

PHYSICAL DESCRIPTION:
SILVER-GRAY BRITTLE, CRYSTALLINE SOLID WITH AN ODOR OF GARLIC.

MOL WT: 74.92

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END OF DOCUMENTS IN LIST_:
3RS SEARCH MODE - ENTER QUERY
37_: 7740-28-0\

7740-28-0\ SEARCH TERM NOT FOUND

RESULT 0 DOCUMENTS
38_: 7440-28-0

RESULT 1 DOCUMENT
39_:

BRS SEARCH MODE - ENTER QUERY
5_: ..PRINT ALL/DOC=1

1
ACCESSION NUMBER: 289. 9205.
CHEMICAL NAME: BARIUM.
SYNONYMS: BARIUM METAL. BARIUM, METALLIC. METALLIC BARIUM. BARIUM METAL, NON-PYROPHORIC. UN 1400. UN 1399.
RN CAS NUMBER: 7440-39-3.

REG. TOXIC NUMBER: CQ8370000.

CHEMICAL FORMULA: BA.
PD
PHYSICAL DESCRIPTION:
SILVERY-WHITE, SOFT METAL, TURNS YELLOW ON EXPOSURE TO AIR.

MOL WT:	137.36
BOILING PT:	2984 F
SOLUBILITY:	REACTS
FLASH PT:	FLAMMABLE SOLID
VAPOR PRES:	10 MM AT 1920 F
MELT PT:	1337 F
UEL IN AIR:	
LEL IN AIR:	
MEC IN AIR:	
SPEC GRAVITY:	3.5
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:	.

PERMISSABLE EXPOSURE:
0.5 MG/M3 OSHA TWA
0.5 MG/M3 ACGIH TWA
0.5 MG/M3 NIOSH RECOMMENDED 10 HR TWA
CERCLA HAZARD RATING - TOXICITY U - IGNITABILITY 0 - REACTIVITY 2 - PERSISTENCE 3
TOXICOLOGY: BARIUM IS AN EYE, SKIN AND MUCOUS MEMBRANE IRRITANT. THERE IS INSUFFICIENT DATA TO QUANTIFY THE TOXICITY. POISONING MAY AFFECT THE CENTRAL NERVOUS SYSTEM, GASTROINTESTINAL SYSTEM, BLOOD AND KIDNEYS. STIMULATION OF ALL MUSCLE TYPES MAY OCCUR, ESPECIALLY CARDIAC. CHRONIC INHALATION MAY RESULT IN A BENIGN RESPIRATORY AFFECTION KNOWN AS BARITOSIS, WHICH, AS A RULE, CAUSES NO SPECIFIC SYMPTOMS AND NO RESPIRATORY INCAPACITY. IT MAY PRODUCE SMALL CIRCUMSCRIBED NODULES THROUGHOUT THE LUNG FIELD. NODULATION DISAPPEARS WITH CESSATION OF EXPOSURE BUT THERE OFTEN REMAIN SOME SIGNS CHARACTERISTIC OF CHRONIC BRONCHICAL IRRITATION.
THE THRESHOLD LIMIT VALUE WAS SET AT 0.5 MG/M3.
PERSONS WITH A HISTORY OF CHRONIC RESPIRATORY, CARDIOVASCULAR OR SKIN DISEASE MAY BE AT AN INCREASED RISK FROM EXPOSURE.

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
1100 MG/M3 OSHA/NIOSH
SILVERY-WHITE, SOFT METAL, TUR.
IC
INCOMPATIBILITIES:

FLAMMABLE IN AIR. REACTS WITH WATER, RELEASING TOXIC AND/OR DANGEROUS GAS(ES). AMMONIA. OXYGEN. HALOGENS (BROMINE, CHLORINE, IODINE, FLUORINE). ACIDS. METAL IN POWDERED FORM IS EXPLOSIVE. CARBON TETRACHLORIDE. REACTS VIGOROUSLY WITH WATER. TRICHLOROTRIFLUOROETHANE. TRICHLOROFLUOROMETHANE. TETRACHLOROETHYLENE. 1,1,2-TRICHLOROETHYLENE. BROMINE PENTAFLUORIDE. IODINE HEPTAFLUORIDE.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROLONGED SKIN CONTACT WITH SOLUBLE BARIUM COMPOUNDS OR LIQUIDS CONTAINING SOLUBLE BARIUM COMPOUNDS. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUSTAND SPLASHPROOF SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE SOLUBLE BARIUM COMPOUNDS OR LIQUIDS CONTAINING SOLUBLE BARIUM COMPOUNDS MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES WET WITH THIS SUBSTANCE PROPMTLY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE SOLUBLE BARIUM COMPOUNDS OR LIQUIDS CONTAINING SOLUBLE BARIUM COMPOUNDS WASH THEIR HANDS THOROUGHLY BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NOT REQUIRED.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES WET WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE SOLUBLE BARIUM COMPOUNDS OR LIQUIDS CONTAINING SOLUBLE BARIUM COMPOUNDS ARE HANDLED, PROCESSED, OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
5 MG/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS AND QUARTERMASK RESPIRATORS
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

12.5 MG/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER

25 MG/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER
- SUPPLIED-AIR RESPIRATOR WITH A TIGHT-FITTING FACEPIECE OPERATED IN A CONTINUOUS FLOW MODE
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE

250 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS
MEDICAL SURVEILLANCE:
NO INFORMATION AVAILABLE FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS'; ADVISE: EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
MEDICAL WARNING FOR REFUSAL OF MEDICAL EXAMINATION.
CARDIOVASCULAR DISEASE.
CHRONIC RESPIRATORY DISEASE.
CENTRAL NERVOUS SYSTEM EXAMINATION.
SPECIAL ATTENTION TO SKIN.
14 BY 17 CHEST P.A. X-RAY.
PULMONARY FUNCTIONS.
RESPIRATORY HISTORY.
ELECTROCARDIOGRAM.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE
ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO
TARGET ORGANS:
HEART. LUNGS. CENTRAL NERVOUS SYSTEM. SKIN. RESPIRATORY SYSTEM. EYES.

SP
SYMPTOMS:

IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). COUGHING, FORCEFUL EXPIRATION (SC0173). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). TREMORS, TREMBLING, SHAKING (SC0197). DERMATITIS, INFLAMMATION OF SKIN (SC0044). CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). WEAKNESS, LACK OF STRENGTH (SC0167). ANXIETY, A TROUBLED FEELING (SC0009). ABDOMINAL CRAMPS, PAINFUL SPASMS OF ABDOMINAL AREA (SC0218). GASTROENTERITIS, STOMACH AND INTESTINAL INFLAMMATION (SC0551). GIDDINESS, FRIVOLOUS, DIZZINESS (SC0071). TINNITUS, RINGING IN EARS (SC0308). VERTIGO, FEELING OF WHIRLING MOTION (SC0163). CONFUSION, IN A BEWILDERED STATE (SC0030). SOMNOLENCE, PROLONGED SLEEPINESS (SC0152). SLOW PULSE, DECREASED HEARTBEAT (SC0437). HYPOKALEMIA, DEPLETION OF BLOOD POTASSIUM (SC0472). ARRHYTHMIA, ABSENCE OF RHYTHM; IRREGULARITY (SC0010).
MUSCLE, TISSUE RESPONSIBLE FOR MOTION (SC0623);
STIMULATION, TO EXCITE (SC0279). PARALYSIS, LOSS OF POWER OF VOLUNTARY MOVEMENT (SC0124). HEMOLYSIS, BLOOD DISSOLUTION, DESTRUCTION (SC0195). HEMORRHAGE, BLEEDING (SC0080). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220).
CARDIAC, PERTAINING TO HEART (SC0023);
FAILURE, LOSS OF FUNCTION (SC0386).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
FAILURE, LOSS OF FUNCTION (SC0386).

FA

FIRST AID.

(1 OF 4)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 4)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 4)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 4)
SOLUBLE BARIUM COMPOUNDS INGESTION: INDUCE VOMITING IMMEDIATELY WHEN SOLUBLE BARIUM COMPOUNDS ARE INGESTED. TREAT SYMPTOMATICALLY AND SUPPORTIVELY (PARMEGGIANI, ENCYCLOPEDIA OF OCCUPATIONAL HEALTH AND SAFETY, 3RD ED). GET MEDICAL ATTENTION IMMEDIATELY. ANTIDOTE: GIVE 30 GRAMS OF SODIUM SULFATE IN 250 ML OF WATER ORALLY AND REPEAT IN ONE HOUR. GIVE BY GASTRIC TUBE IF SYMPTOMS HAVE APPEARED. THE ADMINISTRATION OF SULFATE SALTS INTRAVENOUSLY IS HAZARDOUS, SINCE THEY INDUCE THE PRECIPITATION OF BARIUM SULFATE IN THE KIDNEY, WITH SUBSEQUENT RENAL FAILURE. IF SYMPTOMS ARE SEVERE AND OTHERWISE UNCONTROLLABLE, GIVE 10 M OF 10% SODIUM SULFATE SLOWLY INTRAVENOUSLY WHILE MAINTAINING MAXIMUM DIURESIS (DREISBACH, HANDBOOK OF POISONING, 11TH ED.). ANTIDOTE SHOULD BE ADMINISTED BY QUALIFIED MEDICAL PERSONNEL.

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
ELECTROCARDIOGRAM.

TER DOCUMENT SELECTION._: 2-14

2
AN ACCESSION NUMBER: 322. 9112.
CN CHEMICAL NAME: BENZENE.
SY SYNONYMS: BENZOL. CYCLOHEXATRIENE. COAL TAR NAPHTHA. PHENYL HYDRIDE. NCI-C55276. BENZINE. BENZOLE. ANNULENE. (6)ANNULENE. UN 1114. BENZOLENE. BICARBURET OF HYDROGEN. CARBON OIL. COAL NAPHTHA. STCC 4908110. MOTOR BENZOL. RCRA U019. PHENE. PYROBENZOL. PYROBENZOLE.
RN CAS NUMBER: 71-43-2.

REG. TOXIC NUMBER: CY1400000.

CHEMICAL FORMULA: C6H6.
PD
PHYSICAL DESCRIPTION:
COLORLESS TO LIGHT YELLOW LIQUID WITH AN AROMATIC ODOR.

MOL WT:	78.08
BOILING PT:	176 F (80 C)
SOLUBILITY:	0.18% @ 25 C
FLASH PT:	12 F (-11 C)
VAPOR PRES:	74.6 MMHG
MELT PT:	42 F (6 C)
UEL IN AIR:	7.9%
LEL IN AIR:	1.3%
MEC IN AIR:	928 F (498 C)
SPEC GRAVITY:	0.877
VAPOR DENSITY:	2.8
ODOR THRESHOLD:	1.5 - 5 PPM
OCTANOL/WATER CO-EFFICIENT:	2.13.

EL
PERMISSABLE EXPOSURE:
1 PPM OSHA TWA; 5 PPM OSHA 15 MIN STEL; 0.5 PPM OSHA ACTION LEVEL
10 PPM ACGIH TWA;(NOIC 90-91);ACGIH A2 - SUSPECTED HUMAN CARCINOGEN
0.1 PPM NIOSH RECOMMENDED 10 HR TWA; 1 PPM NIOSH RECOMMENDED STEL
OSHA CARCINOGEN; KNOWN HUMAN CARCINOGEN (NTP)
HUMAN SUFFICIENT EVIDENCE FOR CARCINOGENICITY (IARC GROUP-1)
ANIMAL SUFFICIENT EVIDENCE FOR CARCINOGENICITY (IARC GROUP-1)
HUMAN CARCINOGEN (EPA - CATEGORY A)
REPRODUCTIVE EFFECTS DATA (RTECS); MUTAGENIC DATA (RTECS)
TUMORIGENIC DATA (RTECS)
AQUATIC TOXICITY RATING 2 (TLM96 10-100 PPM)
BLUEGILLS 24.49 PPM
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 0 - PERSISTENCE 1
TOXICOLOGY: BENZENE IS A SKIN AND EYE IRRITANT. IT IS MODERATELY TOXIC BY INGESTION AND SLIGHTLY TOXIC BY INHALATION. BENZENE IS A CENTRAL NERVOUS SYSTEM DEPRESSANT AND BONE MARROW DEPRESSANT. POISONING MAY ALSO AFFECT THE IMMUNE, HEMATOPOIETIC AND NERVOUS SYSTEMS. EXPOSURE MAY CAUSE WEAKNESS, SOMETIMES PRECEDED BY A BRIEF PERIOD OF EUPHORIA, CARDIAC ARRHYTHMIAS AND COMA. CHRONIC EXPOSURE MAY CAUSE DECREASED BLOOD PRESSURE, INCREASED SERUM BILIRUBIN LEVELS, APLASTIC ANEMIA AND IMMUNOSUPRESSION. EPIDEMILOGICAL STUDIES HAVE ESTABLISHED A RELATIONSHIP BETWEEN PROLONGED BENZENE EXPOSURE AND LEUKEMIA.
THE THRESHOLD LIMIT VALUE WAS ESTABLISHED TO PREVENT TOXIC EFFECTS.

PERSONS WITH CERTAIN IMMUNOLOGICAL TENDENCIES MAY BE AT INCREASED RISK.
ALCOHOLIC BEVERAGES MAY INCREASE TOXIC EFFECTS. STIMULANTS, SUCH AS EPINEPHRINE, MAY CAUSE CARDIAC ARRYTHMIAS.
ORL-MAN LDLO: 50 MG/KG IHL-MAN TCLO: 150 PPM/1Y-I
IHL-MAN LCLO: 2 PPH/5M IHL-HMN LCLO: 2000 PPM/5M
IHL-HMN TCLO: 100 PPM IHL-HMN LCLO: 65 MG/M3/5Y
ORL-RAT LD50: 3306 MG/KG ORL-MUS LD50: 4700 MG/KG
IHL-RAT LC50: 10,000 PPM/7H IHL-MUS LC50: 9980 PPM
IPR-RAT LD50: 2890 UG/KG IPR-MUS LD50: 340 MG/KG
ORL-DOG LDLO: 2000 MG/KG IHL-CAT LCLO: 170,000 MG/KG

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
3000 PPM POTENTIAL
CARCINOGENOSHA/NIOSH
COLORLESS TO LIGHT YELLOW LIQU.

IC

INCOMPATIBILITIES:
SEND BACK AREA EXCEDED. ACIDS (STRONG): INCOMPATIBLE ALLYL CHLORIDE WITH DICHLOROETHYL ALUMINUM OR ETHYLALUMINUM SESQUICHLORIDE: POSSIBLE EXPLOSION ARSENIC PENTAFLUORIDE + POTASSIUM METHOXIDE: EXPLOSIVE INTERACTION BASES (STRONG): INCOMPATIBLE BROMINE PENTAFLUORIDE: FIRE AND EXPLOSION HAZARD BROMINE TRIFLUORIDE: POSSIBLE EXPLOSION OR IGNITION BROMINE + IRON: INCOMPATIBLE CHLORINE: EXPLOSION IN THE PRESENCE OF LIGHT CHLORINE TRIFLUORIDE: VIOLENT REACTION WITH POSSIBLE EXPLOSION CHROMIC ANHYDRIDE (POWDERED): IGNITION DIBORANE: SPONTANEOUSLY EXPLOSIVE REACTION IN AIR DIOXYGEN DIFLUOROBORATE: IGNITION REACTION DIOXYGENYL TETRAFLUOROBORATE: IGNITION REACTION INTERHALOGEN COMPOUNDS: IGNITION OR EXPLOSION IODINE HEPTAFLUORIDE: IGNITION ON CONTACT IODINE PENTAFLUORIDE: VIOLENT INTERACTION ABOVE 50 C NITRIC ACID: VIOLENT OR EXPLOSIVE UNLESS PROPERLY AGITATED AND COOLED NITRYL PERCHLORATE: EXPLOSIVE INTERACTION OXIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD OXYGEN (LIQUID): EXPLOSIVE MIXTURE OZONE: FORMATION OF GELATINOUS OZONIDE PERCHLORATES (METAL): FORMATION OF EXPLOSIVE COMPLEX.

CL

CLOTHING:
29CFR1910.1028 BENZENE PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT SHALL BE WORN WHERE APPROPRIATE TO PREVENT EYE CONTACT AND LIMIT DERMAL EXPOSURE TO LIQUID BENZENE. PROTECTIVE CLOTHING AND EQUIPMENT SHALL BE PROVIDED BY THE EMPLOYER AT NO COST TO THE EMPLOYEE AND THE EMPLOYER SHALL ASSURE ITS USE WHERE APPROPRIATE.
-ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A "+" DESIGNATES A BLEND OF MATERIALS, WHILE A "/" DESIGNATES A COATED OR LAMINATED MATERIAL.) -
BENZENE: EXCELLENT/GOOD: NONE INDICATED GOOD/FAIR: VITON/NEOPRENE BUTYL/NEOPRENE POLYVINYL ACETATE SILVERSHIELD POOR/FAIR: CHLORINATED

POLYETHYLENE VITON NEOPRENE+STYRENE-BUTADIENE RUBBER STYRENE-BUTADIENE RUBBER/NEOPRENE POOR: BUTYL RUBBER NEOPRENE NATURAL RUBBER POLYVINYL ALCOHOL POLYVINYL CHLORIDE EVA TEFLON POLYURETHANE NONWOVEN POLYETHYLENE SARANEX STYRENE-BUTADIENE RUBBER NEOPRENE/NATURAL RUBBER NITRILE+POLYVINYL CHLORIDE NITRILE RUBBER POLYETHYLENE.

WEAR EYE PROTECTION TO PREVENT:
29CFR1910.1028 BENZENE EYE AND FACE PROTECTION SHALL MEET THE REQUIREMENTS OF 29CFR1910.133.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE SPLASH-PROOF SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS LIQUID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES WET WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
NOT REQUIRED.

REMOVE CLOTHING:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT ANY CLOTHING WHICH BECOMES WET WITH THIS FLAMMABLE LIQUID BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE SUBSTANCE AND THE PROBABILITY OF EXPOSURE, PROVIDE AN EYE WASH AND FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
BENZENE

THE FOLLOWING RESPIRATORS ARE THE MINIMUM LEGAL REQUIREMENT AS SET FORTH BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION FOUND IN 29CFR1910, SUBPART Z. LESS THAN OR EQUAL TO 10 PPM - HALF-MASK AIR-PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE LESS THAN OR EQUAL TO 50 PPM - FULL FACEPIECE RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES - FULL FACEPIECE GAS MASK WITH CHIN-STYLE CANISTER LESS THAN OR EQUAL TO 100 PPM - FULL FACEPIECE POWERED AIR-PURIFYING RESPIRATOR WITH ORGANIC VAPOR CANISTER LESS THAN OR EQUAL TO 1000 PPM - SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE IN POSITIVE-PRESSURE MODE GREATER THAN 1000 PPM OR UNKNOWN CONCENTRATION - SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE IN POSITIVE PRESSURE MODE - FULL FACEPIECE POSITIVE PRESSURE SUPPLIED-AIR RESPIRATOR WITH AUXILIARY SELF-CONTAINED AIR SUPPLY ESCAPE - ANY ORGANIC VAPOR GAS MASK - ANY SELF-CONTAINED BREATHING APPARATUS

WITH A FULL FACEPIECE FIREFIGHTING - FULL FACEPIECE SELF-CONTAINED BREATHING APPARATUS IN POSITIVE PRESSURE MODE THE FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS BY THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, NIOSH POCKET GUIDE TO CHEMICAL HAZARDS OR NIOSH CRITERIA DOCUMENTS.

ANY DETECTABLE CONC
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

ESCAPE
- GAS MASK WITH AN ORGANIC VAPOR CANISTER (CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
BENZENE 29CFR1910.1028(I) MEDICAL SURVEILLANCE THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REQUIRES EMPLOYERS TO PROVIDE A MEDICAL SURVEILLANCE PROGRAM FOR EMPLOYEES. (1) EMPLOYEES COVERED. (A) EMPLOYEES WHO ARE OR MAY BE EXPOSED TO BENZENE AT OR ABOVE THE ACTION LEVEL 30 OR MORE DAYS PER YEAR. (B) EMPLOYEES WHO ARE OR MAY BE EXPOSED TO BENZENE AT OR ABOVE THE PELS 10 OR MORE DAYS A YEAR. (C) EMPLOYEES WHO HAVE BEEN EXPOSED TO MORE THAN 10 PPM OF BENZENE FOR 30 OR MORE DAYS IN A YEAR PRIOR TO THE EFFECTIVE DATE OF THE STANDARD. (D) EMPLOYEES INVOLVED IN THE TIRE BUILDING OPERATIONS CALLED TIRE BUILDING MACHINE OPERATORS, WHO USE SOLVENTS CONTAINING GREATER THAN 0.1 PERCENT BENZENE. (2) INITIAL EXAMINATION. (A) A DETAILED OCCUPATIONAL HISTORY WHICH INCLUDES: (1) PAST WORK EXPOSURE TO BENZENE AND OTHER HEMATOLOGICAL TOXINS; (2) A FAMILY HISTORY OF BLOOD DYSCRASIAS INCLUDING HEMATOLOGICAL NEOPLASMS; (3) A HISTORY OF BLOOD DYSCRASIAS INCLUDING GENETIC HEMOGLOBIN ABNORMALITIES, BLEEDING ABNORMALITIES, ABNORMAL FUNCTION OF FORMED BLOOD ELEMENTS; (4) A HISTORY OF RENAL OR LIVER DYSFUNCTION; (5) A HISTORY OF MEDICINAL DRUGS ROUTINELY TAKEN; (6) A HISTORY OF PREVIOUS EXPOSURE TO IONIZING RADIATION, AND (7) EXOSURE TO MARROW TOXINS OUTSIDE OF THE ORK SITUATION. (B) COMPLETE PHYSICAL EXAMINATION. (C) LABORATORY TESTS (1) A COMPLETE BLOOD COUNT INCLUDING A LEUKOCYTE COUNT WITH DIFFERENTIAL (2) QUANTITATIVE THROMBOCYTE COUNT (3) HEMATOCRIT (4) HEMOGLOBIN (5) ERYTHROCYTE COUNT (6) ERYTHROCYTE INDICES (MCV,MCH,MCHC) (D) ADDITIONAL TEST AS NECESSARY IN THE OPINION OF THE EXAMINING PHYSICIAN AND; (E) FOR ALL WORKERS REQUIRED TO WEAR RESPIRATORS AT LEAST 30 DAYS OR MORE A YEAR, THE PHYSICAL EXAM SHALL PAY SPECIAL ATTENTION TO THE CARDIOPULMONARY SYSTEM AND SHALL INCLUDE A PULMONARY FUNCTION TEST. (3) PERIODIC EXAMINATIONS. (A) THE EMPLOYER SHALL PROVIDE EACH COVERED EMPLOYEE WITH A MEDICAL EXAM ANNUALLY FOLLOWING THE PREVIOUS EXAM. THESE PERIODIC EXAMS SHALL INCLUDE AT LEAST THE FOLLOWING: (1) BRIEF HISTORY REGARDING NEW EXPOSURE TO POTENTIAL MARROW TOXINS, CHANGES IN DRUG USE AND THE APPEARANCE OF PHYSICAL SIGNS RELATING TO BLOOD DISORDERS; (2) A COMPLETE BLOOD COUNT INCLUDING A LEUKOCYTE COUNT WITH DIFFERENTIAL; (3)

QUANTITATIVE THROMBOCYTE COUNT; (4) HEMOGLOBIN; (5) HEMATOCRIT; (6) ERYTHROCYTE COUNT; (7) ERYTHROCYTE INDICES (MCV,MCH,MCHC) AND (8)APPROPRIATE ADDITIONAL TESTS AS NECESSARY, IN THE OPINION OF THE EXAMINING PHYSICIAN, IN CONSEQUENCE OF. (A) ALTERATIONS IN BLOOD COMPONENTS OR OTHER SIGNS WHICH MAY BE RELATED TO BENZENE EXPOSURE; (B) THE EMPLOYEE DEVELOPING SIGNS AND SYMPTOMS ASSOCIATED WITH BENZENE POISONING; (C) REQUIRED USE OF RESPIRATORS FOR AT LEAST 30 DAYS A YEAR, PULMONARY FUNCTION TEST SHALL BE PERFORMED EVERY 3 YEARS ALONG WITH A SPECIFIC EVALUATION OF THE CARDIOVASCULAR SYSTEM. (4) EMERGENCY EXAMINATIONS. IF AN EMPLOYEE IS EXPOSED TO BENZENE IN AN EMERGENCY SITUATION, THE EMPLOYEE SHALL PROVIDE A URINE SAMPLE AT THE END OF THE SHIFT AND HAVE A URINE PHENOL TEST PERFORMED ON THE SAMPLE WITHIN 72 HOURS. (A) IF THE RESULT OF THE TEST IS BELOW 75 MG PHENOL/L OF URINE, NO FURTHER TESTING IS REQUIRED. (B) IF THE RESULT OF THE URINARY PHENOL TEST IS EQUAL TO OR GREATER THAN 75 MG PHENOL/L OF URINE, THE EMPLOYER SHALL PROVIDE THE EMPLOYEE WITH: (1) A COMPLETE BLOOD COUNT INCLUDING AN ERYTHROCYTE COUNT; (2) A LEUKOCYTE COUNT WITH DIFFERENTIAL AND (3) A THROMBOCYTE COUNT AT MONTHLY INTERVALS FOR A DURATION OF THREE MONTHS FOLLOWING THE EMERGENCY EXPOSURE. (5) ADDITIONAL EXAMINATIONS AND REFERRALS. (A) WHERE THE COMPLETE BLOOD COUNT RESULTS INDICATE ANY OF THE FOLLOWING ABNORMAL CONDITIONS EXIST, THEN THE BLOOD COUNT SHALL BE REPEATED WITHIN TWO WEEKS. (1) IF THE HEMOGLOBIN LEVEL OR HEMATOCRIT FALLS BELOW THE NORMAL LIMIT AND/OR THESE INDICES SHOW A PERSISTENT DOWNWARD TREND FROM PRE-EXPOSURE NORMS; (2) THE THROMBOCYTE COUNT VARIES MORE THAN 20 PERCENT BELOW THE MOST RECENT VALUE OR FALLS OUTSIDE THE NORMAL LIMIT; (3) THE LEUKOCYTE COUNT IS BELOW 4,000 MM3 OR THERE IS AN ABNORMAL DIFFERENTIAL COUNT;.

(A) IF THE ABNORMALITY PERSISTS, THE PHYSICIAN SHALL REFER THE EMPLOYEE TO A HEMATOLOGIST/ INTERNIST FOR FURTHER EVALUATION UNLESS THE PHYSICIAN BELIEVES SUCH A REFERRAL IS UNNECESSARY. (B) THE EMPLOYER SHALL PROVIDE THE HEMOTOLOGIST/INTERNIST WITH ALL AVAILABLE MEDICAL RECORDS ON THE EMPLOYEE. (C) THE HEMATOLOGIST'S OR INTERNIST'S EVALUATION SHALL INCLUDE A DETERMINATION AS TO THE NEED FOR ADDITIONAL TESTS AND THE EMPLOYER SHALL ASSURE THESE TESTS ARE PROVIDED.

(6) INFORMATION PROVIDED TO THE PHYSICIAN. (A) A COPY OF THIS REGULATION AND ITS APPENDICES; (B) A DESCRIPTION OF THE AFFECTED EMPLOYEE'S DUTIES AS THEY RELATE TO EXPOSURE; (C) THE EMPLOYEE'S ACTUAL OR REPRESENTATIVE EXPOSURE LEVEL; (D) A DESCRIPTION OF ANY PERSONAL PROTECTIVE EQUIPMENT USED OR TO BE USED AND (E) INFORMATION FROM PREVIOUS EMPLOYMENT-RELATED MEDICAL EXAMS OF THE AFFECTED EMPLOYEE WHICH IS NOT OTHERWISE AVAILABLE TO THE EXAMINING PHYSICIAN. (7) PHYSICIANS WRITTEN OPINION. FOR EACH EXAM THE EMPLOYER SHALL OBTAIN AND PROVIDE THE EMPLOYEE WITH A COPY OF THE PHYSICIANS WRITTEN OPINION WITHIN 15 DAYS OF THE EXAM. THE WRITTEN OPINION SHALL BE LIMITED TO THE FOLLOWING: (A) THE OCCUPATIONALLY PERTINENT RESULTS OF THE MEDICAL EXAM AND TESTS; (B) PHYSICIANS OPINION CONCERNING WHETHER THE EMPLOYEE HAS ANY DETECTED MEDICAL CONDITIONS WHICH WOULD PLACE THE EMPLOYEE AT INCREASED RISK FROM EXPOSURE; (C) PHYSICIANS RECOMMENDED LIMITATIONS UPON THE EMPLOYEE'S EXPOSURE TO BENZENE OR UPON THE EMPLOYEE'S USE OF PROTECTIVE CLOTHING OR EQUIPMENT AND RESPIRATORS; AND (D) A STATEMENT THAT THE EMPLOYEE HAS BEEN INFORMED BY THE PHYSICIAN OF THE RESULTS OF THE EXAM AND ANY MEDICAL CONDITION RESULTING FROM BENZENE EXPOSURE WHICH REQUIRE FURTHER EXPLANATION OR TREATMENT. THIS STATEMENT SHALL NOT REVEAL SPECIFIC RECORDS, FINDINGS AND DIAGNOSES THAT HAVE NO BEARING ON THE EMPLOYEE'S ABILITY TO WORK IN A BENZENE-EXPOSED WORKPLACE. (8) MEDICAL REMOVAL PLAN. (A) WHEN AN EMPLOYEE HAS BEEN REFERRED TO A HEMATOLOGIST/INTERNIST THE EMPLOYEE SHALL BE REMOVED FROM AREAS WHERE EXPOSURES MAY EXCEED THE ACTION LEVEL UNTIL A DECISION IS MADE BY THE PHYSICIAN IN CONSULTATION WITH THE HEMATOLOGIST/INTERNIST TO

ALLOW THE EMPLOYEE TO RETURN. THIS DECISION SHALL BE GIVEN IN WRITING TO THE EMPLOYER AND EMPLOYEE. IN CASE OF REMOVAL, THE PHYSICIAN SHALL STATE THE PROBABLE DURATION OF REMOVAL AND THE REQUIREMENTS FOR FUTURE MEDICAL EXAMS TO REVIEW THE DECISION. (B) FOR ANY EMPLOYEE WHO IS REMOVED, THE EMPLOYER SHALL PROVIDE A FOLLOW-UP EXAM. WITHIN SIX MONTHS A DECISION SHALL BE MADE BY THE PHYSICIAN, IN CONSULTATION WITH THE HEMOTOLOGIST/ INTERNIST AS TO WHETHER THE EMPLOYEE SHALL BE RETURNED TO THE USUAL JOB OR SHOULD BE REMOVED PERMANENTLY. (C) IF AN EMPLOYEE IS TEMPORARILY REMOVED, THE EMPLOYER SHALL TRANSFER THE EMPLOYEE TO A COMPARABLE JOB THAT IS EXPOSED IN NO EVENT TO BENZENE LEVELS HIGHER THAN THE ACTION LEVEL. THE EMPLOYER SHALL MAINTAIN THE EMPLOYEE'S CURRENT WAGE RATE, SENIORITY AND OTHER BENEFITS. IF NO SUCH JOB IS AVAILABLE THE EMPLOYER SHALL PROVIDE MEDICAL REMOVAL PROTECTION BENEFITS UNTIL SUCH A JOB BECOMES AVAILABLE OR FOR SIX MONTHS, WHICHEVER COMES FIRST. (D) IF AN EMPLOYEE IS PERMANENTLY REMOVED FROM BENZENE EXPOSURE, THE EMPLOYEE SHALL BE GIVEN THE OPPORTUNITY TO TRANSFER TO ANOTHER POSITION WHICH IS AVAILABLE OR SHORTLY BECOMES AVAILABLE FOR WHICH THE EMPLOYEE IS QUALIFIED (OR CAN BE TRAINED FOR IN A SHORTTIME) AND WHERE BENZENE EXPOSURE IS AS LOW AS POSSIBLE - IN NO EVENT HIGHER THAN THE ACTION LEVEL. THE EMPLOYEE SHALL SUFFER NO REDUCTION IN CURRENT WAGE RATE, SENIORITY OR OTHER BENEFITS AS A RESULT OF THE TRANSFER. (9) MEDICAL REMOVAL PROTECTION BENEFITS. (A) THE EMPLOYEE SHALL RECEIVE SIX MONTHS OF MEDICAL REMOVAL PROTECTION BENEFITS IMMEDIATELY FOLLOWING EACH OCCASION AN EMPLOYEE IS REMOVED FROM EXPOSURE BECAUSE OF HEMATOLOGICAL FINDINGS UNLESS THE EMPLOYEE HAS BEEN TRANSFERRED TO A COMPARABLE JOB WHERE BENZENE EXPOSURE IS BELOW ACTION LEVEL. (B) FOR THE PURPOSES OF THIS SECTION, THE REQUIREMENT THAT AN EMPLOYER PROVIDE MEDICAL REMOVAL PROTECTION BENEFITS MEANS THAT THE EMPLOYER SHALL MAINTAIN THE WAGE RATE, SENIORITY AND OTHER BENEFITS OF AN EMPLOYEE AS THOUGH THE EMPLOYEE HAD NOT BEEN REMOVED. (C) THE EMPLOYERS OBLIGATION TO PROVIDE MEDICAL REMOVAL PROTECTION BENEFITS TO A REMOVED EMPLOYEE SHALL BE REDUCED TO THE EXTENT THAT THE EMPLOYEE RECEIVES COMPENSATION FOR LOST EARNINGS FROM A PUBLICLY OR AN EMPLOYER-FUNDED COMPENSATION PROGRAM, OR FROM EMPLOYMENT WITH ANOTHER EMPLOYER MADE POSSIBLE BY VIRTUE OF THE EMPLOYEE'S REMOVAL.
ACGIH BIOLOGICAL EXPOSURE INDICES FOR BENZENE: 50 MG/L TOTAL PHENOL IN URINE / TIMING -END OF SHIFT 0.08 PPM BENZENE IN MIXED EXHALED AIR / TIMING --PRIOR TO NEXT SHIFT 0.12 PPM BENZENE IN EXHALED AIR / TIMING -PRIOR TO NEXT SHIFT.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
BLOOD. CENTRAL NERVOUS SYSTEM. SKIN. BONE MARROW. EYES. RESPIRATORY SYSTEM.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). NAUSEA, SICKNESS

AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). DROWSINESS, FALLING ASLEEP (SC0049). WEAKNESS, LACK OF STRENGTH (SC0167). EUPHORIA, AN EXAGGERATED FEELING OF WELL-BEING (SC0061). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE (SC0091). MALAISE, UNEASINESS, DISCOMFORT, FEELING BAD (SC0106). CONFUSION, IN A BEWILDERED STATE (SC0030). ATAXIA, MUSCULAR INCOORDINATION (SC0013). INCOORDINATION, LACK OF COORDINATION (SC0085).
CHEST, THE THORAX (SC0754);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). PALLOR, PALENESS, AS OF THE SKIN (SC0122). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). TINNITUS, RINGING IN EARS (SC0308). BLURRED VISION, (SC0015). DELIRIUM, STATE OF DISORIENTATION, CONFUSION (SC0288).
CARDIAC, PERTAINING TO HEART (SC0023);
ARRHYTHMIA, ABSENCE OF RHYTHM; IRREGULARITY (SC0010). ANESTHESIA, LOSS OF SENSATION (SC0005). PARALYSIS, LOSS OF POWER OF VOLUNTARY MOVEMENT (SC0124). TREMORS, TREMBLING, SHAKING (SC0197). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). POLYNEURITIS, INFLAMMATION OF MANY NERVES (SC0624). ANOREXIA, DIMINISHED APPETITE (SC0006). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). AGITATION, JERKING OF ARMS (SC0003). ERYTHEMA, REDNESS, SPOTS ON SKIN (SC0060). APLASTIC ANEMIA, ANEMIA FROM BONE MARROW DAMAGE (SC0285). ASPHYXIA, SUFFOCATION (SC0011).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). VENTRICULAR FIBRILLATION, RAPID CONTRACTIONS OF VENTRICLES (SC0162). FATIGUE, TIREDNESS, SLUGGISH (SC0066). FEVER, BODY TEMPERATURE ABOVE NORMAL (SC0067). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). TACHYCARDIA, ABNORMAL RAPID HEARTBEAT (SC0158).
CEREBRAL, PERTAINING TO CEREBRUM (BRAIN) (SC0024);
ATROPHY, WASTING FROM MALNUTRITION (SC0196). BLOOD CHANGES, CHANGES IN BLOOD CELLS OR MORPHOLOGY (SC0227). BRUISE, IMPACT INJURY WITHOUT LACERATION (SC0779). HEMOLYSIS, BLOOD DISSOLUTION, DESTRUCTION (SC0195). LEUKEMIA, CANCER OF BLOOD CELL PRODUCTION (SC0100).
CARCINOMA, MALIGNANT CANCEROUS GROWTH (SC0365);
IN EXPERIMENTAL ANIMALS, (SC0212). MENSTRUAL DISORDERS, DISTURBANCE IN MENSES (SC0752).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
FAILURE, LOSS OF FUNCTION (SC0386).
CIRCULATORY, PERTAINING TO CIRCULATION (SC0613);
COLLAPSE, EXTREME PROSTRATION (SC0029).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

REPRODUCED AT GOVERNMENT EXPENSE

HAZARD COMMUNICATION GUIDE

Material Safety Data Sheet

Date last revised 9/1/88

I. General Information

Chemical Name & Synonyms	N/A	Trade Name & Synonyms	Black Powder
Chemical Family	N/A	Formula	N/A
Proper DOT Shipping Name	Black Powder	DOT Hazard Classification	Class A Explosive
Manufacturer	Goex, Inc. Belin Plant	Manufacturer's Phone Number	(717) 457-6724
Manufacturer's Address	1002 Springbrook Ave. Moosic, PA 18507	Chemtrec Phone Number	800-424-9300

II. Ingredients

Principal Hazardous Components	Percent	Threshold Limit Value (units)
(1) Potassium Nitrate	70-76	N/A
Charcoal	8-18	N/A
Sulphur	9-20	N/A
(1) Is not included in list of hazardous substances		

H HEALTH
F FLAMMABILITY
R REACTIVITY

III. Physical Data

Boiling Point (°F)	N/A	Specific Gravity (H_2O = 1)	1.70 to 1.82 (Mercury Method)
Vapor Pressure (mm Hg.)	N/A	Percent Volatile By Volume (%)	N/A
Vapor Density (Air = 1)	N/A	Evaporation Rate (_____ = 1)	N/A
Solubility In Water	High	pH	6.0 to 8.0
Appearance & Odor	Black/None		

IV. Fire & Explosion Hazard Data

Flash Point (Test Method)	N/A	Auto Ignition Temperature	Approx 464°C(867°F)
Flammable Limits	N/A	LEL / UEL	Explosives Temps (5 Sec)-Ignited approx 427°C(801°F)
Extinguishing Media	Water		

Special Fire Fighting Procedures: Do not fight fires. Evacuate area.

Unusual Fire & Explosion Hazards: Do not fight fires. Black powder may deflagrate or explode in a fire while confined. Evacuate area.

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BLACK POWDER

FRICTION TEST
PA

Steel - Snaps
Fiber - Unaffected

IMPACT TEST
PA

16 Inches (10% Point)

ELECTROSTATIC DISCHARGE TEST

Bureau of Mines
0.8 Joules (Confined)
12.5 Joules (Unconfined)

STABILITY

75° C International Heat Test - 0.31% Loss
Vacuum Stability - 0.5cc @ 100° C

BRISANCE - Sand Test 8 gm.

VELOCITY

In the open, trains of black powder burn very slowly, measurable in seconds per foot. Confined, as in steel pipe, speeds of explosions have been timed at values from 560 feet per second for very coarse granulations to 2,070 feet per second for the finer granulations. Confinement and granulation will affect the values.

CHEMICAL DECOMPOSITION

Use water to dissolve the potassium nitrate. By leaching out the potassium nitrate, the residue of sulfur and charcoal is non-explosive but combustible - dispose separately.

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HAZARDOUS COMPONENT SAFETY DATA STATEMENT

DATE: 12 Mar 85

1. MATERIAL/COMPONENT/ASSEMBLY: Explosive Composition, Black Powder
2. NUMBER: 20
3. REVISION: H

4. APPLICABLE ~~XXX~~ SAFETY CLAUSE: EAR 28.7102

SENSITIVITY (Apparatus and Comparison Values)

5. FRICTION TEST	6. IMPACT TEST	7. ELECTROSTATIC DISCHARGE TEST
PA Steel - Snaps Fiber - Unaffected	PA 16 Inches (10% Point)	Bureau of Mines 0.8 Joules (Confined) >12.5 Joules (Unconfined)

HAZARDS

8. FIRE	9. AUTO IGNITION TEMP.	10. FLASH POINT	11. DECOMPOSITION PRODUCTS
High	464°C (867°F)	NA	Toxic, Avoid Inhalation and Ingestion

12. FLAMMABLE AND/OR EXPLOSIVE LIMITS		13. EXPLOSION	14. EXPLOSIVE TEMPS Sec	15. DUSTS
a. LOWER PERCENT	b. UPPER PERCENT			
NA	NA	High	Ignited 427°C (801°F)	0.12 oz/ft3

16. HEALTH HAZARD INFORMATION (Toxicity): Moderate by Ingestion and Inhalation

17. UNPACKED (In-Process) HAZARD CLASS (Specify Quantities Involved): Class 1.1

18. SPECIAL REQUIREMENTS (Continuation on plain paper authorized)

Ref Spec: MIL-P-223

Approved Packaging Drawings: 299212; 7548077; 7548078; 7548321; 7548322

(See Attached Sheet)

SHIPPING/STORAGE CLASSIFICATION OF ITEM WHEN PACKED IN ACCORDANCE WITH APPROVED PACKING DRAWINGS

19. DOD HAZARD CLASS/DIV	20. DOD COMPAT GROUP	21. DOT HAZARD CLASS	22. DOT CONTAINER MARKING
1.1	D	Class A Explosive	Black Powder

23. PREPARED BY (Name, Signature, Organization): R. W. BATSON

24. CONCURRED IN BY (Name, Signature, Organization): R. W. SNOOK

25. SAFETY OFFICE (Name, Signature, Organization): C. PETERS

The information relating to safety (herein referred to as "safety data") contained in this document is limited to those instances when the document is provided as a part of a procurement/production package which involves the development, testing, storage, manufacture, modification, renovation, demilitarization, packaging, transportation, handling, disposal, inspection, repair or any other use of the item, (material/component/assembly) which is specified in the contract. The safety data contained herein are examples which shall be used by the contractor to alert contractor personnel as well as other personnel of hazards associated with the procurement/production of the item. No representation is made that compliance with the information provided will prevent any accident to persons or property or that additional warnings may not be appropriate. Neither the foregoing nor any act or failure to act by the Government in regard to alerting personnel to the hazards of the item shall affect or relieve the contractor of responsibility for the safety of contractor personnel or property and for the safety of the general public in connection with the performance of the contract, or impose or add to any liability of the Government for such safety.

Sheet 1

REPRODUCED AT GOVERNMENT EXPENSE.

Explosive Composition, Black Powder

Spec: MIL-P-223

HCSDS: 20

- **Potassium Nitrate**
  Spec: MIL-P-156
  HCSDS: 38
- **Sulfur**
  Spec: MIL-S-14929
  HCSDS: 43
- **Charcoal**
  Spec: JAN-C-178
  HCSDS: 42
- **Graphite***

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*Information on hazards associated with commercial chemicals can be obtained from the supplier. Such information may already be available in the DOD Hazardous Material Information System (HMIS) DOD 6050.5.L, which is available from the US Government Printing Office, Superintendent of Documents, Washington, DC.

1. Black Powder is very sensitive to flame and spark and can also be ignited by friction and impact. When ignited unconfined, it burns with explosive violence and will explode if ignited under even slight confinement.

When dry, it is compatible with most metals. However, it is hydroscopic and when wet attacks all common metals except stainless steel.

2. CAUTION: Explosives must be tested for compatibility with any material not specified in the production/procurement package with which they may come in contact. Materials include other explosives, solvents, adhesives, metals, plastics, paints, cleaning compounds, floor and table coverings, packing materials and other similar materials, situations and equipment. Explosives include propellants and pyrotechnics.

3. Hazard Classification Tests (TB 700-2), Department of Defense Explosives Hazard Classification Procedures, Sep 82:

a. Detonation Test: No explosions, samples burned

b. Ignition and Unconfined Burning Test: No explosions, samples burned average burning time less than 2 seconds.

c. Thermal Stability Test: No explosions, ignition or change in configuration.

d. Card Gap Test: Not available

e. Impact Sensitivity Test:

NO. OF TRIALS EXHIBITING

Height, In	Sample Weight, mg	Explosion	Decomposition	No Reaction
3 3/4	10	0	0	10
	20	0	0	10
	30	0	0	10
	40	0	0	10
	50	0	0	10

REPRODUCED AT GOVERNMENT EXPENSE

20
H
12 Mar 85

Height, In	Sample Weight, mg	Explosion	Decomposition	No Reaction
7	20	0	1	9
	30	0	0	10
	40	0	0	10
	50	0	0	10
10	10	1	1	8
	20	3	2	5
	30	0	4	6
	40	0	0	10
	50	0	0	10
15	20	3	4	3
	30	3	4	3
	40	2	6	2
	50	0	1	9

4. Additional Sensitivity Data:

a. Impact, NOL Apparatus (50% Point)

Type 12 Tool: > 320 CM

Type 12B Tool: 232 CM

b. Impact, BM Apparatus, 2 KG Wgt. (10% Point) 32 CM

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1
AN ACCESSION NUMBER: 499. 9204.
CN CHEMICAL NAME: CADMIUM.
SY SYNONYMS: C.I. 77180. CADMIUM ELEMENT.
RN CAS NUMBER: 7440-43-9.

REG. TOXIC NUMBER: EU9800000.

CHEMICAL FORMULA: CD.

PD
PHYSICAL DESCRIPTION:
SOFT, DUCTILE, MALLEABLE SILVER-WHITE, LUSTROUS METAL OR POWDER.

MOL WT:	112.41
BOILING PT:	1409 F (765 C)
SOLUBILITY:	INSOLUBLE
FLASH PT:	FLAMMABLE SOLID
VAPOR PRES:	1 MMHG @ 394 C
MELT PT:	610 F (321 C)
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	482 F (LAYER)
SPEC GRAVITY:	8.642
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
* OSHA EXPOSURE LIMIT REMOVED AS PER OSHA INSTRUCTION PUB 8-1.4
0.05 MG(CS)/M3 ACGIH TWA (DUSTS AND SALTS)
(NOTICE OF INTENDED CHANGES 1990-91)
LOWEST FEASIBLE LIMIT NIOSH RECOMMENDED EXPOSURE CRITERIA
HUMAN LIMITED EVIDENCE FOR CARCINOGENICITY (IARC GROUP-2A CADMIUM)
ANIMAL SUFFICIENT EVIDENCE FOR CARCINOGENICITY (IARC GROUP-2A CADMIUM)
ANTICIPATED HUMAN CARCINOGEN (NTP)
PROBABLE HUMAN CARCINOGEN (EPA-CATEGORY B)
MUTAGENIC DATA (RTECS); TUMORIGENIC DATA (RTECS)
REPRODUCTIVE EFFECTS DATA (RTECS)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 0
PERSISTENCE 3
TOXICOLOGY: CADMIUM IS A RESPIRATORY IRRITANT AND MAY BE A SKIN
AND EYE IRRITANT. IT IS HIGHLY TOXIC BY INHALATION AND TOXIC BY
INGESTION. CADMIUM IS ALSO A NEPHROTOXIN. POISONING MAY AFFECT THE
LIVER, BONE, BLOOD, LUNGS AND NERVOUS SYSTEM. EARLY SYMPTOMS OF
RHINITIS AND VERTIGO MAY BE FOLLOWED BY A LATENT PERIOD OF 1 TO 10
HOURS WHICH MAY PRECEDE THE ONSET OF SUBSTERNAL OR PRECORDIAL CHEST
PAIN, A FLU-LIKE SYNDROME AND MUSCULAR PAIN IN THE BACK AND LIMBS.
CADMIUM IS HIGHLY CUMULATIVE. REPEATED OR PROLONGED EXPOSURE MAY
CAUSE IRREVERSIBLE LUNG INJURY, YELLOW DISCOLORATION OF THE TEETH
AND SEVERE KIDNEY EFFECTS. CADMIUM HAS PRODUCED LOCAL SARCOMAS IN
RATS FOLLOWING INTRAMUSCULAR ADMINISTRATION. OCCUPATIONAL EXPOSURE
TO CADMIUM IS IMPLICATED IN A SIGNIFICANT INCREASE IN THE INCIDENCE
OF PROSTATIC AND RESPIRATORY CANCERS.
THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT PROTEINURIA,
PULMONARY EDEMA AND EMPHYSEMA.
DEFICIENCIES IN IRON, CALCIUM, ZINC, PROTEIN AND VITAMINS C AND
D MAY ENHANCE THE TOXIC EFFECTS. ALTERATIONS OF DRUG METABOLIZING
ACTIVITY HAVE BEEN INDICATED IN ANIMALS.
IHL-HMN LCLO: 39 MG/M3/20M IHL-MAN TCLO: 88 UG/M3/8.6Y
IHL-RAT LC50: 25 MG/M3/30M ORL-RAT LD50: 225 MG/KG
ORL-MUS LD50: 890 MG/KG SCU-RAT LD50: 9 MG/KG
IPR-RAT LD50: 4 MG/KG IVN-RAT LD50: 1800 UG/KG

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFE DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
50 MG/M3 POTENTIAL
CARCINOGENNIOSH
SOFT, DUCTILE, MALLEABLE SILVE.

IC

INCOMPATIBILITIES:
CADMIUM: AMMONIUM NITRATE (FUSED): VIOLENT OR EXPLOSIVE REACTION HYDRAZOIC ACID: MAY EXPLODE VIOLENTLY NITRYL FLUORIDE: INCANDESCENT REACTION WHEN HEATED SLIGHTLY OXIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD SELENIUM: EXOTHERMIC REACTION SULFUR: FIRE AND EXPLOSION HAZARD TELLURIUM: INCANDESCENT REACTION IN HYDROGEN ATMOSPHERE ZINC: INTENSE EXOTHERMIC REACTION. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT CLOTHING WHICH HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
NO SPECIFIC REQUIREMENT. USE APPROPRIATE SAFETY GOGGLES, AS INDICATED BY THE NATURE OF THE CONTAMINANT AND THE LIKELIHOOD OF EXPOSURE.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING OR SMOKING.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, REMOVE CLOTHING AND DO NOT WEAR AGAIN UNTI SUBSTANCE HAS BEEN REMOVED FROM CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE

THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
ANY DETECTABLE CONC.
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS'.
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
URINALYSIS.
14 BY 17 CHEST P.A. X-RAY.
KIDNEY FUNCTION.
FORCED VITAL CAPACITY.
FORCED EXPIRATORY VOLUME (1 SECOND).
RESPIRATORY HISTORY.
LIVER FUNCTION.
PROSTATE EXAM.
COMPLETE BLOOD COUNT.
BLOOD CHEMISTRY.
OTHER MEDICAL SURVEILLANCE RECOMMENDED: SMOKING AND TOBACCO HISTORIES.
CHRONIC RESPIRATORY DISEASE.
ACGIH BIOLOGICAL EXPOSURE INDICES FOR CADMIUM: 10 UG/G CREATININE CADMIUM IN URINE / TIMING -NOT CRITICAL 10 UG/L CADMIUM IN BLOOD / TIMING -NOT CRITICAL.

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
RESPIRATORY SYSTEM. CENTRAL NERVOUS SYSTEM. KIDNEYS. LIVER. SKELETAL. PROSTATE. BLOOD.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).

MUCOUS MEMBRANE, MEMBRANE LINING THROAT/ORIFICES (SC0179).
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). RHINITIS, INFLAMMATION OF NASAL MUCOSA (SC0236). VERTIGO, FEELING OF WHIRLING MOTION (SC0163). METALLIC TASTE, TASTE RESEMBLING METAL IN MOUTH (SC0216). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038).
CHEST, THE THORAX (SC0754);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). WEAKNESS, LACK OF STRENGTH (SC0167). MALAISE, UNEASINESS, DISCOMFORT, FEELING BAD (SC0106). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). FEVER, BODY TEMPERATURE ABOVE NORMAL (SC0067). CHILLS, A SHIVERING OR SHAKING (SC0736). SWEATING, EXCRETING MOISTURE THROUGH THE SKIN (SC0156). COUGHING, FORCEFUL EXPIRATION (SC0173). FROTHY SPUTUM, FOAMY MIXTURE OF SALIVA AND MUCOUS (SC0627). DERMATITIS, INFLAMMATION OF SKIN (SC0044). CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). PULMONARY RALES, ABNORMAL RESPIRATORY SOUNDS (SC0206).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181). PNEUMONITIS, LOCALIZED INFLAMMATION OF LUNG (SC0137). PULMONARY FIBROSIS, FIBROUS TISSUE INVOLVING LUNGS (SC0244). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004). TESTICULAR ATROPHY, WASTING, REDUCTION OF MALE GONADS (SC0268).
NASAL, PERTAINING TO THE NOSE (SC0114);
SEPTUM, WALL DIVIDING 2 CAVITIES OF NOSE (SC0202).
ULCERATION, LESION OF TISSUE (SC0313).
KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
STONES, HARDENED MINERAL MATTER (SC0603).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
FAILURE, LOSS OF FUNCTION (SC0386). OSTEOPOROSIS, DEMINERALIZATION OF BONE (SC0763). LIVER DAMAGE, INJURY TO THE LIVER (SC0221). TENESMUS, INVOLUNTARY DEFECATION/URINATION (SC0261). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). BLURRED VISION, (SC0015). SHOCK, SUDDEN PHYS. OR MENTAL DISTURBANCE(SC0228).
CARDIOPULMONARY, PERTAINING TO THE HEART AND LUNGS (SC0764);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043).
CARDIOVASCULAR, PERTAINING TO HEART & BLOOD VESSELS (SC0037);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).
PROSTATE, SEMEN PRODUCING GLAND OF MALE (SC0203);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212). TOOTH DISCOLORATION, ABNORMAL TOOTH COLOR (SC0553). PROTEINURIA, PROTEIN IN URINE, OFTEN ALBUMIN (SC0140).
GLYCOSURIA, GLUCOSE IN URINE (SC0407).
BONE, PART OF THE SKELETON (SC0185);
EFFECTS, SIGNS AND SYMPTOMS (SC0579). VERTIGO, FEELING OF WHIRLING MOTION (SC0163).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
UNCONSCIOUSNESS, NOT AWAKE; INSENSIBLE (SC0198);.

FA

FIRST AID.

(1 OF 6)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH L. AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 6)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES

AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 6)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 6)
INGESTED CADMIUM AND COMPOUNDS: GIVE MILK OR BEATEN EGGS EVERY 4 HOURS TO REVIEVE GASTROINTESTINAL IRRITATION. REMOVE UNABSORBED CADMIUM BY CATHARSIS WITH FLEET'S PHOSPHO-SODA, 30-60 ML DILUTED 1:4 IN WATER. GET MEDICAL ATTENTION IMMEDIATELY. ANTIDOTE: DO NOT GIVE DIMERCAPROL (BAL). IF SYMPTOMS PERSIST, THE ADMINISTRATION OF CALCIUM DISODIUM EDETATE IS RECOMMENDED. GIVE 15-25 MG/KG (0.08-0.125 ML OF 20% SOLUTION PER KILOGRAM OF BODY WEIGHT) IN 250-500 ML OF 5% DEXTROSE INTRAVENOUSLY OVER A 1 TO 2 HOUR PERIOD, TWICE DAILY. THE MAXIMUM DOSE SHOULD NOT EXCEED 50 MG/KG/DAY. THE DRUG SHOULD BE GIVEN IN 5-DAY COURSES WITH A REST PERIOD OF AT LEAST 2 DAYS BETWEEN COURSES. AFTER THE FIRST COURSE, SUBSEQUENT COURSES SHOULD NOT EXCEED 50 MG/KG/DAY. DAILY URINALYSIS SHOULD BE DONE DURING THE TREATMENT PERIOD. THE DOSAGE SHUOLD BE REDUCED IF ANY UNUSUAL URINARY FINDINGS APPEAR. FOR INTRAMUSCULAR ADMINISTRATION, GIVE 20% SOLUTION (200 MG/ML), 12.5 MG/KG BODY WEIGHT EVERY 4-6 HOURS. DILUTE EACH DOSE WITH AN EQUAL VOLUME OF 1% PROCAINE. DOSE LIMITATION IS THE SAME AS THAT GIVEN ABOVE. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). PROCEDURES MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 6)
ACUTE RENAL FAILURE - TREAT SHOCK. FOR HEMOLYTIC REACTIONS, GIVE SODIUM BICARBONATE, 5 G EVERY 1-2 HOURS AS NECESSARY TO MAINTAIN AN ALKALINE URINE.GET MEDICAL ATTENTION IMMEDIATELY. (MEDICATION MUST BE GIVEN BY QUALIFIED MEDICAL PERSONNEL) (DREISBACH, HANDBOOK OF POISONING, 12TH ED.)
.

(6 OF 6)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
PULMONARY FUNCTION.
URINE PROTEIN.

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IN ACCESSION NUMBER: 675. 9204.
CN CHEMICAL NAME: CHROMIUM.
SY SYNONYMS: CHROME. CHROMIUM ELEMENT. CHROMIUM METAL. METALLIC CHROMIUM.
RN CAS NUMBER: 7440-47-3.

REG. TOXIC NUMBER: GB4200000.

CHEMICAL FORMULA: CR.

PD

PHYSICAL DESCRIPTION:
ODORLESS, STEEL-GRAY, LUSTROUS METAL OR POWDER.

MOL WT:	51.996
BOILING PT:	4842 F (2672 C)
SOLUBILITY:	INSOLUBLE
FLASH PT:	FLAMMABLE DUST
VAPOR PRES:	1 MMHG @ 1616 C
MELT PT:	3339-3411 F
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	0.230 OZ/FT3
MEC IN AIR:	752 F (LAYER)
SPEC GRAVITY:	7.20 @ 28 C
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:	.

EL

PERMISSABLE EXPOSURE:
1 MG/M3 OSHA TWA
0.5 MG/M3 ACGIH TWA
0.5 MG(CR)/M3 NIOSH RECOMMENDED 8 HR TWA
HUMAN INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
ANIMAL INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
TUMORIGENIC DATA (RTECS)
AQUATIC TOXICITY RATING 1 (TLM96 100 - 1000 MG/L)
BLUEGILL - 113 MG/L
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: CHROMIUM MAY BE IRRITATING TO THE EYES, SKIN AND MUCOUS MEMBRANES IN THE DUST FORM. THERE IS INSUFFICIENT DATA TO QUANTIFY THE TOXICITY. POISONING BY CHROMIUM COMPOUNDS MAY AFFECT THE LIVER AND KIDNEYS. REPEATED EXPOSURE TO CHROMIUM COMPOUNDS HAS BEEN REPORTED TO RESULT IN ULCERATION AND PERFORATION OF THE NASAL SEPTUM, GASTROINTESTINAL DISTURBANCES AND BLOOD CHANGES. PROLONGED CONTACT WITH THE SKIN HAS BEEN REPORTED TO CAUSE VARIOUS TYPES OF DERMATITIS, INCLUDING ECZEMA, 'CHROME HOLES', AND SENSITIZATION.
THE THRESHOLD LIMIT VALUE WAS ESTABLISHED TO PREVENT PULMONARY DISEASE OR OTHER TOXIC EFFECTS.
CHROMIUM MAY CROSS THE PLACENTA AND BE EXCRETED IN BREAST MILK.

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NOT REQUIRED
ODORLESS, STEEL-GRAY, LUSTROUS.

IC

AMMONIUM NITRATE (FUSED): VIOLENT OR EXPLOSIVE REACTION. BROMINE PENTAFLUORIDE: VIOLENT REACTION AND POSSIBLE IGNITION. HYDROGEN PEROXIDE: VIOLENT DECOMPOSITION REACTION. LITHIUM (MOLTEN): VIGOROUS REACTION AT ELEVATED TEMPERATURES. NITROGEN OXIDE: INCANDESCENT REACTION. OXIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD. POTASSIUM CHLORATE (FUSED): VIGOROUS INCANDESCENT REACTION. SULFUR DIOXIDE: INCANDESCENT REACTION. THERMAL DECOMPOSITION PRODUCTS MAY INCLUDE TOXIC CHROMIC OXIDE. FINELY DIVIDED MATERIAL MAY IGNITE ON EXPOSURE TO AIR.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE SUBSTANCE AND THE PROBABILITY OF EXPOSURE, PROVIDE AN EYE WASH AND FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
2.5 MG(CR)/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS

5 MG(CR)/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS AND QUARTERMASK RESPIRATORS
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

12.5 MG(CR)/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

25 MG(CR)/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER

- POWERED AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE

0 MG(CR)/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS".
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
RESPIRATORY HISTORY.
14 BY 17 CHEST P.A. X-RAY.
FORCED VITAL CAPACITY.
FORCED EXPIRATORY VOLUME (1 SECOND).

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
SKIN. RESPIRATORY SYSTEM. GASTROINTESTINAL. KIDNEYS. LIVER.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
NASAL, PERTAINING TO THE NOSE (SC0114);
SEPTUM, WALL DIVIDING 2 CAVITIES OF NOSE (SC0202).
PERFORATION, OPENING IN HOLLOW ORGAN OR VISCUS (SC0127).
GASTROINTESTINAL, PERTAINING TO STOMACH & INTESTINE (SC0070).
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). BLOOD CHANGES, CHANGES IN BLOOD CELLS OR MORPHOLOGY (SC0227).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
SENSITIZATION, ALLERGIC REACTION (SC0148). DERMATITIS, INFLAMMATION OF SKIN (SC0044). ECZEMA, CHRONIC DERMATITIS (SC0053).

SENSITIZATION, ALLERGIC REACTION (SC0148). CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). LACRIMATION, DISCHARGE OF TEARS (SC0096). DIZZINESS FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048).
EXCESSIVE, SUPERFLUOUS (SC0737);
THIRST, DESIRE FOR WATER (SC0210).
ABDOMINAL, SECTION BETWEEN THORAX AND PELVIS (SC0750);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). VOMITING, PERTAINING TO NAUSEA (SC0166). SHOCK, SUDDEN PHYSICAL OR MENTAL DISTURBANCE(SC0228). OLIGURIA, DECREASED URINATION (SC0323). ANURIA, COMPLETE LACK OF URINATION (SC0304). UREMIA, NITROGEN IN BLOOD FROM RENAL FAILURE (SC0310).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).
LIVER, BILE-SECRETING GLANDULAR ORGAN (SC0620);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
IF THIS CHEMICAL IS INGESTED, TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD LOWER THAN HIPS TO PREVENT ASPIRATION.

(5 OF 5)
CHROMIUM INGESTION: USE OF DIMERCAPTOL HAS BEEN SUGGESTED ON THE BASIS OF FINDINGS IN ANIMALS. GIVE 3 MG/KG (OR 0.3 ML/10 KG) EVERY 4 HOURS, INTRAMUSCULARLY FOR THE FIRST 2 DAYS AND THE 2 MG/KG EVERY 12 HOURS FOR A TOTAL OF 10 DAYS (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
URINE CHROMIUM LEVEL.
BLOOD CHEMISTRY.
LIVER PROFILE BLOOD TESTS.
(1 OF 42)
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AN ACCESSION NUMBER: 720. 9212.

CN CHEMICAL NAME: CHROMIUM(III) OXIDE.

SYNONYMS: ANADOMIS GREEN. CASALIS GREEN OXIDE PIGMENT. CHROME OXIDE X1134. CHROMIA. CHROMIC ACID GREEN. CHROMIUM SESQUIOXIDE. GREEN ROUGE. CHROMIUM(III) OXIDE (2:3). CHROMIUM(3+) TRIOXIDE. C.I. 77288. DICHROMIUM TRIOXIDE. CHROME OXIDE. CHROMIC OXIDE. CHROMIUM OXIDE. CHROMIUM(3+) OXIDE. C.I. PIGMENT GREEN 17. C.I. NO.77278. PURE CHROMIUM OXIDE. CHROMIUM OXIDE PIGMENT. CHROMIUM OXIDE GREEN.

RN CAS NUMBER: 1308-38-9.

REG. TOXIC NUMBER: GB6475000.

CHEMICAL FORMULA: CR2O3.

PD

PHYSICAL DESCRIPTION:
ODORLESS, LIGHT TO DARK GREEN HEXAGONAL CRYSTALS.

MOL WT:	151.99
BOILING PT:	7232 F (4000 C)
SOLUBILITY:	INSOLUBLE
FLASH PT:	NONCOMBUSTIBLE SOLID
VAPOR PRES:	NOT AVAILABLE
MELT PT:	4415 F (2435 C)
UEL IN AIR:	
LEL IN AIR:	
MEC IN AIR:	
SPEC GRAVITY:	5.21
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL

PERMISSABLE EXPOSURE:
0.5 MG(CR)/M3 OSHA TWA
0.5 MG(CR)/M3 ACGIH TWA
0.5 MG(CR)/M3 NIOSH RECOMMENDED 8 HR TWA
HUMAN INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC TRIVALENT CR)
ANIMAL INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC TRIVALENT CR)
TUMORIGENIC DATA (RTECS); MUTAGENIC DATA (RTECS)
CERCLA HAZARD RATINGS - TOXICITY U - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: CHROMIUM(III) OXIDE MAY BE IRRITATING TO THE SKIN, EYES AND MUCOUS MEMBRANES. THE TOXICITY OF CHROMIUM(III) OXIDE HAS NOT BEEN QUANTIFIED. INSOLUBLE CHROMIUM COMPOUNDS MAY BE RESPIRATORY IRRITANTS AND MAY CAUSE CHRONIC RESPIRATORY DISEASE. DYSTROPHIC CHANGES IN THE LIVER AND KIDNEYS MAY ALSO RESULT FROM EXPOSURE.
THE THRESHOLD LIMIT VALUE WAS ESTABLISHED TO PREVENT PULMONARY DISEASE OR OTHER TOXIC EFFECTS.

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NOT REQUIRED
ODORLESS, LIGHT TO DARK GREEN.

IC

INCOMPATIBILITIES:

POSSIBLE EXPLOSION REACTION. LITHIUM: VIOLENT EXOTHERMIC REACTION AT 180 C. NITROALKANES: POSSIBLE EXPLOSION REACTION. OXYGEN DIFLUORIDE: VIGOROUS REACTION. RUBIDIUM ACETYLIDE: EXOTHERMIC REACTION. THERMAL DECOMPOSITION MAY RELEASE TOXIC AND/OR HAZARDOUS GASES.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES F CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE SUBSTANCE AND THE PROBABILITY OF EXPOSURE, PROVIDE AN EYE WASH AND FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
EYE-WASH FOUNTAIN WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEE'S EYES MAY BE EXPOSED TO SUBSTANCE
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
2.5 MG(CR)/M3
- DUST AND MIST RESPIRATOR

5 MG(CR)/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS AND QUARTERMASK RESPIRATORS

12.5 MG(CR)/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

25 MG(CR)/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE, HELMET, OR HOOD

500 MG(CR)/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS'.
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
14 BY 17 CHEST P.A. X-RAY.
FORCED VITAL CAPACITY.
FORCED EXPIRATORY VOLUME (1 SECOND).
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
LUNGS. RESPIRATORY SYSTEM. LIVER. SKIN. KIDNEYS.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);

MUCOUS MEMBRANE, MEMBRANE LINING THROUGHOUT, ARTIFIED (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
BRONCHIAL, PERTAINING TO THE BRONCHI (SC0346);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
LUNG, RESPIRATORY ORGAN (SC0377);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). DERMATITIS,
INFLAMMATION OF SKIN (SC0044).
SKIN, COVERING OF BODY (SC0174);
SENSITIZATION, ALLERGIC REACTION (SC0148).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
SENSITIZATION, ALLERGIC REACTION (SC0148).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
ADENOMA, NEOPLASM OF GLANDULAR EPITHELIUM (SC0368).
LIVER, BILE-SECRETING GLANDULAR ORGAN (SC0620);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).
MAMMARY, PERTAINING TO THE BREAST (SC0352);
ADENOMA, NEOPLASM OF GLANDULAR EPITHELIUM (SC0368).
MAMMARY, PERTAINING TO THE BREAST (SC0352);
CARCINOMA, MALIGNANT CANCEROUS GROWTH (SC0365).
LUNG, RESPIRATORY ORGAN (SC0377);
CANCER, MALIGNANT TUMOR OR NEOPLASM (SC0020).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOE IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
IF THIS CHEMICAL IS INGESTED, TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD LOWER THAN HIPS TO PREVENT ASPIRATION.

(5 OF 5)
CHROMIUM INGESTION: USE OF DIMERCAPTOL HAS BEEN SUGGESTED ON THE BASIS OF FINDINGS IN ANIMALS. GIVE 3 MG/KG (OR 0.3 ML/10 KG) EVERY 4 HOURS, INTRAMUSCULARLY FOR THE FIRST 2 DAYS AND THE 2 MG/KG EVERY 12 HOURS FOR A TOTAL OF 10 DAYS (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
URINE CHROMIUM LEVEL.

RS

REGULATORY STATUS.

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Genium Publishing Corporation
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(518) 377-8854

Material Safety Data Sheets Collection:

Sheet No. 470
Diesel Fuel Oil No. 2-D

Issued: 10/81 Revision: A, 11/90

Section 1. Material Identification

33

Diesel Fuel Oil No. 2-D Description: Diesel fuel is obtained from the middle distillate in petroleum separation; a distillate oil of low sulfur content. It is composed chiefly of unbranched paraffins. Diesel fuel is available in various grades, one of which is synonymous with fuel oil No. 2-D. This diesel fuel oil requires a minimum Cetane No. (efficiency rating for diesel fuel comparable to octane number ratings for gasoline) of 40 (ASTM D613). Used as a fuel for trucks, ships, and other automotive engines; as mosquito control (coating on breeding waters); and for drilling muds.

Other Designations: CAS No. 68334-30-5, diesel fuel.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(TM) for a suppliers list.

Cautions: Diesel fuel oil No. 2-D is a skin irritant and central nervous depressant with high mist concentrations. It is an environmental hazard and moderate fire risk.

NFPA

R	1
I	-
S	2
K	2

HMIS
H 0
F 2
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Diesel fuel oil No. 2-D*

1989 OSHA PEL	1990-91 ACGIH TLV	1988 NIOSH REL	1985-86 Toxicity Data‡
None established	Mineral Oil Mist TWA: 5 mg/m³† STEL: 10 mg/m³	None established	Rat, oral, LD_{50}: 9 g/kg produces gastrointestinal (hypermotility, diarrhea) effects

* Diesel fuel No. 2-D tends to be low in aromatics and high in paraffinics. This fuel oil is complex mixture of: 1) >95% paraffinic, olefinic, naphthenic, and aromatic hydrocarbons, 2) sulfur (<0.5%), and 3) benzene (<100 ppm). [A low benzene level reduces carcinogenic risk. Fuel oils can be exempted under the benzene standard (29 CFR 1910.1028)]. Although low in the fuel itself, benzene concentrations are likely to be much higher in processing areas.
† As sampled by nonvapor-collecting method.
‡ Monitor NIOSH, *RTECS* (HZ1800000), for future toxicity data.

Section 3. Physical Data

Boiling Point Range: 340 to 675 °F (171 to 358 °C)
Viscosity: 1.9 to 4.1 centistoke at 104 °F (40 °C)
Specific Gravity: <0.86
Water Solubility: Insoluble

Appearance and Odor: Brown, slightly viscous liquid.

Section 4. Fire and Explosion Data

Flash Point: 125 °F (52 °C) min.	Autoignition Temperature: >500 °F (932 °C)	LEL: 0.6% v/v	UEL: 7.5% v/v

Extinguishing Media: Use dry chemical, carbon dioxide, or foam to fight fire. Use a water spray to cool fire exposed containers. Do not use a forced water spray directly on burning oil since this will scatter the fire. Use a smothering technique for extinguishing fire.

Unusual Fire or Explosion Hazards: Diesel fuel oil No. 2-D is a OSHA Class II combustible liquid. Its volatility is similar to that of gas oil. Vapors may travel to a source of ignition and flash back.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. If feasible, remove containers from fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways due to pollution and fire or explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Diesel fuel oil No. 2-D is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: It is incompatible with strong oxidizing agents; heating greatly increases the fire hazard.

Conditions to Avoid: Avoid heat and ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of diesel fuel oil No. 2-D can produce various hydrocarbons and hydrocarbon derivatives, and other partial oxidation products such as carbon dioxide, carbon monoxide, and sulfur dioxide.

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Section 6. Health Hazard Data

Carcinogenicity: Although the IARC has not assigned an overall evaluation to diesel fuels as a group, it has evaluated occupational exposures in petroleum refining as an IARC probable human carcinogen (Group 2A). It has evaluated distillate (light) diesel oils as not classifiable as human carcinogens (Group 3).
Summary of Risks: Although diesel fuel's toxicologic effects should resemble kerosine's, they are somewhat more pronounced due to additives such as sulfurized esters. Excessive inhalation of aerosol or mist can cause respiratory tract irritation, headache, dizziness, nausea, vomiting, and loss of coordination, depending on concentration and exposure time. When removed from exposure area, affected persons usually recover completely. If vomiting occurs after ingestion and if oil is aspirated into the lungs, hemorrhaging and pulmonary edema, progressing to renal involvement and chemical pneumonitis, may result. A comparative ratio of oral to aspirated lethal doses may be 1 pt vs. 5 ml. Aspiration may also result in transient CNS depression or excitement. Secondary effects may include hypoxia (insufficient oxygen in body cells), infection, pneumatocele formation, and chronic lung dysfunction. Inhalation may result in euphoria, cardiac dysrhythmias, respiratory arrest, and CNS toxicity. *Prolonged or repeated skin contact may irritate hair follicles and block sebaceous glands, producing a rash of acne pimples and spots, usually on arms and legs.*
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Central nervous system, skin, and mucous membranes.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: Systemic effects from ingestion include gastrointestinal irritation, vomiting, diarrhea, and in severe cases central nervous system depression, progressing to coma or death. Inhalation of aerosols or mists may result in increased rate of respiration, tachycardia (excessively rapid heart beat), and cyanosis (dark purplish discoloration of the skin and mucous membranes caused by deficient blood oxygenation).
Chronic Effects: Repeated contact with the skin causes dermatitis.
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. If large areas of the body have been exposed or if irritation persists, get medical help immediately. 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, *do not induce vomiting* due to aspiration hazard. Contact a physician immediately. Position to avoid aspiration.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Gastric lavage is contraindicated due to aspiration hazard. Preferred antidotes are charcoal and milk. In cases of severe aspiration pneumonitis, consider monitoring arterial blood gases to ensure adequate ventilation. Observe the patient for 6 hr. If vital signs become abnormal or symptoms develop, obtain a chest x-ray.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate area for large spills, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and liquid contact. Clean up spills promptly to reduce fire or vapor hazards. Use a noncombustible absorbent material to pick up small spills or residues. For large spills, dike far ahead to contain. Pick up liquid for reclamation or disposal. Do not release to sewers or waterways due to health and fire and/or explosion hazard. Follow applicable OSHA regulations (29 CFR 1910.120). Diesel fuel oil No. 2-D spills may be environmental hazards. Report large spills.
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 261.21): Ignitable waste
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
Air Contaminant (29 CFR 1910.1000, Subpart Z): 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: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, use a NIOSH-approved respirator with a mist filter and organic vapor cartridge. 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 that promote worker safety and productivity. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[NIO]
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: Use and storage conditions should be suitable for a OSHA Class II combustible liquid. Store in closed containers in a well-ventilated area away from heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations. Use nonsparking tools and explosion-proof electrical equipment. No smoking in storage or use areas.
Engineering Controls: Avoid vapor or mist inhalation and prolonged skin contact. Wear protective rubber gloves and chemical safety glasses where contact with liquid or high mist concentration may occur. Additional suitable protective clothing may be required depending on working conditions. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures. Do not wear oil contaminated clothing. At least weekly laundering of work clothes is recommended. Do not put oily rags in pockets. When working with this material, wear gloves or use barrier cream.
Transportation Data (49 CFR 172.101)
DOT Shipping Name: Fuel oil
DOT Hazard Class: Combustible liquid
ID No.: NA1993
DOT Label: None
DOT Packaging Exceptions: 173.118a
DOT Packaging Requirements: None

MSDS Collection References: 1, 6, 7, 12, 73, 84, 101, 103, 126, 127, 132, 133, 136, 143, 146
Prepared by: MJ Allison, BS; Industrial Hygiene Review: DJ Wilson, CIH; Medical Review: AC Darlington, MD; Edited by: JR Stuart, MS

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1
AN ACCESSION NUMBER: 2339. 9208.
CN CHEMICAL NAME: O-DINITROBENZENE.
SY SYNONYMS: 1,2-DINITROBENZENE. ORTHO-DINITROBENZENE. UN 1597.
BENZENE, O-DINITRO-.
RN CAS NUMBER: 528-29-0.

REG. TOXIC NUMBER: CZ7450000.

CHEMICAL FORMULA: C6H4N2O4.
PD
PHYSICAL DESCRIPTION:
PALE YELLOW LIQUID.

MOL WT:	168
BOILING PT:	606 F AT 775 MM
SOLUBILITY:	0.015 G
FLASH PT:	EXPLODES
VAPOR PRES:	<1 MM
MELT PT:	245 F
UEL IN AIR:	N/A
LEL IN AIR:	N/A
MEC IN AIR:	
SPEC GRAVITY:	1.565 AT 63 F
VAPOR DENSITY:	5.8
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:	1.58.

EL
PERMISSABLE EXPOSURE:
1 MG/M3 OSHA TWA (SKIN NOTATION)
1 MG/M3 ACGIH TWA (SKIN)
1 MG/M3 NIOSH RECOMMENDED 10 HR TWA
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: O-DINITROBENZENE IS A METHEMOGLOBIN FORMER.
SEE DINITROBENZENE.

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
200 MG/M3 OSHA/NIOSH
PALE YELLOW LIQUID.
IC
INCOMPATIBILITIES:
STRONG OXIDIZERS. CAUSTICS. ACTIVE METALS.
CL
CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR

CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT SKIN CONTACT WITH THIS SUBSTANCE WHERE SKIN CONTACT MAY OCCUR. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.
-ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A "+" DESIGNATES A BLEND OF MATERIALS, WHILE A "/" DESIGNATES A COATED OR LAMINATED MATERIAL.) -
UNSUBSTITUTED NITRO COMPOUNDS: EXCELLENT/GOOD: POLYVINYL ALCOHOL FAIR/POOR: NATURAL RUBBER NITRILE RUBBER FAIR/GOOD: CHLORINATED POLYETHYLENE POLYURETHANE POLYVINYL CHLORIDE VITON A WIDE VARIATION IN RATINGS IS INDICATED FOR THE FOLLOWING MATERIALS: BUTYL RUBBER NEOPRENE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
WHERE EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE MAY OCCUR, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
5 MG/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS

10 MG/M3
- DUST AND MIST RESPIRATOR EXCEPT SINGLE-USE RESPIRATORS AND QUARTERMASK RESPIRATORS
- SUPPLIED-AIR RESPIRATOR
- AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS

25 MG/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

50 MG/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A TIGHT-FITTING FACEPIECE OPERATED IN A CONTINUOUS FLOW MODE

200 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH HALF-MASK OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.

RESPIRATORY HISTORY.
COMPLETE BLOOD COUNT.
BLOOD CHEMISTRY.
WITH EMPHASIS ON: GGTP.
LDH.
SGOT.
SGPT.
PULMONARY FUNCTIONS.
VISION TEST.
EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
URINALYSIS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
ACGIH BIOLOGICAL EXPOSURE INDICIES FOR METHEMOGLOBIN INDUCERS: 1.5% OF HEMOGLOBIN METHEMOGLOBIN IN BLOOD / TIMING -DURING OR END OF SHIFT.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. RESPIRATORY SYSTEM. BLOOD. CENTRAL NERVOUS SYSTEM. CARDIOVASCULAR SYSTEM. GASTROINTESTINAL. KIDNEYS. LIVER.

SP

SYMPTOMS:
VISUAL DISTURBANCE, UPSET IN SIGHT (SC0165). SCOTOMA, BLIND GAP IN VISUAL FIELD (SC0147).
SKIN, COVERING OF BODY (SC0174);
PIGMENTATION, COLORATION (SC0132). METHEMOGLOBINEMIA, BLOOD CONDITION FOLLOWING SOME POSION(SC0230). HYPOXEMIA, INSUFFICIENT OXYGENATION OF BLOOD (SC0083). ASPHYXIA, SUFFOCATION (SC0011). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). CONFUSION, IN A BEWILDERED STATE (SC0030). WEAKNESS, LACK OF STRENGTH (SC0167). HEMOLYTIC ANEMIA, BREAKDOWN OF RED BLOOD CELLS (SC0233). THIRST, DESIRE FOR WATER (SC0210). NAUSEA, SICKNESS AT THE STOMACH (SC0115).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028); DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). STUPOR, LETHARGY, UNCONSCIOUSNESS (SC0214). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). COMATOSE, STATE OF DEEP UNCONSCIOUSNESS (SC0186).
BLADDER, URINE RESERVOIR VESICLE (SC0259);
ULCERATION, LESION OF TISSUE (SC0313). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). JAUNDICE, YELLOWING OF SKIN, EYES (SC0092). LIVER DAMAGE, INJURY TO THE LIVER (SC0221).
SPLEEN, SUBSTERNAL ORGAN; BLOOD FILTER (SC0258);
DAMAGE, PERMANENT INJURY (SC0287). BONE MARROW DEPRESSION, LOWERING OF BONE TISSUE BLOOD PRODUCT(SC0249). VOMITING, PERTAINING TO NAUSEA (SC0166). ATAXIA, MUSCULAR INCOORDINATION (SC0013). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). TACHYCARDIA, ABNORMAL RAPID HEARTBEAT (SC0158). LIGHTHEADEDNESS, DIZZY (SC0102). EUPHORIA, AN EXAGGERATED FEELING OF WELL-BEING (SC0061).

FA

FIRST AID.

(1 OF 7)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 7)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 7)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 7)
WHEN THIS CHEMICAL HAS BEEN SWALLOWED, DO NOT INDUCE VOMITING. REMOVE BY GASTRIC LAVAGE AND CATHARSIS.

(5 OF 7)
INGESTED NITRO/AMINO COMPOUNDS: REMOVE BY GASTRIC LAVAGE OR EMESIS AND CONSIDER USING ACTIVATED CHARCOAL. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS ON AN UNCONSCIOUS PERSON. MAINTAIN BLOOD PRESSURE AND RESPIRATION. GIVE OXYGEN IF RESPIRATION IS SHALLOW OR ANOXIA IS PRESENT. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. LAVAGE AND OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. ANTIDOTE: FOR SEVERE METHEMOGLOBINEMIA, GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG (1 MG/KG) SLOWLY INTRAVENOUSLY. ALL ANTIDOTES MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 7)
METHEMOGLOBINEMIA: (WHEN METHEMOGLOBIN CONCENTRATION IS OVER 25-40% OR IN THE PRESENCE OF SYMPTOMS). GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. CYANOSIS MAY DISAPPEAR WITHIN MINUTES OR PERSIST LONGER DEPENDING ON DEGREE OF METHEMOGLOBINEMIA. INTRAVENOUS ADMINISTRATION OF THERAPEUTIC DOSES OF METHYLENE BLUE MAY CAUSE A RISE IN BLOOD PRESSURE, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS ALSO OCCURRED SEVERAL DAYS AFTER ADMINISTRATION. THESE EFFECTS ARE TEMPORARY, AND FATALITIES HAVE NOT BEEN REPORTED. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 GRAM SLOWLY INTRAVENOUSLY. WITHOUT TREATMENT, METHEMOGLOBINEMIA LEVELS OF 20-30% REVERT TO NORMAL WITHIN 3 DAYS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERD BY QUALIFIED MEDICAL PERSONNEL.

(7 OF 7)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT

CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

END OF REQUEST

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1

AN ACCESSION NUMBER: 3881. 9207.
CN CHEMICAL NAME: 2,4-DINITROTOLUENE.
SY SYNONYMS: DNT. 2,4-DNT. NCI-C01865. 1-METHYL-2,4-DINITROBENZENE. 2,4-DINITROTOLUOL. O,P-DINITROTOLUENE. UN 2038. BENZENE, 1-METHYL-2,4-DINITRO-. RCRA U105.
RN CAS NUMBER: 121-14-2.

REG. TOXIC NUMBER: XT1575000.

CHEMICAL FORMULA: C7H6N2O4.

PD

PHYSICAL DESCRIPTION:
YELLOW CRYSTALS.

MOL WT:	182.15
BOILING PT:	DECOMPOSES 572 F
SOLUBILITY:	300 PPM
FLASH PT:	404 F
VAPOR PRES:	1 MM
MELT PT:	160 F
UEL IN AIR:	EXPLODES
LEL IN AIR:	EXPLODES
MEC IN AIR:	
SPEC GRAVITY:	1.3208 AT 160 F
VAPOR DENSITY:	6.3
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL

PERMISSABLE EXPOSURE:
1.5 MG/M3 OSHA TWA (SKIN NOTATION)
1.5 MG/M3 ACGIH TWA (SKIN NOTATION)
LOWEST FEASIBLE LIMIT NIOSH RECOMMENDED EXPOSURE CRITERIA
PROBABLE HUMAN CARCINOGEN (EPA - CATEGORY B)
NEGATIVE CARCINOGEN IN MICE (NCI)
MUTAGENIC DATA (RTEC)
TUMORIGENIC DATA (RTEC)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 1 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: SEE DINITROTOLUENE.
ORL-RAT LD50: 268 MG/KG
ORL-RAT LD50: 268 MG/KG
ORL-MUS LD50: 790 MG/KG
ORL-GPG LD50:1300 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED
YELLOW CRYSTALS.

IC

INCOMPATIBILITIES:
HEAT. EXPLOSIVE HAZARD AT HIGH TEMPERATURES. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC. STRONG OXIDIZERS. CAUSTICS. ACTIVE METALS. TIN. ZINC.

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH MOLTEN DINITROTOLUENE;
PREVENT SKIN CONTACT WITH DINITROTOLUENE OR LIQUIDS CONTAINING DINITROTOLUENE, WHERE SKIN CONTACT MAY OCCUR
WEAR IMPERVIOUS CLOTHING
WEAR GLOVES
WEAR FACESHIELD (8 INCH MINIMUM)
PLACE CONTAMINATED CLOTHING IN CLOSED CONTAINERS FOR STORAGE UNTIL LAUNDERED OR DISCARDED
IF CLOTHING IS TO BE LAUNDERED, INFORM PERSON PERFORMING OPERATION OF CONTAMINANT'S HAZARDOUS PROPERTIES
-ACGIH 'GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING' INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A '+' DESIGNATES A BLEND OF MATERIALS, WHILE A '/' DESIGNATES A COATED OR LAMINATED MATERIAL.) -
UNSUBSTITUTED NITRO COMPOUNDS: EXCELLENT/GOOD: POLYVINYL ALCOHOL FAIR/POOR: NATURAL RUBBER NITRILE RUBBER FAIR/GOOD: CHLORINATED POLYETHYLENE POLYURETHANE POLYVINYL CHLORIDE VITON A WIDE VARIATION IN RATINGS IS INDICATED FOR THE FOLLOWING MATERIALS: BUTYL RUBBER NEOPRENE.

WEAR EYE PROTECTION TO PREVENT:
PREVENT ANY POSSIBILITY OF EYE CONTACT.

EMPLOYEE SHOULD WASH:
IMMEDIATELY WHEN SKIN BECOMES CONTAMINATED AND AT THE END OF WORK SHIFT.

WORK CLOTHING SHOULD BE CHANGED DAILY:
AFTER WORK SHIFT.

REMOVE CLOTHING:
PROMPTLY IF IT IS NON-IMPERVIOUS AND CONTAMINATED.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
EYE-WASH FOUNTAIN WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES' EYES MAY BE EXPOSED TO SUBSTANCE QUICK DRENCHING FACILITIES WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES MAY BE EXPOSED TO SUBSTANCE.

RP
RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
15 MG/M3
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

75 MG/M3
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE, HELMENT, OR HOOD
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE

200 MG/M3
- TYPE 'C' SUPPLIED-AIR RESPIRATOR
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE, HELMENT, OR HOOD
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

ESCAPE
- GAS MASK
WITH AN ORGANIC VAPOR CANISTER
(CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
MEDICAL WARNING FOR REFUSAL OF MEDICAL EXAMINATION.
RESPIRATORY HISTORY.
BLOOD CHEMISTRY.
GGTP.
LDH.
SGOT.
SGPT.
COMPLETE BLOOD COUNT.
RENAL AND LIVER FUNCTIONS.
WITH EMPHASIS ON: MORPHOLOGICAL BLOOD SLIDES.
SKIN EXAM.
VISION TEST.
PULMONARY FUNCTIONS.
URINALYSIS.
ACGIH BIOLOGICAL EXPOSURE INDICIES FOR METHEMOGLOBIN INDUCERS: 1.5% OF HEMOGLOBIN METHEMOGLOBIN IN BLOOD / TIMING -DURING OR END OF SHIFT.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. RESPIRATORY SYSTEM. BLOOD. CENTRAL NERVOUS SYSTEM. CARDIOVASCULAR SYSTEM. KIDNEYS. LIVER.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). DERMATITIS, INFLAMMATION OF SKIN (SC0044).
SKIN, COVERING OF BODY (SC0174);
PIGMENTATION, COLORATION (SC0132).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). METHEMOGLOBINEMIA BLOOD CONDITION FOLLOWING SOME POSION(SC0230). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). ASPHYXIA, SUFFOCATION (SC0011). RESPIRATORY DISTRESS, DIFFICULTY BREATHING (SC0219). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE (SC0091). DROWSINESS, FALLING ASLEEP (SC0049). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). VERTIGO, FEELING OF WHIRLING MOTION (SC0163). DIZZINESS, FEELING FAINT, LIGHT-HEADED,

CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). HEMOLYTIC ANEMIA, BREAKDOWN OF RED BLOOD CELLS (SC0233). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). STUPOR, LETHARGY, UNCONSCIOUSNESS (SC0214). COMATOSE, STATE OF DEEP UNCONSCIOUSNESS (SC0186). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034).
BLADDER, URINE RESERVOIR VESICLE (SC0259);
ULCERATION, LESION OF TISSUE (SC0313). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). JAUNDICE, YELLOWING OF SKIN, EYES (SC0092). LIVER DAMAGE, INJURY TO THE LIVER (SC0221). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). ARTHRALGIA, JOINT PAIN (SC0417).

FA

FIRST AID.

(1 OF 7)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 7)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 7)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 7)
WHEN THIS CHEMICAL HAS BEEN SWALLOWED, DO NOT INDUCE VOMITING. REMOVE BY GASTRIC LAVAGE AND CATHARSIS.

(5 OF 7)
INGESTED NITRO/AMINO COMPOUNDS: REMOVE BY GASTRIC LAVAGE OR EMESIS AND CONSIDER USING ACTIVATED CHARCOAL. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS ON AN UNCONSCIOUS PERSON. MAINTAIN BLOOD PRESSURE AND RESPIRATION. GIVE OXYGEN IF RESPIRATION IS SHALLOW OR ANOXIA IS PRESENT. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. LAVAGE AND OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. ANTIDOTE: FOR SEVERE METHEMOGLOBINEMIA, GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG (1 MG/KG) SLOWLY INTRAVENOUSLY. ALL ANTIDOTES MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 7)
METHEMOGLOBINEMIA: (WHEN METHEMOGLOBIN CONCENTRATION IS OVER 25-40% OR IN THE PRESENCE OF SYMPTOMS). GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. CYANOSIS MAY DISAPPEAR WITHIN MINUTES OR PERSIST LONGER DEPENDING ON DEGREE OF METHEMOGLOBINEMIA. INTRAVENOUS ADMINISTRATION OF THERAPEUTIC DOSES OF METHYLENE BLUE MAY CAUSE A RISE IN BLOOD PRESSURE, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS ALSO OCCURRED SEVERAL DAYS AFTER ADMINISTRATION. THESE EFFECTS ARE TEMPORARY, AND FATALITIES HAV NOT BEEN REPORTED. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 GRAM SLOWLY INTRAVENOUSLY. WITHOUT TREATMENT, METHEMOGLOBINEMIA LEVELS OF 20-30% REVERT TO NORMAL WITHIN 3 DAYS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERD BY QUALIFIED MEDICAL PERSONNEL.

LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
METHEMOGLOBIN DETERMINATION.
ELECTROCARDIOGRAM.
CONVULSIONS - BLOOD ANALYSIS FOR GLUCOSE, CALCIUM, UREA NTROGEN AND CARBON DIOXIDE.

RS

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1
AN ACCESSION NUMBER: 3953. 9208.
CN CHEMICAL NAME: 2,6-DINITROTOLUENE.
SY SYNONYMS: 2,6-DNT. 2-METHYL-1,3-DINITROBENZENE. UN 2038. TOLUENE, 2,6-DINITRO-. BENZENE, 2-METHYL-1,3-DINITRO-. STCC 4963120. RCRA U016.
RN CAS NUMBER: 606-20-2.

REG. TOXIC NUMBER: XT1925000.

CHEMICAL FORMULA: C7H6N2O4.
PD
PHYSICAL DESCRIPTION:
COLORLESS TO YELLOW CRYSTALS.

MOL WT:	182.14
BOILING PT:	545 F (285 C)
SOLUBILITY:	180 PPM
FLASH PT:	404 F (2,4-ISOMER)
VAPOR PRES:	0.018 MMHG
MELT PT:	151 F (66 C)
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	
SPEC GRAVITY:	1.2933 @ 111 C
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
1.5 MG/M3 OSHA TWA (SKIN)
1.5 MG/M3 ACGIH TWA (SKIN)
1.5 MG/M3 NIOSH RECOMMENDED 10 HR TWA (SKIN)
TUMORIGENIC DATA (RTECS)
MUTAGENIC DATA (RTECS)
AQUATIC TOXICITY (LC50 96HR): FATHEAD MINNOW - 19.8 MG/L
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 1 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: 2,6-DINITROTOLUENE MAY BE MILDLY IRRITATING TO THE SKIN. CONTACT WITH THE MOLTEN MATERIAL MAY CAUSE THERMAL BURNS TO THE SKIN AND EYES. IT IS TOXIC BY INGESTION. IT IS A METHEMOGLOBIN FORMER. POISONING MAY ALSO AFFECT THE CARDIOVASCULAR AND NERVOUS SYSTEMS AND THE LIVER AND KIDNEYS. METHEMOGLOBIN FORMATION AT 15% MAY RESULT IN OBSERVABLE CYANOSIS OF THE LIPS, NOSE AND EARLOBES. ABOVE 60% METHEMOGLOBIN, DYSPNEA, TACHYCARDIA, CONVULSIONS AND COMA MAY OCCUR. PROLONGED EXPOSURE TO DINITROTOLUENE MAY CAUSE ANEMIA ALONG WITH OTHER BLOOD CHANGES. WORKERS EXPOSED TO TECHNICAL GRADE DINITROTOLUENE FOR MORE THAN 15 YEARS EXPERIENCED A SIGNIFICANT INCREASE IN THE DEATH RATE DUE TO ISCHEMIC HEART DISEASE AND OTHER RESIDUAL DISEASES OF THE CIRCULATORY SYSTEM. THERE HAVE BEEN EQUIVOCAL REPORTS OF REPRODUCTIVE EFFECTS OCCURRING IN WORKERS WHO HAVE BEEN OCCUPATIONALLY EXPOSED. RATS FED FOR A YEAR DEVELOPED HEPATOCELLULAR CARCINOMAS.
THE THRESHOLD LIMIT VALUE FOR THE MIXED ISOMERS OF DINITROTOLUENE WAS BASED ON TOXICITY.
ALCOHOLIC BEVERAGES MAY ENHANCE THE TOXIC EFFECTS. HIGH AMBIENT

TEMPERATURES INCREASE THE SUSCEPTIBILITY TO CYANOSIS.
ORL-RAT LD50: 177 MG/KG ORL-MUS LD50: 621 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
200 MG/M3 POTENTIAL
CARCINOGENNIOSH
COLORLESS TO YELLOW CRYSTALS.

IC

INCOMPATIBILITIES:
CAUSTICS. ACTIVE METALS. NITRIC ACID. STRONG OXIDIZERS. REDUCING AGENTS. SODIUM PEROXIDE. EXPLOSIVE HAZARD AT HIGH TEMPERATURES.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES BE PROVIDED WITH AND REQUIRED TO USE IMPERVIOUS CLOTHING, GLOVES, FACE SHIELDS (EIGHT-INCH MINIMUM), AND OTHER APPROPRIATE PROTECTIVE CLOTHING NECESSARY TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS MOLTEN SUBSTANCE OR REPEATED PROBABILITY OF SKIN CONTACT WITH THE LIQUID OR SOLID.
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE I PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES BE PROVIDED WITH AND REQUIRED TO USE SPLASH-PROOF SAFETY GOGGLES WHERE THERE IS ANY POSSIBILITY OF EYE CONTACT WITH THIS SUBSTANCE IN A MOLTEN FORM AND REASONABLE PROBABILITY OF EYE CONTACT WITH LIQUID OR SOLID CONTAINING THE SUBSTANCE.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WASH IMMEDIATELY WHEN THE SKIN BECOMES WET, PROMPTLY WHEN THE SKIN BECOMES CONTAMINATED AND AT THE END OF EACH WORK SHIFT.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:

FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE NON-IMPERVIOUS CLOTHING BECOMES WET WITH THIS SUBSTANCE BE REMOVED IMMEDIATELY AND NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THE SUBSTANCE BE REMOVED PROMPTLY AND SUCH CLOTHING NOT BE REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF TH BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
ANY DETECTABLE CONC.
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONTOR BACK-MOUNTED ORGANIC VAPOR CANISTER HAVING A HIGH EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS".
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
BLOOD CHEMISTRY.
LIVER FUNCTION.
CARDIOVASCULAR DISEASE.
COMPLETE BLOOD COUNT.
ACGIH BIOLOGICAL EXPOSURE INDICIES FOR METHEMOGLOBIN INDUCERS: 1.5% OF HEMOGLOBIN METHEMOGLOBIN IN BLOOD / TIMING -DURING OR END OF SHIFT.

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
BLOOD. CENTRAL NERVOUS SYSTEM. CARDIOVASCULAR SYSTEM. KIDNEYS. LIVER.

SP

SYMPTOMS:
CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). EUPHORIA, AN EXAGGERATED FEELING OF WELL-BEING (SC0061). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). WEAKNESS, LACK OF STRENGTH (SC0167). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). LIGHTHEADEDNESS, DIZZY (SC0102). ATAXIA, MUSCULAR INCOORDINATION (SC0013). DROWSINESS, FALLING ASLEEP (SC0049). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). CONFUSION, IN A BEWILDERED STATE (SC0030). LETHARGY, SLUGGISHNESS (SC0595). STUPOR, LETHARGY, UNCONSCIOUSNESS (SC0214). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). TACHYCARDIA, ABNORMAL RAPID HEARTBEAT (SC0158). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). PALLOR, PALENESS, AS OF THE SKIN (SC0122). DERMATITIS, INFLAMMATION OF SKIN (SC0044). HEMATURIA, RED BLOOD CELLS IN URINE (SC0076). METHEMOGLOBINEMIA, BLOOD CONDITION FOLLOWING SOME POSION(SC0230).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
EFFECTS, SIGNS AND SYMPTOMS (SC0579). BLOOD CHANGES, CHANGES IN BLOOD CELLS OR MORPHOLOGY (SC0227). ARTHRALGIA, JOINT PAIN (SC0417). ANOREXIA DIMINISHED APPETITE (SC0006). GIDDINESS, FRIVOLOUS, DIZZINESS (SC0071). FATIGUE, TIREDNESS, SLUGGISH (SC0066). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). NYSTAGMUS, RHYTHMICAL OSCILLATION OF EYEBALLS (SC0443). TREMORS, TREMBLING, SHAKING (SC0197).
CIRCULATORY, PERTAINING TO CIRCULATION (SC0613);
EFFECTS, SIGNS AND SYMPTOMS (SC0579).
SKIN, COVERING OF BODY (SC0174);
YELLOW DISCOLORATION, ABNORMAL PIGMENTATION OF TISSUE (SC0383).
SKIN, COVERING OF BODY (SC0174);
SENSITIZATION, ALLERGIC REACTION (SC0148).
SKIN, COVERING OF BODY (SC0174);
BURNS, TISSUE DAMAGE FROM HEAT (SC0175).
EYE, ORGAN OF SIGHT (SC0170);
BURNS, TISSUE DAMAGE FROM HEAT (SC0175). INCOORDINATION, LACK OF COORDINATION (SC0085).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). PARALYSIS, LOSS OF POWER OF VOLUNTARY MOVEMENT (SC0124). REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281). LIVER DAMAGE, INJURY TO THE LIVER (SC0221).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-(MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)

IF CONTACT WITH THE SKIN IS NOT WITH MOLTEN MATERIAL, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY. BURNS FROM CONTACT WITH MOLTEN MATERIAL SHOULD BE TREATED LIKE THERMAL BURNS. COOL AFFECTED AREAS AS QUICKLY AS POSSIBLE BY DRENCHING OR IMMERSING IN WATER UNTIL MATERIAL SOLIDIFIES. DO NOT ATTEMPT TO REMOVE SOLIDIFIED MATERIAL. COVER AREA WITH STERILE, DRY DRESSING. GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
INGESTED NITRO/AMINO COMPOUNDS: REMOVE BY GASTRIC LAVAGE OR EMESIS AND CONSIDER USING ACTIVATED CHARCOAL. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS ON AN UNCONSCIOUS PERSON. MAINTAIN BLOOD PRESSURE AND RESPIRATION. GIVE OXYGEN IF RESPIRATION IS SHALLOW OR ANOXIA IS PRESENT. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. LAVAGE AND OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. ANTIDOTE: FOR SEVERE METHEMOGLOBINEMIA, GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG (1 MG/KG) SLOWLY INTRAVENOUSLY. ALL ANTIDOTES MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(5 OF 5)
METHEMOGLOBINEMIA: (WHEN METHEMOGLOBIN CONCENTRATION IS OVER 25-40% OR IN THE PRESENCE OF SYMPTOMS). GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. CYANOSIS MAY DISAPPEAR WITHIN MINUTES OR PERSIST LONGER DEPENDING ON DEGREE OF METHEMOGLOBINEMIA. INTRAVENOUS ADMINISTRATION OF THERAPEUTIC DOSES OF METHYLENE BLUE MAY CAUSE A RISE IN BLOOD PRESSURE, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS ALSO OCCURRED SEVERAL DAYS AFTER ADMINISTRATION. THESE EFFECTS ARE TEMPORARY, AND FATALITIES HAVE NOT BEEN REPORTED. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 GRAM SLOWLY INTRAVENOUSLY. WITHOUT TREATMENT, METHEMOGLOBINEMIA LEVELS OF 20-30% REVERT TO NORMAL WITHIN 3 DAYS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERD BY QUALIFIED MEDICAL PERSONNEL.

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1
AN ACCESSION NUMBER: 856. 9208.
CN CHEMICAL NAME: CYCLOTETRAMETHYLENETETRANITRAMINE.
SY SYNONYMS: CYCLOTETRAMETHYLENE TETRANITRAMINE. HMX. UN 0226. OCTOGEN. 1,3,5,7-TETRAZOCINE, OCTAHYDRO, 1,3,5,7-TETRANITRO-. BETA-HMX. 1,3,5,7-TETRANITROPERHYDRO-1,3,5,7-TETRAZOCINE. CYCLOTETRAMETHYLENE TETRANITRAMINE, WET WITH NOT LESS THAN 10% WATER. STCC 4901548. OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE. HOMOCYCTONITE. TETRAMETHYLENETETRANITRAMINE.
RN CAS NUMBER: 2691-41-0.

REG. TOXIC NUMBER: XF7450000.

CHEMICAL FORMULA: C4H8N8O8.
PD
PHYSICAL DESCRIPTION:
COLORLESS TO WHITE CRYSTALS WETTED WITH WATER.

MOL WT:	296.20
BOILING PT:	NOT AVAILABLE
SOLUBILITY:	INSOLUBLE
FLASH PT:	FLAMMABLE SOLID
VAPOR PRES:	NOT AVAILABLE
MELT PT:	527 F (275 C)
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	NOT AVAILABLE
SPEC GRAVITY:	NOT AVAILABLE
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:	

EL
PERMISSABLE EXPOSURE:
NO OCCUPATIONAL EXPOSURE LIMITS ESTABLISHED BY OSHA, ACGIH OR NIOSH
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: CYCLOTETRAMETHYLENETETRANITRAMINE MAY BE IRRITATING TO THE EYES. IT IS TOXIC BY SKIN ABSORPTION AND SLIGHTLY TOXIC BY INGESTION. INGESTION MAY CAUSE NARCOSIS. DERMATITIS AND CIRCULATORY COLLAPSE WITH CENTRAL NERVOUS SYSTEM DISTURBANCES HAVE BEEN REPORTED IN ANIMALS.
ORL-RAT LD50: 6490 MG/KG ORL-GPG LD50: 300 MG/KG
ORL-MUS LD50: 1500 MG/KG ORL-RBT LD50: 50 MG/KG
SKN-RBT LD50: 630 MG/KG INV-RAT LD50: 25 MG/KG
INV-RBT LD50: 10 MG/KG INV-GPG LD50: 28 MG/KG
INV-DOG LD50: 40 MG/KG
SKIN AND EYE IRRITATION DATA (RTECS)
SKN-RBT 500 MG MLD

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY

DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED
COLORLESS TO WHITE CRYSTALS WE.

IC

INCOMPATIBILITIES:
CYCLOTETRAMETHYLENETETRANITRAMINE: MERCURY FULMINATE: MAY EASILY INITIATE AN EXPLOSION. METAL AZIDES: MAY INITIATE DETONATION. OXIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD. EXPOSURE TO HEAT, FRICTION OR SHOCK MAY INITIATE DETONATION. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC.

CL

CLOTHING:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING WHICH HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
NO SPECIFIC REQUIREMENT. USE APPROPRIATE SAFETY GOGGLES, AS INDICATED BY THE NATURE OF THE CONTAMINANT AND THE LIKELIHOOD OF EXPOSURE.

EMPLOYEE SHOULD WASH:
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF TH BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
HIGH LEVELS
- TYPE 'C' SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE OPERATED

IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE WITH A FULL FACE-PIECE, HELMET, OR HOOD OPERATED IN CONTINUOUS-FLOW MODE
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
NO INFORMATION AVAILABLE FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS"; ADVISE: GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
NO DATA.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). NARCOSIS, STUPOR OR SLEEP DUE TO NARCOTIC (SC0113).
DERMATITIS, INFLAMMATION OF SKIN (SC0044);
IN EXPERIMENTAL ANIMALS, (SC0212).
CIRCULATORY, PERTAINING TO CIRCULATION (SC0613);
COLLAPSE, EXTREME PROSTRATION (SC0029).
IN EXPERIMENTAL ANIMALS, (SC0212).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028).
DISTURBANCE, INTERRUPTION OF A NORMAL STATE (SC0047).
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 4)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 4)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE

AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 4)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 4)
IF THIS CHEMICAL IS INGESTED, TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD LOWER THAN HIPS TO PREVENT ASPIRATION.

END OF REQUEST

****

1 3 DEC 1991 (9112)

1
AN ACCESSION NUMBER: 1655. 9112.
CN CHEMICAL NAME: LEAD.
SY SYNONYMS: C.I. PIGMENT METAL 4. C.I. 77575. LEAD FLAKE. KS-4. LEAD S2. SI. SO. S 1. PLUMBUM. PB-S 100. LEAD ELEMENT. L-18. L-24. L-29. L-27. T-134.
RN CAS NUMBER: 7439-92-1.

REG. TOXIC NUMBER: OF7525000.

CHEMICAL FORMULA: PB.
PD
PHYSICAL DESCRIPTION:
BLUISH-WHITE, SILVERY GRAY, HEAVY MALLEABLE METAL.

MOL WT:	207.19
BOILING PT:	3164 F (1740 C)
SOLUBILITY:	INSOLUBLE
FLASH PT:	NONCOMBUSTIBLE SOLID
VAPOR PRES:	1.3 MMHG @ 970 C
MELT PT:	622 F (328 C)
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	
SPEC GRAVITY:	11.3
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
50 UG(PB)/M3 OSHA TWA; 30 UG(PB)/M3 OSHA TWA ACTION LEVEL
IF AN EMPLOYEE IS EXPOSED TO LEAD FOR MORE THAN 8 HOURS PER DAY THE FOLLOWING FORMULA IS USED:
MAXIMUM PERMISSIBLE LIMIT (IN UG/M3)= 400 DIVIDED BY HOURS WORKED
0.15 MG(PB)/M3 ACGIH TWA
<0.10 MG(PB)/M3 NIOSH RECOMMENDED 10 HOUR TWA
HUMAN INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-2B)
ANIMAL SUFFICIENT EVIDENCE FOR CARCINOGENICITY (IARC GROUP-2B)
REPRODUCTIVE EFFECTS DATA (RTECS); MUTAGENIC DATA (RTECS)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: LEAD MAY BE IRRITATING TO THE EYES AND SKIN. THERE IS INSUFFICIENT DATA TO QUANTIFY THE TOXICITY. IT IS A NEUROTOXIN, NEPHROTOXIN AND TERATOGEN. POISONING MAY ALSO AFFECT THE BLOOD, HEART, ENDOCRINE AND IMMUNE SYSTEMS. THE FATAL DOSE OF ABSORBED LEAD IS APPROXIMATELY 0.5 GRAMS. ACUTE EXPOSURES MAY RESULT IN METAL FUME FEVER WHILE CHRONIC EXPOSURE MAY RESULT IN "PLUMBISM" AND AN ACCUMULATION IN BODY TISSUES. REPRODUCTIVE EFFECTS HAVE BEEN EXHIBITED IN BOTH MALES AND FEMALES. PATERNAL EFFECTS MAY INCLUDE DECREASED SEX DRIVE, IMPOTENCE, STERILITY AND ADVERSE EFFECTS ON THE SPERM WHICH MAY INCREASE THE RISK OF BIRTH DEFECTS. MATERNAL EFFECTS MAY INCLUDE MISCARRIAGE AND STILLBIRTHS IN EXPOSED WOMEN OR WOMEN WHOSE HUSBANDS

WERE EXPOSED, ABORTION, STERILITY OR DECREASED FERTILITY, AND ABNORMAL MENSTRUAL CYCLES. RENAL TUMORS WERE PRODUCED IN ANIMALS BY LEAD ACETATE, SUBACETATE AND PHOSPHATE WHEN GIVEN ORALLY. NO EVALUATION COULD BE MADE OF THE CARCINOGENICITY OF POWDERED LEAD.
DUE TO THE LACK OF INFORMATION ON ODOR THRESHOLD AND EYE IRRITATION LEVELS, INORGANIC LEAD IS TREATED AS A MATERIAL WITH POOR WARNING PROPERTIES. THE THRESHOLD LIMIT VALUE WAS ESTABLISHED BASED ON SYSTEMIC EFFECTS.
PERSONS WITH NERVOUS SYSTEM OR GASTROINTESINAL DISRODERS, ANEMIA OR CHRONIC BRONCHITIS MAY BE AT AN INCREASED RISK FROM EXPOSURE. LEAD MAY CROSS THE PLACENTA AND AFFECT THE FETUS CAUSING BIRTH DEFECTS.
ORL-WMN TDLO: 450 MG/KG/6 Y IHL-HMN TDLO: 10 UG/M3

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
700 MG/M3 OSHA/NIOSH
BLUISH-WHITE, SILVERY GRAY, HE.

IC

INCOMPATIBILITIES:
LEAD: AMMONIUM NITRATE: VIOLENT OR EXPLOSIVE REACTION. CHLORINE TRIFLUORIDE: VIOLENT REACTION. DISODIUM ACETYLIDE: TRITURATION IN MORTAR MAY BE VIOLENT AND LIBERATE CARBON. HYDROGEN PEROXIDE (52% OR GREATER): VIOLENT DECOMPOSITION. HYDROGEN PEROXIDE (60% SOLUTION) AND TRIOXIANE: SPONTANEOUSLY DETONABLE. METALS (ACTIVE): INCOMPATIBLE. NITRIC ACID: LEAD-CONTAINING RUBBER MAY IGNITE. OXIDIZERS (STRONG): INCOMPATIBLE. SODIUM AZIDE: FORMS LEAD AZIDE AND COPPER AZIDE IN COPPER PIPE. SODIUM CARBIDE: VIGOROUS REACTION. SULFURIC ACID (HOT): REACTS. ZIRCONIUM-LEAD ALLOYS: IGNITION ON IMPACT.

CL

CLOTHING:
29CFR1910.1025 LEAD THE EMPLOYERS SHALL ASSURE THAT EMPLOYEES WHO ARE EXPOSED TO LEAD ABOVE THE PERMISSIBLE EXPOSURE LEVEL, WITHOUT REGARD TO THE USE OF RESPIRATORS OR WHERE THE POSSIBILITTY OF SKIN OR EYE IRRITATION EXISTS, BE PROVIDED WITH COVERALLS OR SIMILAR FULL-BODY WORK CLOTHING, GLOVES, HATS AND SHOES OR DISPOSABLE SHOE COVERLETS, FACESHIELDS, VENTED GOGGLES OR OTHER APPROPRIATE PROTECTIVE EQUIPMENT.

WEAR EYE PROTECTION TO PREVENT:
29CFR1910.1025 LEAD THE EMPLOYERS SHALL ASSURE THAT EMPLOYEES WEAR FACESHIELDS, VENTED GOGGLES OR OTHER APPROPRIATE PROTECTIVE EQUIPEMENT WHICH COMPLIES WITH 29CFR1910.133.

EMPLOYEE SHOULD WASH:
29CFR1910.1025 LEAD THE EMPLOYER SHALL ASSURE THAT EMPLOYEES WHO WORK IN AREAS WHERE THEIR AIRBORNE EXPOSURE TO LEAD IS ABOVE THE PERMISSIBLE EXPOSURE LEVEL, WITHOUT REGARD TO THE USE OF A RESPIRATOR, WASH THEIR HANDS AND FACE PRIOR TO EATING, DRINKIND OR APPLYING COSMETICS AND SHOWEI AT THE END OF THE WORKSHIFT.

WORK CLOTHING SHOULD BE CHANGED DAILY:

29CFR1910.1025 LEAD THE EMPLOYER SHALL ASSURE THAT ALL PROTECTIVE CLOTHING IS REMOVED AT THE COMPLETION OF A WORKSHIFT ONLY IN CHANGE ROOMS PROVIDED FOR THAT PURPOSE.

REMOVE CLOTHING:
NO SPECIFIC REGULATIONS UNDER 29CFR1910.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE SUBSTANCE AND THE PROBABILITY OF EXPOSURE, PROVIDE AN EYE WASH AND FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
RP
RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
LEAD
THE FOLLOWING RESPIRATORS ARE THE MINIMUM LEGAL REQUIREMENTS AS SET FORTH BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION FOUND IN 29CFR1910, SUBPART Z. NOT IN EXCESS OF 0.5 MG/M3 (10X PEL) - HALF-MASK, AIR-PURIFYING RESPIRATOR EQUIPPED WITH HIGH-EFFICIENCY FILTERS NOT IN EXCESS OF 2.5 MG/M3 (50X PEL) - FULL FACEPIECE, AIR-PURIFYING RESPIRATOR WITH HIGH-EFFICIENCY FILTERS NOT IN EXCESS OF 50 MG/M3 - ANY POWERED AIR-PURIFYING RESPIRATOR WITH HIGH-EFFICIENCY FILTERS - HALF-MASK SUPPLIED-AIR RESPIRATOR OPERATED IN POSITIVE PRESSURE MODE NOT IN EXCESS OF 100 MG/MG (2000X PEL) - SUPPLIED-AIR RESPIRATORS WITH FULL FACEPIECE, HOOD OR HELMET OR SUIT, OPERATED IN POSITIVE PRESSURE MODE GREATER THAN 100 MG/M3, UNKNOWN CONCENTRATIONS OR FIREFIGHTING - FULL FACEPIECE, SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSUE MODE (RESPIRATORS SPECIFIED FOR HIGHER CONCENTRATIONS CAN BE USED A LOWER CONCENTRATIONS OF LEAD). (FULL FACEPIECE IS REQUIRED IF THE LEAD AEROSOLS CAUSE EYE AND SKIN IRRITATION AT THE USE CONCENTRATIONS.) (A HIGH EFFICIENCY PARTICULATE FILTER MEANS 99.97% EFFICIENT AGAINST 0.3 MICRON PARTICLES) THE FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS BY THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, NIOSH POCKET GUIDE TO CHEMICAL HAZARDS OR NIOSH CRITERIA DOCUMENTS.

0.5 MG(PB)/M3
- SUPPLIED-AIR RESPIRATOR
- AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS

1.25 MG(PB)/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

2.5 MG(PB)/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE

- SUPPLIED-AIR RESPIRATOR WITH A TIGHT-FITTING FACEPIECE OPERATED IN A CONTINUOUS FLOW MODE

50 MG(PB)/M3
- SUPPLIED-AIR RESPIRATOR WITH HALF-MASK OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

100 MG(PB)/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.1025 THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REQUIRES EMPLOYERS TO PROVIDE A MEDICAL SURVEILLANCE PROGRAM FOR ALL EMPLOYEES WHO ARE OR MAY BE EXPOSED TO LEAD ABOVE THE ACTION LEVEL FOR MORE THAN 30 DAYS PER YEAR THIS MEDICAL SURVEILLANCE PROGRAM SHALL CONSIST OF: (1) INITIAL MEDICAL EXAMINATION INCLUDING: (A) WORK HISTORY (B) MEDICAL HISTORY WITH PARTICULAR ATTENTION TO: (1) PAST LEAD EXPOSURE (OCCUPATIONAL AND NON-OCCUPATIONAL) (2) PERSONAL HABITS (SMOKING, HYGIENE) (3) PAST GASTROINTESTINAL, HEMATOLOGIC, RENAL, REPRODUCITVE, CARDIOVASCULAR AND NEUROLOGIC PROBLEMS (C) PHYSICAL EXAMINATION (1) WITH PARTICULAR ATTENTION TO: (A) TEETH AND GUMS (B) HEMATOLOGIC SYSTEM (C) GASTROINTESTINAL SYSTEM (D) KIDNEYS (E) CARDIOVASCULAR SYSTEM (F) NEUROLOGICAL SYSTEM (G) PULMONARY STATUS IF RESPIRATORY PROTECTION WILL BE USED (2) BLOOD PRESSURE MEASUREMENT (3) BLOOD SAMPLE AND ANALYSIS DETERMINING: (A) BLOOD LEAD LEVEL (B) HEMOGLOBIN AND HEMATOCRIT DETERMINATIONS, RED CELL INDICES, EXAM OF PERIPHERAL SMEAR MORPHOLOGY (C) ZINC PROTOPORPHYRIN (D) BLOOD UREA NITROGEN (E) SERUM CREATININE (4) URINALYSIS WITH MICROSCOPIC EXAM (5) ANY LABORATORY OR OTHER TEST DEEMED NECESSARY BY THE PHYSICIAN (2) PERIODIC EXAMINATIONS (A) BLOOD LEAD AND ZPP LEVEL TESTS AND ANALYSIS: (1) EVERY 6 MONTHS FOR EACH EMPLOYEE EXPOSED ABOVE THE ACTION LEVEL FOR MOR THAN 30 DAYS PER YEAR (2) AT LEAST EVERY 2 MONTHS FOR EACH EMPLOYEE WHOSE LAST BLOOD SAMPLING AND ANALYSIS INDICATED A BLOOD LEVEL AT OR ABOVE 40 UG/100 G OF WHOLE BLOOD. THIS FREQUENCY SHALL CONTINUE UNTIL 2 CONSECUTIVE BLOOD SAMPLES AND ANALYSES INDICATE A BLOOD LEAD LEVEL BELOW 40 UG/100 G OF WHOLE BLOOD (3) AT LEAST MONTHLY DURING THE REMOVAL PERIOD OF EACH EMPLOYEE REMOVED FROM EXPOSURE TO LEAD DUE TO AN ELEVATED BLOOD LEAD LEVEL (B) ALL TESTS CONDUCTED IN INITIAL EXAMINATION: (1) AT LEAST ANNUALLY FOR EACH EMPLOYEE FOR WHOM A BLOOD SAMPLING TEST CONDUCTED AT ANY TIME DURING THE PRECEDING 12 MONTHS INDICATED A BLOOD LEAD LEVEL AT OR ABOVE 400 UG/100 G (2) PRIOR TO ASSIGNMENT FOR EACH EMPLOYEE BEING ASSIGNED FOR THE FIRST TIME TO AN AREA IN WHICH AIRBORNE CONCENTRATIONS OF LEAD ARE AT OR ABOVE THE ACTION LEVEL (3) AS SOON AS POSSIBLE, UPON NOTIFICATION BY AN EMPLOYEE HAS DEVELOPED SIGNS OR SYMPTOMS ASSOCIATED WITH LEAD INTOXICATION, THAT THE EMPLOYEE DESIRES MEDICAL ADVICE CONCERNING THE EFFECTS OF CURRENT OR PAST EXPOSURI TO LEAD ON THE EMPLOYEES ABILITY TO PROVIDE A HEALTHY CHILD, OR THAT EMPLOYEE HAS DEMONSTRATED DIFFICULTY IN BREATHING DURING A RESPIRATORY FITTING TEST OR DURING USE (4) AS MEDICALLY APPROPRIATE FOR EACH EMPLOYEE

EITHER REMOVED FROM EXPOSURE TO LEAD DUE TO A RISK OF SUSTAINING MATERIAL IMPAIRMENT TO HEALTH, OR OTHERWISE LIMITED PURSUANT TO A FINAL MEDICAL DETERMINATION.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS. 53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
OTHER MEDICAL SURVEILLANCE RECOMMENDED: ACGIH BIOLOGICAL EXPOSURE INDICES FOR LEAD: 50 UG/100 ML LEAD IN BLOOD / TIMING -NOT CRITICAL 150 UG/G CREATINE LEAD IN URINE / TIMING -NOT CRITICAL 250 UG/100 ML ERYTHROCYTES OF 100 UG/100 ML BLOOD ZINC PROTOPORPHYRIN IN BLOOD / TIMING -AFTER ONE MONTH EXPOSURE.

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
CENTRAL NERVOUS SYSTEM. CARDIOVASCULAR SYSTEM. GASTROINTESTINAL. KIDNEYS. REPRODUCTIVE SYSTEM. GINGIVAL TISSUE. BLOOD.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). SALIVATION, EXCESS DISCHARGE OF SALIVA (SC0146). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). CONSTIPATION, DIFFICULT, INFREQUENT DEFECATION (SC0032). FATIGUE, TIREDNESS, SLUGGISH (SC0066). SLEEP DISORDERS, CHANGE IN NORMAL SLEEP PATTERNS (SC0599). IRRITABILITY QUICK EXCITABILITY TO ANNOYANCE (SC0091). MEMORY DEFECTS, IMPERFECTION IN RECOLLECTION ABILITY (SC0585). INABILITY TO CONCENTRATE, INABILITY TO FOCUS ONE'S THOUGHTS (SC0586). DELIRIUM, STATE OF DISORIENTATION, CONFUSION (SC0288). PARESTHESIA, ABNORMAL SENSATION WITHOUT CAUSE (SC0125).
MUSCLE, TISSUE RESPONSIBLE FOR MOTION (SC0623);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). WEAKNESS, LACK OF STRENGTH (SC0167).
LIVER, BILE-SECRETING GLANDULAR ORGAN (SC0620);
EFFECTS, SIGNS AND SYMPTOMS (SC0579). THIRST, DESIRE FOR WATER (SC0210). LETHARGY, SLUGGISHNESS (SC0595). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). SWEATING, EXCRETING MOISTURE THROUGH THE SKIN (SC0156).
EXCESSIVE, SUPERFLUOUS (SC0737);
URINATION, DISCHARGE OF URINE FROM BODY (SC0617). PROSTRATION, MARKED LOSS OF STRENGTH, EXHAUSTION (SC0139). FEVER, BODY TEMPERATURE ABOVE NORMAL (SC0067). CHILLS, A SHIVERING OR SHAKING (SC0736). PALLOR, PALENESS, AS OF THE SKIN (SC0122). FATIGUE, TIREDNESS, SLUGGISH (SC0066). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). APATHY, LACK OF FEELING OR EMOTION (SC0008). GINGIVAL BLACK LINE, BLACK LINE ON GUMS (SC0207). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004). MYALGIA, MUSCLE PAIN OR TENDERNESS (SC0526).
ABDOMINAL, SECTION BETWEEN THORAX AND PELVIS (SC0750);

PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). ATAXIA, MUSCULAR INCOORDINATION (SC0013). STUPOR, LETHARGY, UNCONSCIOUSNESS (SC0214). VISUAL DISTURBANCE, UPSET IN SIGHT (SC0165). ENCEPHALOPATHY, BRAIN DYSFUNCTION; BRAIN DISEASE (SC0336). DELIRIUM, STATE OF DISORIENTATION, CONFUSION (SC0288). MENTAL DISORDER, PSYCHIC DISTURBANCE (SC0608). SEIZURE, CONVULSION (SC0149). HYPERTENSION, HIGH BLOOD PRESSURE (SC0177).
CRANIAL NERVE, NERVE ARISING FROM THE BRAIN (SC0342);
PARALYSIS, LOSS OF POWER OF VOLUNTARY MOVEMENT (SC0124). KIDNEY DAMAGE INJURY TO THE KIDNEY (SC0220). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281).
KIDNEY, POST-PERITONEUM ORGAN FOR URINE WASTE(SC0094);
TUMORS, BENIGN OR CANCEROUS ENLARGEMENTS (SC0578).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
INGESTED LEAD COMPOUNDS: REMOVE INGESTED POISON BY GASTRIC LAVAGE WITH DILUTE MAGNESIUM SULFATE OR SODIUM SULFATE SOLUTION OR BY EMESIS. TREAT CEREBRAL EDEMA WITH MANNITOL AND PREDNISOLONE OR OTHER CORTICOSTEROID. GET MEDICAL ATTENTION IMMEDIATELY. ANTIDOTE: INITIATE URINE FLOW. GIVE 10% DEXTROSE IN WATER INTRAVENOUSLY, 10-20 ML/KG, FOR ONE TO TWO HOURS. IF URINE FLOW DOES NOT START, GIVE 20% SOLUTION OF MANNITOL, 5-10 ML/KG INTRAVENOUSLY, OVER TWENTY MINUTES. LIMIT FLUID TO REQUIREMENTS, AND CATHETERIZATION MAY BE NECESSARY IN COMA. DAILY URINE OUTPUT SHOULD BE 350-500 ML/M2/24 HOURS. EXCESSIVE FLUIDS FURTHER INCREASE CEREBRAL EDEMA. FOR ADULTS WITH ACUTE ENCEPHALOPATHY, GIVE DIMERCAPROL, 4 MG/KG, INTRAMUSCULARLY EVERY 4 HOURS FOR 30 DOSES. BEGINNING 4 HOURS LATER, GIVE CALCIUM DISODIUM EDETATE AT A SEPERATE INJECTION SITE, 12.5 MG/KG INTRAMUSCULARLY EVERY 4 HOURS AS A 20% SOLUTION, WITH 0.5% PROCAINE ADDED, FOR A TOTAL OF 30 DOSES. IF SIGNIFICANT IMPROVEMENT HAS NOT OCCURRED BY THE FOURTH DAY, INCREASE THE NUMBER OF INJECTIONS BY 10 FOR EACH DRUG. FOR SYMPTOMATIC ADULTS, THE COURSE OF DIMERCAPROL AND CALCIUM DISODIUM EDETATE CAN BE SHORTENED OR CALCIUM DISODIUM EDETATE ONLY CAN BE GIVIN IN A DOSAGE OF 50 MG/KG INTRAVENOUSLY AS 0.5% SOLUTION IN 5% DEXTROSE IN WATER OR NORMAL SAILINE BY INFUSION OVER NOT LESS THAN 8 HOURS FOR NOT MORE THAN 5 DAYS. FOLLOW WITH PENICILLAMINE, 500-750 MG/DAY, ORALLY FOR 1-2 MONTHS OR UNTIL URINE LEAD LEVELS DROPS BELOW 0.3 MG/24 HOURS. (DREISBACH, HANDBOOK OF POISONING, 12TH EDITION.) PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 5)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
COMPLETE BLOOD COUNT.
URINALYSIS.
BLOOD LEAD.
URINE LEAD AS EXPOSURE INDEX.
BLOOD ERYTHROCYTE PROTOPORPHYRIN BLOOD ERYTHOCYTE GAMMA-AMINOLEVULINIC ACID DEHYDRATASE URINE LEAD EXCRETION >0.08 MG/DAY URINE COPROPORPHYRIN >0.8 MG/L URINE GAMMA-AMINOLEVULINIC ACID >6 MG/L.

RS

REGULATORY STATUS.

(1 OF 44)
****
FEDERAL REGULATIONS
**********.

(2 OF 44)
OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

(3 OF 44)
OSHA STANDARD 29CFR1910.1025 LEAD.

(4 OF 44)
OSHA STANDARD 29CFR1910.252 WELDING, CUTTING, AND BRAZING.

5

AN ACCESSION NUMBER: 1843. 9201.

CN CHEMICAL NAME: MERCURY.

SY SYNONYMS: METALLIC MERCURY. INORGANIC MERCURY. MERCURY, METALLIC. MERCURY, INORGANIC. QUICKSILVER. COLLOIDOL MERCURY. NCI-C60399. HYDRARGYRUM. RCRA U151. UN 2809. ELEMENTAL MERCURY.

RN CAS NUMBER: 7439-97-6.

REG. TOXIC NUMBER: OV4550000.

CHEMICAL FORMULA: HG.

PD

PHYSICAL DESCRIPTION:
ODORLESS, SILVERY LIQUID WITH A METALLIC LUSTER.

MOL WT:	200.59
BOILING PT:	674 F (357 C)
SOLUBILITY:	INSOLUBLE
FLASH PT:	NONFLAMMABLE LIQUID
VAPOR PRES:	0.002 MMHG @ 25 C
MELT PT:	-38 F (-39 C)
UEL IN AIR:	
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	

SPEC GRAVITY: 13.5939
VAPOR DENSITY: 7.0
ODOR THRESHOLD:
OCTANOL/WATER CO-EFFICIENT:.

EL

PERMISSABLE EXPOSURE:
0.05 MG(HG)/M3 OSHA TWA (VAPOR); 0.1 MG(HG)/M3 OSHA CEILING (SKIN)
0.05 MG(HG)/M3 ACGIH TWA (VAPOR); 0.1 MG(HG)/M3 ACGIH TWA (SKIN)
0.05 MG(HG)/M3 NIOSH RECOMMENDED 10 HR TWA (SKIN)
TUMORIGENIC DATA (RTECS)
REPRODUCTIVE EFFECTS DATA (RTECS)
MUTAGENIC DATA (RTECS)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: MERCURY IS A MUCOUS MEMBRANE IRRITANT AND A SKIN AND PULMONARY SENSITIZER. THERE IS INSUFFICIENT DATA TO FULLY QUANTIFY THE TOXICITY. IT IS A NEUROTOXIN AND NEPHROTOXIN. POISONING MAY ALSO AFFECT THE RESPIRATORY AND GASTROINTESTINAL SYSTEMS. METAL FUME FEVER, AN INFLUENZA-LIKE ILLNESS, MAY OCCUR DUE TO THE INHALATION OF FRESHLY FORMED METAL OXIDE PARTICLES SIZED USUALLY BETWEEN 0.02-0.05 MICRONS. SYMPTOMS MAY BE DELAYED 4-12 HOURS AND BEGIN WITH A SUDDEN ONSET. REPEATED EXPOSURE MAY CAUSE MERCURIALISM, WHICH IS CHARACTERIZED BY FINE TREMORS AND ERETHISM. TREMORS MAY AFFECT THE HANDS FIRST, BUT THEN BECOME EVIDENT IN THE FACE, ARMS AND LEGS. ERETHISM MAY BE MANIFESTED BY ABNORMAL SHYNESS, BLUSHING, RESENTMENT OF CRITICISM AND IRRITABILITY OR EXCITABILITY.
THE THRESHOLD LIMIT VALUE WAS ESTABLISHED BASED ON THE ABILITY OF MERCURY ABSORBED IN THE BRAIN TO REMAIN.
PERSONS WITH NERVOUS SYSTEM DISORDERS, CHRONIC RESPIRATORY DISEASE AND KIDNEY DISEASE MAY BE AT AN INCREASED RISK FROM EXPOSURE.
IHL-WMN TCLO: 1500 UG/M3/46 D IHL-MAN TCLO: 44,300 UG/M3/8 HR
SKN-MAN TDLO: 129 MG/KG/5 HR C IHL-RBT LCLO: 29 MG/M3/30 HR

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
28 MG/M3 OSHA/NIOSH
ODORLESS, SILVERY LIQUID WITH.

IC

INCOMPATIBILITIES:
SEND BACK AREA EXCEDED. ACETYLENE: FORMATION OF EXPLOSIVE COMPOUND. ACETYLINIC COMPOUNDS: FORMATION OF EXPLOSIVE COMPOUND. ALUMINUM: CORRODES. AMINES: MAY FORM EXPLOSIVE COMPOUNDS. AMMONIA + MOISTURE: FORMS EXPLOSIVE COMPOUND. BORON DIIODOPHOSPHIDE: IGNITES ON CONTACT WITH MERCURY VAPORS. BROMINE: VIOLENT REACTION. 3-BROMOPROPYNE: EXPLOSION HAZARD. CALCIUM: AMALGAM FORMATION @ 390 C IS VIOLENT. CHLORINE: IGNITES @ 200-300 C. CHLORINE DIOXIDE: EXPLODES. COPPER (AND ALLOYS): MAY BE ATTACKED. ETHYLENE OXIDE + TRACES OF ACETYLENE: MAY FORM EXPLOSIVE ACETYLIDES. LITHIUM: AMALGAM FORMATION IS VIOLENTLY EXOTHERM AND MAY BE EXPLOSIVE. METHYL AZIDE: PRODUCES SHOCK SENSITIVE MIXTURE. METHYLSILANE + OXYGEN: PRODUCES SHOCK SENSITIVE MIXTURE. NITRIC ACID + ALCOHOLS: FORMS FULMINATES CAPABLE OF DETONATION. OXALIC ACID: FORMS

SHOCK SENSITIVE COMPOUND. OXIDANTS: VIOLENT REACTION. PEROXYFORMIC ACID: EXPLOSIVE REACTION. POTASSIUM: AMALGAM FORMATION IS VIGOROUSLY EXOTHERMIC AND MAY BE EXPLOSIVE.

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
NO SPECIFIC REQUIREMENT. USE APPROPRIATE SAFETY GOGGLES, AS INDICATED BY THE NATURE OF THE CONTAMINANT AND THE LIKELIHOOD OF EXPOSURE.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
0.5 MG/M3

- CHEMICAL CARTRIDGE RESPIRATOR PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

1.25 MG/M3
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE
- POWERED AIR-PURIFYING RESPIRATOR WITH CARTRIDGE PROVIDING PROTECTION AGAINST THE COMPOUND OF CONCERN

2.5 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A TIGHT-FITTING FACEPIECE OPERATED IN A CONTINUOUS FLOW MODE
- CHEMICAL CARTRIDGE RESPIRATOR PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN WITH A FULL FACE-PIECE
- GAS MASK WITH A CANISTER PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN (CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)
- POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND CARTRIDGE PROVIDING PROTECTION AGAINST COMPOUND OF CONCERN

28 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH HALF-MASK OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- GAS MASK WITH A CANISTER PROVIDING PROTECTION AGAINST SPECIFIC COMPOUND OF CONCERN (CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS".
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
HISTORY OF ASTHMA OR ALLERGIES.
RESPIRATORY HISTORY.
PULMONARY FUNCTIONS.

CENTRAL NERVOUS SYSTEM TESTS, PERIPHERAL NEUROPATHY.
KIDNEY FUNCTION.
URINALYSIS.
NOTICE OF INTENT TO ESTABLISH: ACGIH BIOLOGICAL EXPOSURE INDICIES FOR MERCURY: 35 UG/G CREATININE TOTAL INORGANIC MERCURY IN URINE / TIMING -PRE-SHIFT 15 UG/L TOTAL INORGANIC MERCURY IN BLOOD / TIMING -END OF SHIFT AT END OF WORKWEEK.

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
SKIN. RESPIRATORY SYSTEM. CENTRAL NERVOUS SYSTEM. KIDNEYS. EYES.

SP

SYMPTOMS:
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). COUGHING, FORCEFUL EXPIRATION (SC0173). FEVER, BODY TEMPERATURE ABOVE NORMAL (SC0067). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). STOMATITIS, INFLAMMATION OF THE MOUTH (SC0395). SALIVATION, EXCESS DISCHARGE OF SALIVA (SC0146). METALLIC TASTE, TASTE RESEMBLING METAL IN MOUTH (SC0216).
SKIN, COVERING OF BODY (SC0174);
SENSITIZATION, ALLERGIC REACTION (SC0148). DERMATITIS, INFLAMMATION OF SKIN (SC0044).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
SENSITIZATION, ALLERGIC REACTION (SC0148). BRONCHITIS, INFLAMED BRONCHIAL MUCOUS MEMBRANES (SC0017). PNEUMONITIS, LOCALIZED INFLAMMATION OF LUNG (SC0137). ENCEPHALITIS, INFLAMMATION OF THE BRAIN (SC0307). TREMORS, TREMBLING, SHAKING (SC0197). ERETHISM, EXCESSIVE SENSIBILITY TO STIMULATION (SC0729). MENTAL DEPRESSION, ABSENCE OF CHEERFULNESS (SC0280). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE (SC0091). EXCITABILITY, SENSITIVITY TO EMOTIONAL STIMULATION (SC0592). FATIGUE, TIREDNESS, SLUGGISH (SC0066). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). HALLUCINATIONS, PERCEPTIONS OF WHAT DOES NOT EXIST (SC0074). MEMORY DEFECTS, IMPERFECTION IN RECOLLECTION ABILITY (SC0585). MENTAL DISORDER, PSYCHIC DISTURBANCE (SC0608). PROTEINURIA, PROTEIN IN URINE, OFTEN ALBUMIN (SC0140). ALBUMINURIA, ALBUMIN (PROTEIN) IN URINE (SC0002). ANURIA, COMPLETE LACK OF URINATION (SC0304). GINGIVITIS, GUM INFLAMMATION (SC0515). GINGIVAL BLUE LINE, BLUE LINE ON GUMS (SC0575).
EXTREMITIES, ARMS OR LEGS (SC0062);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182).
EXTREMITIES, ARMS OR LEGS (SC0062);
NUMBNESS, COMBINED ANESTHESIA AND PARESTHESIA (SC0120). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). ANOREXIA, DIMINISHED APPETITE (SC0006). SPEECH DIFFICULTIES, TROUBLES WITH VERBAL EXPRESSION (SC0614). ACIDOSIS ACID IMBALANCE (SC0290).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). INCOORDINATION, LACK OF COORDINATION (SC0085). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220).
NERVE, BUNDLE OF NERVE FIBERS (SC0726);
DAMAGE, PERMANENT INJURY (SC0287).

REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212). HEMATURIA, RED BLOOD CELLS IN URINE (SC0076). ALBUMINURIA, ALBUMIN (PROTEIN) IN URINE (SC0002). FEVER, BOI TEMPERATURE ABOVE NORMAL (SC0067).
BLINDNESS, INABILITY TO SEE (SC0223);.

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
INGESTED MERCURY: REMOVE BY GASTRIC LAVAGE OR EMESIS. MAINTAIN BLOOD PRESSURE AND AIRWAY. GIVE OXYGEN IF RESPIRATION IS DEPRESSED. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS IF VICTIM IS UNCONSCIOUS. GET MEDICAL ATTENTION IMMEDIATELY. ADMINISTRATION OF GASTRIC LAVAGE OR OXYGEN SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. ANTIDOTE: GIVE DIMERCAPROL, 3 MG/KG (OR 0.3 ML/KG) EVERY 4 HOURS FOR THE FIRST 2 DAYS AND THEN 2 MG/KG EVERY 12 HOURS FOR A TOTAL OF 10 DAYS. DIMERAPTROL IS AVAILABLE AS A 10% SOLUTION IN OIL FOR INTRAMUSCULAR ADMINISTRATION. HEMODIALYSIS WILL SPEED THE REMOVAL OF THE MERCURY-DIMERCAPROL COMPLEX. PENICILLAMINE IS ALSO EFFECTIVE. GIVE UP TO 100 MG/KG/DAY (MAXIMUM 1 GM/DAY) DIVIDED INTO 4 DOSES FOR NO LONGER THAN 1 WEEK. IF A LONGER ADMINISTRATION PERIOD IS WARRANTED, DOSAGE SHOULD NOT EXCEED 40 MG/KG/DAY. GIVE THE DRUG ORALLY HALF AN HOUR BEFORE MEALS. A CHELATING AGENT SHOULD BE CONTINUED UNTIL THE URINE-MERCURY LEVEL FALLS BELOW 50 UG/24 HOURS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 5)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFT. TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT

INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

HZDB DEC 1992 (9212)
BRS SEARCH MODE - ENTER QUERY
1_: 55-63-0

RESULT 1 DOCUMENT
2_: ..PRINT ALL/DOC=1

1
AN ACCESSION NUMBER: 2305. 9212.
CN CHEMICAL NAME: **NITROGLYCERIN.**
SY SYNONYMS: NITROGLYCERINE. NITROGLYCOL. NTG. BLASTING GELATIN. BLASTING OIL. 1,2,3-PROPANETRIOL, TRINITRATE. NITRO-SPAN. GLYCERYL TRINITRATE. GLYCEROL TRINITRATE. GLYCEROL, NITRIC ACID TRIESTER. GLYCERYL NITRATE. NITRIC ACID TRIESTER OF GLYCEROL. NITROGLYCERIN, LIQUID, UNDESENSITIZED. NITROGLYCEROL. NITROGLYN. NITROL. 1,2,3-PROPANETRIYL NITRATE. TRINITROGLYCERIN. TRINITROGLYCEROL. RCRA P081.
RN CAS NUMBER: 55-63-0.

REG. TOXIC NUMBER: QX2100000.

CHEMICAL FORMULA: C3H5N3O9.
PD
PHYSICAL DESCRIPTION:
PALE YELLOW, VISCOUS LIQUID. SWEET BURNING TASTE.

MOL WT:	227.1
BOILING PT:	293 F
SOLUBILITY:	0.17 G
FLASH PT:	EXPLODES
VAPOR PRES:	0.0015 MM
MELT PT:	53 F
UEL IN AIR:	N/A
LEL IN AIR:	N/A
MEC IN AIR:	518 F
SPEC GRAVITY:	1.6009
VAPOR DENSITY:	7.8
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
0.1 MG/M3 OSHA STEL (SKIN) MILITARY AND SPACE USE
2 MG/M3 OSHA (CEIL) CIVILIAN USE
0.05 PPM ACGIH TWA (SKIN)
0.1 MG/M3 NIOSH RECOMMENDED STEL (SKIN)
MUTAGENIC DATA (RTEC)
CERCLA HAZARD RATINGS - TOXICITY 2 - IGNITABILITY 2 - REACTIVITY 3 - PERSISTENCE 0
TOXICOLOGY: SEE SODIUM NITRATE.
UNK-HMN LDLO: 28 MG/KG
ORL-RAT LD50:525 MG/KG
ORL-MUS LD50:500 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
80 PPM OSHA/NIOSH
PALE YELLOW, VISCOUS LIQUID. S.
IE

ACIDS. OZONE. SHOCK MAY DETONATE OR EXPLODE. EXPLOSIVE HAZARD AT HIGH TEMPERATURES. HEATING SEALED CONTAINER RESULTS IN EXPLOSION HAZARD. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC. STRONG ACIDS.

CL

CLOTHING:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING WET WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.
-ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A "+" DESIGNATES A BLEND OF MATERIALS, WHILE A "/" DESIGNATES A COATED OR LAMINATED MATERIAL.) -
NITROGLYCERINE: EXCELLENT/GOOD: NONE INDICATED GOOD/FAIR: BUTYL RUBBER CHLORINATED POLYETHYLENE POOR/FAIR: NONE INDICATED POOR: NONE INDICATED.

WEAR EYE PROTECTION TO PREVENT:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE SPLASH-PROOF SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS LIQUID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING HAS HAD ANY POSSIBILITY OF BEING CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
EMPLOYERS SHALL ENSURE THAT ANY CLOTHING WHICH BECOMES WET WITH THIS FLAMMABLE LIQUID BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
WHERE EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE MAY OCCUR, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF THE BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
2 PPM
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

10 PPM
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE, HELMENT, OR HOOD
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE

30 PPM
- TYPE 'C' SUPPLIED-AIR RESPIRATOR

MODE

ESCAPE
- GAS MASK
WITH AN ORGANIC VAPOR CANISTER
(CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)
WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
RESPIRATORY HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
BLOOD CHEMISTRY.
COMPLETE BLOOD COUNT.
14 BY 17 CHEST P.A. X-RAY.
PULMONARY FUNCTIONS.
VISION TEST.
URINALYSIS.
SKIN EXAM.
ELECTROCARDIOGRAM.
CENTRAL NERVOUS SYSTEM TESTS, PERIPHERAL NEUROPATHY.
URIC ACID, CREATININE, AND URINALYSIS. EMPLOYER SHALL PROVIDE COPY OF THE PHYSICIAN'S WRITTEN OPINION TO THE AFFECTED EMPLOYEE WITHIN 15 DAYS OF RECEIPT.
ACGIH BIOLOGICAL EXPOSURE INDICIES FOR METHEMOGLOBIN INDUCERS: 1.5% OF HEMOGLOBIN METHEMOGLOBIN IN BLOOD / TIMING -DURING OR END OF SHIFT.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
CARDIOVASCULAR SYSTEM. BLOOD. SKIN. CENTRAL NERVOUS SYSTEM.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). ABDOMINAL CRAMPS, PAINFUL SPASMS OF ABDOMINAL AREA (SC0218). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088). FATIGUE TIREDNESS, SLUGGISH (SC0066). CONFUSION, IN A BEWILDERED STATE (SC0030). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). FACE/NECK FLUSHED, VASODILATION WITH HEAT OF FACE/NECK (SC0215). PALPITATIONS, FORCIBLE PULSATIONS OF THE HEART (SC0123). HALLUCINATIONS, PERCEPTIONS OF WHAT DOES NOT EXIST (SC0074). DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). ANGINA, SENSE OF SUFFOCATION (SC0209).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043).
SKIN, COVERING OF BODY (SC0174);

DIFFICULTY IN BREATHING (SC0052).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
PARALYSIS, LOSS OF POWER OF VOLUNTARY MOVEMENT (SC0124). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038).

FA

FIRST AID.

(1 OF 8)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 8)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 8)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 8)
IF THIS SUBSTANCE IS INGESTED AND EXTENSIVE VOMITING HAS NOT OCCURED, THIS SUBSTANCE SHOULD BE REMOVED BY EMESIS OR GASTRIC LAVAGE PROVIDED THAT THE PATIENT IS CONSCIOUS AND CONVULSIONS ARE NOT PRESENT. DO NOT ATTEMPT TO MAKE AN UNCONSCIOUS PERSON VOMIT. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY (DREISBACH, HANDBOOK OF POISONING 12TH ED.). TREATMENT SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 8)
NITRITE/NITRATE INGESTION: REMOVE INGESTED OVERDOSES BY IPECAC EMESIS FOLLOWED BY ACTIVATED CHARCOAL. GASTRIC LAVAGE MAY BE USEFUL. MAINTAIN BLOOD PRESSURE BY FLUID ADMINISTRATION. GET MEDICAL ATTENTION IMMEDIATELY. GENERAL MEASURES - TREAT METHEMOGLOBINEMIA OVER 30% BY INJECTION OF METHYLENE BLUE. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.) PROCEDURES MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL.

(6 OF 8)
SYRUP OF IPECAC - GIVE 15 ML (ONE TABLESPOON) OF SYRUP OF IPECAC FOLLOWED BY ONE-HALF GLASS OF WATER. IF EMESIS DOES NOT OCCUR IN THIRTY MINUTES, REPEAT WITH SAME DOSE. IF PATIENT MUST BE MOVED, KEEP IN HEAD DOWN POSITION TO FACILITATE EMESIS AND PREVENT ASPIRATION OF VOMITUS. IF EMESIS DOES NOT OCCUR AFTER SYRUP OF IPECAC IS GIVEN, PERFORM GASTRIC LAVAGE TO PREVENT EMETINE POISONING. SAVE SPECIMENS OF EMESIS FOR ANALYSIS.(DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(7 OF 8)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY

INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(8 OF 8)
METHEMOGLOBINEMIA: (WHEN METHEMOGLOBIN CONCENTRATION IS OVER 25-40% OR IN THE PRESENCE OF SYMPTOMS). GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. CYANOSIS MAY DISAPPEAR WITHIN MINUTES OR PERSIST LONGER DEPENDING ON DEGREE OF METHEMOGLOBINEMIA. INTRAVENOUS ADMINISTRATION OF THERAPEUTIC DOSES OF METHYLENE BLUE MAY CAUSE A RISE IN BLOOD PRESSURE, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS ALSO OCCURRED SEVERAL DAYS AFTER ADMINISTRATION. THESE EFFECTS ARE TEMPORARY, AND FATALITIES HAVE NOT BEEN REPORTED. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 GRAM SLOWLY INTRAVENOUSLY. WITHOUT TREATMENT, METHEMOGLOBINEMIA LEVELS OF 20-30% REVERT TO NORMAL WITHIN 3 DAYS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERD BY QUALIFIED MEDICAL PERSONNEL.

DT
SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
BLOOD CHEMISTRY.
URINALYSIS.

(1 OF 29)
29CFR1910.1200 OSHA
ENTER DOCU
MENT SELECTION._:

END OF DOCUMENTS IN LIST_:
BRS SEARCH MODE - ENTER QUERY
2_: 1308-74

1308-74
SEARCH TERM NOT FOUND

RESULT 0 DOCUMENTS
3_:
3_: 1308-38-9

RESULT 1 DOCUMENT
4_:

1
AN ACCESSION NUMBER: 2580. 9208.
CN CHEMICAL NAME: PHOSPHORUS, RED.
SY SYNONYMS: RED PHOSPHOROUS. PHOSPHORUS. PHORPHOROUS. PHOSPHORUS, AMORPHOUS, RED. UN 1338. PHOSPHORUS (RED). PHOSPHORUS-31.
RN CAS NUMBER: 7723-14-0.

REG. TOXIC NUMBER: TH3495000.

CHEMICAL FORMULA: P.
PD
PHYSICAL DESCRIPTION:
DARK RED TO VIOLET POLYMORPHIC POWDER,HIGHLY TOXIC.

MOL WT:	124.08
BOILING PT:	536 F
SOLUBILITY:	INSOLUBLE
FLASH PT:	FLAMMABLE
VAPOR PRES:	N/A
MELT PT:	1094 F AT 43 ATM
UEL IN AIR:	FLAMMABLE
LEL IN AIR:	FLAMMABLE
MEC IN AIR:	500 F
SPEC GRAVITY:	2.34
VAPOR DENSITY:	4.3
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
NONE ESTABLISHED
CERCLA HAZARD RATINGS - TOXICITY 1 - IGNITABILITY 1 - REACTIVITY 1 - PERSISTENCE 3

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED
DARK RED TO VIOLET POLYMORPHIC.
IC
INCOMPATIBILITIES:
POTASSIUM CHLORATE. PERMANGANATES. PEROXIDES. OXYGEN. SHOCK MAY DETONATE OR EXPLODE. ORGANIC MATTER. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC. REDUCING AGENTS.
CL
CLOTHING:
NO NIOSH/OSHA DATA; RECOMMEND
PREVENT ANY POSSIBILITY OF SKIN CONTACT
WEAR FLAME RESISTANT CLOTHING
WEAR IMPERVIOUS CLOTHING

WEAR GLOVES
WEAR FACESHIELD (8 INCH MINIMUM)
PLACE CONTAMINATED CLOTHING IN CLOSED CONTAINERS FOR STORAGE UNTIL LAUNDERED OR DISCARDED
IF CLOTHING IS TO BE LAUNDERED, INFORM PERSON PERFORMING OPERATION OF CONTAMINANT'S HAZARDOUS PROPERTIES.

WEAR EYE PROTECTION TO PREVENT:
NO STANDARD REQUIREMENT, BUT ADVISE EYE PROTECTION TO PREVENT REASONABLE PROBABILITY OF EYE CONTACT.

EMPLOYEE SHOULD WASH:
NO STANDARD REQUIREMENT, BUT ADVISE WASHING PROMPTLY WHEN SKIN BECOMES CONTAMINATED.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO STANDARD REQUIREMENT, BUT ADVISE CHANGING IF IT IS REASONABLY PROBABLE THAT CLOTHING IS CONTAMINATED.

REMOVE CLOTHING:
NO STANDARD REQUIREMENT, BUT ADVISE REMOVING PROMPTLY IF IT IS NON-IMPERVIOUS AND CONTAMINATED.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO NIOSH/OSHA DATA, ADVISE:
EYE-WASH FOUNTAIN WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEE'S EYES MAY BE EXPOSED TO SUBSTANCE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):

1 MG/M3
- DUST AND MIST RESPIRATOR WITH A FULL FACEPIECE

2.5 MG/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

5 MG/M3
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER

200 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE

FIREFIGHTING

(3 OF 9)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 9)
WHEN THIS CHEMICAL HAS BEEN SWALLOWED, DO NOT INDUCE VOMITING. REMOVE GASTRIC LAVAGE AND CATHARSIS.

(5 OF 9)
PHOSPHORUS/PHOSPHINE/PHOSPHIDE EXPOSURE: EMERGENCY TREATMENT - REMOVE POISON BY GASTRIC LAVAGE WITH 5-10 L OF TAP WATER. IF A GASTRIC TUBE NOT IMMEDIATELY AVAILABLE, INDUCE EMESIS. TREATMENT MUST BE PERFORME QUALIFIED MEDICAL PERSONNEL. FURTHER TREATMENT - TREAT PULMONARY EDE AND SHOCK. GIVE 10% CALCIUM GLUCONATE, 10 ML INTRAVENOUSLY, TO MAINT SERUM CALCIUM. GIVE 1-4 LITERS OF 5% GLUCOSE IN WATER OR 10% INVERT SUGAR IN WATER INTRAVENOUSLY DAILY UNTIL A HIGH CARBOHYDRATE DIET CAN GIVEN ORALLY. TREAT HEPATIC FAILURE. GET MEDICAL ATTENTION IMMEDIAT (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 9)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOM TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILI A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TU FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUT USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEE DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED W INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPE INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGI OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF I FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTC SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID C LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA W CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER I TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFI MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(7 OF 9)
PULMONARY EDEMA - RELIEVE ANXIETY. GIVE MORPHINE SULFATE, 10 MG, T DECREASE RATE OF RAPID, INEFFICIENT RESPIRATION. GIVE 40% OXYGEN B MASK. USE INTERMITTENT POSITIVE-PRESSURE OXYGEN RESUSCITATOR FOR S PERIODS. GIVE AMINOPHYLLINE, 0.5 G, INTRAVENOUSLY, TO RELIEVE ASSO BRONCHIAL CONSTRICTION. TREAT EDEMA CAUSED BY MORPHINE OR MORPHINE ANALOGS BY GIVING NALOXONE AND OXYGEN. GENERAL MEASURES - DIURESIS ETHACRYNIC ACID (EDECRIN), 25 MG ORALLY OR INTRAVENOUSLY, OR FLUROS 20-80 MG ORALLY OR INTRAVENOUSLY, IS HELPFUL BECAUSE IT REDUCES FLU VOLUME. DO NOT INJECT AT A RATE FASTER THAN 10 MG/MIN. GIVE

- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
NO INFORMATION AVAILABLE FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS"; ADVISE: CENTRAL NERVOUS SYSTEM TESTS, PERIPHERAL NEUROPATHY.
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
MEDICAL WARNING FOR REFUSAL OF MEDICAL EXAMINATION.
PULMONARY FUNCTIONS.
RESPIRATORY HISTORY.
SKIN EXAM.
VISION TEST.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. RESPIRATORY SYSTEM. MUCOUS MEMBRANES.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181).

FA

FIRST AID.

(1 OF 9)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 9)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOE IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

CORTICOSTEROID ANTI-INFLAMMATORY AGENT IN MAXIMUM DOSES. IF PULMONARY EDEMA IS THE RESULT OF HEART FAILURE, DIGITALIZE THE PATIENT. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(8 OF 9)
CIRCULATORY FAILURE/SHOCK - PLACE PATIENT IN SUPINE POSITION WITH FEET ELEVATED. ESTABLISH AND MAINTAIN AN ADEQUATE AIRWAY. MAINTAIN BODY WARMTH BY APPLICATION OF BLANKETS, BUT DO NOT APPLY EXTERNAL HEAT. RELIEVE PAIN WITH MORPHINE SULFATE, 10 MG/70 KG SUBCUTANEOUSLY OR INTRAVENOUSLY, FOR OTHERWISE UNCONTROLLABLE PAIN. DO NOT GIVE MORPHINE TO UNCONSCIOUS OR STUPOROUS PATIENTS. PATIENTS WITH DEPRESSED RESPIRATION SHOULD NOT BE GIVEN MORPHINE UNLESS PERSONNEL AND EQUIPMENT TO MAINTAIN RESPIRATION ARE IMMEDIATELY AVAILABLE. RESTORE AND MAINTAIN ADEQUATE BLOOD VOLUME. PROCEDURE MUST PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(9 OF 9)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

2
AN ACCESSION NUMBER: 2581. 9208.
CN CHEMICAL NAME: PHOSPHORUS, WHITE.
SY SYNONYMS: WHITE PHOSPHOROUS. YELLOW PHOSPHORUS. YELLOW PHOSPHOROUS. PHOSPHOROUS. PHOSPHORUS. UN 1381. CRYSTALLINE PHOSPHORUS. PHOSPHORUS YELLOW. PHOSPHORUS (WHITE). PHOSPHOROUS WHITE DRY. WHITE PHOSPHORUS. PHOSPHORUS (YELLOW). PHOSPHORUS, ELEMENTAL, WHITE. PHOSPHORUS YELLOW DRY. RAT-NIP. STCC 4916140. WP.
RN CAS NUMBER: 7723-14-0.

REG. TOXIC NUMBER: TH3500000.

CHEMICAL FORMULA: P4.

PHYSICAL DESCRIPTION:
WHITE, YELLOW, OR COLORLESS, TRANSPARENT, SOFT, WAXY, CUBIC, CRYSTALLINE SOLID WITH A PUNGENT, GARLIC-LIKE ODOR; DARKENS UPON EXPOSURE TO LIGHT; GLOWS IN THE DARK WITH A GREENISH LIGHT.

MOL WT:	123.89
BOILING PT:	536 F (280 C)
SOLUBILITY:	NEGLIGIBLE
FLASH PT:	FLAMMABLE SOLID
VAPOR PRES:	0.028 MMHG @ 21 C
MELT PT:	111 F (44 C)
UEL IN AIR:	NOT AVAILABLE
LEL IN AIR:	NOT AVAILABLE
MEC IN AIR:	86 F (30 C)
SPEC GRAVITY:	1.82
VAPOR DENSITY:	4.4
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL

PERMISSABLE EXPOSURE:
0.1 MG/M3 OSHA TWA
0.1 MG/M3 ACGIH TWA
0.1 MG/M3 NIOSH RECOMMENDED 10 HOUR TWA
REPRODUCTIVE EFFECTS DATA (RTECS)
AQUATIC TOXICITY RATING 4/+ (TLM96 <1 PPM)
LEPMOIS MACROCHIRUS 0.072 PPM
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 2
PERSISTENCE-3
TOXICOLOGY: PHOSPHORUS, WHITE IS CORROSIVE TO THE SKIN, EYES AND MUCOUS MEMBRANES. IT IS HIGHLY TOXIC BY INGESTION. POISONING MAY AFFECT THE LIVER, KIDNEYS, BRAIN, TEETH AND BONES. SOLID PHOSPHORUS MAY IGNITE AND PRODUCE SEVERE YELLOWISH NECROTIC THERMAL BURNS. THEY MAY FLUORESCE UNDER ULTRAVIOLET LIGHT AND HAVE A GARLIC LIKE ODOR. SYMPTOMS MAY INCLUDE PHOTOPHOBIA, INTENSE THIRST, FUMING OF BREATH OR EXCRETA AND CARDIAC ARRHYTHMIA WITHIN 1 TO 2 HOURS. DEATH FROM PERIPHERAL VASCULAR COLLAPSE OR CARDIAC ARREST MAY OCCUR IN 24 TO 48 HOURS OR SYMPTOMS MAY SUBSIDE AND RECUR IN SEVERAL DAYS WITH GREATER INTENSITY. A FEW MILLIGRAMS MAY CAUSE ACUTE HEPATIC DAMAGE WITH RENAL PATHOLOGIC CHANGES, HEPATIC ENCEPHALOPATHY OR DEATH DUE TO ACUTE YELLOW ATROPHY OF THE LIVER. PHOSPHORUS ACTS AS A SOLVENT ON THE TEETH CAUSING CHANGES WHICH LEAD TO BONE DESTRUCTION RESULTING IN A SEVERE DEFORMITY KNOWN AS "PHOSSY JAW". THE SHORTEST PERIOD OF EXPOSURE RESULTING IN PHOSSY JAW WAS 10 MONTHS.
THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT ACUTE POISONING BUT MAY NOT PROVIDE A WIDE MARGIN OF SAFETY FROM UNDESIRABLE EFFECTS. PERSONS WITH CARIOUS TEETH AND POOR DENTAL HYGIENE MAY BE AT AN INCREASED RISK FROM EXPOSURE. INGESTION OF ALCOHOL, DIGESTIBLE FATS AND OILS MAY ENHANCE THE TOXIC EFFECTS.
ORL-HMN LDLO: 1400 UG/KG ORL-WMN LDLO: 22 MG/KG
ORL-WMN TDLO: 11 MG/KG ORL-WMN LDLO: 4600 UG/KG
ORL-WMN TDLO: 2600 UG/KG ORL-RAT LD50: 3030 UG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED

WHITE, YELLOW, OR COLORLESS, T.

INCOMPATIBILITIES:
ACIDS. BROMATES. CHLORATES. HALOGENS (BROMINE, CHLORINE, IODINE, FLUORINE). HYPOCHLORITES. IODATES. METAL ACETYLIDES OR CARBIDES. METALS. OXIDIZERS. ALKALI METAL NITRIDES. METAL FUME FEVER CAUSED BY EXPOSURE TO SOME METAL OXIDES; CHILLS,FEVER,MUSCULAR PAIN. INTERHALOGENS. HALOGEN AZIDES. REACTS WITH WATER TO FORM AN ACID. POLYMERIZES AT HIGH TEMPERATURES. SPONTANEOUSLY FLAMMABLE IN AIR.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE FLAME-RETARDANT PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH SOLID OR LIQUID PHOSPHORUS. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6). EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH PHOSPHORUS IS PLACED UNDERWATER IN CLOSED CONTAINERS FOR STORAGE UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF PHOSPHORUS FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE PHOSPHORUS, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE OPERATION OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THERE IS ANY POSSIBILITY OF THIS SOLID CONTACTING THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT ANY CLOTHING WHICH BECOMES WET WITH THIS FLAMMABLE LIQUID BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:

FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THI SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF TH BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):

1 MG/M3
- SUPPLIED-AIR RESPIRATOR

2.5 MG/M3
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

5 MG/M3
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE

200 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS".
VISION TEST.
CHRONIC RESPIRATORY DISEASE.
RENAL AND LIVER FUNCTIONS.
DENTAL X-RAY.
EYE DISEASE.
PULMONARY FUNCTIONS.
SKIN EXAM.

RESPIRATORY HISTORY.
COMPLETE BLOOD COUNT.
BLOOD CHEMISTRY.
WITH EMPHASIS ON: GUMS AND TEETH.

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. RESPIRATORY SYSTEM. EYES. CARDIOVASCULAR SYSTEM.
KIDNEYS. LIVER. TEETH. JAW. BLOOD.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). COUGHING, FORCEFUL EXPIRATION (SC0173). DYSPNEA, DIFFICULTY IN BREATHING (SC0052).
HALITOSIS, OFFENSIVE BREATH (SC0333).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181). ABDOMINAL CRAMPS, PAINFUL SPASMS OF ABDOMINAL AREA (SC0218). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). UNCONSCIOUSNESS, NOT AWAKE; INSENSIBLE (SC0198).
BONE, PART OF THE SKELETON (SC0185);
NECROSIS, DEAD TISSUE SURROUNDED BY WELL TISSUE(SC0116). WEAKNESS, LACK OF STRENGTH (SC0167). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004). ANOREXIA, DIMINISHED APPETITE (SC0006). BRONCHITIS, INFLAMED BRONCHIAL MUCOUS MEMBRANES (SC0017). TOOTHACHE, PAIN IN A TOOTH (SC0461). VESICULATION, BLISTERING (SC0164). PHOTOPHOBIA, INTOLERANCE TO LIGHT (SC0131). SHOCK, SUDDEN PHYSICAL OR MENTAL DISTURBANCE(SC0228).
BLEPHAROSPASM, SPASMODIC WINKING (SC0449).
SKIN, COVERING OF BODY (SC0174);
BURNS, TISSUE DAMAGE FROM HEAT (SC0175).
EYE, ORGAN OF SIGHT (SC0170);
BURNS, TISSUE DAMAGE FROM HEAT (SC0175). THIRST, DESIRE FOR WATER (SC0210). HEMATEMESIS, BLOODY VOMITUS (SC0273). OLIGURIA, DECREASED URINATION (SC0323). ALBUMINURIA, ALBUMIN (PROTEIN) IN URINE (SC0002).
ANURIA, COMPLETE LACK OF URINATION (SC0304).
CARDIAC, PERTAINING TO HEART (SC0023);
ARRHYTHMIA, ABSENCE OF RHYTHM; IRREGULARITY (SC0010).
SKIN, COVERING OF BODY (SC0174);
ERUPTION, A RASH OR LESION (SC0602). DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). DELIRIUM, STATE OF DISORIENTATION, CONFUSION (SC0288). HYPOTENSION, LOW BLOOD PRESSURE (SC0180). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). HYPOGLYCEMIA, ABNORMALLY LOW BLOOD SUGAR (SC0321). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). LIVER DAMAGE, INJURY TO THE LIVER (SC0221). CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031). STOMATITIS, INFLAMMATION OF THE MOUTH (SC0395). LACRIMATION, DISCHARGE OF TEARS (SC0096). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). COMA, STATE OF DEEP UNCONSCIOUSNESS (SC0583).
CARDIAC, PERTAINING TO HEART (SC0023);
ARREST, A STOPPAGE (SC0577).
CIRCULATORY, PERTAINING TO CIRCULATION (SC0613);
COLLAPSE, EXTREME PROSTRATION (SC0029).

HEPATIC, PERTAINING TO THE LIVER (SC0081);
FAILURE, LOSS OF FUNCTION (SC0386).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 8)
IF THIS CHEMICAL GETS INTO THE EYES, WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-60 MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 8)
PHOSPHORUS BURNS IN THE SKIN SHOULD BE IMMERSED IMMEDIATELY IN WATER TO AVOID CONTACT WITH AIR. PHOSPHORUS PARTICLES ARE REMOVED GENTLY UNDER WATER AND THE WOUND IS WASHED WITH 1% COPPER SULFATE SOLUTION TO COAT THE RESIDUAL PARTICLES WITH A PROTECTIVE FILM OF COPPER PHOSPHIDE; THESE FLUORESCE AND CAN BE READILY REMOVED IN A DARKENED ROOM. FOLLOWING INITIAL TREATMENT, CHEMICAL BURNS SHOULD BE TREATED AS THERMAL BURNS OF COMPARABLE SIZE AND EXTENT. (MERCK MANUAL, 15TH ED.). FOR BURNS, COVER AREA WITH STERILE, DRY DRESSING. BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 8)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 8)
PHOSPHORUS/PHOSPHINE/PHOSPHIDE EXPOSURE: EMERGENCY TREATMENT - REMOVE POISON BY GASTRIC LAVAGE WITH 5-10 L OF TAP WATER. IF A GASTRIC TUBE IS NOT IMMEDIATELY AVAILABLE, INDUCE EMESIS. TREATMENT MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. FURTHER TREATMENT - TREAT PULMONARY EDEMA AND SHOCK. GIVE 10% CALCIUM GLUCONATE, 10 ML INTRAVENOUSLY, TO MAINTAIN SERUM CALCIUM. GIVE 1-4 LITERS OF 5% GLUCOSE IN WATER OR 10% INVERT SUGAR IN WATER INTRAVENOUSLY DAILY UNTIL A HIGH CARBOHYDRATE DIET CAN BE GIVEN ORALLY. TREAT HEPATIC FAILURE. GET MEDICAL ATTENTION IMMEDIATELY. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(5 OF 8)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY

IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 8)
PULMONARY EDEMA - RELIEVE ANXIETY. GIVE MORPHINE SULFATE, 10 MG, TO DECREASE RATE OF RAPID, INEFFICIENT RESPIRATION. GIVE 40% OXYGEN BY FACE MASK. USE INTERMITTENT POSITIVE-PRESSURE OXYGEN RESUSCITATOR FOR SHORT PERIODS. GIVE AMINOPHYLLINE, 0.5 G, INTRAVENOUSLY, TO RELIEVE ASSOCIATED BRONCHIAL CONSTRICTION. TREAT EDEMA CAUSED BY MORPHINE OR MORPHINE ANALOGS BY GIVING NALOXONE AND OXYGEN. GENERAL MEASURES - DIURESIS WITH ETHACRYNIC ACID (EDECRIN), 25 MG ORALLY OR INTRAVENOUSLY, OR FLUROSEMIDE, 20-80 MG ORALLY OR INTRAVENOUSLY, IS HELPFUL BECAUSE IT REDUCES FLUID VOLUME. DO NOT INJECT AT A RATE FASTER THAN 10 MG/MIN. GIVE CORTICOSTEROID ANTI-INFLAMMATORY AGENT IN MAXIMUM DOSES. IF PULMONARY EDEMA IS THE RESULT OF HEART FAILURE, DIGITALIZE THE PATIENT. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(7 OF 8)
CIRCULATORY FAILURE/SHOCK - PLACE PATIENT IN SUPINE POSITION WITH FEET ELEVATED. ESTABLISH AND MAINTAIN AN ADEQUATE AIRWAY. MAINTAIN BODY WARMTH BY APPLICATION OF BLANKETS, BUT DO NOT APPLY EXTERNAL HEAT. RELIEVE PAIN WITH MORPHINE SULFATE, 10 MG/70 KG SUBCUTANEOUSLY OR INTRAVENOUSLY, FOR OTHERWISE UNCONTROLLABLE PAIN. DO NOT GIVE MORPHINE TO UNCONSCIOUS OR STUPOROUS PATIENTS. PATIENTS WITH DEPRESSED RESPIRATION SHOULD NOT BE GIVEN MORPHINE UNLESS PERSONNEL AND EQUIPMENT TO MAINTAIN RESPIRATION ARE IMMEDIATELY AVAILABLE. RESTORE AND MAINTAIN ADEQUATE BLOOD VOLUME. PROCEDURE MUST PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(8 OF 8)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

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RESULT              1 DOCUMENT
2_:  ..PRINT 1 ALLDOC=1

D003 RE-ENTER PARAGRAPH SELECTION...INVALID CODE WAS ALLDOC=1_:  ..PRINT 1 ALL/

     1
 N ACCESSION NUMBER:  851.  9207.
CN CHEMICAL NAME:  CYCLOTRIMETHYLENETRINITRAMINE.
SY SYNONYMS:  UN 0072.  CYCLOTRIMETHYLENENITRAMINE.  HEXOLITE.  UN 0118.
   CYCLONITE.  HEXOGEN.  RDX.  S-TRIAZINE, HEXAHYDRO-1,3,5-TRINITRO-.
   HEXAHYDRO-1,3,5-TRINITRO-S-TRIAZINE.
   HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE.  HEXOGEN (EXPLOSIVE).  HEXOGEN
   5W.  PBX(AF) 108.  T4.  TRIMETHYLENETRINITRAMINE.
   SYM-TRIMETHYLENETRINITRAMINE.  TRINITROCYCLOTRIMETHYLENE TRIAMINE.
   1,3,5-TRINITRO-1,3,5-TRIAZACYCLOHEXANE.
RN CAS NUMBER:          121-82-4.

   REG. TOXIC NUMBER:  XY9450000.

   CHEMICAL FORMULA:   C3H6N6O6.
PD
   PHYSICAL DESCRIPTION:
   COLORLESS OR WHITE CRYSTALLINE POWDER.

        MOL WT:                        222.15
        BOILING PT:                    EXPLOSIVE
        SOLUBILITY:                    INSOLUBLE
        FLASH PT:                      EXPLODES
        VAPOR PRES:                    0.0004 MM AT 230 F
        MELT PT:                       399 F
        UEL IN AIR:                    EXPLOSIVE
        LEL IN AIR:                    EXPLOSIVE
        MEC IN AIR:
        SPEC GRAVITY:                  1.82
        VAPOR DENSITY:
        ODOR THRESHOLD:
        OCTANOL/WATER CO-EFFICIENT:.
EL
   PERMISSABLE EXPOSURE:
   1.5 MG/M3 OSHA TWA (SKIN)
   1.5 MG/M3 ACGIH TWA (SKIN)
   3 MG/M3 ACGIH STEL (NOTICE OF INTENDED CHANGES 1988-89)
   CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 3 -
   PERSISTENCE 0
   TOXICOLOGY: TRINITROTRIAZINE IS TOXIC TO THE NERVOUS SYSTEM, LIVER AND
   KIDNEYS.  POISONING WILL RESULT IN NAUSEA, VOMITING, CONVULSIONS, UNCON-
   SCIOUSNESS, ANEMIA, LIVER AND KIDNEY DAMAGE.
   THE THRESHOLD LIMIT VALUE WAS SET BY ANALOGY WITH TRINITROTOLUENE TO
   PREVENT SYSTEMIC INJURY.
   ORL-RAT LD50:100 MG/KG
   ORL-MUS LD50: 59 MG/KG
   ORL-CAT LDLO:100 MG/KG
   ORL-RBT LDLO:500 MG/KG

   29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL
   MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY
   PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR
   EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD
   COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY
   DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO
   TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

   DANGEROUS EXPOSURE:
     NONE SPECIFIED
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INCOMPATIBILITIES:
EXPLOSIVE HAZARD AT HIGH TEMPERATURES. SHOCK MAY DETONATE OR EXPLODE. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC. REDUCING AGENTS. ALUMINUM POWDER. CYANIDES. ESTERS. PHOSPHOROUS. THIOCYANATES. KETONES. CAUSTICS. AMMONIA. AMINES.

CL

CLOTHING:
NO NIOSH/OSHA DATA; RECOMMEND
PREVENT ANY POSSIBILITY OF SKIN CONTACT
WEAR IMPERVIOUS CLOTHING
WEAR GLOVES
WEAR FACESHIELD (8 INCH MINIMUM)
PLACE CONTAMINATED CLOTHING IN CLOSED CONTAINERS FOR STORAGE UNTIL LAUNDERED OR DISCARDED
IF CLOTHING IS TO BE LAUNDERED, INFORM PERSON PERFORMING OPERATION OF CONTAMINANT'S HAZARDOUS PROPERTIES.

WEAR EYE PROTECTION TO PREVENT:
NO STANDARD REQUIREMENT, BUT ADVISE EYE PROTECTION TO PREVENT ANY POSSIBILITY OF EYE CONTACT
WEAR FACE SHIELD OR VENTED GOGGLES.

EMPLOYEE SHOULD WASH:
NO STANDARD REQUIREMENT, BUT ADVISE WASHING IMMEDIATELY WHEN SKIN BECOMES CONTAMINATED.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO STANDARD REQUIREMENT, BUT ADVISE CHANGING
IF THERE IS ANY POSSIBILITY THAT CLOTHING MAY BE CONTAMINATED
LEAVE CLOTHING & EQUIPMENT FOR DECONTAMINATION & DISPOSAL.

REMOVE CLOTHING:
NO STANDARD REQUIREMENT, BUT ADVISE REMOVING
EMPLOYERS SHALL ENSURE THAT CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED IMMEDIATELY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO NIOSH/OSHA DATA, ADVISE:
EYE-WASH FOUNTAIN WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES' EYES MAY BE EXPOSED TO SUBSTANCE QUICK DRENCHING FACILITIES WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES MAY BE EXPOSED TO SUBSTANCE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
HIGH LEVELS
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE, HELMENT, OR HOOD

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
NO INFORMATION AVAILABLE FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS"; ADVISE: EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.

CENTRAL NERVOUS SYSTEM EXAMINATION.
CONVULSIVE DISORDER.
GASTROINTESTINAL.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AN
PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTAT
ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECOR
EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSIC
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INGESTION. SKIN ABSORPTION. SKIN OR EYE CONTACT. INHA

TO

TARGET ORGANS:
EYES. RESPIRATORY SYSTEM. SKIN. MUCOUS MEMBRANES. CE
SYSTEM. KIDNEYS. LIVER.

SP

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC01(
ULCERATION, LESION OF TISSUE (SC0313). DERMATITIS, INFL
(SC0044).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). NAUS
THE STOMACH (SC0115). INSOMNIA, INABILITY TO OBTAIN NORI
(SC0088). VOMITING, PERTAINING TO NAUSEA (SC0166). HEAI
HEAD OR CRANIUM AREA (SC0075). SALIVATION, EXCESS DISCHA
(SC0146). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE
UNCONSCIOUSNESS, NOT AWAKE; INSENSIBLE (SC0198). CONVULS
MUSCLE CONTRACTIONS (SC0034). ANOREXIA, DIMINISHED APPET
ASTHENIA, LOSS OF STRENGTH (SC0430). ANEMIA, RED BLOOD C
NORMAL (SC0004). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC
DAMAGE, INJURY TO THE LIVER (SC0221).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 4)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDI
AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING U
LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATEL
MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 4)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CL(
IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGE
AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AI
15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 4)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AR
IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL
KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND S
GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 4)
IF THIS SUBSTANCE IS INGESTED AND EXTENSIVE VOMITING HAS N
THIS SUBSTANCE SHOULD BE REMOVED BY EMESIS OR GASTRIC LAVA
THAT THE PATIENT IS CONSCIOUS AND CONVULSIONS ARE NOT PRES
ATTEMPT TO MAKE AN UNCONSCIOUS PERSON VOMIT. TREAT SYMPTO
SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY (DREISBAC
POISONING 12TH ED.). TREATMENT SHOULD BE PERFORMED BY QUA

BULLETIN:

EPA ANNOUNCED IN THE MAY 13 /FEDERAL REGISTER/ IN AN ADVANCE NOTICE OF PROPOSED RULEMAKING TO PHASE OUT OR BAN SOME LEAD USES. (56FR22096).

OC FIELD
RN (1)

END OF REQUEST

END OF DOCUMENTS IN LIST_: ..p 6 all/doc=1

1

AN ACCESSION NUMBER: 3132. 9112.

CN CHEMICAL NAME: TRICHLOROETHYLENE.

SY SYNONYMS: TRICHLOROETHENE. DOW-TRI. NCI-C04546. CHLORYLEN. CECOLENE. TRILENE. TCE. UN 1710. ETHYLENE, TRICHLORO-. 1-CHLORO-2,2-DICHLOROETHYLENE. 1,1-DICHLORO-2-CHLOROETHYLENE. 1,1,2-TRICHLOROETHYLENE. 1,2,2-TRICHLOROETHYLENE. ETHYLENE TRICHLORIDE. ETHINYL TRICHLORIDE. TRICHLORETHYLENE. TRIAD. THRETHYLENE. TRETHYLENE. RCRA U228.

RN CAS NUMBER: 79-01-6.

REG. TOXIC NUMBER: KX4550000.

CHEMICAL FORMULA: C2HCL3.

PD

PHYSICAL DESCRIPTION:
COLORLESS MOBILE LIQUID; CHLOROFORM-LIKE ODOR; PHOTOREACTIVE.

MOL WT:	131
BOILING PT:	189 F
SOLUBILITY:	0.1%
FLASH PT:	90 F *
VAPOR PRES:	58 MM
MELT PT:	-99 F
UEL IN AIR:	90%
LEL IN AIR:	12.5%
MEC IN AIR:	788 F
SPEC GRAVITY:	1.4642
VAPOR DENSITY:	4.5
ODOR THRESHOLD:	20 PPM
OCTANOL/WATER CO-EFFICIENT:.	

EL

PERMISSABLE EXPOSURE:
50 PPM OSHA TWA; 200 PPM OSHA STEL
50 PPM ACGIH TWA; 200 PPM ACGIH STEL
25 PPM NIOSH RECOMMENDED 10 HR TWA
HUMAN INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
ANIMAL LIMITED EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
PROBABLE HUMAN CARCINOGEN (EPA - CATEGORY B)
POSITIVE CARCINOGEN IN MICE; NEGATIVE CARCINOGEN IN RATS (NCI, 1976)
POSITIVE CARCINOGEN IN MICE; INADEQUATE STUDY IN RATS (NCI, 1984)
TERATOGENIC DATA (RTEC); MUTAGENIC DATA (RTEC)
AQUATIC TOXICITY RATING 1/Z (TLM96 100 - 1000 PPM)
LC RANGE, 96H (IN SEA WATER) - PLAICE 15 PPM
CERCLA HAZARD RATINGS - TOXICITY 1 - IGNITABILITY 1 - REACTIVITY 0 - PERSISTENCE 2
TOXICOLOGY: TRICHLOROETHYLENE IS AN EYE, MUCOUS MEMBRANE, AND PRIMARY SKIN IRRITANT AND CENTRAL NERVOUS SYSTEM DEPRESSANT.

ACUTE EXPOSURE DEPRESSES THE NERVOUS SYSTEM, AND MAY DAMAGE THE GASTRO-INTESTINAL TRACT, LIVER AND KIDNEYS. THE PRESENCE OF TETRACHLOROETHANE INCREASES IN COMMERCIAL GRADES INCREASES THE CELLULAR TOXICITY.
CHRONIC INHALATION OR ABSORPTION CAUSES CENTRAL NERVOUS SYSTEM EFFECTS, JOINT PAIN, DERMATITIS, AND POSSIBLY JAUNDICE. INGESTION OF ALCOHOL MAY INCREASE THE TOXICITY OF TRICHLOROETHYLENE.
TRICHLOROETHYLENE IS A MILD RESPIRATORY IRRITANT.
THE THRESHOLD LIMIT VALUE WAS ESTABLISHED TO PREVENT TOXIC EFFECTS.
IHL-HMN TCLO: 6900 MG/M3/10 MIN
IHL-HMN TCLO: 160 PPM/83 MIN
IHL-HMN TDLO: 812 MG/KG
IHL-MAN TCLO: 110 PPM/8 HR
IHL-MAN LCLO: 2900 PPM
ORL-HMN LDLO: 7 GM/KG
ORL-RAT LD50: 4920 MG/KG
ORL-MUS LD50: 2402 MG/KG
IHL-RAT LCLO: 8000 PPM/4 HR
IHL-CAT LCLO:32500 MG/M3/2 HR

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
1000 PPM POTENTIAL
CARCINOGENNIOSH
COLORLESS MOBILE LIQUID; CHLOR.

IC

INCOMPATIBILITIES:
ACTIVE METALS. BARIUM. LITHIUM. SODIUM. MAGNESIUM. TITANIUM.

CL

CLOTHING:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
-ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A "+" DESIGNATES A BLEND OF MATERIALS, WHILE A "/" DESIGNATES A COATED OR LAMINATED MATERIAL.) -
TRICHLOROETHYLENE: EXCELLENT/GOOD: TEFLON GOOD/FAIR: CHLOROBUTYL SILVERSHIELD POOR/FAIR: CHLORINATED POLYETHYLENE VITON NEOPRENE+STYRENE-BUTADIENE RUBBER POLYURETHANE STYRENE-BUTADIENE RUBBER/NEOPRENE POOR: BUTYL RUBBER NATURAL RUBBER NEOPRENE NITRILE + POLYVINYL CHLORIDE NITRILE POLYETHYLENE POLYVINYL ALCOHOL POLYVINYL CHLORIDE NEOPRENE+NATURAL RUBBER SARANEX STYRENE-BUTADIENE RUBBER NEOPRENE/NATURAL RUBBER.

WEAR EYE PROTECTION TO PREVENT:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE SPLASH-PROOF SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS LIQUID

MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES WET WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NOT REQUIRED.

REMOVE CLOTHING:
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES WET WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NONE REQUIRED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
ANY DETECTABLE CONC
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE

ESCAPE
- GAS MASK WITH AN ORGANIC VAPOR CANISTER (CHIN-STYLE OR FRONTOR BACK-MOUNTED CANISTER)
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
RESPIRATORY HISTORY.
WITH EMPHASIS ON: RENAL AND LIVER FUNCTIONS.
BLOOD CHEMISTRY.
COMPLETE BLOOD COUNT.
WITH EMPHASIS ON: PULMONARY FUNCTIONS.
WITH EMPHASIS ON: CENTRAL NERVOUS SYSTEM TESTS, PERIPHERAL NEUROPATHY.
WITH EMPHASIS ON: ELECTROCARDIOGRAM.
WITH EMPHASIS ON: SKIN EXAM.
VISION TEST.
URINALYSIS.
ATTENTION TO SMOKING, ALCOHOL, MEDICATION, AND EXPOSURE TO CARCINOGENS.
WITH EMPHASIS ON: 14 BY 17 CHEST P.A. X-RAY.
ACGIH BIOLOGICAL EXPOSURE INDICES FOR TRICHLOROETHYLENE: 100 MG/L TRICHLOROACETIC ACID IN URINE / TIMING -END OF WORKWEEK 300 MG/L TRICHLOROACETIC ACID AND TRICHLOROETHANOL IN URINE / TIMING -END OF

WORKWEEK AND END OF SHIFT 320 MG/G CREAT. TRICHLOROACETIC ACID AND TRICHLOROETHANOL IN URINE/ TIMING -END OF WORKWEEK AND END OF SHIFT 4 MG/L FREE TRICHLOROETHANOL IN BLOOD / TIMING -END OF SHIFT AND END OF WORKWEEK 0.5 PPM TRICHLOROETHYLENE IN END-EXHALED AIR / TIMING -PRIOR TO SHIFT AND END OF WORKWEEK.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
RESPIRATORY SYSTEM. SKIN. HEART. LIVER. KIDNEYS. CENTRAL NERVOUS SYSTEM.

SP

SYMPTOMS:
HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). VERTIGO, FEELING OF WHIRLING MOTION (SC0163). VISUAL DISTURBANCE, UPSET IN SIGHT (SC0165). TREMORS, TREMBLING, SHAKING (SC0197). SOMNOLENCE, PROLONGED SLEEPINESS (SC0152). DERMATITIS, INFLAMMATION OF SKIN (SC0044). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166).
CARDIAC, PERTAINING TO HEART (SC0023);
ARRHYTHMIA, ABSENCE OF RHYTHM; IRREGULARITY (SC0010). PARESTHESIA, ABNORMAL SENSATION WITHOUT CAUSE (SC0125). NARCOSIS, STUPOR OR SLEEP DUE TO NARCOTIC (SC0113). ANESTHESIA, LOSS OF SENSATION (SC0005). LIVER DAMAGE, INJURY TO THE LIVER (SC0221). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE (SC0091).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). VENTRICULAR FIBRILLATION, RAPID CONTRACTIONS OF VENTRICLES (SC0162).
CARDIAC, PERTAINING TO HEART (SC0023);
DEGENERATION, DETERIORATION, A WORSENING (SC0040).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);
DEGENERATION, DETERIORATION, A WORSENING (SC0040). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). UNCONSCIOUSNESS, NOT AWAKE; INSENSIBLE (SC0198). JAUNDICE, YELLOWING OF SKIN, EYES (SC0092). WHEEZING, NOISY BREATHING WITH DIFFICULTY (SC0168). UNCONSCIOUSNESS, NOT AWAKE; INSENSIBLE (SC0198). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). EXCITATION, CENTRAL NERVOUS SYSTEM STIMULATION (SC0289). IRREGULAR PULSE ALTERNATING WEAK AND STRONG PULSE (SC0143). ARTHRALGIA, JOINT PAIN (SC0417).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181). WHEEZING, NOISY BREATHING WITH DIFFICULTY (SC0168). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104). ANOREXIA, DIMINISHED APPETITE (SC0006). FATIGUE, TIREDNESS, SLUGGISH (SC0066).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 8)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20

MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 8)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 8)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 8)
WHEN THIS CHEMICAL HAS BEEN SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE PERSON LARGE QUANTITIES OF WATER. AFTER WATER HAS BEEN SWALLOWED, TRY TO GET THE PERSON TO VOMIT BY HAVING HIM TOUCH THE BACK OF HIS THROAT WITH HIS FINGER. DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT. GET MEDICAL ATTENTION IMMEDIATELY.

(5 OF 8)
VOLATILE AND GASEOUS ANESTHETICS: EMERGENCY TREATMENT - ESTABLISH AIRWAY AND MAINTAIN RESPIRATION. REMOVE ANESTHETIC BY FORCED VENTILATION. FURTHER TREATMENT - MAINTAIN BLOOD PRESSURE BY INTRAVENOUS SALINE OR BLOOD TRANSFUSION. MAINTAIN BODY WARMTH. MAINTAIN ADEQUATE AIRWAY BY REMOVING SECRETIONS FROM TRACHEA BY CATHETER SUCTION. PREVENT HYPOXIA. IF HYPERTHERMIA OCCURS, LOWER BODY TEMPERATURE BY APPLICATION OF WET TOWELS. FOR MALIGNANT HYPERTHERMIA, GIVE DANTROLENE SODIUM, 1 MG/KG, EVERY FIFTEEN MINUTES, INTRAVENOUSLY TO A TOTAL OF 10 MG/KG, AND PROCAINAMIDE, 15 MG/KG, INTRAVENOUSLY, OVER TEN MINUTES. GIVE ICED NORMAL SALINE INTRAVENOUSLY AT A RATE OF 1 LITER EVERY TEN MINUTES FOR THIRTY MINUTES. LAVAGE STOMACH, URINARY BLADDER, RECTUM, AND PERITONEUM WITH ICED SALINE. TREAT ACIDOSIS WITH INTRAVENOUS SODIUM BICARBONATE. MONITOR SERUM TOTAL BASE, SERUM POTASSIUM, AND ARTERIAL PH AND TREAT APPROPIATELY. MAINTAIN URINE OUTPUT AT 1-2 LITERS DAILY WITH FUROSEMIDE AND MANNITOL. AFTER FIRST DAY, GIVE DANTROLENE, 1 MG/KG ORALY DAILY, FOR THREE DAYS. (MEDICATION MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL) SPECIAL TREATMENT - TREAT LIVER DAMAGE. (DREISBACH, HANDBOOK OF POISONING, 11TH ED.).

(6 OF 8)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL

SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(7 OF 8)
PULMONARY EDEMA - RELIEVE ANXIETY. GIVE MORPHINE SULFATE, 10 MG, TO DECREASE RATE OF RAPID, INEFFICIENT RESPIRATION. GIVE 40% OXYGEN BY FACE MASK. USE INTERMITTENT POSITIVE-PRESSURE OXYGEN RESUSCITATOR FOR SHORT PERIODS. GIVE AMINOPHYLLINE, 0.5 G, INTRAVENOUSLY, TO RELIEVE ASSOCIATED BRONCHIAL CONSTRICTION. TREAT EDEMA CAUSED BY MORPHINE OR MORPHINE ANALOGS BY GIVING NALOXONE AND OXYGEN. GENERAL MEASURES - DIURESIS WITH ETHACRYNIC ACID (EDECRIN), 25 MG ORALLY OR INTRAVENOUSLY, OR FLUROSEMIDE, 20-80 MG ORALLY OR INTRAVENOUSLY, IS HELPFUL BECAUSE IT REDUCES FLUID VOLUME. DO NOT INJECT AT A RATE FASTER THAN 10 MG/MIN. GIVE CORTICOSTEROID ANTI-INFLAMMATORY AGENT IN MAXIMUM DOSES. IF PULMONARY EDEMA IS THE RESULT OF HEART FAILURE, DIGITALIZE THE PATIENT. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(8 OF 8)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
URINE TRICHLOROETHYLENE METABOLITES >20 MG/DAY.

RS

REGULATORY STATUS.

(1 OF 65)
OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

(2 OF 65)
OSHA STANDARD 29CFR1910.1000 AIR CONTAMINANTS TABLE Z-2.

(3 OF 65)
OSHA STANDARD 29CFR1910.94 VENTILATION OSHA STANDARD 29CFR1910.134 RESPIRATORY PROTECTION.

,3,5 TNB

1
AN ACCESSION NUMBER: 3324. 9208.
CN CHEMICAL NAME: TRINITROBENZENE.
SY SYNONYMS: TNB. 1,3,5-TRINITROBENZENE. UN 0214. TRINITROBENZENE, DRY. TRINITROBENZENE, WET. DC3860000. BENZENITE. UN 1354. BENZENE, 1,3,5-TRINITRO-. S-TRINITROBENZENE. SYM-TRINITROBENZENE. SYMMETRIC TRINITROBENZENE. RCRA U234.
RN CAS NUMBER: 99-35-4.

REG. TOXIC NUMBER: DC3850000.

CHEMICAL FORMULA: C6H3N3O6.
PD
PHYSICAL DESCRIPTION:
LIGHT GREENISH-YELLOW CRYSTALS.

MOL WT:	213.12
BOILING PT:	DECOMPOSES
SOLUBILITY:	0.035 G
FLASH PT:	EXPLODES
VAPOR PRES:	0.3846 MM AT 252 F
MELT PT:	254 F
UEL IN AIR:	EXPLOSIVE
LEL IN AIR:	EXPLOSIVE
MEC IN AIR:	
SPEC GRAVITY:	1.76
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
NONE ESTABLISHED
MUTAGENIC DATA (RTEC)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: SEE TRINITROTOLUENE.
ORL-RAT LD50:450 MG/KG
ORL-MUS LD50:572 MG/KG
ORL-GPG LD50:730 MG/KG
IVN-MUS LD50: 32 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NONE SPECIFIED
LIGHT GREENISH-YELLOW CRYSTALS.
IC
INCOMPATIBILITIES:

EXPLOSIVE HAZARD AT HIGH TEMPERATURES. SHOCK MAY DETONATE OR EXPLODE. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOXIC. REDUCING AGENTS.

CL

CLOTHING:
NO NIOSH/OSHA DATA; RECOMMEND
PREVENT ANY POSSIBILITY OF SKIN CONTACT
WEAR IMPERVIOUS CLOTHING
WEAR GLOVES
WEAR FACESHIELD (8 INCH MINIMUM)
PLACE CONTAMINATED CLOTHING IN CLOSED CONTAINERS FOR STORAGE UNTIL LAUNDERED OR DISCARDED
IF CLOTHING IS TO BE LAUNDERED, INFORM PERSON PERFORMING OPERATION OF CONTAMINANT'S HAZARDOUS PROPERTIES
-ACGIH "GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING" INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A "+" DESIGNATES A BLEND OF MATERIALS, WHILE A "/" DESIGNATES A COATED OR LAMINATED MATERIAL.) -
UNSUBSTITUTED NITRO COMPOUNDS: EXCELLENT/GOOD: POLYVINYL ALCOHOL FAIR/POOR: NATURAL RUBBER NITRILE RUBBER FAIR/GOOD: CHLORINATED POLYETHYLENE POLYURETHANE POLYVINYL CHLORIDE VITON A WIDE VARIATION IN RATINGS IS INDICATED FOR THE FOLLOWING MATERIALS: BUTYL RUBBER NEOPRENE.

WEAR EYE PROTECTION TO PREVENT:
NO STANDARD REQUIREMENT, BUT ADVISE EYE PROTECTION TO PREVENT ANY POSSIBILITY OF EYE CONTACT
WEAR FACE SHIELD OR VENTED GOGGLES.

EMPLOYEE SHOULD WASH:
NO STANDARD REQUIREMENT, BUT ADVISE WASHING IMMEDIATELY WHEN SKIN BECOMES CONTAMINATED.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO STANDARD REQUIREMENT, BUT ADVISE CHANGING IF THERE IS ANY POSSIBILITY THAT CLOTHING MAY BE CONTAMINATED.

REMOVE CLOTHING:
NO STANDARD REQUIREMENT, BUT ADVISE REMOVING IMMEDIATELY IF IT BECOMES WET.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
NO NIOSH/OSHA DATA, ADVISE:
EYE-WASH FOUNTAIN WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES' EYES MAY BE EXPOSED TO SUBSTANCE QUICK DRENCHING FACILITIES WITHIN IMMEDIATE WORK AREA WHERE EMPLOYEES MAY BE EXPOSED TO SUBSTANCE.

ESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
) SPEC ADVISE
- DUST MASK
EXCEPT SINGLE-USE RESPIRATORS
AND QUARTER-MASK RESPIRATORS
- FUME OR HIGH-EFFICIENCY PARTICULATE RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS
- SUPPLIED-AIR RESPIRATOR

HIGH LEVELS
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE, HELMENT, OR HOOD

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS
WITH A FULL FACE-PIECE
OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
NO INFORMATION AVAILABLE FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS"; ADVISE: EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
MEDICAL WARNING FOR REFUSAL OF MEDICAL EXAMINATION.
BLOOD CHEMISTRY.
SKIN EXAM.
WEIGHT.
GASTROINTESTINAL.
CENTRAL NERVOUS SYSTEM EXAMINATION.
LIVER FUNCTION.
URINALYSIS.
KIDNEY FUNCTION.
RENAL AND LIVER FUNCTIONS.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN ABSORPTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. RESPIRATORY SYSTEM. SKIN. BLOOD. CENTRAL NERVOUS SYSTEM. GASTROINTESTINAL. KIDNEYS. LIVER. BONE MARROW.

SP

SYMPTOMS:
NASAL, OLFACTORY ORGAN (SC0171);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
PIGMENTATION, COLORATION (SC0132). FATIGUE, TIREDNESS, SLUGGISH (SC0066). WEAKNESS, LACK OF STRENGTH (SC0167). DIZZINESS, FEELING FAINT, LIGHT-HEADED, UNSTEADY(SC0048). HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). INSOMNIA, INABILITY TO OBTAIN NORMAL SLEEP (SC0088).
HEMOLYSIS, BLOOD DISSOLUTION, DESTRUCTION (SC0195). WEIGHT LOSS, DROP IN BODY WEIGHT (SC0104).
CENTRAL NERVOUS SYSTEM, PERTAINING TO NEURAL BODY SYSTEM (SC0028);

DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043). LIVER DAMAGE, INJURY TO THE LIVER (SC0221). TOXIC HEPATITIS, INFLAMED LIVER OF TOXIC ORIGIN (SC0257). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). JAUNDICE, YELLOWING OF SKIN, EYES (SC0092). DERMATITIS, INFLAMMATION OF SKIN (SC0044). ANOREXIA, DIMINISHED APPETITE (SC0006). ANURIA, COMPLETE LACK OF URINATION (SC0304). OLIGURIA, DECREASED URINATION (SC0323). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC0034). COMATOSE, STATE OF DEEP UNCONSCIOUSNESS (SC0186). HEMATURIA, RED BLOOD CELLS IN URINE (SC0076).
BONE MARROW, SOFT, BLOOD-FORMING TISSUE (SC0381);
DAMAGE, PERMANENT INJURY (SC0287). METHEMOGLOBINEMIA, BLOOD CONDITION FOLLOWING SOME POSION(SC0230). DYSPNEA, DIFFICULTY IN BREATHING (SC0052).

FA

FIRST AID.

(1 OF 4)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 4)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 4)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 4)
INGESTED NITRO/AMINO COMPOUNDS: REMOVE BY GASTRIC LAVAGE OR EMESIS AND CONSIDER USING ACTIVATED CHARCOAL. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS ON AN UNCONSCIOUS PERSON. MAINTAIN BLOOD PRESSURE AND RESPIRATION. GIVE OXYGEN IF RESPIRATION IS SHALLOW OR ANOXIA IS PRESENT. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. LAVAGE AND OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. ANTIDOTE: FOR SEVERE METHEMOGLOBINEMIA, GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG (1 MG/KG) SLOWLY INTRAVENOUSLY. ALL ANTIDOTES MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

END OF REQUEST

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1

AN ACCESSION NUMBER: 3315. 9207.
CN CHEMICAL NAME: TRINITROTOLUENE.
SY SYNONYMS: TNT. 2,4,6-TRINITROTOLUENE. NCI-C56155. UN 0209. TRITON. TOLITE. TOLUENE, 2,4,6-TRINITRO-. UN 1356. BENZENE, 2-METHYL-1,3,5-TRINITRO-. ENTSUFON. ALPHA-TNT. TNT-TOLITE. TOLIT. TRINITROTOLUENE, DRY. S-TRINITROTOLUENE. SYM-TRINITROTOLUOL. 2,4,6-TRINITROTOLUOL. TRITOL. TROTYL. TROTYL OIL.
RN CAS NUMBER: 118-96-7.

REG. TOXIC NUMBER: XU0175000.

CHEMICAL FORMULA: C7H5N3O6.
PD
PHYSICAL DESCRIPTION:
COLORLESS TO PALE YELLOW, ODORLESS SOLID.

MOL WT:	227
BOILING PT:	EXPLODES 464 F
SOLUBILITY:	0.013 G
FLASH PT:	EXPLODES
VAPOR PRES:	0.05 MM
MELT PT:	178 F
UEL IN AIR:	N/A
LEL IN AIR:	N/A
MEC IN AIR:	887 F
SPEC GRAVITY:	1.654
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
0.5 MG/M3 OSHA TWA (SKIN)
0.5 MG/M3 ACGIH TWA (SKIN NOTATION)
0.5 MG/M3 NIOSH RECOMMENDED 10 HR TWA (SKIN)
MUTAGENIC DATA (RTEC)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 3 - REACTIVITY 3 - PERSISTENCE 2
TOXICOLOGY: TNT IS A PRIMARY SKIN IRRITANT, SKIN SENSITIZER, NUERO-TOXIN, NEPHROTOXIN, HEPATOTOXIN, AND BONE MARROW DEPRESSANT.
ACUTE POISONING RESULTS IN CYANOSIS, NAUSEA, APLASTIC OR HEMOLYTIC ANEMIA,JAUNDICE, AND POSSIBLY OLIGURIA OR ANURIA. IN EXTREME CASES, PERIPHERAL NEURITIS, CONVULSIONS AND COMA MAY OCCUR.
VAPORS AND DUSTS IRRITATE THE EYES AND MUCOUS MEMBRANES. EXPOSURE MAY DISCOLOR THE SKIN, HAIR, AND NAILS. SEVERE DERMATITIS IS PRODUCED IN MANY WORKERS EXPOSED TO TNT. CASES OF SENSITIZATION HAVE BEEN REPORTED.
INFORMATION IS NOT AVAILABLE ON WARNING PROPERTIES OF TRINITROTOLUENE.
THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT SYSTEMIC POISONING.
ORL-RAT LD50: 820 MG/KG
ORL-MUS LD50:1009 MG/KG
ORL-CAT LDLO:1850 MG/KG
ORL-RBT LDLO: 500 MG/KG

29CFR1910.1200 OSHA HAZARD COMMUNICATION STANDARD REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

COLORLESS TO PALE YELLOW, ODOR.

IC

INCOMPATIBILITIES:
STRONG OXIDIZERS. AMMONIA. STRONG ALKALIES. EXPLOSIVE HAZARD AT HIGH TEMPERATURES. THERMAL DECOMPOSITION PRODUCTS ARE HAZARDOUS AND/OR TOX
SHOCK MAY DETONATE OR EXPLODE. REDUCING AGENTS.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.
-ACGIH 'GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING' INDICATED THE FOLLOWING PROTECTIVE RATINGS FOR MATERIALS COMMONLY USED FOR PROTECTIVE CLOTHING. THESE RATINGS ARE BASED PRIMARILY ON QUANTITATIVE TEST RESULTS AND QUALITATIVE RESISTANCE INFORMATION. (THE RECOMMENDATIONS APPLY TO THE PURE SUBSTANCE ONLY; BREAKTHROUGH-TIME MAY VARY FOR MIXTURES.) (A '+' DESIGNATES A BLEND OF MATERIALS, WHILE A '/' DESIGNATES A COATED OR LAMINATED MATERIAL.) -
UNSUBSTITUTED NITRO COMPOUNDS: EXCELLENT/GOOD: POLYVINYL ALCOHOL FAIR/POOR: NATURAL RUBBER NITRILE RUBBER FAIR/GOOD: CHLORINATED POLYETHYLENE POLYURETHANE POLYVINYL CHLORIDE VITON A WIDE VARIATION IN RATINGS IS INDICATED FOR THE FOLLOWING MATERIALS: BUTYL RUBBER NEOPRE

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT ALL EMPLOYEES SUBJECT TO SKIN CONTACT WITH THIS SUBSTANCE WASH WITH SOAP OR MILD DETERGENT AND WATER ANY AREAS OF THE BODY WHICH MAY HAVE CONTACTED THE SUBSTANCE AT THE END OF EACH WORK DAY.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER WITH SOAP OR MILD DETERGENT AND WATER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY WITH SOAP OR MILD DETERGENT AND WATER BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':

THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
5 MG/M3
- SUPPLIED-AIR RESPIRATOR
- SELF-CONTAINED BREATHING APPARATUS

12.5 MG/M3
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

25 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE

1000 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONTOR BACK-MOUNTED ORGANIC VAPOR CANISTER HAVING A HIGH EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
GENERAL MEDICAL HISTORY.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
RESPIRATORY HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
HISTORY OF ASTHMA OR ALLERGIES.
BLOOD DISEASE.
BLOOD CHEMISTRY.
RENAL AND LIVER FUNCTIONS.
LIVER FUNCTION.
VISION TEST.
EYE DISEASE.
CHRONIC RESPIRATORY DISEASE.
CENTRAL NERVOUS SYSTEM EXAMINATION.
KIDNEY FUNCTION.
URINALYSIS.
COMPLETE BLOOD COUNT.
HEMATOLOGY.
SGOT.
SGPT.
EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
PRE-PLACEMENT AND UP TO SEMI-ANNUAL UNDER SPECIFIC CONDITIONS.
ATTENTION TO SMOKING, ALCOHOL, MEDICATION, AND EXPOSURE TO CARCINOGENS.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA

EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. RESPIRATORY SYSTEM. BLOOD. CENTRAL NERVOUS SYSTEM.
CARDIOVASCULAR SYSTEM. GASTROINTESTINAL. KIDNEYS. LIVER.

SP

SYMPTOMS:
LIVER DAMAGE, INJURY TO THE LIVER (SC0221). JAUNDICE, YELLOWING OF SKIN, EYES (SC0092). CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). SNEEZING FORCABLE EXPIRATION OF AIR (SC0151). COUGHING, FORCEFUL EXPIRATION (SC0173). THIRST, DESIRE FOR WATER (SC0210). PERIPHERAL NEURITIS, INFLAMED NERVES OF EXTREMITIES (SC0129).
MUSCULAR, ORGAN RESPONSIBLE FOR MOTION (SC0110);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). DERMATITIS, INFLAMMATION OF SKIN (SC0044). LEUKOCYTOSIS, INCREASED WHITE BLOOD CELLS (SC0099). TOXIC HEPATITIS, INFLAMED LIVER OF TOXIC ORIGIN (SC0257).
CARDIOVASCULAR, PERTAINING TO HEART & BLOOD VESSELS (SC0037);
DISTURBANCE, INTERRUPTION OF A NORMAL STATE (SC0047). ALBUMINURIA, ALBUMIN (PROTEIN) IN URINE (SC0002). SEIZURE, CONVULSION (SC0149). NEPHRITIS, INFLAMMATION OF THE KIDNEYS (SC0117). PALLOR, PALENESS, AS OF THE SKIN (SC0122). NAUSEA, SICKNESS AT THE STOMACH (SC0115). ANOREXIA DIMINISHED APPETITE (SC0006). BONE MARROW DEPRESSION, LOWERING OF BONE TISSUE BLOOD PRODUCT(SC0249). APLASTIC ANEMIA, ANEMIA FROM BONE MARROW DAMAGE (SC0285). HEMOLYTIC ANEMIA, BREAKDOWN OF RED BLOOD CELLS (SC0233). OLIGURIA, DECREASED URINATION (SC0323). ANURIA, COMPLETE LACK OF URINATION (SC0304). CONVULSIONS, SUDDEN MUSCLE CONTRACTIONS (SC007 COMATOSE, STATE OF DEEP UNCONSCIOUSNESS (SC0186). HEADACHE, PAIN IN OR CRANIUM AREA (SC0075). METHEMOGLOBINEMIA, BLOOD CONDITION FOLLOWING SOME POSION(SC0230).
SKIN, COVERING OF BODY (SC0174);
SENSITIZATION, ALLERGIC REACTION (SC0148).
GASTROINTESTINAL, PERTAINING TO STOMACH & INTESTINE (SC0070);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). LEUKOPENIA, DECREASED WHITE BLOOD CELLS (SC0101). CATARACTS, LOSS OF TRANSPARENCY OF EYE LENS (SC0409). ECZEMA, CHRONIC DERMATITIS (SC0053). ERYTHEMA, REDNESS, SPOTS ON SKIN (SC0060). ICTERUS, DISCOLORATION OF TISSUE (SC0084). CONJUNCTIVITIS, INFLAMMATION OF EYES (SC0031).
RESPIRATORY, PERTAINING TO THE LUNGS (SC0142);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090). ANGINA, SENSE OF SUFFOCATION (SC0209). VOMITING, PERTAINING TO NAUSEA (SC0166). DIARRHEA UNCONTROLLED LOOSE BOWELS (SC0046).
HEPATIC, PERTAINING TO THE LIVER (SC0081);
ENLARGEMENT, BEING LARGER (SC0055).

FA

FIRST AID.

(1 OF 8)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 8)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 8)
WHEN THIS CHEMICAL HAS BEEN SWALLOWED, DO NOT INDUCE VOMITING. REMOVE BY GASTRIC LAVAGE AND CATHARSIS.

(5 OF 8)
INGESTED TRINITROTOLUENE/TRINITROBENZENE: EMERGENCY TREATMENT - REMOVE BY GASTRIC LAVAGE OR EMESIS. FURTHER TREATMENT - TREAT LIVER FAILURE AND HEMOLYTIC REACTIONS. (DREISBACH, HANDBOOK OF POISONING, 11TH ED.).

(6 OF 8)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH, USE GAG IF NECESSARY. EXTEND HEAD BY LIFTING CHIN. PASS TUBE OVER TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(7 OF 8)
LIVER DAMAGE - DISCONTINUE ALL DRUGS AND CHEMICALS. MAINTAIN COMPLETE BED REST. AVOID ANESTHESIA OR SURGICAL PROCEDURES. AVOID DEHYDRATION OR OVERHYDRATION. IF VOMITING IS SEVERE AND ORAL FLUIDS ARE NOT RETAINED, REPLACE VOMITUS WITH AN EQUAL QUANTITY OF 5-10% DEXTROSE IN 0.3-0.5 N SALINE. ADMINISTER MAINTENANCE FLUIDS AND ELECTROLYTES AS NECESSARY, DEPENDING ON RENAL FUNCTION. RESUME ORAL FEEDINGS AS SOON AS THE PATIENT CAN TOLERATE THEM. CONTROL THE AMOUNT OF PROTEIN IN THE DIET IN ORDER TO CORRECT THE SERUM PROTEIN LEVEL. GIVE VITAMIN K, PHYTONADIONE, 2.5 MG DAILY. IF ANEMIA IS SEVERE, CONSIDER A BLOOD TRANSFUSION. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(8 OF 8)
HEMOLYTIC REACTION - IN THE PRESENCE OF HEMOGLOBINURIA WITH NORMAL KIDNEY FUNCTION, MAINTAIN URINE OUTPUT AT 2-3 ML/KG/HOUR. FUROSEMIDE, 20-80 MG ORALLY OR INTRAVENOUSLY EVERY 4-8 HOURS, MAY BE HELPFUL. ALKALINIZE THE URINE BY GIVING SODIUM BICARBONATE, 1-2 MEQ/KG EVERY 12 HOURS. MONITOR CENTRAL VENOUS PRESSURE AND ELECTROLYTES. MANNITOL ADMINISTRATION HAS BEEN USED TO MAINTAIN URINE OUTPUT. IF SERUM HEMOGLOBIN EXCEEDS 1.5 GM/DL, TOTAL EXCHANGE TRANSFUSION MAY PREVENT RENAL FAILURE. IN THE PRESENCE OF METHEMOGLOBINEMIA WITH HEMOLYSIS, TREAT METHEMOGLOBINEMIA BY GIVING METHYLENE BLUE, 1 MG/KG. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

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1
AN ACCESSION NUMBER: 2773. 9205.
CN CHEMICAL NAME: SELENIUM.
SYNONYMS: SELENIUM, METALLIC. SELENIUM, ELEMENTAL. C.I. 77805. UN 658. ELEMENTAL SELENIUM. SELENIUM METAL.
RN CAS NUMBER: 7782-49-2.

REG. TOXIC NUMBER: VS7700000.

CHEMICAL FORMULA: SE.

PD
PHYSICAL DESCRIPTION:
ODORLESS, BLUISH-GRAY, BLACK OR RED SOLID.

MOL WT:	78.96
BOILING PT:	1261-1265 F
SOLUBILITY:	INSOLUBLE
FLASH PT:	NONCOMBUSTIBLE SOLID
VAPOR PRES:	10 MMHG @ 29 C
MELT PT:	423 F (217 C)
UEL IN AIR:	N/A
LEL IN AIR:	N/A
MEC IN AIR:	
SPEC GRAVITY:	4.81
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

EL
PERMISSABLE EXPOSURE:
0.2 MG/M3 OSHA TWA
0.2 MG/M3 ACGIH TWA
0.2 MG/M3 NIOSH RECOMMENDED 10 HR TWA
HUMAN INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
ANIMAL INADEQUATE EVIDENCE FOR CARCINOGENICITY (IARC GROUP-3)
TUMORIGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS)
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: SELENIUM IS AN EYE, SKIN AND MUCOUS MEMBRANE IRRITANT. IT IS SLIGHTLY TOXIC BY INGESTION. POISONING MAY AFFECT THE LIVER, KIDNEYS AND RESPIRATORY SYSTEM. METAL FUME FEVER, AN INFLUENZA-LIKE ILLNESS MAY OCCUR DUE TO THE INHALATION OF FRESHLY FORMED METAL OXIDES AND RESULT IN SYMPTOMS INCLUDING A SWEET, METALLIC OR FOUL TASTE IN THE MOUTH, EXAGGERATED MENTAL ACTIVITY AND PROSTRATION. REPEATED OR PROLONGED EXPOSURE MAY CAUSE A GARLIC ODOR ON THE BREATH AND SWEAT, PALLOR, COATED TONGUE AND GASTROINTESTINAL DISTURBANCES.
TOLERANCE TO THE FUMES DEVELOPS RAPIDLY, BUT IS QUICKLY LOST AND, THEREFORE, DOES NOT HAVE ADEQUATE WARNING PROPERTIES. THE THRESHOLD LIMIT VALUE WAS ESTABLISHED TO BE LOW ENOUGH TO PREVENT SYSTEMIC TOXICITY AND MINIMIZE IRRITATION OF THE EYES AND RESPIRATORY PASSAGES.
PERSONS WITH A HISTORY OF CHRONIC RESPIRATORY DISEASE, GASTROINTESTINAL DISTURBANCES, ALLERGIES, LIVER OR KIDNEY DISEASE OR RECURRENT DERMATITIS MAY BE AT AN INCREASED RISK FROM EXPOSURE.
ORL-RAT LD50: 6700 MG/KG IHL-RAT LDLO: 33 MG/KG/8 HR
INV-RAT LD50: 6 MG/KG INV-RBT LDLO: 2500 UG/KG

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

NONE SPECIFIED
ODORLESS, BLUISH-GRAY, BLACK O.

IC

INCOMPATIBILITIES:
SEND BACK AREA EXCEDED. ALKALI METAL AMIDES: PRODUCES EXPLOSIVE PRODUCTS ALKALINE EARTH METAL AMIDES: PRODUCES EXPLOSIVE PRODUCTS BARIUM PEROXIDE: IGNITES AT 265 C BROMINE PENTAFLUORIDE: VIOLENT REACTION AND POSSIBLE IGNITION CADMIUM: POSSIBLE EXPLOSION WHEN HEATED CHLORINE TRIFLUORIDE: REACTS VIOLENTLY, IGNITION OFTEN OCCURRING CHROMIC ANHYDRIDE: VIOLENT REACTION FLUORINE: IGNITES ON CONTACT LITHIUM SILICIDE: INCANDESCENT REACTION METAL ACETYLIDES: INCANDESCENT REACTION ON HEATING METAL CARBIDES: INCANDESCENT REACTION ON HEATING METAL CHLORATES (EXCEPT ALKALI): INCANDESCENT REACTION IN THE PRESENCE OF WATER. METALS: CONTACT OF MANY METALS WITH SELENIUM RESULTS IN INCANDESCENCE NITROGEN TRICHLORIDE: EXPLODES ON CONTACT OXIDIZERS (STRONG): FIRE AND EXPLOSION HAZARD) PHOSPHOROUS: INCANDESCENT REACTION WHEN HEATED POTASSIUM: INCANDESCENCE REACTION WITH POSSIBLE EXPLOSION POTASSIUM BROMATE: VIOLENT, EXPLOSIVE REACTION SILVER BROMATE: VIOLENT EXPLOSIVE REACTION SILVER OXIDE: IGNITION ON GRINDING SODIUM PEROXIDE: FORMS EXPLOSIVE MIXTURE TIN (POWDERED): EXTREMELY EXOTHERMIC, INCANDESCENT REACTION.

CL

CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).

WEAR EYE PROTECTION TO PREVENT:
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THIS SOLID MAY CONTACT THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE IMMEDIATELY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.

WORK CLOTHING SHOULD BE CHANGED DAILY:
NO SPECIFIC REQUIREMENT. IF INDICATED BY THE NATURE OF THE CONTAMINANT AND THE EXTENT OF EXPOSURE, CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS":
WHERE THERE IS ANY POSSIBILITY OF EXPOSURE OF AN EMPLOYEE'S BODY TO THIS SUBSTANCE, EMPLOYERS SHALL PROVIDE FACILITIES FOR QUICK DRENCHING OF TH BODY WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
2 MG/M3
- DUST AND MIST RESPIRATOR WITH A FULL FACEPIECE
- SUPPLIED-AIR RESPIRATOR
- [illegible] APPARATUS

5 MG(SE)/M3
- POWERED AIR-PURIFYING RESPIRATOR WITH A DUST AND MIST FILTER
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE

10 MG/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR
WITH A FULL FACE-PIECE

100 MG/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

ESCAPE
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE WITH AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN POSITIVE PRESSURE MODE.

MS
MEDICAL SURVEILLANCE:
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
FOLLOWING INFORMATION FROM NIOSH/OSHA "OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS".
GENERAL MEDICAL HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
EYE DISEASE.
RESPIRATORY HISTORY.
LIVER FUNCTION.
KIDNEY FUNCTION.
BLOOD CHEMISTRY.
SKIN EXAM.
URINALYSIS.
HISTORY OF ASTHMA OR ALLERGIES.

RE
ROUTE OF ENTRY:
INHALATION. SKIN ABSORPTION. INGESTION. SKIN OR EYE CONTACT.

TO
TARGET ORGANS:
RESPIRATORY SYSTEM. EYES. SKIN. KIDNEYS. LIVER. BLOOD. GASTROINTESTINAL.

SYMPTOMS:
EYE, ORGAN OF SIGHT (SC0170);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
SKIN, COVERING OF BODY (SC0174);
IRRITATION, EXTREME REACTION TO A CONDITION (SC0090).
MUCOUS MEMBRANE, MEMBRANE LINING PASSAGES/CAVITIES (SC0109);

EXPIRATION OF AIR (SC0151). COUGHING, FORCEFUL EXPIRATION (SC0173).
HEADACHE, PAIN IN HEAD OR CRANIUM AREA (SC0075). DYSPNEA, DIFFICULTY IN BREATHING (SC0052). ANOSMIA, LACKING SENSE OF SMELL (SC0007). EPISTAXIS NOSEBLEED (SC0057). PNEUMONITIS, LOCALIZED INFLAMMATION OF LUNG (SC0137). THIRST, DESIRE FOR WATER (SC0210). METALLIC TASTE, TASTE RESEMBLING METAL IN MOUTH (SC0216). LASSITUDE, A SENSE OF WEARINESS (SC0098). MALAISE, UNEASINESS, DISCOMFORT, FEELING BAD (SC0106). FEVI BODY TEMPERATURE ABOVE NORMAL (SC0067). CHILLS, A SHIVERING OR SHAKING (SC0736).
MUSCULAR, ORGAN RESPONSIBLE FOR MOTION (SC0110);
PAIN, SUFFERING, EITHER PHYSICAL OR MENTAL (SC0182). NAUSEA, SICKNESS AT THE STOMACH (SC0115). VOMITING, PERTAINING TO NAUSEA (SC0166). SWEATING EXCRETING MOISTURE THROUGH THE SKIN (SC0156).
EXCESSIVE, SUPERFLUOUS (SC0737);
URINATION, DISCHARGE OF URINE FROM BODY (SC0617). DIARRHEA, UNCONTROLLED LOOSE BOWELS (SC0046). PROSTRATION, MARKED LOSS OF STRENGTH, EXHAUSTION (SC0139). HALITOSIS, OFFENSIVE BREATH (SC0333). PALLOR, PALENESS, AS OF THE SKIN (SC0122). NERVOUSNESS, STATE OF UNREST, UNEASINESS (SC0118).
DEPRESSION, DECREASE IN ACTIVITY/FUNCTION (SC0043).
GASTROINTESTINAL, PERTAINING TO STOMACH & INTESTINE (SC0070);
DISTURBANCE, INTERRUPTION OF A NORMAL STATE (SC0047). FATIGUE, TIREDNESS, SLUGGISH (SC0066). IRRITABILITY, QUICK EXCITABILITY TO ANNOYANCE (SC0091). ANEMIA, RED BLOOD CELLS LESS THAN NORMAL (SC0004).
PULMONARY, PERTAINING TO THE RESPIRATORY TRACT (SC0500);
EDEMA, FLUID RETENTION WITH SWELLING (SC0181). KIDNEY DAMAGE, INJURY TO THE KIDNEY (SC0220). LIVER DAMAGE, INJURY TO THE LIVER (SC0221).
CARDIAC, PERTAINING TO HEART (SC0023);
DAMAGE, PERMANENT INJURY (SC0287).
REPRODUCTIVE EFFECTS, BIRTH DEFECTS (SC0281);
IN EXPERIMENTAL ANIMALS, (SC0212).

FA

FIRST AID.

(1 OF 5)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 5)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 5)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 5)
SELENIUM DERIVATIVES: REMOVE INGESTED POISON BY GASTRIC LAVAGE OR EMESIS. FOLLOW WITH A SALINE CATHARTIC. MAINTAIN BLOOD PRESSURE, AIRWAY, AND GIVE OXYGEN IF VICTIM IS UNCONSCIOUS. GET MEDICAL ATTENTION IMMEDIATELY. (GOSSELIN, CLINICAL TOXICOLOGY OF COMMERCIAL PRODUCTS, 5TH EDITION). ADMINISTRATION OF GASTRIC LAVAGE OR OXYGEN SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL.

(5 OF 5)
GASTRIC LAVAGE - GIVE PATIENT GLASS OF WATER PRIOR TO PASSING OF STOMACH TUBE. LAY PATIENT ON ONE SIDE, WITH HEAD LOWER THAN WAIST. IMMOBILIZE A STRUGGLING PATIENT WITH A SHEET OR BLANKET. MEASURE DISTANCE ON TUBE FROM MOUTH TO EPIGASTRIUM, MARK TUBE WITH INDELIBLE MARKING OR TAPE. REMOVE DENTURES AND OTHER FOREIGN OBJECTS FROM THE MOUTH. OPEN MOUTH,

TONGUE AND TOWARD BACK OF THROAT WITHOUT EXTENDING HEAD OR NECK. IF OBSTRUCTION IS MET BEFORE THE MARK ON TUBE REACHES LEVELS OF THE TEETH, DO NOT FORCE, BUT REMOVE TUBE AND REPEAT PROCEDURE UNTIL TUBE PASSES TO MARK. PLACE END OF TUBE IN GLASS OF WATER. IF TUBE IS OBSTRUCTED WHEN INTRODUCED ABOUT HALFWAY TO THE MARK, IT MAY HAVE ENTERED TRACHEA. AFTER TUBE IS PLACED IN STOMACH, ASPIRATE FIRST TO REMOVE STOMACH CONTENTS BY IRRIGATION SYRINGE. SAVE STOMACH CONTENTS FOR EXAMINATION, AND REPEAT INTRODUCTION AND WITHDRAWL OF 100-300 ML WARM WATER UNTIL AT LEAST 3 LITERS OF CLEAR RETURN ARE OBTAINED. USE ACTIVATED CHARCOAL AT BEGINNING OF LAVAGE TO AID IN POISON INACTIVATION. LEAVE 50 GRAMS OF CHARCOAL SUSPENDED IN WATER IN THE STOMACH. IF INTRODUCTION AND REMOVAL OF LAVAGE FLUID BY GRAVITY REQUIRES MORE THAN FIVE MINUTES, ASSIST WITH ASEPTO SYRINGE. PREVENT ASPIRATION WITH CUFFED ENDOTRACHEAL TUBE. AVOID GIVING LARGE QUANTITIES OF WATER. IF PATIENT COMATOSE, INTUBATE TRACHEA WITH CUFFED ENDOTRACHEAL TUBE. SUCCINYLCHLORINE MAY BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL TO EASE INSERTION OF TRACHEAL CATHETER PRIOR TO PASSAGE OF STOMACH TUBE. PROCEDURE MUST BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

DT

SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
URINE SELENIUM AS EXPOSURE INDEX.
DIFFERENTIAL WHITE BLOOD CELL COUNT.

RS

REGULATORY STATUS.

(1 OF 42)
****
FEDERAL REGULATIONS
**********.

P096 THE REQUEST YOU MADE WAS AGAINST A ZERO RESULT LIST. PLEASE TRY AGAIN.:

P096 THE REQUEST YOU MADE WAS AGAINST A ZERO RESULT LIST. PLEASE TRY AGAIN.:

1
ACCESSION NUMBER: 2799. 9205.
CN CHEMICAL NAME: SILVER.
SY SYNONYMS: ARGENTUM. C.I. 77820. L-3. SHELL SILVER. SILVER ATOM. SILVER, METAL. SILFLAKE 135. V 9. SILVER METAL. SR 999.
RN CAS NUMBER: 7440-22-4.

REG. TOXIC NUMBER: VW3500000.

CHEMICAL FORMULA: AG.

PD
PHYSICAL DESCRIPTION:
SOFT, DUCTILE, LUSTROUS WHITE SOLID.

MOL WT:	107.9
BOILING PT:	4014 F
SOLUBILITY:	INSOLUBLE
FLASH PT:	INCOMBUSTABLE
VAPOR PRES:	NEGLIGIBLE
MELT PT:	1763 F
UEL IN AIR:	INCOMBUSTABLE
LEL IN AIR:	INCOMBUSTABLE
MEC IN AIR:	
SPEC GRAVITY:	10.5
VAPOR DENSITY:	
ODOR THRESHOLD:	
OCTANOL/WATER CO-EFFICIENT:.	

PERMISSABLE EXPOSURE:
0.01 MG/M3 OSHA TWA
0.1 MG/M3 ACGIH TWA (DUST, FUME)
0.01 MG/M3 NIOSH RECOMMENDED 10 HR TWA
CERCLA HAZARD RATINGS - TOXICITY 3 - IGNITABILITY 0 - REACTIVITY 0 - PERSISTENCE 3
TOXICOLOGY: SILVER IS AN EYE AND MUCOUS MEMBRANE IRRITANT AND PRIMARY SKIN IRRITANT.
ACUTE INGESTION OF SOLUBLE SILVER COMPOUNDS CAUSES ORAL PAIN, MUCOUS MEMBRANE PIGMENTATION, SALIVATION, BLACK VOMITUS, DIARRHEA, ANURIA, COLLAPSE AND SHOCK. TERMINAL SIGNS ARE CONVULSIONS OR COMA.
CHRONIC SKIN CONTACT WILL RESULT IN ARGYRIA.
THE THRESHOLD LIMIT VALUE WAS SET TO PREVENT ARGYRIA.

OSHA STANDARD 1910.1200 HAZARD COMMUNICATION REQUIRES CHEMICAL MANUFACTURERS AND IMPORTERS TO ASSESS THE HAZARDS OF CHEMICALS WHICH THEY PRODUCE OR IMPORT, AND ALL EMPLOYERS TO PROVIDE INFORMATION TO THEIR EMPLOYEES CONCERNING HAZARDOUS CHEMICALS BY MEANS OF A HAZARD COMMUNICATION PROGRAM, LABELS AND OTHER FORMS OF WARNING, MATERIAL SAFETY DATA SHEETS, AND INFORMATION AND TRAINING. REQUIRES DISTRIBUTORS TO TRANSMIT REQUIRED INFORMATION TO EMPLOYEES.

DANGEROUS EXPOSURE:
NOT REQUIRED
SOFT, DUCTILE, LUSTROUS WHITE.

IC
INCOMPATIBILITIES:
ACETYLENE GAS. AMMONIA. HYDROGEN. PEROXIDES. METAL IN POWDERED FORM IS EXPLOSIVE.

CL
CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR

CHEMICAL HAZARDS :
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT NECESSARY TO PREVENT SKIN CONTACT WITH THIS SUBSTANCE WHERE SKIN CONTACT MAY OCCUR. FACE SHIELDS SHALL COMPLY WITH 29CFR1910.133(A)(2), (A)(4), (A)(5), AND (A)(6).
EMPLOYERS SHALL ENSURE THAT CLOTHING CONTAMINATED WITH THIS SUBSTANCE IS PLACED IN CLOSED CONTAINERS FOR STORAGE UNTIL IT CAN BE DISCARDED OR UNTIL THE EMPLOYER PROVIDES FOR THE REMOVAL OF THE CONTAMINANT FROM THE CLOTHING. IF THE CLOTHING IS TO BE LAUNDERED OR OTHERWISE CLEANED TO REMOVE THE CONTAMINANT, THE EMPLOYER SHALL INFORM THE PERSON PERFORMING THE CLEANING OF THE HAZARDOUS PROPERTIES OF THE SUBSTANCE.

WEAR EYE PROTECTION TO PREVENT:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL PROVIDE AND ENSURE THAT EMPLOYEES USE DUST-RESISTANT SAFETY GOGGLES WHICH COMPLY WITH 29CFR1910.133(A)(2)-(A)(6) WHERE THERE IS ANY POSSIBILITY OF THIS SOLID CONTACTING THE EYES.

EMPLOYEE SHOULD WASH:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE SKIN BECOMES CONTAMINATED WITH THIS SUBSTANCE PROMPTLY WASH OR SHOWER TO REMOVE ANY CONTAMINANT FROM THE SKIN.
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHO HANDLE THIS SUBSTANCE WASH THEIR HANDS THOROUGHLY BEFORE EATING, SMOKING, OR USING TOILET FACILITIES.

WORK CLOTHING SHOULD BE CHANGED DAILY:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES WHOSE CLOTHING MAY HAVE BECOME CONTAMINATED WITH THIS SUBSTANCE CHANGE INTO UNCONTAMINATED CLOTHING BEFORE LEAVING THE WORK PREMISES.

REMOVE CLOTHING:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT NON-IMPERVIOUS CLOTHING WHICH BECOMES CONTAMINATED WITH THIS SUBSTANCE BE REMOVED PROMPTLY AND NOT REWORN UNTIL THE SUBSTANCE IS REMOVED FROM THE CLOTHING.

THE FOLLOWING EQUIPMENT SHOULD BE AVAILABLE:
FOLLOWING INFORMATION FROM NIOSH/OSHA 'OCCUPATIONAL HEALTH GUIDELINES FOR CHEMICAL HAZARDS':
EMPLOYERS SHALL ENSURE THAT EMPLOYEES DO NOT EAT OR SMOKE IN AREAS WHERE THIS SUBSTANCE IS HANDLED, PROCESSED OR STORED.

RP

RESPIRATOR SELECTION (UPPER LIMIT DEVICES PERMITTED):
0.25 MG(AG)/M3
- SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE
- POWERED AIR-PURIFYING RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER

0.5 MG(AG)/M3
- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE
- SUPPLIED-AIR RESPIRATOR WITH A FULL FACE-PIECE

20 MG(AG)/M3
- SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE

- AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER
- APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS

FIREFIGHTING
- SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACE-PIECE OPERATED IN PRESSURE-DEMAND OR POSITIVE-PRESSURE MODE.

MS

MEDICAL SURVEILLANCE:
GENERAL MEDICAL HISTORY.
RESPIRATORY HISTORY.
PHYSICIAN PRE-PLACEMENT AND ANNUAL EXAMS.
NASAL SEPTUM.
VISION TEST.
EYE DISEASE.
SKIN EXAM.
SPECIAL ATTENTION TO SKIN.
SKIN EXAMINATION FOR EVIDENCE OF PIGMENTATION.
40CFR717 RECORDS AND REPORTS OF ALLEGATIONS THAT CHEMICAL SUBSTANCES CAUSE SIGNIFICANT ADVERSE REACTIONS TO HEALTH OR THE ENVIRONMENT TOXIC SUBSTANCES CONTROL ACT (TSCA) SECTION 8(C) RULE REQUIRES MANUFACTURERS AND CERTAIN PROCESSORS OF CHEMICAL SUBSTANCES AND MIXTURES TO KEEP RECORDS OF SIGNIFICANT ADVERSE REACTIONS TO EMPLOYEE HEALTH FOR 30 YEARS.
PERIODIC EXAM FOLLOWING EXPOSURE.
EKG RECOMMENDED IF EMPLOYEE TO WEAR FULL-FACE RESPIRATOR.
ACGIH BIOLOGICAL EXPOSURE INDICIES FOR METHEMOGLOBIN INDUCERS: 1.5% OF HEMOGLOBIN METHEMOGLOBIN IN BLOOD / TIMING -DURING OR END OF SHIFT.
29CFR1910.20 OSHA STANDARD SUBPART C - GENERAL SAFETY AND HEALTH PROVISIONS PROVIDES FOR EMPLOYEE, DESIGNATED REPRESENTATIVE, AND OSHA ACCESS TO EMPLOYER-MAINTAINED EXPOSURE AND MEDICAL RECORDS RELEVANT TO EMPLOYEES EXPOSED TO TOXIC SUBSTANCES AND HARMFUL PHYSICAL AGENTS.
53FR38140 9/29/88 (AMENDED).

RE

ROUTE OF ENTRY:
INHALATION. INGESTION. SKIN OR EYE CONTACT.

TO

TARGET ORGANS:
EYES. SKIN. NASAL SEPTUM.

SP

SYMPTOMS:
CYANOSIS, DARK BLUE/PURPLE SKIN COLOR (SC0038). THIRST, DESIRE FOR WATER (SC0210). SKIN BURNS, INJURY OF SKIN CAUSED BY HEAT (SC0176).
EYE, ORGAN OF SIGHT (SC0170);
BURNS, TISSUE DAMAGE FROM HEAT (SC0175). GASTROENTERITIS, STOMACH AND INTESTINAL INFLAMMATION (SC0551). SHOCK, SUDDEN PHYSICAL OR MENTAL DISTURBANCE(SC0228). CHEMOSIS, EDEMA OF CONJUNCTIVA AROUND CORNEA (SC0450). ARGYRIA, BLUISH OR BLACK SKIN DISCOLORATION (SC0552).

FA

FIRST AID.

(1 OF 6)
IF THIS CHEMICAL GETS INTO THE EYES, WASH THE EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(2 OF 6)
IF THIS CHEMICAL GETS ON THE SKIN, REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

(3 OF 6)
IF THIS CHEMICAL HAS BEEN INHALED, REMOVE FROM EXPOSURE AREA TO FRESH AIR

[illegible]
KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

(4 OF 6)
INGESTED SILVER SALTS: EMERGENCY TREATMENT - DILUTE WITH WATER CONTAINING SODIUM CHLORIDE, 10 GRAMS/LITER, REPEATEDLY TO PRECIPITATE SILVER ION. FOLLOW WITH CATHARSIS USING 30-60 ML FLEET'S PHOSPHOSODA DILUTED 1:4 IN WATER CONTAINING 5 GRAMS SODIUM CHLORIDE TO PRECIPITATE AND REMOVE SILVER FROM INTESTINES. TREAT SHOCK AND METHEMOGLOBINEMIA. FURTHER TREATMENT - GIVE MILK TO REDUCE GASTRIC IRRITATION. GIVE MEPERIDINE, 100 MG, OR CODEINE, 60 MG, TO RELIEVE PAIN. (MEDICATION MUST BE GIVEN BY QUALIFIED MEDICAL PERSONNEL) (DREISBACH, HANDBOOK OF POISONING, 11TH ED.).

(5 OF 6)
CIRCULATORY FAILURE/SHOCK - PLACE PATIENT IN SUPINE POSITION WITH FEET ELEVATED. ESTABLISH AND MAINTAIN AN ADEQUATE AIRWAY. MAINTAIN BODY WARMTH BY APPLICATION OF BLANKETS, BUT DO NOT APPLY EXTERNAL HEAT. RELIEVE PAIN WITH MORPHINE SULFATE, 10 MG/70 KG SUBCUTANEOUSLY OR INTRAVENOUSLY, FOR OTHERWISE UNCONTROLLABLE PAIN. DO NOT GIVE MORPHINE TO UNCONSCIOUS OR STUPOROUS PATIENTS. PATIENTS WITH DEPRESSED RESPIRATION SHOULD NOT BE GIVEN MORPHINE UNLESS PERSONNEL AND EQUIPMENT TO MAINTAIN RESPIRATION ARE IMMEDIATELY AVAILABLE. RESTORE AND MAINTAIN ADEQUATE BLOOD VOLUME. PROCEDURE MUST PERFORMED BY QUALIFIED MEDICAL PERSONNEL. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.).

(6 OF 6)
METHEMOGLOBINEMIA: (WHEN METHEMOGLOBIN CONCENTRATION IS OVER 25-40% OR IN THE PRESENCE OF SYMPTOMS). GIVE METHYLENE BLUE, 1% SOLUTION, 0.1 ML/KG INTRAVENOUSLY OVER A 10 MINUTE PERIOD. CYANOSIS MAY DISAPPEAR WITHIN MINUTES OR PERSIST LONGER DEPENDING ON DEGREE OF METHEMOGLOBINEMIA. INTRAVENOUS ADMINISTRATION OF THERAPEUTIC DOSES OF METHYLENE BLUE MAY CAUSE A RISE IN BLOOD PRESSURE, NAUSEA, AND DIZZINESS. LARGER DOSES (>500 MG) CAUSE VOMITING, DIARRHEA, CHEST PAIN, MENTAL CONFUSION, CYANOSIS, AND SWEATING. HEMOLYTIC ANEMIA HAS ALSO OCCURRED SEVERAL DAYS AFTER ADMINISTRATION. THESE EFFECTS ARE TEMPORARY, AND FATALITIES HAVE NOT BEEN REPORTED. IF METHYLENE BLUE IS NOT AVAILABLE, GIVE ASCORBIC ACID, 1 GRAM SLOWLY INTRAVENOUSLY. WITHOUT TREATMENT, METHEMOGLOBINEMIA LEVELS OF 20-30% REVERT TO NORMAL WITHIN 3 DAYS. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). ANTIDOTE SHOULD BE ADMINISTERD BY QUALIFIED MEDICAL PERSONNEL.

DT
SPECIAL DIAGNOSTIC TESTS AND INDEXES OF EXPOSURE:
NONE IN COMMON USE.

RS
REGULATORY STATUS.

(1 OF 320 HAZARD COMMUNICATION REQUIRES CHEMICAL
ENTER DOCUMENT SELECTION._: 7440-39-3

P002 INVALID...ENTER DOCUMENT SELECTION (DOC=)._:

1
AN ACCESSION NUMBER: 2799. 9205.
CN CHEMICAL NAME: SILVER.
SY SYNONYMS: ARGENTUM. C.I. 77820. L-3. SHELL SILVER. SILVER ATOM. SILVER, METAL. SILFLAKE 135. V 9. SILVER METAL. SR 999.
RN CAS NUMBER: 7440-22-4.

REG. TOXIC NUMBER: VW3500000.

CHEMICAL FORMULA: AG.

PD
PHYSICAL DESCRIPTION:
SOFT, DUCTILE, LUSTROUS WHITE SOLID.

APPENDIX B
TO HEALTH AND SAFETY PLAN

RESPIRATORY PROTECTION PROGRAM

APPENDIX B

RESPIRATORY PROTECTION PROGRAM FOR NAVAL SURFACE WARFARE CENTER CRANE DIVISION CRANE, INDIANA

The following respirator program is in accordance with OSHA 29 CFR 1910.134 Respiratory Protection Program requirements. These govern the selection and use of respirators on the sites.

Respirators for the Rust E&I field sampling team will be provided by RUST E&I. The respirator protection program will be administered by, and is the responsibility of the Corporate Health and Safety Manager (CHSM) and/or Site Safety Officer (SSO) for the site. Subcontractors, if any, will furnish their own respirators and medical surveillance for their employees. The CHSM and/or SSO will be responsible for determining if they are in compliance with this respirator program before work begins.

The respirators will be selected according to the hazard and level of protection determined by air monitoring, action levels, and the decision of the CHSM and/or the SSO. The respirators and levels are:

Level	Respirator
	The determination of level will be based on air monitoring results using a PID and/or OVA.
B	Positive Pressure-Pressure Demand SCBA or Supplied Air Respirator with 5 minute escape bottle. Level B is 5 to 250 ppm above background in breathing zone (BZ).
C	Full-face air purifying respirator with combination dust (HEPA) and organic vapor/acid gas cartridge. Level C is 1 ppm to 5 ppm above background in BZ. The full facepiece respirator with combination dust and organic vapor/acid gas cartridge will be appropriate for the dust conditions and organics that may be encountered.
D	No respirator required. Level D is 1 ppm above background (typically 0.2 ppm) in the worker's BZ.

The respirator users will be fit-tested with the size, style, and make of the respirator they will be using on-site. The fit-test will be recorded and these Fit-Test Records will be maintained at the Command Post.

Employee respirator training is provided on an annual basis or at six-month intervals for those working with asbestos and at site-specific training sessions. This training includes:

- A discussion of the nature of the respiratory hazards and the dangers if the respirator is not used properly.
- The reasons that respirators are required for protection, along with any engineering controls that may be used.
- Instruction in the selection, use, sanitary care, maintenance, proper storage, and limitation of the full facepiece respirator with combination cartridge.
- Practice in proper fitting, wearing, adjusting, and checking the face seal of a respirator.
- An opportunity to handle the respirator.
- Instruction on how to recognize and cope with emergency situations requiring respiratory protection.
- Explanation of the medical surveillance program and how it relates to respirator use.
- Explanation of the requirements for maintaining a tight seal, why beard and facial hair, chewing gum, or tobacco or smoking is prohibited, and why use of contact lenses while wearing respirators is prohibited.

Respirators will be assigned to individual workers. Each individual shall be responsible for cleaning and maintaining their assigned respirator. They will be cleaned and disinfected before being reassigned. Respirators will be cleaned after each day of work according to manufacturer's instruction or more frequently as needed. The cleaning will be done at the Command Post. Used cartridges will be properly disposed of and replaced with new ones.

After cleaning, the respirators will be inspected and checked for defects such as excessive dirt, cracks or other distortions, scratches, incorrectly mounted lens, broken or worn cartridge holders on the facepiece, breaks, loss of elasticity, broken buckles, and excessively worn serrations on head harness that may cause slippage on the headstraps or head harness.

Further checks include:

- A check of the tightness of the connections.
- A check of the facepiece, valves, connecting tube, and canisters.

- For air purifying:

  - Check the exhalation valve after removing its cover for:

    -- Foreign material, such as detergent residue, dust particles, or human hair under the valve seat.

    -- Cracks, tears, or distortion in the valve material.

    -- Improper insertion of the valve body in the facepiece.

    -- Cracks, breaks, or chips in the valve body, particularly in the sealing surface.

    -- Missing or defective valve cover.

    -- Improper installation of the valve in the valve body.

  - Check the air purifying elements for:

    -- Incorrect cartridges, canister, or filter for the hazard.

    -- Incorrect installation, loose connections, missing or worn gaskets, or cross threading in holder.

    -- Expired shelf life of cartridge or canister.

    -- Cracks, dents, or breaks in the cartridge or canisters case.

    -- Evidence of prior use of cartridge or canister, such as broken seal tape foil or other sealing material.

  - Check the breathing tube on supplied air units for:

    -- Broken or missing end connectors, gaskets, or O-rings.

    -- Missing or loose hose clamp.

    -- Deterioration (done by stretching hose and looking for cracks).

Air monitoring of the work zone will be performed and the results will be used to select the appropriate level of protection. Refer to the air monitoring section of the Health and Safety Plan (HASP, Section 9.0).

The respiratory protection program will be re-evaluated and revisions and updates added regularly.

Persons will not be assigned to tasks requiring the use of respirators unless it has been determined by a physician that they are physically able to perform the work and use the equipment. Rust E&I personnel will be examined by the Rust E&I contracted physician who will determine what health and physical conditions are pertinent.

Only those respirators jointly approved by NIOSH/MSHA shall be used. All component parts (i.e., canister, replacement straps, etc.) will be of the same manufacturer.

D:\CTO7601\HASP1\APPENDIX.B

APPENDIX C
TO HEALTH AND SAFETY PLAN

HEALTH AND SAFETY FIELD MODIFICATION FORM

RUST ENVIRONMENT & INFRASTRUCTURE

Health and Safety Plan
Field Modification Form

Page No. _____ of _____

Project: _____

Project Location: _____

Project No.: _____

Site Safety Officer: _____

Field Modification To HASP: _____

Prepared By: _____
Site Safety Officer — Date

Accepted By: _____
RUST Environment & Infrastructure Field Manager — Date

Accepted By: _____
Contractor Representative (If Applicable) — Date

Approved By: _____
RUST Environment & Infrastructure Regional Health and Safety Specialist or Alternate HASP Reviewer — Date

NOTE: Field Modifications to HASP's must be discussed with the RUST Environment & Infrastructure RHSS or CHSM with subsequent written approval. Secure approval through fax.

APPENDIX C
TO WORK PLAN

QUALITY ASSURANCE PROJECT PLAN

USEPA ID No. IN5 170 023 498

RISK ASSESSMENT WORK PLAN
QUALITY ASSURANCE PROJECT PLAN
FOR
SOLID WASTE MANAGEMENT UNITS
#03/10, #06/09, #07/09
NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

Submitted to:
Southern Division
Environmental Branch, Code 186 ND
Naval Facilities Engineering Command
2155 Eagle Drive
Charleston, South Carolina 29411-0068

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

Contract No. N62472-90-D-1298
Contract Task Order 0076

July 1995

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Under subcontract to Halliburton NUS

APPROVED BY:

DEBRA A. SCHEIB
CLEAN QUALITY ASSURANCE MANAGER
HALLIBURTON NUS CORPORATION

RISK ASSESSMENT WORK PLAN
QUALITY ASSURANCE PROJECT PLAN
FOR
SOLID WASTE MANAGEMENT UNITS
#03/10, #06/09, #07/09
NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Reviewed by: _____ Date: _____

Project Coordinator
Region V USEPA

Reviewed by: _____ Date: _____

Quality Assurance Manager
Region V USEPA

D:\CTO7601\QAPP1\COVER

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LIST OF ACRONYMS/ABBREVIATIONS

ABG	Ammunition Burning Ground
ASTM	American Society of Testing and Materials
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
CTO	Contract Task Order
DOT	Department of Transportation
DQO	Data Quality Objective
DR	Demonlition Range
FTL	Field Team Leader
HDPE	High Density Polyethylene
IATA	International Air Transport Association
LCS	Laboratory Control Standard
MPR	Monthly Progress Report
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAVSURFWARCENDIV	Naval Surface Warfare Center, Crane Division
NEESA	Naval Energy and Environmental Support Activity
NEIC	National Enforcement Investigation Center
NIOSH	National Institute of Occupational Safety and Health
NPL	National Priorities List
ORR	Old Rifle Range
OSHA	Occupational Safety and Health Administration
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
%R	Percent Recovery
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovry Act
RPD	Relative Percent Difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedures
SOW	Statement of Work
SVOC	Semivolatile Organic Compounds
SWMU	Solid Waste Management Unit
USEPA	United States Environmental Protection Agency

LIST OF ACRONYMS/ABBREVIATIONS (Continued)

VOA	Volatile Organic Analysis
VOC	Volatile Organic Compounds
WP	Work Plan

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1.0 PROJECT DESCRIPTION

This Risk Assessment Work Plan (RA WP) Quality Assurance Project Plan (QAPP) is submitted to the Southern Division, Naval Facilities Engineering Command in response to Contract Task Order (CTO) No. 0076 under Comprehensive Long-Term Environmental Action Navy (CLEAN) Prime Contract No. N62472-90-D-1298 and Subcontract No. GCPP-91-001-1298.

The purpose of the RA WP is to identify the activities associated with performing a baseline risk assessment to address the human health and ecological impacts of past, present, and expected waste explosive open burning activities at Solid Waste Management Units (SWMU) #03/10 (Ammunition Burning Ground), and #07/09 (Old Rifle Range), and detonation activities at SWMU #06/09 (Demolition Range) at the Naval Surface Warfare Center, Crane Division, Crane, Indiana (NAVSURFWARCENDIV). It should be noted that the Ammunition Burning Ground (ABG) includes an area known as the "Jeep Trail." The Jeep Trail is located approximately one-half mile southeast of the ABG. This RA WP QAPP identifies the sampling and analytical activities associated with gathering the additional information necessary to perform the baseline risk assessment. It should be noted that air emission and air dispersion modeling results to be generated by CLEAN CTO Nos. 0052 and 0108 will be needed to perform the baseline risk assessment in order to address impacts caused by inhalation and deposition of airborne contaminants resulting from the open burning and detonation activities.

The NAVSURFWARCENDIV is located approximately 75 miles southwest of Indianapolis in south central Indiana and encompasses 63,000 acres in Martin County. The location of the NAVSURFWARCENDIV is shown on Figure 1-1.

1.1 RISK ASSESSMENT WORK PLAN OBJECTIVES

The primary objectives of this project are to identify the activities associated with performing a baseline risk assessment for soils, air, groundwater, and surface water/sediment at the ABG, Demolition Range (DR), and Old Rifle Range (ORR), and to prepare a Sampling and Analysis Plan (SAP) that describes how additional information necessary to perform the baseline risk assessment will be collected. The baseline risk assessment will address the human health and ecological impacts of the ABG, DR, and ORR in accordance with the requirements of 40 CFR Part 264 Subpart X, the Resource Conservation and Recovery Act (RCRA) Corrective Action requirements for ABG, DR, and

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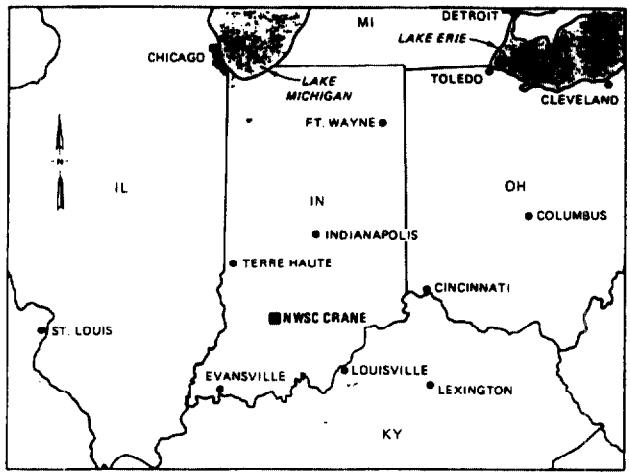
CLEAN CTO #0076

EPA ID NO. IN5 170 023 498
NAVSURFWARCENDIV RA QAPP
JULY 1995



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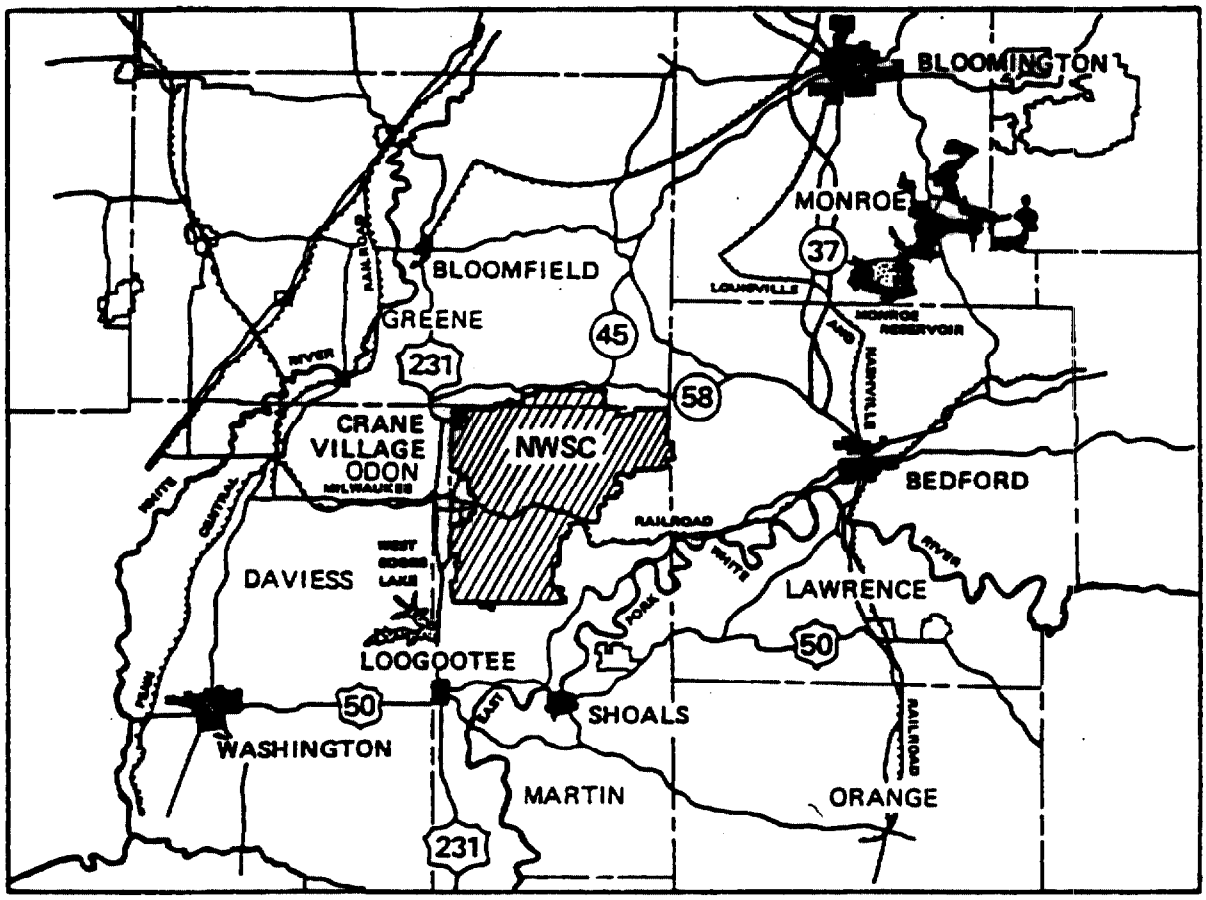

SOURCES: CHESAPEAKE DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, 1979 AND NAVAL ENERGY AND ENVIRONMENTAL SUPPORT AGENCY, 1983.

RUST ENVIRONMENT & INFRASTRUCTURE

JULY 1995

FIGURE 1-1

SITE LOCATION MAP

RISK ASSESSMENT WORK PLAN
NAVSURFWARCENDIV
CRANE, INDIANA

20615

DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

ORR identified in NAVSURFWARCENDIV's RCRA Part B permit, and the December 1989 Risk Assessment Guidance for Superfund (RAGS).

1.2 SAMPLING APPROACH AND OBJECTIVES

Based upon potential primary contaminant sources and potential contaminant migration pathways and impacts presented in Section 4.0 of the Work Plan for each SWMU, sampling needs specific to risk assessment within each SWMU have been identified. Samples to be collected as part of the risk assessment are presented in Section 4.0 of the Work Plan and summarized in Table 1-1. Section 4.0 of the Work Plan identifies, by medium, the numbers and locations of samples to be collected, analytical parameters, and the rationale for sample collection. Sampling locations for each media at the respective SWMUs are depicted on figures in Section 4.0 of the Work Plan.

The risk assessment investigative approach focuses on contaminant source characterization and the corresponding media impacts as indicated in Section 4.0 of the Work Plan. The nature and extent of hazardous waste or constituents and their concentrations in the respective media serve as the basis for evaluating human health and ecological risk with regard to the exposure scenarios depicted in the Work Plan. The risk assessment investigative approach incorporates the results of previous SWMU investigations completed as part of the federal portion of the RCRA Permit for NAVSURFWARCENDIV. Additionally, the objective of the risk assessment is to satisfy the requirements of 40 CFR Part 264 Subpart X, and comply with recommendations in the RAGS (December 1989), and the Corrective Action requirements as identified in the site's RCRA Part B permit.

The summary tables in Section 4.0 of the Work Plan also reflect a sampling approach involving selection of sample locations based on data needs identified from previous investigations. Both composite and grab samples will be collected for most media. Grab samples are targeted at potential contaminant hot spots, coincident with areas displaying observable impacts (i.e., soil staining) or within those areas considered most likely impacted based on past or present operations (i.e., sumps). Composite samples will be collected in conjunction with potential primary sources in an attempt to provide adequate source characterization, yet reduce the total number of samples. Subsamples are targeted at the perimeters of potential primary sources (i.e. burn pans, surface impoundments). Limited grid sampling will be conducted for less well defined potentially impacted areas (i.e., Army detonation area of the Demolition Range). Sampling procedures, equipment, decontamination, and documentation will be consistent for each of the three SWMUs.

TABLE 1-1

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #03/10 - AMMUNITION BURNING GROUND (and Old Jeep Trail)										
Soil		SVOC	IV	5	1	--	--	1	7	1
		Metals	IV	5	1	--	--	1	7	1
		Cyanide	IV	5	1	--	--	1	7	1
		Explosives	III	5	1	--	--	1	7	1
		Dioxin/Furan	III	3	1	1	--	1	6	1
Surface Water	Temp., pH, Specific Conductance		I	10	--	--	--	--	--	--
		VOC	IV	10	--	1	2	1	14	1
		SVOC	IV	10	--	1	--	1	12	1
		Metals(3)	IV	10	--	1	--	1	12	1
		Cyanide	IV	10	--	1	--	1	12	1
		Explosives	III	10	--	1	--	1	12	1
		COD	III	10	--	1	--	1	12	1
		TDS	III	10	--	1	--	1	12	1
		Sulfate	III	10	--	1	--	1	12	1
		Chloride	III	10	--	1	--	1	12	1
		Alkalinity	III	10	--	1	--	1	12	1
		NO_2+NO_3	III	10	--	1	--	1	12	1
Sediment		VOC	IV	5	1	--	1	1	8	1
		SVOC	IV	5	1	--	--	1	7	1
		Metals	IV	5	1	--	--	1	7	1
		Cyanide	IV	5	1	--	--	1	7	1
		Explosives	III	5	1	--	--	1	7	1
		NO_2+NO_3	III	5	1	--	--	1	7	1
Tissue		VOC	IV	25	--	--	2	3	30	1
		SVOC	IV	25	--	--	--	3	28	1
		Metals	IV	25	--	--	--	3	28	1
		Cyanide	IV	25	--	--	--	3	28	1
		Explosives	III	25	--	--	--	3	28	1
		NO_2+NO_3	III	25	--	--	--	3	28	1
Groundwater	Temp., pH, Specific Conductance		I	6	--	--	--	--	--	--
		VOC	IV	6	1	1	1	1	10	--
		SVOC	IV	6	1	1	--	1	9	--
		Metals(3)	IV	6	1	1	--	1	9	--

TABLE 1-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #03/10 - AMMUNITION BURNING GROUND (and Old Jeep Trail) (Continued)										
Groundwater (Continued)		Cyanide	IV	6	1	1	--	1	9	--
		Explosives	III	6	1	1	--	1	9	--
		COD	III	6	1	1	--	1	9	--
		TDS	III	6	1	1	--	1	9	--
		Sulfate	III	6	1	1	--	1	9	--
		Chloride	III	6	1	1	--	1	9	--
		Alkalinity	III	6	1	1	--	1	9	--
		NO_2+NO_3	III	6	1	1	--	1	9	--
SWMU #06/09 - DEMOLITION RANGE										
Soil		SVOC	IV	14	2	--	--	2	18	1
		Metals	IV	14	2	--	--	2	18	1
		Cyanide	IV	14	2	--	--	2	18	1
		Explosives	III	14	2	--	--	2	18	1
		Dioxin/Furan	III	3	1	--	--	--	4	--
Surface Water	Temp., pH, Specific Conductance		I	4	--	--	--	--	--	--
		VOC	IV	4	--	--	1	1	6	--
		SVOC	IV	4	--	--	--	1	5	--
		Metals(3)	IV	4	--	--	--	1	5	--
		Cyanide	IV	4	--	--	--	1	5	--
		Explosives	III	4	--	--	--	1	5	--
		Alkalinity	III	4	--	--	--	1	5	--
		COD	III	4	--	--	--	1	5	--
		TDS	III	4	--	--	--	1	5	--
		Chloride	III	4	--	--	--	1	5	--
		Sulfate	III	4	--	--	--	1	5	--
		NO_2+NO_3	III	4	--	--	--	1	5	--
Sediment		VOC	IV	4	--	--	1	--	5	--
		SVOC	IV	4	--	--	--	--	4	--
		Metals	IV	4	--	--	--	--	4	--
		Cyanide	IV	4	--	--	--	--	4	--
		Explosives	III	4	--	--	--	--	4	--
		NO_2+NO_3	III	4	--	--	--	--	4	--

TABLE 1-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #06/09 - DEMOLITION RANGE (Continued)										
Tissue		VOC	IV	25	--	--	2	3	30	2
		SVOC	IV	25	--	--	--	3	28	2
		Metals	IV	25	--	--	--	3	28	2
		Cyanide	IV	25	--	--	--	3	28	2
		Explosive	III	25	--	--	--	3	28	2
		NO_2+NO_3	III	25	--	--	--	3	28	2
Groundwater	Temp., pH, Specific Conductance		I	10	--	--	--	--	--	--
		VOC	IV	10	1	1	2	1	15	1
		SVOC	IV	10	1	1	--	1	13	1
		Metals(3)	IV	10	1	1	--	1	13	1
		Cyanide	IV	10	1	1	--	1	13	1
		Explosives	III	10	1	1	--	1	13	1
		COD	III	10	1	1	--	1	13	1
		TDS	III	10	1	1	--	1	13	1
		Chloride	III	10	1	1	--	1	13	1
		Sulfate	III	10	1	1	--	1	13	1
		Alkalinity	III	10	1	1	--	1	13	1
		NO_2+NO_3	III	10	1	1	--	1	13	1
SWMU #07/09 - OLD RIFLE RANGE										
Soil		SVOC	IV	6	1	--	--	--	7	--
		Metals	IV	6	1	--	--	--	7	--
		Cyanide	IV	6	1	--	--	--	7	--
		Explosives	III	6	1	--	--	--	7	--
		NO_2+NO_3	III	6	1	--	--	--	7	--
Surface Water	Temp., pH, Specific Conductance		I	2	--	--	--	--	--	--
		VOC	IV	2	--	1	1	--	4	--
		SVOC	IV	2	--	1	--	--	3	--
		Metals(3)	IV	2	--	1	--	--	3	--
		Cyanide	IV	2	--	1	--	--	3	--
		Explosives	III	2	--	1	--	--	3	--
		COD	III	2	--	1	--	--	3	--

TABLE 1-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

Location/Matrix	Field Parameters	Laboratory Parameters	EPA Level	Field Samples	Field QC(1) RB	FB	TB	FD	No. of Samples	Laboratory QC(2) LD/MS/MSD
SWMU #07/09 - OLD RIFLE RANGE (Continued)										
Surface Water (Continued)		TDS	III	2	--	1	--	--	3	--
		Sulfate	III	2	--	1	--	--	3	--
		Chloride	III	2	--	1	--	--	3	--
		Alkalinity	III	2	--	1	--	--	3	--
		NO_2+NO_3	III	2	--	1	--	--	3	--
Sediment		VOC	IV	2	--	--	1	1	4	--
		SVOC	IV	2	--	--	--	--	2	--
		Metals	IV	2	--	--	--	--	2	--
		Cyanide	IV	2	--	--	--	--	2	--
		Explosives	III	2	--	--	--	--	2	--
		NO_2+NO_2	III	2	--	--	--	--	2	--
Tissue		VOC	IV	25	--	--	2	2	29	1
		SVOC	IV	25	--	--	--	2	27	1
		Metals	IV	25	--	--	--	2	27	1
		Cyanide	IV	25	--	--	--	2	27	1
		Explosive	III	25	--	--	--	2	27	1
		NO_2+NO_3	III	25	--	--	--	2	27	1
Groundwater	Temp., pH, Specific Conductance		I	9	--	--	--	--	--	--
		VOC	IV	9	1	1	2	1	14	1
		SVOC	IV	9	1	1	--	1	12	1
		Metals(3)	IV	9	1	1	--	1	12	1
		Cyanide	IV	9	1	1	--	1	12	1
		Explosives	III	9	1	1	--	1	12	1
		COD	III	9	1	1	--	1	12	1
		TDS	III	9	1	1	--	1	12	1
		Sulfate	III	9	1	1	--	1	12	1
		Chloride	III	9	1	1	--	1	12	1
		Alkalinity	III	9	1	1	--	1	12	1
		NO_3+NO_2	III	9	1	1	--	1	12	1

TABLE 1-1 (Continued)

SAMPLING AND ANALYSIS SUMMARY
SWMUs #03/10, #06/09, #07/09

NOTES:

(1) Trip blanks will be provided at a frequency of one per cooler containing VOC samples (soil and water). The number of field blanks are based on two water sources. Rinsate blanks are collected at one per sampling method per day. Only samples obtained from every other day are analyzed. Field duplicates will be collected at a frequency of one per 10 samples collected. See Section 16.0 of Work Plan for event schedule.

(2) MS/MSD Samples are required for organic analysis. Samples shall be collected with extra sample volume at a frequency of one per 20 or fewer investigative samples per matrix. Triple the normal volume for aqueous collected for aqueous VOCs, SVOCs, explosives, and dioxin/furans. Double the normal volume for all other analysis.

(3) Metals and cyanide will be analyzed as total (unfiltered) samples.

FB - Field Blank
RB - Rinsate Blank
FD - Field Duplicate
LD - Laboratory Duplicate
MS - Matrix Spike
MSD - Matrix Spike Duplicate
TB - Trip Blank
SWMU - Solid Waste Management Unit
DQO - Data Quality Objective
QC - Quality Control
VOC - Volatile Organic Compound
SVOC - Semivolatile Organic Compound
COD - Chemical Oxygen Demand
TDS - Total Dissolved Solids
NO_3+ NO_2 - Nitrate Plus Nitrite

1.3 SAMPLE COLLECTION AND RATIONALE

The rationale and locations for sample collection are described in Section 4.0 of the Work Plan.

1.4 PARAMETERS TO BE TESTED AND FREQUENCY

A summary of the samples to be collected and analyses to be performed is presented in Table 1-1.

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2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Navy Remedial Project Manager (RPM) through the Naval Facilities CLEAN Program Director will provide direction for the Halliburton NUS Team Project Manager through the CLEAN Program Manager at Halliburton NUS. The various management and Quality Assurance (QA) responsibilities of key project personnel are shown on Figure 2-1 and are described below.

CLEAN Program Manager

The CLEAN Program Manager, John Trepanowski, has overall responsibility for ensuring that the project meets the CLEAN quality objectives and standards. In addition, the CLEAN Program Manager is responsible for technical Quality Control (QC) and project oversight, and will provide communication with management at the Department of the Navy.

CLEAN Quality Assurance Manager

The CLEAN QA Manager, Debra Scheib, is responsible for QA/QC monitoring at the program level, QA/QC monitoring of the subcontractors, QA/QC training, and updates to the CLEAN QC Management Plan. The CLEAN QA Manager will also assist the Program and Project Managers in resolution of issues related to quality that may occur in the field.

Project Manager

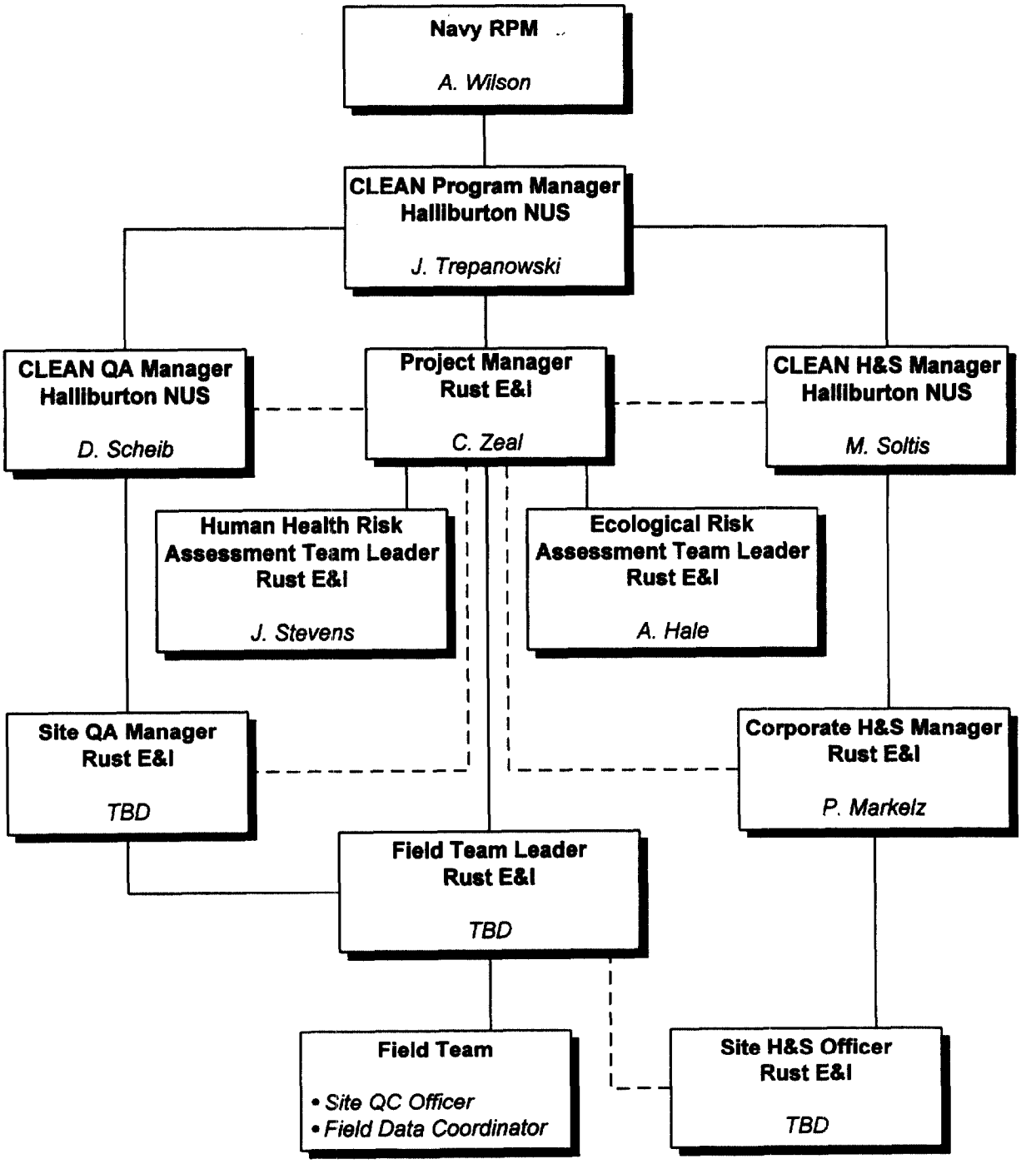
The Project Manager, Charles Zeal, P.E., is responsible for implementing the project, and has the authority to commit the resources necessary to meet project objectives and requirements. The Project Manager's primary function is to ensure that technical, financial, and scheduling objectives are achieved successfully. He will also be responsible for the preparation and quality of interim and final reports.

Field Team Leader

The Field Team Leader (FTL) is responsible for leading and coordinating the daily field activities, including sample collection. The FTL reports directly to the Project Manager and will assist in report preparation. He will also identify problems at the field team level, resolve identified problems with the Project Manager, and provide the communication link between the field team and upper management. The FTL has not been identified at this time.

FIGURE 2-1

PROJECT ORGANIZATION CHART
ABG, DR, & ORR BASELINE RISK ASSESSMENT
NAVSURFWARCENDIV
CRANE, INDIANA



Site Quality Assurance Manager

The Site QA Manager, Greg Ruechel, in conjunction with the CLEAN QA Manager, will oversee implementation of the Quality Assurance Project Plan (QAPP) on the project. He will also be responsible for the evaluation of the field and laboratory QC measures for this project.

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3.0 QUALITY ASSURANCE OBJECTIVES FOR ANALYTICAL DATA

The overall QA objective is to ensure that the data are of known and acceptable quality. The analytical quality will be maintained through the use of United States Environmental Protection Agency (USEPA) or National Institute of Occupational Safety and Health (NIOSH) analysis methods and EPA Level III and IV QC data packages with diskette deliverables, as defined in Data Quality Objectives for Remedial Response Activities (NTIS PB90-272634).

3.1 DATA QUALITY OBJECTIVE LEVELS

The QC levels proposed for this project are EPA Levels I, III, and IV.

3.1.1 EPA Level IV

EPA Level IV QC is used for sites that are on or about to be on the National Priorities List (NPL). These sites are typically near populated areas and are likely to undergo litigation. Level IV QC includes review and approval of the laboratory QC plan, the site work plan, and the field QC plan. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit, and provide monthly progress reports (MPRs) on QA. These activities will be administered and evaluated by the NCR. This audit and the analysis performance sample are in addition to those related to the EPA Superfund Program. The laboratory that performs Level IV QC must have passed the performance sample furnished through the Superfund Contract Laboratory Protocol (CLP) and must be able to generate the CLP deliverables. For a Level IV site, the CLP methods are used and the CLP data package generated. The Navy audit and performance sample are required in addition to any specified by the EPA Superfund Program.

To assess whether the overall quality assurance objectives have been met, analysis of specific field quality control samples and laboratory quality control samples are required for Level IV. These quality control samples include field blanks, field duplicates, laboratory duplicates, matrix spike, matrix spike duplicates and laboratory control samples. The preparation of each of these types of samples is described in Sections 3.2 and 9.0. The frequency with which they will be collected/analyzed is presented in Table 1-1.

3.1.2 EPA Level III

A site requiring Level III QC would be a site near a populated area, not on the NPL, and not likely to be undergoing litigation. The Level III QC includes review and approval of the laboratory QA and the site work plan. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit, and provide MPRs on QA. The laboratory that performs Level III QC must have passed the performance sample furnished by the Superfund CLP in the past year. The laboratory does not need to be receiving CLP bid lots of samples.

Level III allows the use of non-CLP methods but requires that the methods be accepted EPA methods. All methods used must be EPA methods or be equivalent to EPA methods. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit, and provide MPRs on QA. These audits will be administered and evaluated by the NCR. The Navy audit and performance sample are required in addition to any specified by the EPA Superfund Program.

3.1.3 EPA Level I

EPA Level I will be used for field parameters such as temperature, pH, and specific conductance. Equipment rinsate blanks, field blanks, and field duplicates are not required for this level.

3.2 FIELD SPECIFIC QUALITY CONTROL SAMPLES

To achieve the overall Data Quality Objectives (DQOs), proper sample handling, sample analysis, and data handling procedures will be followed. These procedures are described in the following sections of this QAPP and are in accordance with the requirements and recommendations of each analytical method. This document describes the specific objectives for analytical precision, accuracy, representativeness, completeness, and comparability (PARCC).

3.2.1 Field Blanks

Field blanks are samples of source water used for decontamination and steam cleaning. At a minimum, one sample for each source of water for a given event will be collected for analyses. There will be two field blanks per event: a sample of the potable water used for steam cleaning and a sample of the deionized water used for decontamination. If more than one source of deionized water is used or if potable water is taken from more than one

location, then additional field blanks will be collected and analyzed for the same suite of parameters as that of samples.

3.2.2 Field Duplicates

Field duplicate results will be used to assess the precision of the sample results. They will be used to monitor overall precision, including the reproducibility of sampling and analytical procedures. Field duplicate samples will be collected at a frequency of 1 per group of 10 or fewer investigative samples.

3.2.3 Trip Blanks

Trip blanks are used to detect potential contamination by volatile organic compounds (VOCs) during sample shipping and handling. Trip blanks are 40 ml volatile organic analysis (VOA) vials of ASTM Type II water that are filled in the laboratory, transported to the sampling site, and returned to the laboratory with VOC samples. Each trip blank is to be stored at the laboratory with associated samples and analyzed with those samples. Trip blanks are only analyzed for VOCs. Trip blanks must be sent with both water and soil samples; however, they are always analyzed and reported as water samples. Trip blanks will also accompany and be analyzed for associated tissue samples.

3.2.4 Equipment Rinsates

Equipment rinsates are samples of ASTM Type II water passed through decontaminated sampling equipment immediately prior to sample collection. They are used as a measure of decontamination process effectiveness. Equipment rinsates are collected daily during the sampling event. Matrices for this purpose are considered to be soils, sediments, or waters. One rinsate blank will be collected per sampling team. Equipment rinsates are analyzed for the same analytes as samples collected that day. Equipment rinsates are always analyzed and reported as water samples. Equipment rinsates collected every other day will be analyzed. Others will be marked "hold" on the chain of custody forms and analysis will be as deemed necessary by the Navy RPM, Project Manager, and QA Manager with consideration of elapsed holding time.

3.3 PARCC CRITERIA

Critical indicators of project data quality are precision, accuracy, representativeness, completeness, and comparability. Objectives for these indicator parameters were developed for this project based on past experience and on the objectives of this RA. Field

procedures, analytical methods, and the project QA Program were selected and developed to meet these objectives.

3.3.1 Precision

Precision refers to the reproducibility of measurements of the same characteristics, usually under a set of conditions. For large data sets, precision is expressed as the measure of variability of a group of measurements compared to their average value [i.e. Relative Percent Difference (RPD) of the pair].

The precision of field measurements (e.g. temperature, specific conductance, and pH) will be evaluated based on the results of duplicate measurements. The results will be compared to the established acceptance criteria shown in Table 3-1.

The precision of chemical analyses will be assessed through the analysis of field duplicate samples, matrix spike/matrix spike duplicate (MS/MSD) samples, and laboratory duplicates. MS/MSD samples and laboratory duplicates will be analyzed at a frequency of 1 per group of 20 or fewer investigative samples per sample matrix. Each QC sample type will provide unique information regarding the precision of the program:

- Field duplicate samples: sampling and laboratory precision.
- MS/MSD samples, laboratory duplicates: analytical precision.

General precision acceptance criteria for duplicate and MS/MSD samples are presented in Table 3-1. When analytes are present in samples either near the method detection limit or substantially above the detection limit, these objectives may not be met. If precision objectives are not met, other QC data will be evaluated to determine the usability of the data.

3.3.2 Accuracy

Accuracy refers to the degree of agreement of a measurement to the true value. The accuracy of a measurement system is impacted by errors introduced through the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques. Sampling accuracy will be evaluated based on the results of the analysis of field blanks, VOCs trip blanks, and equipment rinsate samples. Analytical accuracy will be evaluated on the basis of MS samples, surrogate compounds, laboratory control standards (LCSs), and method blank samples. MS samples, LCSs, and method blank samples will be analyzed at a frequency of 1 per group of 20 or fewer investigative

TABLE 3-1
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

		Precision				Accuracy					
Analyte Group	Matrix	Laboratory Duplicates or Matrix Spike Duplicate (RPD)		Field Duplicate (RPD)		Matrix Spike and/or MSD (% Recovery)		Surrogate Spike (% Recovery)		Rinsate Blank (max. conc.)	Trip Blank (max. conc.)
Volatile Organics	Soil/ Tissue	1,1-Dichloroethene:	22	All compounds:	110	1,1-Dichloroethene:	59-172	Toluene-d8:	84-138	5x DL except lab solvents	5x DL except lab solvents
		Trichloroethene:	24			Trichloroethene:	62-137	BFB:	59-113		
		Benzene:	21			Benzene:	66-142	1,2-DCA-d4:	70-121		
		Toluene:	21			Toluene:	59-139				
		Chlorobenzene:	21			Chlorobenzene:	60-133				
Volatile Organics	Water	1,1-Dichloroethene:	14	All compounds:	80	1,1-Dichloroethene:	61-145	Toluene-d8:	88-110	5x DL except lab solvents	5x DL except lab solvents
		Trichloroethene:	14			Trichloroethene:	71-120	BFB:	86-115		
		Benzene:	11			Benzene:	76-127	1,2-DCA-d4:	76-114		
		Toluene:	13			Toluene:	76-125				
		Chlorobenzene:	13			Chlorobenzene:	75-130				
Semivolatile Organics	Soil/ Tissue	Phenol:	35	All compounds:	75	Phenol:	26-90	Nitrobenzene-d5:	23-120	<DL	N/A
		2-Chlorophenol:	50			2-Chlorophenol:	25-102	2-Fluourobiphenyl:	30-115		
		1,4-Dichlorobenzene:	27			1,4-Dichlorobenzene:	28-104	Terphenyl-d14:	18-137		
		N-Nitroso-di-n-prop.:	38			N-Nitroso-di-n-prop.:	41-126	Phenol-d5:	24-113		
		1,2,4-Trichlorobenzene:	23			1,2,4-Trichlorobenzene:	38-107	2-Fluorophenol:	25-121		
		4-Chloro-3-methylphenol:	33			4-Chloro-3-methylphenol:	26-103	2,4,6-Tribromophenol:	19-122		
		Acenaphthene:	19			Acenaphthene:	31-137	2-Chlorophenol-d4:	20-130		
		4-Nitrophenol:	50			4-Nitrophenol:	11-114	1,2-Dichlorobenzene-d4:	20-130		
		2,4-Dinitrotoluene:	47			2,4-Dinitrotoluene:	28-89				
		Pentachlorophenol:	47			Pentachlorophenol:	17-109				
		Pyrene:	36			Pyrene:	35-142				
Semivolatile Organics	Water	Phenol:	42	All compounds:	75	Phenol:	12-110	Nitrobenzene-d5:	35-114	<DL	N/A
		2-Chlorophenol:	40			2-Chlorophenol:	27-123	2-Fluourobiphenyl:	43-116		
		1,4-Dichlorobenzene:	28			1,4-Dichlorobenzene:	36-97	Terphenyl-d4:	33-141		
		N-Nitroso-di-n-prop.:	38			N-Nitroso-di-n-prop.:	41-116	Phenol-d5:	10-110		
		1,2,4-Trichlorobenzene:	28			1,2,4-Trichlorobenzene:	39-98	2-Fluorophenol:	21-110		
		4-Chloro-3-methylphenol:	42			4-Chloro-3-methylphenol:	23-97	2,4,6-Tribromophenol:	10-123		
		Acenaphthene:	31			Acenaphthene:	46-118	2-Chlorophenol-d4:	33-110		
		4-Nitrophenol:	50			4-Nitrophenol:	10-80	1,2-Dichlorobenzene-d4:	16-110		
		2,4-Dinitrotoluene:	38			2,4-Dinitrotoluene:	24-96				
		Pentachlorophenol:	50			Pentachlorophenol:	9-103				
		Pyrene:	31			Pyrene:	26-127				

TABLE 3-1 (Continued)
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

		Precision				Accuracy				
Analyte Group	Matrix	Laboratory Duplicates or Matrix Spike Duplicate (RPD)		Field Duplicate (RPD)		Matrix Spike and/or MSD (% Recovery)		Surrogate Spike (% Recovery)	Rinsate Blank (max. conc.)	Trip Blank (max. conc.)
Dioxin/Furans	Soil	NA		All Compounds:	75	N/A		NA	<DL	N/A
Metals	Soil/ Tissue	Aluminum:	20	Aluminum:	50	Aluminum:	75-125	N/A	<DL	N/A
		Antimony:	20	Antimony:	50	Antimony:	75-125	N/A	<DL	N/A
		Arsenic:	20	Arsenic:	50	Arsenic:	75-125	N/A	<DL	N/A
		Beryllium:	20	Beryllium:	50	Beryllium:	75-125	N/A	<DL	N/A
		Barium:	20	Barium:	50	Barium:	75-125	N/A	<DL	N/A
		Cadmium:	20	Cadmium:	50	Cadmium:	75-125	N/A	<DL	N/A
		Calcium:	20	Calcium:	50	Calcium:	75-125	N/A	<DL	N/A
		Chromium:	20	Chromium:	50	Chromium:	75-125	N/A	<DL	N/A
		Cobalt:	20	Cobalt:	50	Cobalt:	75-125	N/A	<DL	N/A
		Copper:	20	Copper:	50	Copper:	75-125	N/A	<DL	N/A
		Iron:	20	Iron:	50	Iron:	75-125	N/A	<DL	N/A
		Lead:	20	Lead:	50	Lead:	75-125	N/A	<DL	N/A
		Magnesium:	20	Magnesium:	50	Magnesium:	75-125	N/A	<DL	N/A
		Manganese:	20	Manganese:	50	Manganese:	75-125	N/A	<DL	N/A
		Mercury:	20	Mercury:	50	Mercury:	75-125	N/A	<DL	N/A
		Nickel:	20	Nickel:	50	Nickel:	75-125	N/A	<DL	N/A
		Potassium:	20	Potassium:	50	Potassium:	75-125	N/A	<DL	N/A
		Selenium:	20	Selenium:	50	Selenium:	75-125	N/A	<DL	N/A
		Silver:	20	Silver:	50	Silver:	75-125	N/A	<DL	N/A
		Sodium:	20	Sodium:	50	Sodium:	75-125	N/A	<DL	N/A
		Thallium:	20	Thallium:	50	Thallium:	75-125	N/A	<DL	N/A
		Tin:	20	Tin:	50	Tin:	75-125	N/A	<DL	N/A
		Vanadium:	20	Vanadium:	50	Vanadium:	75-125	N/A	<DL	N/A
		Zinc:	20	Zinc:	50	Zinc:	75-125	N/A	<DL	N/A

TABLE 3-1 (Continued)
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

		Precision				Accuracy				
Analyte Group	Matrix	Laboratory Duplicates or Matrix Spike Duplicate (RPD)		Field Duplicate (RPD)		Matrix Spike and/or MSD (% Recovery)		Surrogate Spike (% Recovery)	Rinsate Blank (max. conc.)	Trip Blank (max. conc.)
Metals	Water	Aluminum:	20	Aluminum:	40	Aluminum:	75-125	N/A	<DL	N/A
		Antimony:	20	Antimony:	40	Antimony:	75-125	N/A	<DL	N/A
		Arsenic:	20	Arsenic:	40	Arsenic:	75-125	N/A	<DL	N/A
		Beryllium:	20	Beryllium:	40	Beryllium:	75-125	N/A	<DL	N/A
		Barium:	20	Barium:	40	Barium:	75-125	N/A	<DL	N/A
		Cadmium:	20	Cadmium:	40	Cadmium:	75-125	N/A	<DL	N/A
		Calcium:	20	Calcium:	40	Calcium:	75-125	N/A	<DL	N/A
		Chromium:	20	Chromium:	40	Chromium:	75-125	N/A	<DL	N/A
		Cobalt:	20	Cobalt:	40	Cobalt:	75-125	N/A	<DL	N/A
		Copper:	20	Copper:	40	Copper:	75-125	N/A	<DL	N/A
		Iron:	20	Iron:	40	Iron:	75-125	N/A	<DL	N/A
		Lead:	20	Lead:	40	Lead:	75-125	N/A	<DL	N/A
		Magnesium:	20	Magnesium:	40	Magnesium:	75-125	N/A	<DL	N/A
		Manganese:	20	Manganese:	40	Manganese:	75-125	N/A	<DL	N/A
		Mercury:	20	Mercury:	40	Mercury:	75-125	N/A	<DL	N/A
		Nickel:	20	Nickel:	40	Nickel:	75-125	N/A	<DL	N/A
		Potassium:	20	Potassium:	40	Potassium:	75-125	N/A	<DL	N/A
		Selenium:	20	Selenium:	40	Selenium:	75-125	N/A	<DL	N/A
		Silver:	20	Silver:	40	Silver:	75-125	N/A	<DL	N/A
		Sodium:	20	Sodium:	40	Sodium:	75-125	N/A	<DL	N/A
		Thallium:	20	Thallium:	40	Thallium:	75-125	N/A	<DL	N/A
		Vanadium:	20	Vanadium:	40	Vanadium:	75-125	N/A	<DL	N/A
		Zinc:	20	Zinc:	40	Zinc:	75-125	N/A	<DL	N/A
Explosives	Soil/ Tissue	All compounds:	25	All compounds:	50	All compounds:	75-125	N/A	<DL	N/A
Explosives	Water	All compounds:	25	All compounds:	50	All compounds:	75-125	N/A	<DL	N/A
Cyanide	Soil/ Tissue	All compounds:	35		40	75-125		N/A	<DL	N/A
Cyanide	Water		20		40	75-125		N/A	<DL	N/A
Nitrite+Nitrate	Soil/ Tissue		20		40	80-120		N/A	<DL	N/A
Nitrite+Nitrate	Water		20		40	80-120		N/A	<DL	N/A
Chemical Oxygen Demand (COD)	Water		20		40	N/A		N/A	<DL	N/A
Chloride	Water		20		40	80-120		N/A	<DL	N/A
Sulfate	Water		20		40	80-120		N/A	<DL	N/A

TABLE 3-1 (Continued)
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

		Precision		Accuracy			
Analyte Group	Matrix	Laboratory Duplicates or Matrix Spike Duplicate (RPD)	Field Duplicate (RPD)	Matrix Spike and/or MSD (% Recovery)	Surrogate Spike (% Recovery)	Rinsate Blank (max. conc.)	Trip Blank (max. conc.)
Alkalinity	Water	20	40	N/A	N/A	<DL	N/A
Total Dissolved Solids (TDS)	Water	20	40	N/A	N/A	<DL	N/A
pH	Water	10	10	N/A	N/A	N/A	N/A
Temperature	Water	N/A	10	N/A	N/A	N/A	N/A
Conductivity	Water	N/A	10	N/A	N/A	N/A	N/A

Notes: 1,2-DCA-d4 = 1,2-Dichloroethane-d4
BFB = 4-Bromofluorobenzene
N/A = Not Applicable
RPD = Relative Percent Difference
DL = Detection Limit
MSD = Matrix Spike Duplicate
RPDs and % Recoveries for Volatile Organic compounds and Semivolatile Organic Compounds for soil and water are determined from USEPA Contract Laboratory Program Statement of Work for Organic Analysis, Document Number OLM01.0 with current revisions.
RPDs and % Recoveries for TAL Metals and Cyanide for soil and water are determined from U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, Document Number ILM02.1 with current revisions
RPDs and % Recoveries for explosives, dioxin/furans, and water quality parameters are determined from internal laboratory quality control/quality assurance limits.

samples per sample matrix. Surrogate compounds are added to every sample and standard that require them.

The results of blank samples, expressed in the units of measurement (e.g. ug/l), will provide information on positive bias. Blank samples should not contain analytes of interest above background levels, preferably not above method detection limits. The results of spiked samples and reference standards will be expressed as percent recovery (%R) and will provide information on positive and negative bias. Objectives for MS samples and surrogate compounds, expressed in %R, are presented in Table 3-1. Objectives for LCSs are those provided by the supplier for LCSs purchased commercially or procured from the USEPA.

3.3.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness will be satisfied by ensuring that the proper sampling techniques are used, proper analytical procedures are followed, and sample holding times are not exceeded by the laboratory.

3.3.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. It is expected that the laboratories will provide data meeting QC acceptance criteria for 90 percent or more for all samples tested using the analytical methods listed in Table 8-1.

3.3.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. The use of standard USEPA analytical methodologies, CLP methods or non-CLP methods, to obtain the planned analytical data, as documented in the QAPP, are expected to provide comparable data. The new analytical data, however, may not be directly comparable to previously collected data at the SWMUs because of differences in procedures and QA objectives.

3.4 SENSITIVITY

The sensitivity of analysis is measured by the use of detection limits. The detection limits to be used for this project are given in Tables 3-2 through 3-7.

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TABLE 3-2

VOCs AND REQUIRED QUANTITATION LIMITS

	Compound	Quantitation Limits* Water ug/L	Low Soil/Tissue ug/Kg	Med. Soil/Tissue ug/kg
1.	Chloromethane	10	10	1200
2.	Bromomethane	10	10	1200
3.	Vinyl Chloride	10	10	1200
4.	Chloroethane	10	10	1200
5.	Methylene Chloride	10	10	1200
6.	Acetone	10	10	1200
7.	Carbon Disulfide	10	10	1200
8.	1,1-Dichloroethene	10	10	1200
9.	1,1-Dichloroethane	10	10	1200
10.	1,2-Dichloroethene (total)	10	10	1200
11.	Chloroform	10	10	1200
12.	1,2-Dichloroethane	10	10	1200
13.	2-Butanone	10	10	1200
14.	1,1,1-Trichloroethane	10	10	1200
15.	Carbon Tetrachloride	10	10	1200
16.	Bromodichloromethane	10	10	1200
17.	1,2-Dichloropropane	10	10	1200
18.	cis-1,3-Dichloropropene	10	10	1200
19.	Trichloroethene	10	10	1200
20.	Dibromochloromethane	10	10	1200
21.	1,1,2-Trichloroethane	10	10	1200
22.	Benzene	10	10	1200
23.	trans-1,3-Dichloropropene	10	10	1200
24.	Bromoform	10	10	1200
25.	4-Methyl-2-pentanone	10	10	1200
26.	2-Hexanone	10	10	1200
27.	Tetrachloroethene	10	10	1200
28.	Toluene	10	10	1200
29.	1,1,2,2-Tetrachloroethane	10	10	1200
30.	Chlorobenzene	10	10	1200
31.	Ethyl benzene	10	10	1200
32.	Styrene	10	10	1200
33.	Xylenes (total)	10	10	1200

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

TABLE 3-3

SVOCs AND REQUIRED QUANTITATION LIMITS

Compound	Quantitation Limits* Water ug/L	Low Soil/Tissue ug/Kg	Med. Soil/Tissue ug/kg
34. Phenol	10	330	10000
35. bis(2-Chloroethyl) ether	10	330	10000
36. 2-Chlorophenol	10	330	10000
37. 1,3-Dichlorobenzene	10	330	10000
38. 1,4-Dichlorobenzene	10	330	10000
39. 1,2-Dichlorobenzene	10	330	10000
40. 2-Methylphenol	10	330	10000
41. 2,2'-oxybis-(1-Chloropropane)**	10	330	10000
42. 4-Methylphenol	10	330	10000
43. N-Nitroso-di-n-dipropylamine	10	330	10000
44. Hexachloroethane	10	330	10000
45. Nitrobenzene	10	330	10000
46. Isophorone	10	330	10000
47. 2-Nitrophenol	10	330	10000
48. 2,4-Dimethylphenol	10	330	10000
49. bis(2-Chloroethoxy) methane	10	330	10000
50. 2,4-Dichlorophenol	10	330	10000
51. 1,2,4-Trichlorobenzene	10	330	10000
52. Naphthalene	10	330	10000
53. 4-Chloroaniline	10	330	10000
54. Hexachlorobutadiene	10	330	10000
55. 4-Chloro-3-methylphenol	10	330	10000
56. 2-Methylnaphthalene	10	330	10000
57. Hexachlorocyclopentadiene	10	330	10000
58. 2,4,6-Trichlorophenol	10	330	10000

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

** Previously known by the name of bis(2-chloroisopropyl) ether.

TABLE 3-3 (Continued)

SVOCs AND REQUIRED QUANTITATION LIMITS

Compound	Quantitation Limits* Water ug/L	Low Soil/Tissue ug/Kg	Med. Soil/Tissue ug/kg
59. 2,4,5-Trichlorophenol	25	800	25000
60. 2-Chloronaphthalene	10	330	10000
61. 2-Nitroaniline	25	800	25000
62. Dimethylphthalate	10	330	10000
63. Acenaphthalene	10	330	10000
64. 2,6-Dinitrotoluene	10	330	10000
65. 3-Nitroaniline	25	800	25000
66. Acenaphthene	10	330	10000
67. 2,4-Dinitrophenol	25	800	25000
68. 4-Nitrophenol	25	800	25000
69. Dibenzofuran	10	330	10000
70. 2,4-Dinitrotoluene	10	330	10000
71. Diethylphthalate	10	330	10000
72. 4-Chlorophenyl-phenyl ether	10	330	10000
73. Fluorene	10	330	10000
74. 4-Nitroaniline	25	800	25000
75. 4,6-Dinitro-2-methylphenol	25	800	25000
76. N-Nitrosodiphenylamine	10	330	10000
77. 4-Bromophenyl-phenyl ether	10	330	10000
78. Hexachlorobenzene	10	330	10000
79. Pentachlorophenol	25	800	25000
80. Phenanthrene	10	330	10000
81. Anthracene	10	330	10000
82. Carbazole	10	330	10000
83. Di-n-butylphthalate	10	330	10000
84. Fluoranthene	10	330	10000
85. Pyrene	10	330	10000
86. Butylbenzylphthalate	10	330	10000
87. 3,3-Dichlorobenzidine	10	330	10000

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

TABLE 3-3 (Continued)

SVOCs AND REQUIRED QUANTITATION LIMITS

Compound	Quantitation Limits* Water ug/L	Low Soil/Tissue ug/Kg	Med. Soil/Tissue ug/kg
88. Benzo(a)anthracene	10	330	10000
89. Chrysene	10	330	10000
90. bis(2-Ethylhexyl)phthalate	10	330	10000
91. Di-n-octylphthalate	10	330	10000
92. Benzo(b)fluoranthene	10	330	10000
93. Benzo(k)fluoranthene	10	330	10000
94. Benzo(a)pyrene	10	330	10000
95. Indeno(1,2,3-cd)pyrene	10	330	10000
96. Dibenzo(a,h)anthracene	10	330	10000
97. Benzo(g,h,i)perylene	10	330	10000

* Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

TABLE 3-4

METALS QUANTITATION LIMITS (1,2,3)

Analyte	Water (ug/L)	Soil/Tissue (mg/kg)
Aluminum	200	20
Antimony	60	6
Arsenic	10	1
Barium	200	20
Beryllium	5	0.5
Cadmium	5	0.5
Calcium	5000	500
Chromium	10	1
Cobalt	50	5
Copper	25	2.5
Iron	100	10
Lead	3	0.3
Magnesium	5000	500
Manganese	15	1.5
Mercury	0.2	0.02
Nickel	40	4
Potassium	5000	500
Selenium	5	0.5
Silver	10	1
Sodium	5000	500
Thallium	10	1
Tin	N/A	2
Vanadium	50	5
Zinc	20	2
Cyanide	10	1

(1) Subject to the restrictions specified in the first page of Part G, Section IV of Exhibit D for ILM01.0 (Alternate Methods - Catastrophic Failure). Any analytical method specified in SOW Exhibit D may be utilized as long as the documented instrument or method detection limits meet the Required Detection Limit requirements. Higher detection limits may only be used in the following circumstances:

If the sample concentration exceeds five times the detection limit of the instrument or method in use, the values may be reported even though the instrument or method detection limit may not equal the Required Detection Limit. This is illustrated in the example below:

For lead:	Method in use=ICP	Instrument Detection Limit (IDL)=40
	Sample concentration=200	Required Detection Limit (RDL)=3

The value of 200 may be reported even though the instrument detection limit is greater than the required detection limit. The instrument or method detection limit must be documented as described in Exhibit E.

(2) The instrument detection limits obtained in pure water that must be met using the procedure in Exhibit E of OLM01.0. The detection limits for samples may be considerably higher depending on the sample matrix.

(3) Detection limits for soil are based on wet weight. The detection limits are calculated by the laboratory for soil. Sample results will be reported on a dry weight basis.

N/A = Not applicable

TABLE 3-5

EXPLOSIVES COMPOUND LIST AND QUANTITATION LIMITS

Explosives	Abbrev	Water (ug/L)	Soil/ Tissue (ug/kg)
Octahydro-1,3,5,7-tetranitro-1,3, 5,7-tetrazocine	HMX	13.0	2.2
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	14.0	1.0
1,3,5-Trinitrobenzene	TNB	7.3	0.25
1,3-Dinitrobenzene	DNB	4.0	0.25
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	44.0	0.65
Nitrobenzene	NB	9.0	0.26
2,4,6-Trinitrotoluene	TNT	6.9	0.25
2,4-Dinitrotoluene	24DNT	5.7	0.25
2,6-Dinitrotoluene	26DNT	9.4	0.26
o-Nitrotoluene	2NT	12.0	0.25
m-Nitrotoluene	3NT	7.9	0.25
p-Nitrotoluene	4NT	8.5	0.25

TABLE 3-6

WATER QUALITY ANALYTE LIST

Analyte	Quantitatation Limit Aqueous mg/l	Quantitation Limit Soil/Tissue[a] mg/kg
Chemical Oxygen Demand (COD)	10	-
Total Dissolved Solids (TDS)	1.0	-
Alkalinity	20	-
Chloride (Cl)	0.2	-
Sulfate (SO_4)	0.2	-
Nitrite + Nitrate Nitrogen (NO_2+NO_3)	0.2	0.4

(a) Quantitation limits for soil are based on wet weight. The quantitation limits are calculated by the laboratory for soils. Sample results will be reported on a dry weight basis.

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TABLE 3-7

DIOXIN/FURAN COMPOUND LIST AND QUANTITATION LIMITS

Analytes	Abbrev	Soil ng/kg
2,3,7,8-Tetrachlorodibenzo-p-dioxin	2,3,7,8-TCDD	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeCDD	5
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD	5
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD	5
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD	5
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpCDD	5
2,3,7,8-Tetrachlorodibenzofuran	2,3,7,8-TCDF	1
1,2,3,7,8-Pentachlorodibenzofuran	1,2,3,7,8-PeCDF	5
2,3,4,7,8-Pentachlorodibenxofuran	2,3,4,7,8-PeCDF	5
1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF	5
1,2,3,7,8,9-Hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF	5
1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF	5
2,3,4,6,7,8-Hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF	5
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF	5
1,2,3,4,7,8,9-Heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF	5
1,2,3,4,5,6,7,8-Octachlorodibenzo-p-dioxin	1,2,3,4,5,6,7,8-OCDD	10
1,2,3,4,5,6,7,8-Octachlorodibenzofuran	1,2,3,4,5,6,7,8-OCDF	10

ng/kg = nanogram per kilogram
ng/kg = parts per trillion (ppt)

1 ppm = 1000 ppb
1 ppb = 1000 ppt

4.0 SAMPLING PROCEDURES

Media-specific sampling procedures are briefly described below. Sampling procedures are detailed in Section 9.0 of the Work Plan and integrate Halliburton NUS Standard Operating Procedures (SOPs) as contained in Appendix A of the Work Plan. Sample containers will be certified clean by the laboratory or vendor responsible for supplying them. Table 4-1 contains a list of the type and quantities of sample containers required for each analysis, the sample preservation techniques, and holding times.

4.1 SURFACE SOIL SAMPLING

Surface (0 to 6 inches) soil samples will be collected to characterize potential releases to soil from primary sources and subsequently evaluate risk to human and environmental receptors. Sample locations are described in Table 4-1 of the Work Plan and shown on figures in Section 3.0 in the Work Plan. Discrete grab as well as composite samples will be collected with a stainless steel hand trowel, examined for visual signs of contamination, and placed directly into appropriate sample jars or mixing bowls (composites only). Sampling procedures, equipment, quality control, and decontamination are detailed in Section 9.0 of the Work Plan.

4.2 SURFACE WATER AND SEDIMENT SAMPLING

One round of surface water and sediment samples will be collected to evaluate potential contaminant impacts to water bodies and drainageways adjacent to, and within, the SWMUs. At the ABG, surface water sampling will also include springs identified as being hydraulically connected to the ABG. Sample locations are described in tables in Section 4.0 of the Work Plan and shown on figures in Section 3.0 of the Work Plan. Surface water grab samples will be collected by immersing the sample container in the body of water. Sediment grab samples will be collected with a sampling tube, split spoon or mud auger. Sampling procedures, equipment, decontamination, quality control, and documentation are detailed in Section 9.0 of the Work Plan.

4.3 MONITORING WELL INSTALLATION

Groundwater monitoring well installation will include subsurface soil sampling and rock coring to allow characterization of subsurface stratigraphy and ensure placement of well

TABLE 4-1

REQUIRED SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
Soil/ Sediment	VOC	Two 60-ml septum-seal wide-mouth glass jars	4°C	14 days
	SVOC	One 8-oz. wide-mouth glass jar	4°C	Extract in 7 days Analyze in 40 days
	Metals	One 8-oz. wide-mouth glass jar	4°C	Mercury 28 days, All others 6 months
	Cyanide	One 8-oz. wide-mouth glass jar	4°C	14 days
	Explosives	One 4-oz. wide-mouth glass jar	4°C	Extract in 14 days Analyze in 40 days
	Dioxin/Furan	One 4-oz. wide-mouth glass jar	4°C (dark)	Extract in 30 days Analyze in 45 days after collection
	NO_2+NO_3	One 4-oz. wide-mouth glass jar	4°C	28 days
Groundwater/ Surface Water	VOC	Two 40-ml septum seal glass vial	1:1 HCl, pH <2, 4°C	14 days
	SVOC	Two 1-liter amber glass	4°C	Extract in 7 days Analyze in 40 days
	Metals	One 1-liter HDPE	1:1 HNO_3, pH <2, 4°C	Mercury 28 days, All others 6 months
	Cyanide	One 1-liter HDPE	NaOH, pH >12, 4°C	14 days

TABLE 4-1 (Continued)

REQUIRED SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
Groundwater/ Surface Water (Continued)	Explosives	Two 1-liter amber glass	4°C	Extract in 7 days Analyze in 40 days
	Chloride Sulfate Alkalinity TDS	One 1-liter HDPE	4°C	28 days 28 days 14 days 7 days
	COD NO_2+NO_3	One 1-liter HDPE	1:1 H_2SO_4, pH <2, 4°C	28 days
Tissue	VOC	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	14 days
	SVOC	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Extract in 7 days Analyze in 40 days
	Metals	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Mercury 28 days All others 6 months
	Cyanide	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	14 days
	Explosives	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	Extract in 14 days Analyze in 40 days

TABLE 4-1 (Continued)

REQUIRED SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Matrix	Parameter	Container	Preservation	Holding Time
	NO_2+NO_3	Appropriate size wide-mouth glass jars or Ziploc bags	4°C	28 days

HDPE - High Density Polyethylene
VOC - Volatile Organic Compound
SVOC - Semivolatile Organic Compound
NO_3+NO_2 - Nitrate Plus Nitrite
TDS - Total Dissolved Solids
COD - Chemical Oxygen Demand
HCl - Hydrochloric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide
H_2SO_4 - Sulfuric Acid

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screens within targeted aquifers at each SWMU. Monitoring wells will be installed within each borehole to provide hydrogeologic characterization as well as groundwater chemistry data useful in assessing risk to human and environmental receptors. The installation of groundwater monitoring wells is intended to compliment existing monitoring networks at each SWMU and to address risk assessment data gaps not addressed during previous hydrogeologic investigations at the SWMUs.

Soil borings will be completed in conjunction with monitoring well installation as shown on figures in Section 3.0 of the Work Plan. The sample locations are also described in tables in Section 4.0 of the Work Plan. Sampling procedures, equipment, decontamination, quality control, and documentation are detailed in Section 9.0 of the Work Plan.

4.4 GROUNDWATER SAMPLING

One round of groundwater sampling will be conducted from all newly installed and select existing monitoring wells at the ABG, the DR, and the ORR. The monitoring wells to be sampled are shown on figures in Section 3.0 of the Work Plan and tables in Section 4.0 of the Work Plan.

Groundwater samples will be collected from the monitoring wells following purging. Samples will be collected within 24 hours of well purging, with the exception of those wells where recovery from the purging process exceeds 24 hours. Groundwater samples will be collected with a pump or bailer. Sampling procedures, equipment, quality control, and decontamination are detailed in Section 9.0 of the Work Plan.

4.5 TISSUE SAMPLING

Vegetation and wildlife tissue samples will be collected to determine if any of the contaminants of concern are present in living tissue and represent potential sources for bioaccumulation of contaminant materials. This is important to the overall evaluation of the potential for transport of contaminants through the ecological food chain at and surrounding the individual SWMU sites. Tissue samples will be collected from vegetation and wildlife species located upgradient, at and downgradient of the ABG, ORR and the DR sites. Both aquatic and terrestrial tissue samples will be collected. Sampling procedures, equipment, decontamination, quality control, and documentation are detailed in Sections 8.0 and 9.0 of the Work Plan.

4.6 ECOLOGICAL POPULATION SURVEY

An ecological population survey of the three SWMUs will be conducted to fill a significant site specific data gap concerning the ecological relationships present at the site and how they are at and affected by the continued operation of the ABG, ORR and the DR sites. The ecological population survey is a general assessment of the aquatic and the terrestrial ecosystems in the area of the three SWMUs and the surrounding site environs. Sampling procedures, equipment, decontamination, quality control, and documentation are detailed in Sections 8.0 and 9.0 of the Work Plan.

4.7 SURFACE WATER AND GROUNDWATER HYDRAULIC CHARACTERIZATION

Staff gauges will be installed in Little Sulphur, Turkey, and Boggs Creek to serve as surface water level measurement points. These points will serve as additional control when integrated with groundwater level measurements obtained from well installations.

Staff gauges will be installed at locations shown on figures in Section 3.0 of the Work Plan. Procedures, equipment, quality control, and documentation are detailed in Section 9.0 of the Work Plan.

4.8 SAMPLE IDENTIFICATION NUMBERS AND DOCUMENTATION

4.8.1 Sample Logbook

A bound Sample Logbook with sequentially numbered pages will provide the means for recording samples sent to laboratories.

The cover of each notebook will contain:

Naval Surface Warfare Center - Crane
Start Date
End Date
Book Number

The Sample Logbook will contain the following information for each sample collected for chemical analysis:

- Field sample identification number.

- Type of sample (field, QC, QA).
- Depth of sample.
- Date and time sample collected.
- Initials of sampler.
- Number and type of sample containers filled.
- Field screening readings, if any.
- Analyte(s).
- Laboratory destination.
- Date shipped.
- Airbill number.

4.8.2 Field Sample Identification Number

The field sample identification number will consist of the project identifier, the sample matrix, the year, location number, and depth. The scheme used is listed below:

CR95-AABB-CC-DD

Where: CR = project identifier for Naval Surface Warfare Center, Crane Division
95 = 1995 Field Investigation

AA = SWMU:
- 03 = SWMU #03/10, Ammunition Burning Ground
- 06 = SWMU #06/09, Demolition Range
- 07 = SWMU #07/09, Old Rifle Range

BB = sample matrix:
- GW = Groundwater Sample
- SD = Sediment Sample
- SS = Soil Sample
- SW = Surface Water Sample
- VT = Vegetation Tissue
- WT = Wildlife Tissue

CC = Sample location number (numbered sequentially within each SWMU). In the case of existing monitoring wells, existing well numbers/nomenclature will be used.

DD = Sample depth in feet:
- A = less than 2 feet below surface
- B = 2 to 4 feet
- C = 4 to 6 feet
- D = 6 to 8 feet
- etc.

Field duplicate, rinsate blanks and field blanks samples will be identified by noting a fictitious sample location number. Trip blanks and field blanks will be designated with the alpha codes "TB".

Examples of field sample identification numbers are as follows:

CR95-03SW01-01	NAVSURFWARCENDIV, 1995 Field Investigation, Surface Water Sample No. 1 from SWMU #03/10 (Ammunition Burning Ground).
CR95-06SS-A01-01	NAVSURFWARCENDIV, 1995 Field Investigation, Soil Sample No. 1 collected from 0-6 inches below the surface at SWMU #06/09 (Demolition Range).

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5.0 SAMPLE CUSTODY, PACKAGING, AND SHIPPING

5.1 SAMPLE CUSTODY

The USEPA chain of custody protocols, as described in "NEIC Policies and Procedures," USEPA-330/9-78-001-R, revised June 1985, will be followed. Custody is in three parts: sample collection, laboratory analysis, and final evidence files. Field evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. Custody procedures are outlined in Halliburton NUS SOP SA 6.1 (Work Plan Appendix A).

5.2 PACKAGING AND SHIPPING

For purposes of shipping, samples are classified as environmental samples or environmental hazardous substance (liquid or solid n.o.s). Each classification requires specific packaging, labeling, and shipping as determined by the U.S. Department of Transportation (DOT), the International Air Transport Association (IATA), and each commercial carrier. Samples will be prepared according to applicable Halliburton NUS SOP SA-6.2 (Work Plan, Appendix A), DOT, IATA, and commercial carrier requirements.

5.3 SHIPMENT COORDINATION

The field data coordinator (FDC) will notify the laboratories of all sample shipments on the day of shipment. At that time the following information will be provided:

- FDC name and site office telephone number.
- Site name.
- Number(s) and matrix(ces).
- Carrier name and airbill number(s) for the shipment.
- Method of shipment (i.e. Fed Ex. overnight).
- Date of shipment.

- Suspected hazards associated with the samples or site.

- Irregularities or anticipated problems with the samples, including special handling instruction or deviations from established sampling procedures or numbers of samples.

- Status of the sampling project (i.e. final shipment, update of future shipping schedule).

Sample shipments made after 5:00 p.m. Eastern Standard Time (EST) will be called in at the start of business the next day (8:00 a.m. EST). Laboratories will be notified by 3:00 p.m. EST Friday concerning information about sample shipments being sent Friday intended for Saturday delivery/pickup.

5.3 FINAL EVIDENCE FILES CUSTODY PROCEDURES

Relevant records, reports, logs, field notebooks, pictures, and the data review will be maintained in a secure, limited access area and under custody of the Project Manager. Raw data will be retained by the Navy at the end of the project and under custody of the Project Manager until that time.

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6.0 CALIBRATION PROCEDURES

6.1 FIELD EQUIPMENT

Equipment to be used during the field sampling will be examined to determine that it is in an operable condition and will be calibrated at the beginning of each day. This includes checking the manufacturer's operating manual and the instructions for each instrument to ensure that all maintenance and operating requirements are being observed.

6.2 LABORATORY EQUIPMENT

Instruments used in the laboratory will be calibrated according to the specific method used and Southwest Laboratory of Oklahoma's (SWLOK) general quality assurance manual (Attachment A).

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7.0 PREVENTIVE MAINTENANCE

7.1 FIELD EQUIPMENT

Field equipment will be maintained and calibrated according to manufacturer's specifications.

7.2 LABORATORY EQUIPMENT

Laboratory equipment will be maintained according to manufacturer's specifications and in such a way that the QC requirements of the methods will be met for all analyses performed. Preventive maintenance of laboratory instruments will be performed as described in SWLOKs general QA Manual (Attachment A).

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8.0 ANALYTICAL PROCEDURES

Analyses will be accomplished using only USEPA approved laboratories.

Analysis of samples collected will be performed according to the methods shown in Table 8-1. Samples for volatiles, semivolatiles, metals, and cyanide will be analyzed according to analytical procedures in the USEPA Statement of Work (SOW) 0LM01.8 for organic analysis and SOW ILM02.1 for inorganic analysis, or their most recent updates.

Samples analyzed for explosives, dioxin/furans, and indicator parameters, will follow the appropriate method as presented in Table 8-1. Southwest Laboratory of Oklahoma Standard Operating procedures are presented in Attachment B.

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TABLE 8-1

ANALYTICAL METHODS

Parameters	Method	
	Aqueous	Soil/Sediment/Tissue(b)
Volatiles	(a)	(a)
Semivolatiles	(a)	(a)
Metals	(a)	(a)
Cyanide	(a)	(a)
Explosives	SW-846 8330	SW-846 8330
Nitrate+Nitrite Nitrogen	USEPA 300	USEPA 300
Chloride	USEPA 300	--
Sulfate	USEPA 300	--
Alkalinity	SM 403[c]	--
Total Dissolved Solids (TDS)	USEPA 160.1	--
Chemical Oxygen Demand (COD)	USEPA 410.1	--
Dioxin/Furan	--	SW-846 8290

(a) USEPA Contract Laboratory Program Statements of Work. 0LM01.0-0LM01.8 for organic analyses and 1LM02.1 for TAL metals and cyanide.

USEPA "Methods for Chemical Analysis of Water and Waste," USEPA 41791020, March 1983.

SW-846 Test Methods for Evaluating Solid Wastes Physical/Chemical Methods, 3rd Edition.

(b) Analytical methods for tissue samples are the same as soil/sediment samples, except for sample preparation. Tissue samples will be homogenized in a blender with distilled water and filtered by vacuum filtration. The extract will then be analyzed as a soil/sediment sample.

(c) Standard methods for the examination of water and wastewater, 16th Edition, 1985.

9.0 INTERNAL QUALITY CONTROL CHECKS

9.1 FIELD QUALITY CONTROL SAMPLES

The assessment of field sampling precision and accuracy will be made through the collection of field duplicates, field blanks, equipment rinsates, and trip blanks as discussed in Section 3.2 of this QAPP.

9.2 LABORATORY QUALITY CONTROL SAMPLES

Internal QC procedures for laboratory analyses are specified in the appropriate CLP SOW for volatiles, semivolatiles, and metals, and in the laboratory SOPs and analytical methods for explosives, dioxin/furans, and indicator parameters (Attachment B).

A brief discussion of the laboratory QC samples is provided in the following paragraphs:

9.2.1 Method Blanks

The method blank is an analytical control consisting of deionized water, reagents, and internal standards and surrogates (if appropriate for the analysis), which is carried through the entire analytical procedure. An aqueous method blank is treated the same as a sample with a water matrix; a solid method blank is treated the same as a soil sample. The method blank is used to define the level of laboratory background contamination.

9.2.2 Laboratory Duplicates

Laboratory duplicates are a second aliquot of a sample that is treated the same as the original sample in order to determine the analytical precision of the method. Precision is measured by calculating the RPD of the laboratory duplicates.

9.2.3 Matrix Spike

An aliquot of a sample that is fortified (spiked) with known quantities of specific analytes and subjected to the entire analytical procedure. The percent recoveries are calculated for each of the added analytes in order to evaluate the effect of the sample matrix on accuracy of the method.

9.2.4 Matrix Spike Duplicate

A second aliquot of the same sample as the matrix spike (Section 9.2.3 above) that is spiked the same as the matrix spike. The RPD is calculated for the results of the analytes added to the MS/MSD samples to evaluate the effect of the sample matrix on analytical precision.

9.2.5 Surrogate Compounds

Surrogates are compounds that are added to every blank, sample, MS/MSD, and standard that are not expected to be detected in environmental media. Surrogates are brominated, fluorinated, deuterated, or isotopically labelled compounds used to evaluate analytical efficiency by measuring %R.

9.2.6 Laboratory Control Sample

An aqueous or solid sample of known composition. The LCS is subjected to the same sample preparation, reagents, and analytical methods as the field samples submitted for analysis. The results of the LCS are calculated as a %R and used to evaluate analytical accuracy.

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10.0 DATA REDUCTION, VALIDATION, AND REPORTING

10.1 FIELD MEASUREMENTS

Data from field measurements and sample collection activities will be appropriately recorded on field forms (Work Plan Appendix A). If the data are to be used on the project reports, they will be reduced or summarized and presented in the RA report.

10.2 LABORATORY SERVICES

All laboratory analysis will be performed by the Southwest Laboratory of Oklahoma.

Data reduction will be performed by the laboratory in accordance with the requirements of the laboratory-specific SOPs (Attachment B). Subsequent to receipt of data from the laboratory, data validation will be performed by Halliburton NUS Team personnel in accordance with the USEPA National Functional Guidelines for Evaluating Organic and Inorganic Laboratory Data (February 1994) and method-specific quality control criteria as applicable. Data evaluation of validated analytical data may include data reduction and tabulation, statistical analysis, environmental fate and transport modeling, and mapping. The results will be incorporated into the RA report.

Diskette deliverables received from the laboratory will be utilized for EPA Level III and IV reporting. The diskettes will be uploaded to Oracle relational database software. Oracle may be used to provide statistical analysis of the data and for generation of report tables. Report tables generated from Oracle are backchecked against hardcopy reports received from the laboratory to verify correctness of uploaded data. Organic and inorganic analytical results will be reported using CLP SOW format and forms. Explosives, dioxin/ furans, and indicator parameter analytical results will be reported using CLP "equivalent" format and forms.

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11.0 DATA ASSESSMENT PROCEDURES

Analytical data will be evaluated for precision, accuracy, and completeness. The acceptability of the analytical precision and accuracy will be determined by comparing them to the control limits recommended in the methods. Data determined to be insufficiently precise or accurate will be subject to the corrective action prescribed by the appropriate analytical method. The QC samples used in the determination of precision and accuracy have been described in Section 3.0. Specific equations used to calculate precision, accuracy, and completeness are presented below.

Precision will be expressed in terms of Relative Percent Difference (RPD).

$$RPD = \frac{\text{Concentration 1 - Concentration 2}}{\text{(Concentration 1 + Concentration 2)/2}} \times 100$$

Accuracy as determined from the analysis of a laboratory control sample or surrogate will be expressed as Percent Recovery (%R).

$$\%R = \frac{\text{Measured Concentration}}{\text{Actual Concentration}} \times 100$$

Accuracy as determined from the analysis of a spiked sample will also be expressed as %R.

$$\%R = \frac{\text{Measured Spike Value - Unspiked Value}}{\text{Known Spike Value}} \times 100$$

Completeness will describe the number of usable analytical results as a percentage of the total number of samples submitted for analysis.

$$\%\ \text{Complete} = \frac{\text{Valid Data}}{\text{Total Data Planned}} \times 100$$

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12.0 CORRECTIVE ACTION

Corrective actions may be required for problems that occur during sampling and sample handling, sample preparation, laboratory instrumental analysis, and data review. A formal corrective action program will be determined and implemented at the time the problem is identified. The person who identifies the problem is responsible for notifying the Project Manager who in turn, will notify the QA Managers as appropriate. Implementation of corrective action will be confirmed in writing through the same channels. Any nonconformance with the established QC procedures in the QAPP or Work Plan will be identified and corrected in accordance with the QAPP. The Project Manager or his designee will prepare a nonconformance report for each nonconformance/corrective action situation. No staff member may initiate corrective action without prior communication of findings through the proper channels.

12.1 FIELD ACTIVITIES

Project field personnel will be responsible for reporting all suspected nonconformances or deficiencies to the Project Manager or designee. The Project Manager will be responsible for assessing the suspected problems in consultation with the QA Managers, as appropriate. The final decision is to be based on the potential for the situation to impact the quality of the data. If the situation warrants corrective action measures, the Project Manager will prepare a nonconformance report.

The FTL at times is required to adjust the site activities to accommodate site-specific needs. The changes will be documented in the field log notebook and signed by the initiators and the FTL. The Project Manager must approve the changes in writing or verbally prior to field implementation. A Field Modification Record form (Work Plan Appendix A) will also be prepared and distributed as appropriate.

12.2 LABORATORY ACTIVITIES

Corrective actions are required whenever an out-of-control event or potential out-of-control event is noted. The investigative action taken is dependent upon the analysis and the event. Specific analytical corrective actions are described in the methods and should be followed by the laboratory personnel.

Laboratory personnel are alerted that corrective action may be necessary if:

- QC data are outside the warning or acceptance window for precision or accuracy.
- Blanks contain target analytes above acceptable levels.
- Undesirable trends are detected in spike recoveries or RPD between duplicates.
- There are unusual changes in detection limits.
- Inquiries concerning data quality are received.
- Deficiencies are detected by the QA Department during internal or external audits or from the results of performance evaluation samples.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and so on. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor and the QA Department for further investigation. Once resolved, full documentation of the corrective action procedure is filed with the QA Department and the CLEAN and Site QA Manager.

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13.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits of field and laboratory activities will be conducted to verify that sampling and analysis are performed in accordance with the procedures established in the Work Plan and QAPP. The audits of field and laboratory activities include internal and external audits.

13.1 FIELD AUDITS

Internal audits of field activities (sampling and measurements) will be conducted by the Project Manager. The audits will include examination of field sampling records, sample collection, handling and packaging in compliance with the established procedures, and chain of custody. These audits will occur at the onset of the project to verify that all established procedures are followed. Follow-up audits will be conducted to correct deficiencies and to verify that QA procedures are maintained throughout the inspection. The audits will involve review of field measurement records and sample documentation.

External audits may be conducted by the Navy or USEPA.

13.2 LABORATORY AUDITS

The performance and system audits of the laboratory will be conducted as part of the laboratory's participation in the USEPA contract lab program. Additional audits may be conducted by the QA Manager and/or Project Manager based upon the review of monthly progress reports. The system audits, which will be performed on an annual basis, will include examination of laboratory documentation on sample receiving, sample log-in, sample storage, chain of custody procedure, sample preparation and analysis, instrument operating records, etc. The performance audits will be conducted at least annually and may be conducted on a quarterly basis. The analytical results of performance samples will be evaluated to ensure the laboratory maintains a good performance.

External performance and system audits of the laboratory selected for the project may be conducted by the USEPA.

14.0 QUALITY ASSURANCE REPORTS

A summary QA report will be prepared for the analytical results by the QA Manager or designee and submitted to the Project Manager. This QA report will include an assessment of data quality based upon the quality control data, as well as an account of any significant QA problems encountered and corrective actions taken. This report will be in writing and provided as a final report to the Project Manager.

The summary QA report contents will include:

- Any deviations from the QAPP.
- Summary of the QA/QC program.
- Data quality assessment in terms of precision, accuracy, and completeness.
- Conformance of data quality to QAPP requirements.
- An indication of whether the QA objectives were met.
- A discussion of the limitations on use of the data collected, as applicable.
- Significance of any QA/QC problems encountered, recommended solutions, and results of corrective action.

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ATTACHMENT A
TO QUALITY ASSURANCE PROJECT PLAN

LABORATORY QUALITY ASSURANCE MANUAL

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

QUALITY ASSURANCE MANUAL

for
SOUTHWEST LABORATORY
OF OKLAHOMA, INC.
Broken Arrow, Oklahoma

REVISED: August 10, 1994

DOCUMENT LOG NO : 95/03-023

PREPARED FOR :
RUST

IN RESPONSE TO:
Libertyville Training Center

APPROVAL:

QA/QC Officer _____ Date : March 14, 1995

Restriction on Disclosure Statement:

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1.0 QUALITY ASSURANCE

1.1 INTRODUCTION

This document details the quality assurance plan employed by Southwest Laboratory of Oklahoma (SWLO) to address various client and contract requirements necessary to provide service as an analytical laboratory. It details laboratory procedures with emphasis on the Quality Assurance/ Quality Control (QA/QC) requirements based on EPA guidelines for the analysis of multimedia samples for a broad range of inorganic and organic contaminants. It reflects the necessary specifications to assure accuracy, precision, completeness, representativeness, and comparability on all tasks of the contract or project. The purpose of this plan is to assure that data of the highest quality are being reported by SWLO.

1.2 DEFINITION OF TERMS

Quality Assurance

A quality assurance program is an essential part of a sound analytical protocol used by individuals and laboratories to detect and correct problems in the measurement process or to demonstrate attainment of a state of statistical control. The objective of a quality assurance program in analysis is to reduce measurement errors to agreed-upon limits and to produce results of acceptable quality. Two concepts are involved in quality assurance: (1) quality control, the mechanism established to control errors, (2) quality assessment, the system used to verify that the analysis is operating within acceptable limits.

Quality Control

A quality control program includes the following:

- Development of and strict adherence to principles of good laboratory practice,
- Consistent use of standard operation procedures,
- Establishment of and adherence to carefully designed protocols for specific measurement programs,
- The consistent use of qualified personnel,
- Reliable and well-maintained equipment,
- Appropriate calibrations and standards,
- The close supervision of all operations by management and senior personnel.

When properly conceived and executed, a quality control program will result in a measurement system operating in a state of statistical control, which means errors have been reduced to acceptable levels and have been characterized statistically.

Quality Assessment

Quality assessment includes a variety of techniques required to assess the quality of the measurement process and the results. The establishment of a system of "control charts" is a basic principle. Control charts are plots of multiple data points from the same or similar samples or processes versus time. They are used to determine if a system is in a state of statistical control. Control charts should be used to visualize or monitor the relative variability of repetitive data. They can be used with reference materials, spiked samples, and the analysis of surrogates as a means to assessing the accuracy of measurements.

Quality Assessment Procedures

Procedures used to assess the effectiveness of the quality control system include:

(a) Internal Performance Audits—conducted by the use of control samples, replicate measurements and use of reference materials in conjunction with control charts

(b) External Performance Audits—conducted by the use of inter-laboratory checks such as:

- Participation in laboratory evaluation programs; State Programs (Utah, Florida, California, Oklahoma, etc.), and Corps of Engineers D.E.R.A. Program.

- Participation in performance evaluation samples available from EPA (WP & WS Studies).

Quality Assessment Procedure Summary

A simplified working document or chart which enables one to preview the basic quality control program and its effectiveness shall be maintained on a daily basis. The following parameters are to be tracked:

- Areas of the internal standard for all samples,

- Surrogate spike recovery for all samples,

- Matrix spike and matrix spike duplicate sample results for accuracy and precision.

QA Organization

Assembled data shall be reviewed by the Project Officer before technical compilation into contract deliverables. Final review of about 20% of the assembled deliverables package is performed by the Quality Assurance Officer (QA Officer).

Data Quality

Data quality is the totality of features and characteristics of data that bear on their ability to satisfy a given purpose. Parameters of major importance are accuracy, precision, completeness, representativeness, and comparability. These are defined as follows:

(a) Accuracy - The degree of the difference between measured or calculated values and true value.

(b) Precision - The reproducibility or degree of agreement among replicate measurements of the same quantity.

(c) Completeness - The percentage of valid data obtained from a measurement system.

(d) Representativeness - The degree to which the data accurately represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

(e) Comparability - The confidence with which one data set can be compared to another.

1.3 ORGANIZATION AND RESPONSIBILITIES

Corporate Organization

SWL is located at 1700 West Albany, Broken Arrow, Oklahoma 74012, with additional facilities located in Tulsa, Oklahoma, Cushing Oklahoma, Baton Rouge, Louisiana, and St. Louis, Missouri.

Specific QA/QC responsibilities are summarized in the following subsections. Figure 1.1 shows the line-staff relationships within the laboratory.

Laboratory Director

The Laboratory Director has overall responsibility for the technical quality, cost control, laboratory personnel management, and adherence to project schedules. His overall management involves the quality assurance of the following items:

- Delivery order/work assignments

- Adherence to delivery schedules

- Deliverable reports
- Subcontractor work product if required

- Project/contract cost control and accounting

- Task performance of key personnel

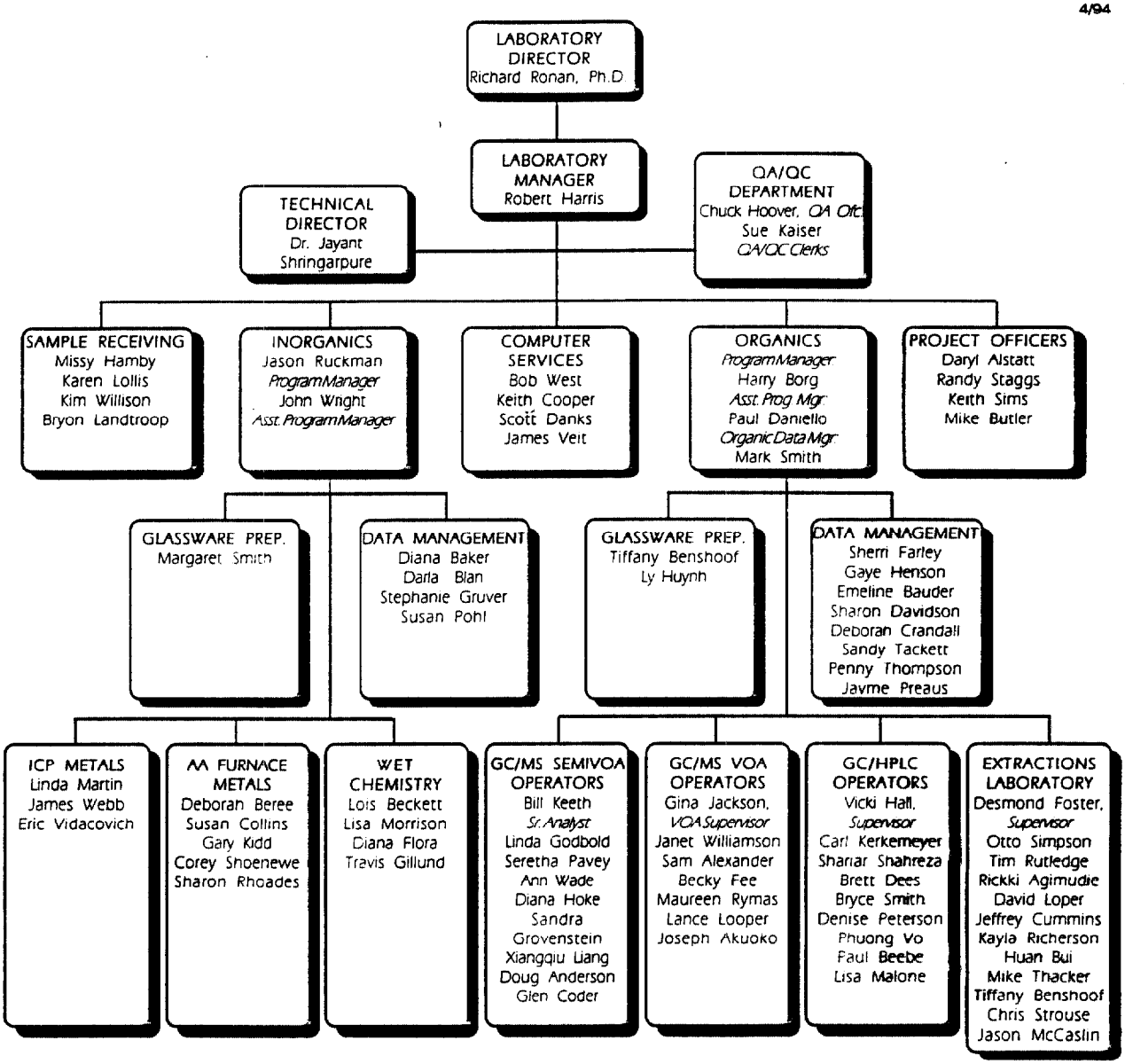

FIGURE 1.1
Laboratory Organizational Chart

Laboratory Manager

The Laboratory Manager assists the Laboratory Director as the need arises, and is closely involved with the day-to-day activities of sample preparation/analyses. The Laboratory Manager coordinates all laboratory activities necessary to fulfill contract requirements.

Quality Assurance Officer

The QA Officer is responsible for monitoring the quality of laboratory work and taking appropriate actions to ensure that quality standards are being met. The QA Officer reports directly to the Laboratory Manager in reviewing the work of teams and individuals. The QA Officer is responsible for the following:

■ Preparing and overseeing the preparation of the laboratory QA/QC plan;

■ Establishing QC procedures and setting warning and action limits for every test or parameter to standardize laboratory operation for quality performance;

■ Coordinating State & Federal Performance Evaluation Studies.

■ Monitoring compliance with the laboratory's QA/QC plan by:

1. Reviewing QC-related activities and documentation for completeness in accordance with the QA/QC plan

2. Identifying and referring any instances in which the QA/QC objectives are not being met to Group Leaders or Laboratory Supervisors for remedial and/or corrective action.

Analytical Program Manager

The Analytical Program Manager oversees the primary functions of this group: sample control, document control, data management, and client services. The Program Manager provides supervision and guidelines for sample handling and storage prior to analyses, maintenance of project files, data entries into the computer system after sample analysis, and quality review of the final data deliverables. Under the Program Manager, the following personnel play a vital role in the QA/QC program:

■ Project Officer (PO) - responsibilities include direct client representation within the laboratory. The PO acts in an advocacy role for the client. As needed, the PO will review with clients the technical aspects of the analytical results and how they relate to the needs of the client. The PO will monitor all analytical projects as they progress through the laboratory.

■ Sample Custodian (SC) - handles all sample receipt, adheres to chain-of-custody procedures, does computerized sample log-in, assigns secure sample storage for samples and initiates the set-up of the project file. The SC is responsible for maintaining the integrity and validity of the samples.

■ Data Clerk - responsibilities include: document organization, assembly of all documents relating to contracts or projects (including project file and analytical file) to ensure clerical veracity during data-handling, data assembly, and data report production.

Inorganic and Organic Supervisors

These Laboratory Supervisors have primary responsibility for the technical quality of all data generated within their respective sections. In addition they are responsible for the adherence to delivery schedules, management and utilization of manpower and the technical aspects of all Standard Operating Procedures (SOPs).

Systems Manager

Responsible for the management and quality control of all computing systems (hardware, software, documentation and procedures), generating, updating, and performing quality control reviews of automated deliverables.

Programmer Analyst

Responsible for the installation, operation, and maintenance of software and programs, generating, updating and performing quality control reviews of analytical databases and automated deliverables.

1.4 CERTIFICATIONS AND ACCREDITATIONS

The SWLO laboratory has participated in available certification programs pertaining to environmental chemistry. Table 1.2 lists the various certifications and accreditation programs in which SWLO participates.

1.5 EQUIPMENT AND SUPPLIES

Procurement and Inventory

To assure a good laboratory quality assurance program in the procurement of equipment and supplies, SWLO has established criteria and specifications for the purchase of important pieces of equipment. Factors such as cost, volume of work, ease of operation, inherent accuracy, expected equipment lifetime, length and condition of warranties or service contracts, expected downtime and repair costs are considered in the basis of selection. The increased usage of electronic analytical instruments has improved the quality and quantity of data and has increased productivity.

Control of materials (i.e., reagents, standards, solvents, etc.) and glassware used in the analyses is maintained as part of the quality assurance program. Reagents & Solvents are analyzed prior to use to verify purity; documentation of these analyses are maintained. Lot numbers are recorded on extraction logs to facilitate the tracking of these items. All reagents are dated as they are received and when they are opened to ensure systematic use. The identity, purity, shelf-life, source, tests to be conducted for quality and purity, storage and handling procedures, and replacement dates are factors that are considered in making purchase requisitions.

Before any purchases are made, purchase requisition orders and requests are checked and verified by the Laboratory Supervisors. Approval for such purchases is made by the Laboratory Supervisors, and the Laboratory Director.

Equipment Management

Information on performance of the equipment is obtained before a purchase request is made. Service availability for installation specification and verification is considered in purchase negotiation. When the instrument/equipment is installed, an internal calibration is made on the instrument to meet manufacturer's specifications. Calibration checks are done by using analytical reference standards for qualitative and quantitative checks to verify instrument performance during the sample run. Routine preventive maintenance of the instruments or equipment is made on a regular basis. Section 9.2 discusses preventive maintenance employed by the different laboratory sections to ensure instrument/equipment working conditions.

The laboratory maintains sufficient inventory of analysis and/or testing equipment to meet client requirements for analytical services. Table 1.3 contains current lists of instrumentation and associated equipment which the laboratory uses in providing analytical services.

Supplies Management

Materials, reagents, solvents and gases are carefully selected to meet specifications as prescribed by the method of analyses. Each new supply of these items is verified for performance capability based on the required certified assay/analysis of chemicals and freedom from impurities that would interfere with the analysis. Background levels are measured to check the degree of contamination. In storage, these items are protected from degradation and contamination through conformance of storage requirements according to the manufacturer's directions and/or individual method of analysis. Solvents used for extraction are pre-analyzed to determine impurities that might interfere with the analytes of interest. (See Appendix D for Standard Operating Procedures for Checking Analytical Solvents). Standards and reagents are dated upon receipt, and the date of expiration recorded. This procedure establishes the order of use and eliminates the possibility of exceeding shelf-life. (See Appendix D for Standard Operating Procedure for Standard Expiration)

Source of Standard Reagents

Primary standards and/or stock standards are obtained from a reliable, certifiable source and are high purity. Standards are purchased from approved commercial vendors such as Chem Services, Fisher Scientific, Supelco, Altrex, etc., for use in all analytical testing. Standards are protected from degradation, deterioration, and contamination based on storage requirements (e.g. polyethylene containers for alkali solutions, glass

containers for organics and brown glass for light-sensitive solutions; temperature storage and segregation of standards based on reactivity). Prepared commercial standards are verified against certified standard reference materials, (SRM) from EPA or NBS for traceability. (See Appendix D for Standard Operating Procedure for Traceability of Standards)

Stock and working standard solutions are prepared fresh as required by their stability, and are checked regularly for signs of deterioration, (i.e., discoloration, formation of precipitates, and changes in concentration). Standard solutions are labeled with compound name, concentration, solvent, date of preparation, and preparer. (See Appendix D for Standard Operating Procedure for Standard Expiration)

Glassware

Class A volumetric glassware is used by the laboratory for measuring trace constituents in both inorganic and organic analysis.

Laboratory contamination is minimized through implementation of a standard operating procedure (SOP) for glassware and labware cleaning. It is followed to ensure the removal of all traces of parameters of interest and contaminants that could interfere with analysis. (See Appendix D for Standard Operating Procedure for Glassware and Labware Cleaning)

Reagents, Solvents and Gases

Chemical reagents aside from the primary standard reagents, solvents and gases are carefully selected to conform to specifications defined in the method of analyses. Selection is based on the required priority for parameters being measured, sensitivity of the method and specificity of the detection system (i.e., AA, ICAP, GC-ED, GC/MS).

Laboratory reagents obtained from approved commercial vendors shall meet ACS standards and are labeled indicating contents, date of receipt or preparation, and expiration. Hazardous reagents are adequately labeled and stored segregated from the rest of the reagents to indicate type and degree of hazard. (See Appendix D for Standard Operating Procedure for Standard Expiration)

Solvents to be used for extraction are pre-analyzed to detect the presence of impurities which might possibly interfere with analytes of interest. When a particular lot is found to be acceptable, the manufacturer is notified to set aside a specified number of cases of this lot for SWLO laboratory usage. The solvent is checked on a regular basis to ensure high level of solvent quality control is maintained within the lot. (See Appendix D for Standard Operating Procedure for Checking Analytical Solvents). All solvents are dated upon receipt and again upon opening to ensure first-in — first out useage. Solvent bottles are stored in a grounded flameable liquid storage cabinet.

Gases used in inorganic and organic analyses are of commercial grade or are laboratory-supplied gases. For organic analyses, the type of detection (i.e., GC-EC, Hall, GC-FID, GC/MS) used affects gas quality requirement. Molecular sieves carrier-gas filters, and drying tubes are required on combustion gases to improve quality. Gas cylinders are immediately replaced when the pressure falls to 100-200 pounds per square inch (psi) to minimize detector contamination that will affect sensitivity of the detector.

Laboratory Reagent Water

ASTM Type II water is used in the laboratory for dilution, preparation of reagent solutions and final rinsing of glassware. It is free from interferences and other contaminants. After passing through two ion exchange canisters and one carbon filter canister, water purity is monitored by an indicator light at each outlet and at the filtration apparatus. (See Appendix D, Preparation and QA/QC for the Laboratory Water Supply)

Compressed Air

Compressed air is employed mainly in instruments using GC oven-door control and autosamplers. Absorption filters are installed between the outlet and the point of use to trap oil, moisture, and other contaminants entering the compressed air transfer lines. These lines are checked periodically for the presence of moisture and contaminants and are replaced as soon as moisture is detected.

Hood System

An efficient hood system is necessary to remove the various toxic and hazardous fumes that may be generated when using organic solvents or that may be formed during an acid digestion step. It is also used to remove toxic gases that may be formed during atomic absorption analysis reactions. The laboratory fume hood face velocity is regularly checked every four months for optimum face velocity.

Electrical Services

The laboratory electrical system provides adequate and constant voltage, appropriate grounding, and efficient lighting which is required for satisfactory lighting, proper functioning of sensitive instruments and operation of high-current devices. A licensed electrical contractor provides repairs and services in the event of a power failure or electrical problems.

Computer Capabilities

Computer systems in current use include the following:

- Microcomputers - (IBM, AT, XT, Compaq, etc.) are used primarily for data processing. These may also be directly interfaced with instrumentation.

- Minicomputers - Used primarily for instrument control.

- LIMS System - A laboratory information management system. This system is attached to our local area network system and is used for sample log-in, sample tracking, data reports, invoicing, and management reports.

1.6 QUALITY ASSURANCE OBJECTIVES

The purpose of SWLO's quality assurance plan is to ensure that the laboratory provides high-quality and cost-effective services and products to its clients. Although specific quality assurance procedures will be designed to meet the needs of each individual program, SWLO's general objectives are:

- Data should be accurate in terms of their agreement with a reference or true values.

- Data should be precise in that there is agreement among individual measurements made under similar condition

- Data should be complete in terms of the amount of data available vs. the amount of data evaluated.

- Data should be comparable to prior relevant data for evaluation and testing purposes.

- Data should be representative of the overall population or data base of parameter measurements.

- Data should be reproducibly obtainable under similar conditions, whether generated by the SWLO or another firm.

- Upgrade the overall quality of laboratory performance.

All of the above objectives are ensured by the QA/QC program which monitors all phases of data generation, ranging from sample collection to sample handling, to the actual analysis and data reporting that involves measurements of both inorganic and organic constituents. These procedures will be followed by all personnel and will routinely be reviewed by both the Laboratory Director and QA Officer.

Scope and Approach Relating to Measurement of Data in Terms of Precision, Accuracy, Completeness, Representativeness, and Comparability

The laboratory scope and approach to produce data of known and sufficient quality are described in this section. Guidelines are provided for the assessment and reporting of data quality for any environmentally related measurements, and for the incorporation of such assessments into major environmental data bases.

Controlled sample receiving, logging, and tracking throughout the length of the project/contract is maintained to ensure sample integrity throughout the sample analysis scheme. Documentation of instrument performance and preventive maintenance is used to provide a permanent record for data validation. SWLO routinely checks the quality of analytical work through analysis of quality control (QC) reference samples, duplicate samples, or matrix spike duplicate and spike samples.

Accuracy

The accuracy of the measurement data is evaluated by the comparison of the percent recovery of the QC reference material of known or established concentration, independent of routine calibration. Statistically based control limits are established for each method of analysis and sample matrix. A spike sample is analyzed routinely for each batch of 20 samples (5%) and are dependent upon the sample matrix, method of analysis and concentration level. A more frequent analysis is performed (i.e., one in 10 samples) on a contract-specific basis. Recoveries are assessed to determine method efficiency and matrix interference effects. Analytical accuracy is expressed as the percent of recovery of an analyte/parameter which has been added to the environmental samples at a known concentration before preparation and analysis. The equation used to calculate percent recovery is

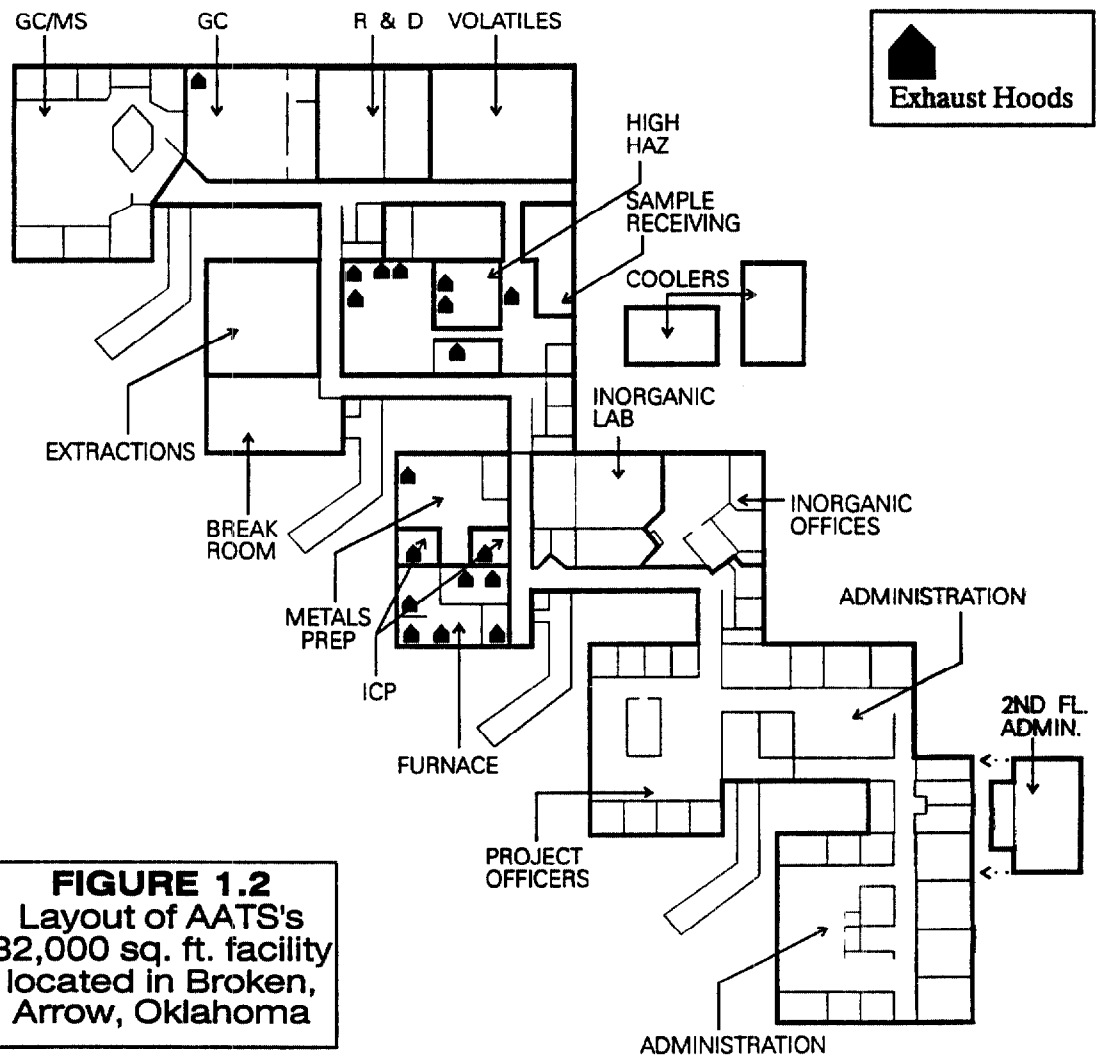

FIGURE 1.2
Layout of AATS's 32,000 sq. ft. facility located in Broken, Arrow, Oklahoma

as follows:

$$\text{Percent Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result}) \times 100}{\text{Amount of Spike Added}}$$

Precision

The laboratory uses matrix spike duplicates or duplicate sample analysis to assess precision. A matrix spike duplicate or a duplicate sample is analyzed for each batch of 20 samples (5%) for in-house QC and is dependent upon the sample matrix and method of analysis. A more frequent analysis is performed (i.e., one in 10 samples) on a contract-specific basis. The basic precision statistics obtained from the multiple batch frequency may be compared to develop a graph assessment (using control limits) for given sample matrix.

Analytical precision is expressed as a percentage of the difference between the results of two matrix spike samples or two duplicate sample analysis for a given analyte. Relative percent difference (RPD) is calculated as follows:

$$RPD = \frac{(\text{MS Result} - \text{MS Duplicate Result}) \times 100}{\text{Mean of MS and MS Duplicate Results}}$$

where MS denotes Matrix Spike.

or

$$RPD = \frac{\left(\text{Sample Result} - \text{Duplicate Result}\right) \times 100}{\text{Mean of Sample and Duplicate Results}}$$

Completeness

For the data to be valid, it must meet all the acceptance criteria including accuracy, precision and any other criteria specified by the analytical method used. Data validation procedures are employed to minimize the amount of bad data from getting through data collection.

While the quality objective is to obtain the greatest accuracy and precision, the specific accuracy/precision level is dependent on the method of analysis and type of sample matrix. The laboratory historical statistical control limits (see Appendix E) are used as guidelines to validate the data generated unless client or contract requirements set more stringent criteria.

Representativeness

Data generated by the laboratory shall be representative of the overall population of samples collected and analyzed. It shall be representative of the laboratory data base of accuracy and precision measurements of the particular parameter(s), matrix and analytical method. If the same results are reproducible, the data can be said to represent the environmental condition.

Comparability

Data generated shall be used to evaluate completeness of extensive monitoring programs and testing purposes based on the previous data measurements of parameters, matrix and analytical method. It shall be comparable to data sets recorded in the past to check for historical consistency. In order to maximize its usefulness, data shall be reported in appropriate units and in a consistent manner. Appropriate units are in accordance with the requirements stated in the October 26, 1984, proposed rules 40 CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants. Data should be reproducible under similar conditions whether generated by the laboratory or another firm.

TABLE 1.0

Technical Staff and Experience

RICHARD J. RONAN
Laboratory Director
Ph.D, Inorganic Chemistry

GC/MS	2 years
ICP	20 years
Gas Chromatography	15 years
Atomic Absorption	20 years
Data Review	20 years
Inorganic Analysis	20 years

ROBERT HARRIS, Laboratory Manager
B.S., Microbiology

GC/MS	4 years
ICP	1 year
Purge and Trap	3 years
Gas Chromatography	10 years
Atomic Absorption	15 years
Sample Preparation	15 years
Data Review	15 years

DR. JAYANT SHRINGARPURE
Technical Director
Ph.D., Organic Chemistry

GC/MS	12 years
Purge & Trap	12 years
Gas Chromatography	15 years
High Perf. Liquid Chromatography	5 years
Sample Preparation	5 years
Data Review	12 years

CHUCK HOOVER, QA/QC Officer
B.A., Biology, (Chemistry Minor)

GC/MS	2 years
Purge and Trap	2 years
Gas Chromatography	5 years
Atomic Absorption	4 years
Sample Preparation	8 years
Data Review	6 years

HARRY BORG, Organic Program Mgr.
B.A., Chemistry/Minor: Physics, Math

GC/MS	7 years
Purge & Trap	1 year
Gas Chromatography	10 years
Atomic Absorption	1-1/2 years
Sample Preparation	2 years
Data Review	7 years
Inorganic Analysis	2-1/2 years
High Perf. Liq. Chromatography	1-1/2 years

PAUL DANIELLO, Ass. Organic Prog. Mgr.
B.A., Biology

GC/MS	9 years
Purge & Trap	11 years
Gas Chromatography	11 years
Sample Preparation	11 years

MARK SMITH, Organic Data Manager
B.S., Chemistry

GC/MS	5 years
Purge & Trap	5 years
Sample Preparation	1 year
Data Review	3 years
Inorganic Analysis	0.5 years

DARYL ALSTATT, Project Officer
B.A., Chemistry

Sample Preparation	5 years
Data Review	4 years
Inorganic Analysis	5 years

KEITH SIMS, Project Officer
B.S., Biology, (Chemistry Minor)

ICP	4 years
Atomic Absorption	10 years
Sample Preparation	12 years

RANDY STAGGS, Project Officer
B.S., Biology

Gas Chromatography	3 years
Atomic Absorption	5 years
Sample Preparation	5 years
Data Review	10 years
Inorganic Analysis	15 years

8/94

JASON RUCKMAN
Inorganics Program Manager
B.S., Chemistry

ICP ..... 4 years
Atomic Absorption ..... 5 years
Sample Preparation ..... 4 years
Data Review ..... 4 years

JOHN WRIGHT
Asst. Inorganic Prog. Manager
B.S., Chemistry

Atomic Absorption ..... 3 years
Sample Preparation ..... 3 years
Data Review ..... 3 years
Inorganic Analysis ..... 5 year
ICP ..... 2 years

LOIS BECKET, Inorganic Analysis
B.A., Chemistry

Gas Chromatography ..... 2 years
Atomic Absorption ..... 3 years
Sample Preparation ..... 12 years
Inorganic Analysis ..... 16 years
Organic Extractions ..... 5 years

DEBORAH BEREE, Wet Chemistry
B.S., Biochemistry

Atomic Absorption ..... 2 years
Inorganic Analysis ..... 2 years

SUSAN COLLINS, AA Furnace
A.S., Chemistry (pending 5/92)

ICP ..... 1 year
Gas Chromatography ..... 2 years
Atomic Absorption ..... 11 years
Data Review ..... 10 years
Inorganic Analysis ..... 10 years
High Perf. Liq. Chromatography ..... 1 year

DIANA FLORA, Inorganic Analysis
H.S. Diploma

Inorganic Analysis ..... 1 year
Sample Preparation ..... 2 years

GARY KIDD, AA Furnace
H.S. Diploma

Atomic Absorption ..... 2 years
Sample Preparation ..... 2 years
Inorganic Analysis ..... 2 years

LISA MORRISON, Inorganic Analysis
H.S. Diploma

Sample Preparation ..... 3 years
Inorganic Analysis ..... 3 years

COREY SHOENEWE, AA Furnace
B.S., Biomedical Science

Sample Preparation ..... 1 year
Atomic Absorption ..... 1 year

JAMES WEBB, AA Furnace
B.S., Biology

Atomic Absorption ..... 6 years

ERIC VIDACOVICH
ICP Trace Analysis
3 years college, Biology/Chemistry

ICP ..... 5 years
Atomic Absorption ..... 8 years
Sample Preparation ..... 8 years
Data Review ..... 6 years

GINA JACKSON,
GC/MS Volatile Organics Section Supv.
B.S., Chemistry

GC/MS ..... 4 years
Purge & Trap ..... 1 year
Sample Preparation ..... 1 year

SAM ALEXANDER, GC/MS Laboratory
B.S. Chemistry

GC/MS ..... 2 years
Gas Chromatography ..... 4 years
Atomic Absorption ..... 3 years
Sample Preparation ..... 3 years
Data Review ..... 3 years

REBECCA FEE, GC/MS Laboratory
B.S., Chemistry

GC/MS ..... 3 years
Purge & Trap ..... 5 years
Gas Chromatography ..... 3 years
High Perf. Liq. Chorm. ..... 3 years

MAUREEN RYMAS, GC/MS Laboratory
Certified Lab Technician

GC/MS ..... 1 year
ICP ..... 2 years
Atomic Absorption ..... 4 years
Sample Preparation ..... 4 years
Purge & Trap ..... 1 year

JANET WILLIAMSON, GC/MS Laboratory
M.S., Analytical Chemistry

GC/MS	5 years
Purge & Trap	3 years
Gas Chromatography	10 years
High Perf. Liq. Chromatography	3 years
Atomic Absorption	2 years
Sample Preparation	6 years
Data Review	4 years

BILL KEETH, GC/MS Laboratory
Sr. Analyst, Semivolatile Organics
B.S., Chemistry

GC/MS	6 years
Purge & Trap	1 year
Atomic Absorption	4 years

DOUG ANDERSON, GC/MS Laboratory
B.S., Natural Science

Sample Preparation	2 years
GC/MS	1 year

LINDA GODBOLD, GC/MS Laboratory
A.S., Medical Technology

GC/MS	3 years

SANDY GROVENSTEIN, GC/MS Laboratory
B.S., Biology

GC/MS	10 years
Data Review	8 years
Gas Chromatography	14 years
Atomic Absorption	2 years
High Performance Liquid Chromatog.	4 years

DIANA HOKE, GC/MS Laboratory
B.A. Chemistry

GC/MS	6 years
Data Review	6 years
Purge & Trap	6 years
Gas Chromatography	6 years
Sample Prep	2 years
Wet Chemistry	1.5 years

SERETHA PAVEY, GC/MS Laboratory
B.A. Mathematics, A.S. Chemistry

GC/MS	1 year

ANN WADE, GC/MS Laboratory
B.S., Environmental Health

GC/MS	3.5 years
Gas Chromatography	6 years
Sample Preparation	4 years
Purge & Trap	3.5 years
Purge & Trap Data Review	3.5 years
Atomic Absorption	1 year

XIANGQUI LANG, GC/MS LABORATORY
High Res Mass Spec Operator
M.S. , Chemistry

High Res GC/MS	6 years
Gas Chromatography	3 years
Purge & Trap	3 years
Data Review	3 years

VICKI L. HALL,
GC Laboratory SectionSupervisor
M.S., Chemistry

ICP	1 year
Gas Chromatography	7 years
High Performance Liq. Chromatography	1 year
Sample Preparation	2 years
Data Review	3 years

PAUL BEEBE, GC Laboratory
B.S., Biology

Sample Preparation	1 year
Gas Chromatography	training

BRETT DEES, GC Laboratory
B.S., Biology/Minor: Chemistry

GC/MS	1 year
Gas Chromatography	3 years
Sample Preparation	1 year
Data Review	2 years

CARL KERKEMEYER, GC Laboratory
B.S., Chemistry

Gas Chromatography	10 years
Sample Preparation	3 years

LISA MALONE, GC Operator
B.A., Poly. Sci.

Gas Chromatography	1 year
Sample Preparation	training
Data Review	1 year

DENISE PETERSON, GC Laboratory
A.S., Environmental Lab Chemistry

Gas Chromatography	4 years
Atomic Absorption	1 year
Sample Preparation	2 years
Data Review	5 years
Inorganic Analysis	1 year
High Perf. Liq. Chromatography	5 years

PHUONG VO, GC Laboratory
B.S., Biology

Gas Chromatography	2 years
High Perf. Liq. Chromatography	2 years

SHAHRIAR "ALI" SHAHREZA, GC Lab
B.S., Biology/Chemistry
Gas Chromatography ..... 2 years
High Performance Liq. Chromatography ..... 4 years
Atomic Absorption ..... 1 year
Sample Preparation ..... 4 years
Data Review ..... 3 years

BRYCE SMITH, GC Laboratory
B.S., Zoology
Sample Preparation ..... 3 years
Data Reveiw ..... 3 years
Inorganic Analysis ..... 1 year
Gas Chromatography ..... 3 years

DESMOND FOSTER, Extractions Lab Supv.
H.S. Diploma
Sample Preparation ..... 13 years
Inorganic Analysis ..... 5 years

RICKKI AGIMUDIE, Extractions Laboratory
A.S., Drafting
Sample Preparation ..... 4 years

HUAN BUI, Extractions Lab
B.S., Chemistry
Sample Preparation ..... training
GC/MS ..... college training
GC ..... college training

JEFF CUMMINS, Extractions Lab
B.S., Chemistry
Sample Preparation ..... 6 mo.
GC ..... college training

DAVID LOPER, Extractions Lab
A.S., Accounting
Glassware Prep ..... 2 years
Sample Preparation ..... 1 year

JASON McCASLIN, Extractions Lab
B.S., Biology
Sample Preparation ..... training

KAYLA RICHERSON, Extractions Lab
H.S. Diploma, College Biology/Zoology
Atomic Absorption ..... 7 years
Sample Preparation ..... 7 years
Data Review ..... 7 years
Inorganic Analysis ..... 7 years
GC/MS ..... college training
GC ..... college training

TIM RUTLEDGE, Extractions Lab
H.S. Diploma
ICP ..... 2 years
Gas Chromatography ..... 3 years
Atomic Absorption ..... 4 years
Sample Preparation ..... 10 years
Data Review ..... 5 years
Inorganic Analysis ..... 11 years
High Perf. Liq. Chromatography ..... 2 years

OTTO SIMPSON, Extractions Laboratory
H.S. Diploma
Sample Preparation ..... 3 years

CHRIS STROUSE, Extractions Lab
B. S. Chemistry
Sample Preparation ..... training

MISSY HAMBY
Lead Sample Custodian
High School Diploma
GC ..... 5 years
Purge & Trap ..... 5 years
Atomic Absorption ..... 2-1/2 years
Sample Preparation ..... 7-1/2 years
Data Review ..... 11-1/2 years
Inorganic Analysis ..... 5 years

KAREN LOLLIS, Sample Custodian
A.S., Chemistry
Sample Receiving ..... 2 year

Kim Willison
Sample Custodian
High School Diploma
Sample Receiving ..... 1 year

TABLE 1.1 RESUMES

Richard J. Ronan, Ph.D., Laboratory Director

EDUCATION: Ph.D., Inorganic Chemistry
University of Hawaii, 1970

Master of Science, Inorganic Chemistry
University of Hawaii, 1970

Bachelor of Science, Chemistry
Franklin College of Indiana, 1965

PROJECT EXAMPLES:

■ For over 20 years Dr. Ronan has provided technical and management leadership to the environmental community. As principal of ASO Consulting, Inc., he focused these skills to solve problems for senior industrial management and the legal community. Assignments have ranged from project management, document review, and expert witness testimony, to full-time management of the multimillion dollar, multidisciplinary laboratory.

■ Dr. Ronan has over twenty years of government (USEPA) and private sector experience in teaching, basic and applied research, marketing, operations, financial control, client relationships, and major project management. His unique experience has prepared him to handle the integration of all of these areas.

PROFESSIONAL EXPERIENCE SUMMARY:

4/94 to Present
Southwest Laboratory of Oklahoma, Inc., Laboratory Director
As Laboratory Director, Richard Ronan directs the operational functions of all sections of the corporation's largest laboratory, located in Broken Arrow, Oklahoma, including both administrative and analytical. This includes working directly with supervisors and managers from all departments. He is also directly responsible for marketing, business planning and all aspects of the business.

5/90 to 3/94
Principal, ASO Consulting
Experience included support of litigations for six law firms (investigations, depositions, and trials,) a two year business assignment for Huntingdon International Holdings, and other similar assignments. Dr. Ronan designed and developed the QA/QC Program for a $4 billion property owner that oversaw all real estate transactions.

1987 to 1990 **Division Manager and Vice President,** Analytics Div., Roy F. Weston, Inc. Board of Directors (88/90).

1978 to 1987 **Operations Manager and Vice President,** Versar, Inc.

1975 to 1978 **Director Engineering and Research,** Fisher Scientific, Jarrell-Ash Division

1973 to 1975 **Section Chief, Metals,** US EPA Region V, Central Regional Lab, Chicago, IL

1971 to 1975 **Associate Scientist,** Iowa State University, Ames Laboratory

1970 to 1973 **Assistant Professor,** Simpson College, Indianola, IA

Robert W. Harris, Laboratory Manager

EDUCATION: Bachelor of Science Degree, Microbiology
Oklahoma State University, 1971

PROFESSIONAL EXPERIENCE:

1983 to Present
Southwest Laboratory of Oklahoma, Inc.
Laboratory Manager
As the Laboratory Manager of Southwest Laboratory of Oklahoma Mr. Harris directs all aspects of laboratory operation in the Company's newly constructed facility, including scheduling and cost control, staffing, training, customer support, and business development. He holds a B.S. in Microbiology from Oklahoma State University and has over 15 years experience in management of commercial laboratories. Analytical services under his direction include hazardous waste, drinking water and ground water investigation sponsored by a wide variety of governmental and private clients including EPA (e.g.,CLP,RCRA) Corps of Engineers (DERA) and the Air force (OHEL/HSD).

Prior to joining SWL he managed a geochemisty laboratory for Williams Brothers Engineering which supported major oil companies. Mr.Harris has developed supplemental methods for the analysis of hazardous waste when there were no applicable ones available for specific project requirements. His experience in directing the operations of environmental laboratories is exemplified by successful participation in the EPA CLP, U.S. Army Corps of Engineers, and other federal and State certification and accreditation programs. As an analyst Mr. Harris is experienced in the application of analytical methods using SW846, CLP, ASTM, and Standard Methods for organic and inorganic samples.

1981 to 1983 **Assistant Laboratory Director**
Williams Brothers Engineering,
Tulsa, Oklahoma
1975 to 1981—**Senior Research Engineer**

1971 to 1975 **Laboratory Manager**
Kansas City Testing Laboratory,
Kansas City, Missouri;

HARRY M. BORG, Organic Program Mgr.

EDUCATION:
Bachelor of Arts Degree, Chemistry, Minor: Physics, Math
Mount Mary College, Yankton, South Dakota

Additional Training
Hewlett Packard 5988 RTE - 6 System Mgr. Course, 9/97
Hewlett Packard 5987/88/96, Operators Course, 4/86

PROFESSIONAL EXPERIENCE:
2/92 to Present
Southwest Laboratory of Oklahoma, Inc.
Organic Program Manager — Responsible for day to day operations inOrganic department. Oversees performance for all GC/MS operations including extractions, analyses, data review, and data management. Provides technical management for organic EPA contracts. Interviews prospects for organic personnel.

11/89 to 2/92
Laboratory Manager
Conref Labs, Brighton, Colorado — Management of an environmental production laboratory. Responsible for day to day operations and technical management, as well as evaluation and interpretation of analytical results. Responsible as client liaison and for coordination of laboratory projects.

11/88 to 11/89
Technical Services Representative/Environmental Chemistry Manager
Hager Laboratories, Golden, Colorado — Responsible for management of day to day operations in an environmental production laboratory. Technical management, evaluation and interpretation of analytical results. Client liaison and project coordinator.

12/87 to 11/88
Organic Section Supervisor
metaTRACE, Inc., Earth City, Missouri — Responsible for hiring and scheduling of personnel, and Quality control and data review for GC and GC/MS depts.

12/83 to 11/87
Analytical Scientist II
Western Research Institute, Laramie, Wyoming — Responsible for scheduling and training personnel. Analyst in the semivolatile and volatile GC/MS laboratories. Analyses included semivolatile extracts from water, soil, high concentration samples, Pesticide/PCBs by GC and GC/MS, Inorganic analyses of oil shale by-product waters by non-supressed ion chromatography, separation and etection of sulphur anions by non-supressed ion chromatography (HPLC). Responsible for quality control of data. Utilized EPA 600 methods, SW846 methods, RCRA and EPA CLP protocols. Routine maintenance and troubleshooting of the HP59858 and HP5996 GC/MS systems with RTE-6 software and REV D/E.

3/80 to 11/83 **Chemist** — Tosco Corporation, Golden, Colorado & Martinez, Calif. — Responsible for supervision of evening shift personnel during oil-shale project. Coordinated pilot plant ball test program. Coordinated personnel schedule to accommodate research refinery program.

PAUL P. DANIELLO, Assistant Organic Program Mgr.

EDUCATION:
Bachelor of Arts Degree, Biology
Hofstra University, Hampstead, New York, 1977

PROFESSIONAL EXPERIENCE:
5/91 to Present
Southwest Laboratory of Oklahoma
Assistant Organic Program Manager
Responsible for personnel supervision and the daily operations of the Volatiles, BNA, and Dioxins areas. Train operators in the use of instrumentation and data system. Troubleshoot hardware/software problems on GC/MS systems. Review VOA, BNA, and Dioxins/Furans data.

3/88 to 5/91
GC/MS Section Manager
Professional Service Industries/Hall Kimbrell Division,Lawrence, Kansas — Responsible for maintaining three Mass Selective Detectors, an RTE-VI data system, training and supervising operators, scheduling analyses, and final client report production including both electronic and paper deliverables for the USEPA Contract Laboratory Program. Extensive experience in volatile and semivolatile organics, dioxins, furans, pesticides, herbicides, and PCB's in water, soil, air, produce, and other complex matrices. Additionally, supervised the TCLP Zero Headspace Extraction. Responsible for initiating the quality control samples into the laboratory's organic TCLP program.

9/86 to 2/88 **Group Leader** — MetaTrace, Inc., Earth City, Missouri, GC/MS—Responsible for maintenance of six GC/MS units (1-5988, 1-5996, 4-5970), three data systems and the scheduling of sample analysis. Review of Data produced from the six GC/MS Instruments.

5/86 to 8/86 **GC/MS Group Leader** — York Laboratories, Division of YWC, Inc., Whippany, New Jersey, — Operation and maintenance of two GC/MS systems and training of two operators.

6/85 to 5/86 **Organics Department Manager** — Century Laboratories, Inc., Thorofare, New Jersey—oversaw all activities of GC/MS Unit, GC Unit and Sample Preparation Unit. Responsible for properly maintaining nine instruments (3-GC/MS's, 5-GC's, 1-HPLC). Data Review and Report Production.

5/80 to 6/85 **GC/MS Laboratory Supervisor** — H2M Corporation, Melville, New York, Resonsibilities included operation and maintenance of Finnigan OWA and HP-5996 GC/MS systems. Mass Spectral Interpretation of GC/MS Data.

Laboratory Technician—Responsibilities included sample preparation and analysis of trace organic.

Mark Smith, Organic Data Manager

EDUCATION:

Masters of Biomedical Science Program
Major: Pharmacology, 25 credit hrs.
Oral Roberts University, Tulsa, Oklahoma, 1985

Bachelor of Science, Chemistry
Minor, Computer Science
Oral Roberts University, Tulsa, Oklahoma, 1984

PROFESSIONAL EXPERIENCE:

9/91 to Present
Southwest Laboratory of Oklahoma, Inc.
Organics Data Manager
Assembly and review of Organic Data Packages. Development of automation software.

9/89 to 9/91
NET, Inc., Carrollton, Texas
GC/MS Supervisor
Responsible for the scheduling and analysis of all samples for volatiles and semivolatiles by GC/MS. Responsible for the operation and maintenance of four Hewlett-Packard Gc/MS systems: three 5970 MSDs and a 5996. Duties include data review, standards preparation, methods development, SOP writing and updating, writing instrument automation software, employee training, and instrument operation.

11/88 to 9/89
Southwest Laboratory of Oklahoma, Inc., Broken Arrow
Volatile Organics Group Leader
Leader of volatiles GC/MS laboratory. Responsible for the scheduling and analysis of all VOA samples, so that holding time deadlines and turnaround times were met. EPA CLP, 624 and 8240 methods were used. Responsibility to have QA/QC executed at the proper level and frequency. Reviewed data for quality and completeness. Responsible for maintenance of the GC/MS systems.

8/86 to 11/88
Southwest Laboratory of Oklahoma, Inc., Broken Arrow
GC/MS Chemist - Analyzed water, soil, and petroleum based samples for volatiles, semivolatiles, and dioxins in accordance with EPA CLP or SW846 methods and requirements. Wrote procedure files to help automate the analysis of samples and data review. Performed instrument maintenance and repairs.

3/86 to 8/86
Southwest Laboratory of Oklahoma, Inc., Broken Arrow
Extractions and Inorganics Chemist - Prepared sample extracts for semivolatiles, pesticides, PCBs, dioxins, and herbicides per EPA CLP or SW846 requirements. Performed analysis for total organic carbon, oil and grease, chemical oxidation demand, and ion chromatography.

JASON D. RUCKMAN, Inorganic Program Mgr.

EDUCATION: Bachelor of Science, Chemistry
Kansas Wesleyan University, Salina, Kansas, 1985

Additional Studies:
14 hours graduate credit
University of Kansas, Lawrence, Kansas, 1985-86

PROFESSIONAL EXPERIENCE:

6/89 to Present **Southwest Laboratory of Oklahoma, Inc. —Inorganic Program Manager**
Manages and oversees the Contract Laboratory Program (CLP). Reviews data, resolves reporting problems and provides technical assistance to analysts. Directs troubleshooting of instruments to minimize instrument downtime. Performs sample analysis as needed to meet deadline requirements.

3/87 to 6/89 **EPA Metals Manager**
Wilson Laboratories, Salina, Kansas
Primary operator for the Perkin-Elmer 5100. Responsible for analyzing water and soils samples for the EPA according to the 787 contract and assembling CLP packages.

Primary ICP operator (8/86-8/88)
Responsible for everyday maintenance and upkeep of the ICP (Perkin-Elmer 6000).

8/85 to 5/86 **Teaching Assistant, Department of Chemistry**
University of Kansas, Lawrence, KS
Responsible for pre-laboratory lectures, enforcing safety requirements and grading labs and lecture tests.

JOHN WRIGHT, Assistant Inorganic Program Manager

EDUCATION: Bachelor of Science, Chemistry
Northeastern State University, Tahlequah, OK 1984

School of Pharmacy, senior status
Southwestern State University, Weatherford, OK 1986-89

PROFESSIONAL EXPERIENCE:

12/91 to Present **Southwest Laboratory of Oklahoma, Inc. — Assistant Inorganic Program Manager** (12/93 to Present)
Assists the Inorganic Program in overseeing daily operations in the Inorganic Laboratory. Reviews data, resolves reporting problems and provides technical assistance to analysts. Directs troubleshooting of instruments to minimize instrument downtime. Performs sample analysis as needed to meet deadline requirements.

AA Operator (12/91 to 12/93)
Graphite Furnace operation, including all analysis of Pb, Tl, As, and Se. Data review of analyses performed.

2/90 to 12/91 **Analyst III/Group Leader**
National Environmental Testing
— Inorganic analysis and methodology according to EPA protocol. Followed N.E.T. guidelines for quality control. Some cross-training for organics sample preparation for diesels, PAHs, gasolines, and BTXs. Performed analyses for hazardous waste, waste water, and ground water samples. Reviewed data for quality control.

1989 to 1990 **Environmental Chemist**
Environmental Services Company
Performed analytical analyses on waste water, soil, sludge, groundwater, and potable water samples. Also performed analysis for BOD, Cn^-, Phenol, $N0_3$—$N0_2$, TKN, N-

NH_3, EPA-WP standards, AOCS standards, and EPA-WS standards. Performed AA analysis using Varian 200

1984 to 1985 **Shift Technician/Analytical Chemist**
Fort Howard Paper Company
Responsible for polymer addition to the kroftas and the resin/caustic system. Tested paper for proper wet strength. Ensured paper met guidelines for quality control. Responsible for paper standards and process. Research to increase productivity involving zeta potentiometry.

CHUCK HOOVER
Quality Assurance Officer

EDUCATION:
Bachelor of Arts Degree in Biology
Minor in Chemistry
Wichita State University, 1976

PROJECT

- Experience with PCB analyses on transformer oils, Hydraulic fluids, soil/sediment, waters and fish flesh.

- Experience in EPA 600 series Methodologies, both extractions and analyses.

- Experience in Trihalomethane Studies on source and drinking water supplies.

- Experience in data review of analyses performed on samples from EPA's Superfund Sites; performed in various laboratories in the EPA's Contract Laboratory Program.

- Metal analysis using Flame/Furnace Atomic Absorption. Extraction/Clean-up of Dioxin/Furans using method 613.

PROFESSIONAL EXPERIENCE:
1987 to Present
Southwest Laboratory
Of Oklahoma, Inc.
QA/QC Officer

1985-1987
Lockheed Engineering and
Management Services
Las Vegas, Nevada, Technical Support Supervisor, Laboratory Performance Monitoring Section.

1983-1985
Southwest Laboratory
Of Oklahoma, Inc.
QA/QC Officer/Extractions Chemist/AA Operator

1982-1983
National Analytical Laboratories, Tulsa, OK
Gas Chromatography/GC/MS Chemist

1980-1982
Williams Brothers Laboratories, Tulsa, OK
Wet Chemistry Section Supervisor

1977-1980
Wichita Water Department,
Water and Waste-water Laboratory,
Wichita, KS
Laboratory Technician

1976-Summer
U.S. Department of Labor
Occupational Health & Safety Administration (OSHA), Kansas City, MO,
Industrial Hygienist (Summer Merit)

Robert A. West,
Computer Services

EDUCATION:
Langston University, Tulsa, OK
Bachelor of Science degree in Computer Science (December 1988)

Coursework:
Computer Management Information Sys.
Software Design and Development
Data Structures and Algorithms II
Database Design

Tulsa Junior College, Tulsa, Oklahoma, Associate degree in Mathematics (May 1986)

PROFESSIONAL EXPERIENCE:

10/90 to Present **Southwest Laboratory of Oklahoma, Inc., Assistant Programmer, Computer Services Department.**

10/88 to 9/90 **Programer Analyst**
Tulsa, Oklahoma
Developed and administrated a UNIX software for retail shelf labeling industry to drive Postscript and Laserjet printers. (ie. NCR Tower, AT&T, Unisys, Intel 386's, IBM AIX, FLEX OS on IBM 4680, SCO Xenix, ALTOS, MS-DOS)

7/88 to 10/88 **Programmer Analyst**
Voice Systems and Services Inc., Mannford
Developed and supported the Voice Mail System software.

6/84 to 7/88 **Data Processing Coordinator**
St. Francis Hospital, Tulsa, Oklahoma
Coordination of Data Processing projects, software product evaluation, created inventory control programs.

TABLE 1.2 LABORATORY CREDENTIALS

PROGRAM PARTICIPATION

USEPA CLP (Contract Laboratory Program)

- Organics Analysis, Multi-Media, Multi Concentration, by GC/MS and GC/EC Techniques. *Note: continuous participation since 1985.*
- Rapid Turn-Around Organics Analysis, Multi-Media, Multi Concentration, by GC/MS and GC/EC Techniques.
- Chemical Analytical Services for Multi-Media, Multi-Concentration Metals and Inorganics.

EMSL Cincinnati, WP/WS
Water Pollution/Water Supply Study Program.

U.S. Army Corps of Engineers, DERP
DERP certification(Defense Environmental Restoration Program).

U.S. Air Force, AFCEE IRP
Installation Restoration Program participant, analytical services for AFB Projects.

U.S. Navy, NEESA CLEAN IRP
Installation Restoration Program participant, analytical services

INEL, (Idaho National Engineering Lab.)
Qualified by ERPSMO to perform analytical services.

HAZWRAP
Certified to perform analytical services for Hazardous Waste Remedial Actions Program.

NRC License
Licensed to perform analysis of coal contaminated waste for environmental pollutants. (License #35-27413-01)

STATE CERTIFICATION

ALABAMA ..... Lab ID #40890
Department of Environmental Management

ARKANSAS ..... Lab ID #N/A
Department of Pollution Control & Ecology

CALIFORNIA ..... Lab ID #1221
Department of Health Services, Env. Lab Program

COLORADO ..... Lab ID #335
Department of Health, Drinking Water Parameters

FLORIDA ..... Lab ID #87326
Department of Health and Rehabilitation

IOWA ..... Lab ID #104
Department of Natural Resources

KANSAS ..... Lab ID #E-1126
Department of Health and Environment

KENTUCKY ..... Lab ID #90065
Department of Environmental Protection

LOUISIANA ..... Lab ID #93-19
Department of Health and Hospitals

MICHIGAN ..... Lab ID #N/A
Department of Public Health

NORTH CAROLINA ..... Lab ID #404
Department of Env. Health & Natural Resources

NORTH DAKOTA ..... Lab ID #R-073
Department of Health and Conservation

OKLAHOMA ..... Lab ID #8728
Water Resources Board

SOUTH CAROLINA ..... Lab ID #79003
Department of Health and Environmental Control

TENNESSEE ..... Lab ID #02929
Department of Health and Environment

UTAH ..... Lab ID #E-117
Department of Health

VIRGINIA ..... Lab ID #00322
Department of Drinking Water

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TABLE 1.3 LABORATORY INSTRUMENTATION & EQUIPMENT INVENTORY

GC/MS Laboratory

DESCRIPTION **YEAR**

GC/MS Hewlett Packard 5985/87/88 1978
Connected to RTE Aquarius Data System (V)
Packed/Capillary Injector
EI/CI Heated Source
Direct Insertion Probe
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5995/5996 1982
Connected to RTE Aquarius Data System (VI)
Packed/Capillary Injector
Heated Source
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1986
Connected to DOS Chemstation with Target data procession on HP710
Packed/Capillary Injector W/ Jet Separator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1987
Connected to DOS Chemstation with Target data procession on HP715a
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1988
Connected to DOS Chemstation with Target data procession on HP710
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1988
Connected to RTE Aquarius Data System (VIII)
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5988 1988
Connected to RTE Aquarius Data System (VI)
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1989
Connected to RTE Aquarius Data System (V)
Electronic Pressure Control Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1989
Connected to RTE Aquarius Data System (VIII)
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1989
Connected to DOS Chemstation with Target data procession on HP715b
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1990
Connected to DOS Chemstation with Target data procession on HP720b
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5971 MSD 1990
Connected to DOS Chemstation with Target data procession on HP710
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

GC/MS Hewlett Packard 5971 MSD 1991
Connected to DOS Chemstation with Target data procession on HP715b
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

GC/MS Hewlett Packard 5971 MSD 1991
Connected to DOS Chemstation with Target data procession on HP715b
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 2000 with 2016, 2032 Auto Sampler

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GC/MS Laboratory
(continued)

DESCRIPTION **YEAR**

GC/MS Hewlett Packard 5971 MSD 1991
Connected to DOS Chemstation with Target data procession on HP720b
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS VG Trio-1 1991
Connected to LABBASE data system
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5970 MSD 1992
Connected to DOS Chemstation with Target data procession on HP715a
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5972 MSD 1993
Connected to DOS Chemstation with Target data procession on HP720b
Electronic Pressure Control Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Hewlett Packard 7673 Auto Sampler

GC/MS Hewlett Packard 5972 MSD 1993
Connected to DOS Chemstation with Target data procession on HP715b
Packed/Capillary Injector W/ Jet Spearator
Hewlett Packard 5890 Gas Chromatograph
Tekmar 3000 with 2032 Auto Sampler

High Resolution GC/MS VG-70S 1989
Connected to Vax 4000 data system
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Fisons A200S Autosampler

High Resolution GC/MS Autospec 1989
Connected to Vax 4000 data system
Packed/Capillary Injector
Hewlett Packard 5890 Gas Chromatograph
Fisons A200S Autosampler

Data Systems

RTE Data System (VI)
HP A-900 Computer w/Aquarius Rev. F.
HP 7937 H/XP 571 MB Disk Drive
HP 2934 Printer, 200 CPS (3)
HP 9144 16-Track Streaming Tape Drive
HP Ethernet LAN connection
Terminals (4)

RTE Data System (VIII)
HP A-900 Computer w/Aquarius Rev. F.
HP 7937 H/XP 571 MB Disk Drive
HP 3SI Laser Printer, 16ppm
TI Microlaser Printer, 9ppm
HP 9145 32-Track Streaming Tape Drive
HP Ethernet LAN connection
Terminals (3)

Unix Data System (HP720)
HP 735 Workstation w/HP-UX 9.01
Thruputt Maestro Software
48 MB RAM
Quantum 425S 425 MB Disk Drive
Micropolis 1928 2.0 GB Disk Drive
HP 2.0 GB Dat Tape Drive
HP 1.4 MB Floppy Disk Drive
TI Microlaser Printer, 9ppm
19" Color Monitor
17" Samsung X-terminal

Unix Data System (HP710)
HP 710 Workstation w/ HP-UX 8.07
Thruputt Target Software
32 MB RAM
Quantum 425S 425 MB Disk Drive
HP 1.3 GB Disk Drive
HP 4SI Laser Printer, 16ppm
19" Color Monitor
17" Samsung X-terminal

Unix Data System (HP715a)
HP 715/33 Workstation w/ HP-UX 9.01
Thruputt Target Software
32 MB RAM
HP 1.0 GB 3.5" Disk Drive
HP 3SI Laser Printer, 16ppm
19" Color Monitor
17" Samsung X-terminal

GC/MS Laboratory

Data Systems *(continued)*

Unix Data System (HP715b)
HP 715/33 Workstation w/ HP-UX 9.01
Thruputt Target Software
32 MB RAM
HP 1.0 GB 3.5" Disk Drive
HP 2.0 GB external Dat Drive
HP 3SI Laser Printer, 16ppm
19" Color Monitor
17" Samsung X-terminal

Unix Data System (HP720b)
HP 720 Workstation w/ HP-UX 9.01
Thruputt Target Software
32 MB RAM
Quantum 425S 425 MB Disk Drive
Micropolis 1524 1.3 GB Disk Drive
HP 3SI Laser Printer, 16ppm
19" Color Monitor
17" Samsung X-terminal

Support Equipment

Purge and Trap, Tekmar LSC2 (2)
Tekmar, ALS - 10 Position Auto Samplers (2)
Tekmar 1000 - Capillary CRYO Focuser (1)
NesLab Refrigeration Cooler (3)
Ultra Sonic Cleaner, Mettler (1) 1984
Frigidaire Coolers - Extract Storage (2)
PC Designs 80286 Computers
Formsmaster Software (4)
Tekmar LSC 2000 Purge & Trap Units (4)
Tekmar 2016, 16 port ALS's (4)
Tekmar 2032, 16 port ALS's (4)
Tekmar 6016 16 port ALS's
Tekmar 6032 16 port ALS's
Entech 2000 preconcentrator
2016 cm Autosampler for Summa Canisters

GC Laboratory

DESCRIPTION	YEAR
Gas Chromatograph	**1978**
Carle TCD (Nat Gas)	
Gas Chromatograph	**1978**
Carle TCD (Nat Gas)	
Gas Chromatograph	**1989**
Carle TCD (Nat Gas	
Gas Chromatograph	**1989**
Carle TCD (Nat Gas)	
Gas Chromatograph	**1989**
Carle TCD (Nat Gas)	
Gas Chromatograph, VARIAN 3400 ECD/ECD	**1985**
Packed Capillary Injectors	
CTC A200S Auto Sampler	
Gas Chromatograph, HP 5890 ECD/ECD	**1986**
Dual Split/Splitless Injectors	
Dual HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 ECD/ECD	**1987**
Dual Split/Splitless Injectors	
Dual HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 PID/HALL	**1987**
Tekmar LSC2000 Purge and Trap	
Tekmar ALS 2016 & 2032 Position Auto Sampler	
Gas Chromatograph, HP 5890 FID/NPD	**1988**
Dual Split/Splitless Injectors	
HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 ECD/ECD	**1988**
Dual Split/Splitless Injectors	
HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 Series II ECD/ECD	**1989**
Dual Split/Splitless Injectors	
Dual HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 Series II ECD/ECD	**1989**
Dual Split/Splitless Injector	
Dual HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 PID	**1989**
ALS 2016 & ALS 2032	
Gas Chromatograph, HP 5890 HALL/PID/FID	**1989**
Split/Splitless Injectors	
HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 HALL/PID	**1989**
Split/Splitless Injectors	
HP 7673 Auto Sampler	
Gas Chromatograph, HP 5890 PID	**1989**
Split/Splitless Injectors	
HP 7673 Auto Sampler	
Gas Chromatograph HP-5890 TCD	**1989**
Split/Splitless Injectors	
Gas Chromatograph HP-5890B ECD	**1991**
Dual Split/Splitless Injectors	
Twin 7673A Auto Samplers	
Gas Chromatograph HP-5890 Series II ECD/ECD	**1992**
Dual Split/Splitless Injectors	
Twin 7673A Auto Samplers	
Electronic Pressure Control (EPC)	

GC Laboratory
(continued)

COMPUTERS/INTEGRATORS /DATA SYSTEMS

VG 4 Channel Data Systems (4)
Hewlett Packard 3393 Integrators (2)
Hitachi D2000 Chromatographic Integrators (2)
HP 3396 Integrators (2)
486 Computer (2)
386 Computer (5)
286 Computer (5)
Maxima Data System (8 channels)

LIQUID CHROMATOGRAPHY

Kratos HPLC (1) .....
Spectroflow 400 Pumps (2)
Spectroflow 480 Injector (1)
Spectroflow 783 Programmable Absorbance Detector (1)
Hitachi 655A - 40 Auto Sampler (1)
Fluorescence Detector (1)
Waters HPLC (1) **1992**
715 Ultr Wisp Sample Processor
510 HPLC Pump
486 Tunable Absorbance Detector

SUPPORT EQUIPMENT

Oven, VWR 1310 (1)
Frigidaire Cooler - Sample Storage (1)

Extractions Laboratory

DESCRIPTION	YEAR
Concentrators	
Centrifuge, International Equip. Co.	1988
Kudera Danish (124) 1000	1987
Dessicator, Boekel	1985
Drying Oven, Blue M	1980
Millipore (24)	1987
Extraction Apparatus	
Continuous Liquid Extractors (102)	1987
Extraction Apparatus	
Soxhlet Extractors (20)	1987
Gel Permeation Clean-up (GPC) Apparatus, ABC	1987
Applied BioSystems UV Detector, Model 757	1988
Gel Permeation Clean-up (GPC) Apparatus, ABC	1991
Sontek UV Detector	1991
Hitachi D2500 Inetgrator	
Varian 4400 Integrator	
Zymark Benchmate	1992
SSI Pumps (2)	
Sontek UV Detectors (2)	
Zymark Turbovap (2)	1992
Marathon GPC	1994
Sontek Pump (1)	
Sontek UV Apparatus (1)	
Delfield Storage Refrigerator, Extracts	
General Electric Storage Refrigerator, Standards	
8-Place Auto Seperatory-funnel Shaker	1988
Glass Columns	
Extraction Apparatus (20) Seperatory Funnels, 2000 ml	
Funnels (75)	
Dioxin Columns (80 sets)	
400 ml Beakers (75)	
250 ml Erlenmeyers (50)	
500 ml Boiling Flask (90)	
Sample Concentrator, Nitrogen Blow Down, 30 Place	1984
Sample Concentrator, Nitrogen Blow Down, 30 Place	1988
Sonic Disruptor, Sonicator (Sonics)	1989
Sonic Disruptor, Sonicator (Sonics)	1990
Sonic Disruptor, Sonicator (Sonics)	1990
Top Loading Balance, Ohaus 400	1992
Top Loading Balance, Ohaus GT 4000	
Knauer UV Photometer	
Kipp & Loven Printer Controller	

Metal Analyses Laboratory

DESCRIPTION	YEAR
Atomic Absorption	
Instrumentation Laboratory Video 22 Double Beam Dual Channel Spectrophotometer with Graphics	1983
TJA Autosampler	
TJA Prep station	
TJA Video 22 Double Beam, Dual Channel Spectro-photometer with Graphics	1991
TJA CTF 188	
TJA Autosampler	
TJA Prep Station	
TJA 188 Controlled Temperature Furnace	1991
Perkin Elmer 5100 Zeeman	1990
PE HGA 600	
PE AS-60	
Varian 400Z GFAA (2)	1992
Buck Scientific Mercury Analyzer 400	1990
Buck Scientific Mercury Analyzer 400	1991
Leeman PS200 Mercury Analyzer	1992
Leeman PS200 Mercury Analyzer	1993

Inductively Coupled Plasma

ICP 61 Plasma Spectrometer
(Thermo Jarrel Ash) 1988
Auto sampler-TJA
ARL 3560 ICP 1990
ARL Auto sampler
ICP 61E Trace Analyzer
(Thermo Jarrel Ash) 1993
ICP, TJA Trace Analyzer 1994

Wet Chemistry - Inorganic

DESCRIPTION	YEAR
Air Compressor	1990
Analytical Balance, Mettler H80	1984
Ash Furnace, Lindberg	1984
Balance Analytical, Mettler H80	1984
Balance, toploading, Ohaus model 400	
Balance, heavy duty solution, Ohaus	
Cadmium Reduction Nitrate Columns	1985
Centrifuge, Damon IEC Clinical	1984
Conductivity Meter, HACH	1983
Digestor, 36 place LABCONCO	
Electrode (Ammonia) 95-12 Orion	
Electrode (Fluoride) 94-09-00 Orion	
Flow Injection Analyzer, Lachet Quikchem	1991
Six Place TCLP/EP TOX Tumblers (2)	
Extractors	
Zero head (12)	
Funnels, Buchner	
Millipore Membrane	
Gooch Crucibles	1983
GCA Heater Dessicator/Precision	1984
Glass Dessicators, Large and Small	1983
Glassware	
Heating Mantles	
Electrothermal 500-C (12)	
Hoods, Labconco - 6 Foot	
Hot Plates & Stirrers	1983
Integrator, Hitachi D2000	
Ion Chromatograph, Dionex,	1982
Dionex-DX100 Ion Chromatograph	1992
Karl Fisher Titrimeter, Bechman KF4	1983
Mettler Ultrasonic Cleaner	1982
MuffleFurnace, Lindberg 51828	
Neslab Coolflow CFT-33	1985
Neslab Coolflow CFT-75	1989
Oven, CMS Equatherm D1262	
Oven, Precision	1986
pH Meter, Orion (Portable)	1982
pH Meter, Corning	1983
Plastic Dessicators, Large	1984
Spectrometer, Bausch & Lomb	1984
Spectrometer 21 DB, Bausch & Lomb	
Stack Sampling Equipment, Joy Unit -2	1982
Total Organic Carbon Analyzer, Ionics	1982
Total Organic Carbon Analyzer, Schmadzu 5050	1991
Carbon Analyzer Leco CR12	1989
Total Organic Halogens	1983
Dohrman Microcoulometer MCTS-20	
Tumbler (TCLP), Millipore	
Vacuum-Pressure Pump, Thomas	1984
ISCO Autosampler	
CEM Microwave Digestion System-205	
Dionex DX300 Ion Chromatograph	1993

High Hazards Laboratory

DESCRIPTION	YEAR
Analytical Balance, ASP Model 2410	1986
Blender, Waring	1984
Chemical Carcinogen Glove Box, LABCONCO	1984
Heated Dessicator, Precision Scientific	1984
Shaker, Eberbach	1984
Special Glassware	
Columbia Fisheries Dioxin Protocol	1985
Sonic Disruptor, Sonicator - Heat Systems	1985
Infrared Spectrophotometer, Perkin Elmer (model 337)	
Muffle Furnace, Linberg	
Samsung Storage Refrigerator	
Laboratory Furniture	
1 - Four Foot Hood, KEEWANEE	1985
1 - Six Foot Hood, KEEWANEE	1985

Data Management

DESCRIPTION	YEAR
Computer, Gateway 2000 486/33	1991
16 Mb Memory	
300 Mb Hard Disk	
150 Mb Tape Backup	
450 Watts UPS	
WYSE 60 Terminals (7)	
Epson FX-850 Printers (7)	
EX800 Printers (1)	
LaserJet III Printers (1)	
Computer, Perkin Elmer 3203	1986
LIMS System, 6 Terminals	

Data Management
(continued)

Copiers
Xerox 1065 1989
Xerox 5065 1990
MITA 4055 1987
Savin 7500 1991
MITA DE131
Sharp SF-2027

Facsimiles
Canon FAX-730
Canon FAX 410
Canon FAX L770 1991
Canon FAX L700

Miscellaneous Computer Equipment
GANDALF PACX IV, PBX
Terminal Ports (196)
Computer Ports (96)
INMAC 64 port Smart Switch
Packard Bell 2400 baud modems (4)
Five Hewlett Packard Computers 2117F 1986-1990
2 Megabyte Memory W/RTE 6/VM & Aquarius Rev.E
Disk Drive, HP 7933, 404 Megabyte (5)
Hewlett Packard A900 Computer , 4 mb(3) 1990
Disk Drive, HP 7937, 500 Mb
Tape Drive, HP 9144 (3)
Disk Drive, HP 7935, 404 Megabyte
Disk Drive, HP 7914, 130 Megabyte
Tape Drive, HP 7970B, 9 Track 800 BPI (2)
Tape Drive, HP 7970E, 9 Track 1600 BPI(4)
Terminals, HP2623 (20)
Terminals, HP2648 (2)
Terminals, HP2627 (3)
Terminals, HP2621P (3)
Terminal, HP 2397A (1)
Terminal, HP 2393A (1)
Terminal, HP 2622 (1)
Terminal, HP 2392 (1)
Terminal, HP 150 (1)
Printers, HP2934A (11)
Printer, HP Ruggedwriter (3)
Printer, HP 2563B (1)

One Hundred Computers, IBM PCs and Compatibles 1986-1991
40 to 200 Megabyte Disk Drives
Streamer Tape Back-Up System (2)

Printers 1987-1991
LaserJet, Hewlett Packard Series III (2)
LaserJet, Hewlett Packard Series IIIsi (2)
LaserJet, Hewlett Packard Series II (1)
LaserJet, Hewlett Packard Series IIP (1)
Paint Jet, Hewlett Packard (1)
DeskJet Plus, Hewlett Packard (1)
ScanJet Plus, Hewlett Packard (1)
Epson FX850s (18)
Epson EX1000s (6)
Epson FX100 (1)
Epson FX286 (1)
Epson LQ500 (1)
Epson EX800 (4)
Epson LX800 (1)
Epson EPL-7000 (5)
Epson Action Laser II (4)
Star SG10 (1)
Panasonic KX-P1191 (1)
Panasonic KX P1180 (1)
Panasonic KX-P1092i (1)
Okidata Microline 182 (1)
IBM Proprinter II (1)
Texas Instruments Microlaser (4)

Personnel Training

All positions involve on-the-job training. This training requires the reading of a Standard Operating Procedure; performace of that procedure under close supervision; and documentation of the understanding and proficiency on a form which is part of each departments' SOPs (see figure 1.3).

All training information including method QA/QC as well as health and safety documentation is maintained in the employees' training file. The training files are maintained by the QA/QC section and include resumes, classes taken by the employee, and any certifications obtained by the employee from attending these classes. All refresher training is included in these files also.

GC DEPARTMENT PAGE 1 OF 2

DOCUMENTATION OF QUALIFIED PERSONNEL PERFORMING ANALYTICAL TESTS

ANALYST NAME:	TITLE:	DATE OF HIRE:

TEST CODE:	METHODOLOGY:	ANALYST INITIALS:	SUPERVISOR INITIALS:	DATE APPROVED:
GC110	EPA 601/SW 8010			
GC120	EPA 602/SW 8020			
GC130	SW 8010/8020			
GC140	EPA 501			
GC150	SW 8020			
GC160	EPA 504.1			
GC199	SW 8020			
GC200	SW 846 8330			
GC210	USAE 30			
GC299				
GC300	MOD 8015			
GC310				
GC320	CALIF. GC/FID			
GC330	IOWA GC/FID			
GC400	EPA 610/SW 8100			
GC405	GC/PID			
GC420	SW 8310/HPLC			
GC430	SW 8315			
GC550	EPA 615/SW 8150			
GC560	EPA 615/SW 8150			
GC570	SW 8150			
GC580	EPA 615/SW 8150			
GC599	SW 8150			
GC600	EPA 608/SW 8080			
GC610	SW 8080			
GC620	SW 8080			
GC700	EPA 604			
GC710				
GC720	HPLC			
GC800	EPA 608/SW 8080			

SOUTHWEST LABORATORY OF OKLAHOMA, INC. • AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 WEST ALBANY • BROKEN ARROW, OK 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [QA003-0492-01]

FIGURE 1.3 Example of Training Documentation

2.0 SAMPLING PROCEDURES

2.1 REFERENCES

The laboratory follows the established procedures contained in the Field Manual section of SW-846, Volume II (3rd edition, September 1986), the methods contained in 40 CFR, Part 136, Federal Register, Volume 49, Number 209 (October 26, 1984), and in the USEPA publication A Compendium of Superfund Field Operations Methods, EPA/540/p-87/001, December 1987, whichever is appropriate, to obtain samples which are representative of the sample matrix.

Each material sampled (i.e., surface water, ground water, soil, etc.) is transferred to its required prelabeled sampling container, stored, and preserved in accordance with Tables 2.1 and 2.2.

2.2 SOIL & SEDIMENT SAMPLES

The following is a listing of the procedures that are followed for transferring soil and sediment samples during field sampling:

- All sampling equipment, including internal components, is decontaminated prior to use and between samples, using laboratory-grade detergent and drinking water, ASTM Type II reagent water, and pesticide-grade methanol and hexane rinses, in that order.

- Drilling ring(s) and tools are thoroughly steam-cleaned before initial use and after each borehole completion.

- Decontaminated equipment is allowed to air-dry, then wrapped in a non-plastic material (aluminum foil or teflon) and stored in a fashion that reduces the potential for accidental contamination.

- Containers necessary for soil samples are described in Table 2.2.

Volatiles

For volatile analyses, two 4-oz. wide mouth bottles are filled as full as possible. The teflon-lined lid is replaced and the jar put in the cooler. All samples are kept at 4°C. All volatile analysis samples are collected independently of the extractable and inorganic portions.

Sample portions for all volatile analyses (e.g. SW8240, 8010, 8020) from one discrete sampling location may be combined in one jar if collected at the same time.

Extractable Organics

For extractable organics and petroleum hydrocarbon analyses, a 32-oz. wide mouth bottle is filled as full as possible. The teflon-lined lid is replaced and the jar put in the cooler. All samples are kept at 4° C. Sample portions for all extractable analyses from one discrete sampling location may be combined in one jar if collected at the same time.

Metals and General Chemical Analyses

An 8-oz. wide mouth bottle is filled as full as possible. The teflon-lined lid is replaced and the jar put in the cooler. All samples are kept at 4° C. Sample portions for all metals and general chemical analyses from one discrete sampling location may be combined in one jar if collected at the same time.

2.3 AQUEOUS SAMPLES

The following is a listing of the procedures that are followed when collecting water samples:

- The procedure listed above for the transference of soil also is observed here, except that filtration may be required prior to filling sample containers destined for certain types of analyses.

- Monofilament line or steel wire for lowering sampling equipment into the well is dedicated for each well.

- Water-level probes are decontaminated before use in each well.

- Precautionary steps for decontaminated tool storage are also adopted from Section 2.2.

- All prescribed preservation techniques are implemented at this stage.

- Containers necessary for water samples are described in Table 2.1.

Volatiles

Purgeable Halocarbons and Aromatics—The following is a description of the procedures that are followed for sampling for GC volatile analyses:

Sample containers are not pre-rinsed with sample nor overfilled. For each discrete sampling location, two 40 mL VOA vials are filled until the meniscus bulges over the rim of the vial. The cap liner is slid across the rim of the vial teflon side down and the plastic cap replaced on the vial. To make certain the vials contain no headspace, the vials are inverted to check for bubbles. Any preservation technique is noted on the sample label and the COC. The vials are placed in the cooler and kept at 4° C.

Extractable Organics

Extractable Organics—The following is a description of the procedures that are followed when sampling water for extractable organics:

Sample containers are not pre-rinsed with the sample nor overfilled. For each discrete sampling location, two 1-liter (L) glass containers are filled to the top with sample and the teflon-lined container caps replaced. The containers are placed in the cooler and kept at 4° C.

Metals

Total Recoverable Metals—The following is a description of the procedures that are followed when sampling water for total recoverable metals:

Sample containers are not pre-rinsed with sample nor overfilled. Before sampling, approximately 2 mL of 1 + 1 nitric acid (HNO_3) will be added to each sample container. This preservation technique is noted on the sample label and the COC. For each discrete sampling location, one 250 mL plastic bottle is filled with sample before replacing the plastic cap. The turbidity of each sample is noted at this time. The bottle is placed in the cooler and kept at 4° C.

General Chemical Analyses

Total Dissolved Solids—The following is a description of the procedures that are followed when sampling water for total dissolved solids:

Sample containers are not pre-rinsed with sample nor overfilled. For each discrete sampling location, one 250 mL plastic bottle is filled with filtered sample before replacing the plastic cap. Each water sample is filtered through a 0.45 micro (u) GFA glass fiber filter using nitrogen (N_2) pressurization. After sampling, the sample is preserved by adding approximately 2 mL 1 + 1 HNO_3. This preservation technique is to be noted on the sample label and COC.

Common Anions—The following is a description of the procedure that is to be followed when sampling water from common ions:

Sample containers are not pre-rinsed with sample nor over filled. For each discrete sampling location, one 250 mL plastic bottle is filled with sample before replacing the plastic top. The bottle is placed in the cooler and kept at 4° C.

2.4 REPLICATE/DUPLICATE SAMPLING PROCEDURES

Soil & Sediment Samples

Replicate soil samples are collected as a means of assessing the precision of the sampling effort at a site. One replicate sample is taken every 20 sampling locations, or one per site or zone if that site or zone contains less than 20 sampling locations. For clients requiring more frequent duplicate sampling, this can be accomodated. A significant problem that arises during soil sampling from a borehole is accurately duplicating the sample interval. To alleviate this problem, samples are collected using a 3-inch split spoon sampler. This sampler generally provides an adequate sample volume so that replicate samples can be collected. The procedure for collecting and containerizing the samples is detailed below.

The volatile sample portion is collected first to minimize compound volatilization. The soil is split lengthwise using a teflon or stainless steel spatula, and then the sample portion for volatile organic analysis is immediately collected. Spatulas are used to transfer the sample from the exposed core directly into the vials or jars. Replicate samples are collected at the same time, employing the same techniques.

After the volatile organic samples have been collected, the sample description is noted. Once the description has been recorded, the remaining sample is mixed on a teflon board and evenly subdivided between the remaining sample containers. This mixing minimizes the heterogeneity of the soil samples and provides a representative replicate sample. This mixing is used only for inorganic and nonvolatile samples, since agitation may allow escape of the volatile contaminant from the soil.

After collection, all sample bottles are properly labeled and stored on-site in an ice chest at 4°C until they are packed and shipped via overnight delivery to the laboratory for analysis.

Aqueous Samples

Duplicate water samples are collected as a means of assessing the precision of the sampling effort at a site. One duplicate is taken for every 20 wells, or one per site or zone if that site or zone contains less than 20 wells. Duplicates are coded in a manner so that laboratory personnel will not recognize them as QC samples. Field duplicates do not release the laboratory from its own QC requirements for duplicate analyses. The procedures for collecting and containerizing these samples are described below.

The volatile fraction is collected first to minimize compound volatilization. The first bailer volume is used to fill the sample vials. The next bailer volume is used to fill the duplicate sample vials. Sample collection, preservation, and containerization procedures follow those described in Section 2.3. After the volatile fractions have been collected, the sample volume for the remaining analyses is collected in the manner described above. Sample collection, preservation, and containerization procedures follow those described in Section 2.3 for the applicable analysis. After collection, all sample bottles are labeled properly and stored on-site at 4°C until they are packed and shipped via overnight delivery to the laboratory for analysis.

2.5 DECONTAMINATION PROCEDURES

Prior to the commencement of sampling activities, between wells, and after sampling activities have been completed, all sampling equipment is decontaminated. The bailer is scrubbed with laboratory-grade detergent (e.g., Liqui-Nox, Alconox) and rinsed with potable water, ASTM Type II reagent water, and pesticide-grade methanol and hexane, in that order. The bailer is allowed to air dry prior to lowering it into the well. The line used to lower the bailer into the well is replaced between wells. Water level monitoring devices and measuring tapes are scrubbed with laboratory-grade detergent and rinsed with ASTM Type II reagent water.

Split spoon samplers are decontaminated between sample intervals with a laboratory-grade detergent (e.g., Liqui-Nox, Alconox) and rinsed with potable water, ASTM Type II reagent water, pesticide-grade methanol and hexane, in that order and allowed to dry. The procedure prevents cross-contaminating between samples. Field personnel are strongly cautioned to allow ample time for the hexane to evaporate completely. The hydrocarbon mixture that makes up pesticide-grade hexane interferes with GC/MS volatiles analysis if field equipment is not dried completely between uses.

Drilling equipment (including rods, bits, tools, etc.) is decontaminated at the decontamination area with a steam cleaner and laboratory-grade detergent (e.g.,, Liqui-Nox, Alconox) prior to the initiation of field activities between drilling locations. The decontamination area is cleaned after each use.

Equipment used to dispense ASTM Type II reagent water, methanol, and hexane is made of glass and teflon.

Plastic dispensing devices are prohibited.

Uncontaminated sample containers that are commercially precleaned are used for collection. Reuse of sample containers is not permitted.

TABLE 2.1 RECOMMENDATION FOR SAMPLING AND PRESERVATION OF SAMPLES ACCORDING TO MEASUREMENT[1]

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
Physical Properties				
Color	50	P,G	Cool, 4°C	48 Hrs.
Conductance	100	P,G	Cool, 4°C	28 days
Hardness	100	P	HNO_3 to pH <2	6 mos.
Odor	200	G only	Cool, 4°C	24 Hrs.
pH	2	P,G	None Req.	Analyze Immediately
Residue				
Filterable	100	P,G	Cool, 4°C	7 days
Non-Filterable	100	P,G	Cool, 4°C	7 days
Total	100	P,G	Cool, 4°C	7 days
Volatile	100	P,G	Cool, 4°C	7 days
Settleable Matter	1,000	P,G	Cool, 4°C	48 Hrs.
Temperature	1,000	P,G	None Req.	Analyze
Turbidity	100	P,G	Cool, 4°C	48 Hrs.
Metals				
Dissolved	200	P	Filter on site HNO_3 to pH <2	6 Mos.
Suspended	200		Filter on site	6 Mos.[8]
Total	100	P	HNO_3 to pH <2	6 Mos.
Chromium^{+6}	200	P	Cool, 4°C	24 Hrs.
Mercury (Dissolved)	100	P	Filter HNO_3 to pH <2	28 Days
Mercury (Total)	100	P	HNO_3 to pH <2	28 Days
Inorganics, Non-Metallics				
Acidity	100	P,G	Cool, 4°C	14 Days
Alkalinity	100	P,G	Cool, 4°C	14 Days
Bromide	100	P,G	None Req.	28 Days
Chloride	50	P,G	None Req.	28 Days
Chlorine	200	P,G	None Req.	Analyze Immediately
Cyanides	500	P,G	Cool, 4°C NaOH to pH >12 0.6g ascorbic acid[6]	14 Days[7]
Fluoride	300	P,G	None Req.	28 Days
Iodide	100	P,G	Cool, 4°C	24 Hrs.

TABLE 2.1 (CONTINUED)

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
Nitrogen				
Ammonia	400	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Kjeldahl, Total	500	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Nitrate plus Nitrite	100	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Nitrate[9]	100	P,G	Cool, 4°C	48 Hrs.
Nitrite	50	P,G	Cool, 4°C	48 Hrs.
Dissolved Oxygen				
Probe	300	G bottle and top	None Req.	Analyze Immediately
Winkler	300	G bottle and top	Fix on site and store in dark	8 Hrs.
Phosphorus				
Ortho-phosphate Dissolved	50	P,G	Filter on site Cool, 4°C	48 Hrs.
Hydrolyzable	50	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Total	50	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Total, Dissolved	50	P,G	Filter on site Cool, 4°C H_2SO_4 to pH <2	24 Hrs.
Silica	50	P only	Cool, 4°C	28 Days
Sulfate	50	P,G	Cool, 4°C	28 Days
Sulfide	500	P,G	Cool, 4°C add 2 mL zinc acetate plus NaOH to pH >9	7 Days
Sulfite	50	P,G	None Req.	Analyze Immediately
Organics				
BOD	1,000	P,G	Cool, 4°C	48 Hrs.
COD	50	P,G	Cool, 4°C H_2SO_4 to pH <2	28 Days
Oil & Grease	1,000	G only	Cool, 4°C H_2SO_4 or HCl to pH <2	28 Days
Organic Carbon	25	P,G	Cool, 4°C H_2SO_4 or HCl to pH <2	28 Days
Phenolics	500	G only	Cool, 4°C H_2SO_4 or HCl to pH <2	28 Days

TABLE 2.1 (CONTINUED)

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
Organics (Cont.)				
MBAS	250	P,G	Cool, 4°C	48 Hrs.
NTA	50	P,G	Cool, 4°C	24 Hrs.
Purgeable Halocarbons (601)	40	G, Teflon-lined Septum	Cool, 4°C 0.008% $Na_2S_2O_3$[6]	14 Days
Purgeable Aromatic Hydrocarbons (602)	40	G, Teflon-lined Septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[6], HCl to Ph 2	14 Days
Acrylonitrile & Acrolein (603)	40	G, Teflon-lined Septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[6], Adjust pH to 4-5[11]	14 Days
Phenols[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 604		Cap	$Na_2S_2O_3$	40 days after extraction
Benzidines[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 605		Cap	$Na_2S_2O_3$[6], H_2SO_4 to pH 2-7[13]	
Phthalate Esters[12]	1,000	G, Teflon-lined	Cool, 4°C	7 days until extraction
EPA Method 606		Cap		40 days after extraction
Nitrosamines[12]	1,000	G, Teflon-lined	Cool, 4°C, store in	7 days until extraction
EPA Method 607		Cap	dark, 0.008% $Na_2S_2O_3$[6]	40 days after extraction
Organochlorine	1,000	G, Teflon-lined	Cool, 4°C, pH 5-9	7 days until extraction
Pesticides/PCBs[12]		Cap		40 days after extraction
EPA Method 608				
Nitroaromatics and Isophorone[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 609		Cap	$Na_2S_2O_3$[6], store in dark	40 days after extraction
Polynuclear Aromatic Hydrocarbons[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 610		Cap	$Na_2S_2O_3$[6], store in dark	40 days after extraction
Haloethers[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 611		Cap	$Na_2S_2O_3$	40 days after extraction

TABLE 2.1 (CONTINUED)

Measurement	Vol. Req. (mL)	Container[2]	Preservative[3,4]	Holding Time[5]
Organics (Cont.)				
Chlorinated	1,000	G, Teflon-lined	Cool, 4°C	7 days until extraction
Hydrocarbon[12] (612)		Cap		40 days after extraction
TCDD[12]	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 613		Cap	$Na_2S_2O_3$[6]	40 days after extraction
Purgeables	2 x 40	G, Teflon-lined	Cool, 4°C, 0.008%	14 Days
EPA Method 624		Septum	$Na_2S_2O_3$[6]	
Base/Neutrals Acids	1,000	G, Teflon-lined	Cool, 4°C, 0.008%	7 days until extraction
EPA Method 625		Cap	$Na_2S_2O_3$[6]	40 days after extraction

1. More specific instructions for preservation and sampling are found with procedures as detailed in EPA-600/4-79-020, revised March 1983, and in the Federal Register, Vol. 49, No. 209, Oct. 26, 1984, EPA 40 CFR part 136.

2. Plastic (P) or Glass (G). Only EPA certified precleaned bottles are used. For metals, polyethylene with a polypropylene cap (no liner) is preferred.

3. Sample preservation should be performed immediately upon sample collection. For composite samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

4. When any sample is to be shipped by common carrier of sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

7. Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before the pH adjustment in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

8. Samples should be filtered immediately on-site before adding preservatives for dissolved metals.

9. For samples from non-chlorinated drinking water supplies concentrated H_2SO_4 should be added to lower sample pH to less than 2. The sample should be analyzed before 14 days.

TABLE 2.1 (CONTINUED)

10. Sample receiving no pH adjustment must be analyzed within seven days of sampling.

11. The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within three days of sampling.

12. When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 6 (requirement for thiosulfate reduction of residual chlorine).

13. If 1,2-diphenylhydrazine is likely to be present, adjust the sample pH to 4.0 + 0.2 to prevent rearrangement to benzidine.

TABLE 2.2 RECOMMENDATION FOR SAMPLING AND PRESERVATION OF SOIL SAMPLES ACCORDING TO MEASUREMENT[A]

Measurement	Vol. Req. (oz)	Container[b]	Preservative[c,d]	Holding Time[e]
Inorganics, Non-Metallics				
Petroleum Hydrocarbons	32	G	Cool, 4°C	28 days
Metals				
Total Recoverable	8	G	Cool, 4°C	6 months
Extraction Procedure Toxicity	32	G	Cool, 4°C	6 months
Organics				
VOCs and Xylenes, EPA Method 8240	2 x 4	G	Cool, 4°C	14 days
Extractable Priority Pollutants EPA Method 8270	32	G	Cool, 4°C	14 days - extraction 40 days - analysis

a. More specific instructions for preservation and sampling are found with procedures as detailed in EPA-600/4-79-020, revised March 1983, and in the Federal Register, Vol. 49, No. 209, Oct. 26, 1984, EPA 40 CFR Part 136, Table II.

b. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

c. Sample preservation should be performed immediately upon sample collection. for composite samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

d. When any sample is to be shipped by common carrier of sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.30 or less).

e. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

f. Should only be used in the presence of residual chlorine.

g. For samples from non-chlorinated drinking water supplies, concentrated H_2SO_4 should be added to lower sample pH to less than 2. The sample should be analyzed before 14 days.

h. Sample receiving no pH adjustment must be analyzed within 7 days of sampling.

i. If analysis is to include benzene, toluene, and/or ethyl benzene, sample must be analyzed within 7 days of sampling.

A critical aspect of sound sample collection and analysis protocols is the maintenance of strict COC procedures. COC procedures include inventorying and documentation during sample collection, shipment, and laboratory processing. A sample is considered to be in an individual's custody if the sample is: (1) in the physical possession or view of the responsible party; (2) secured to prevent tampering; or (3) placed in a restricted area by the responsible party.

3.1 CHAIN-OF-CUSTODY

Sample Label

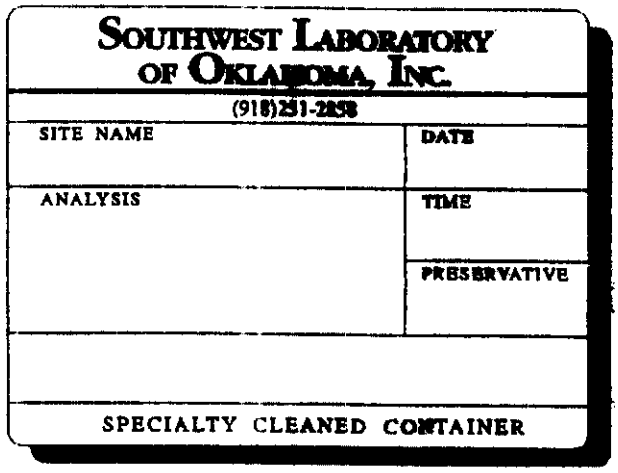
A label is attached to all sample containers at the time of collection. The label is written in indelible ink and contains the following information:

- Sample number/identification
- Date and time collected
- Purpose of the sample (analyte and sample group)
- Source/location and location of the sample
- Contract task number and title of project
- Preservative used (if any)
- Collector's name or initials

An example of a sample label is presented in Figure 3.1.

Chain-of-Custody Record

Sample custody is initiated with the detailed record keeping by the field sampling personnel. COC establishes the documentation and control necessary to identify and trace a sample from sample collection to final analysis. It includes field sample


SOUTHWEST LABORATORY OF OKLAHOMA, INC.
(918)251-2858
SITE NAME
DATE
ANALYSIS
TIME
PRESERVATIVE
SPECIALTY CLEANED CONTAINER

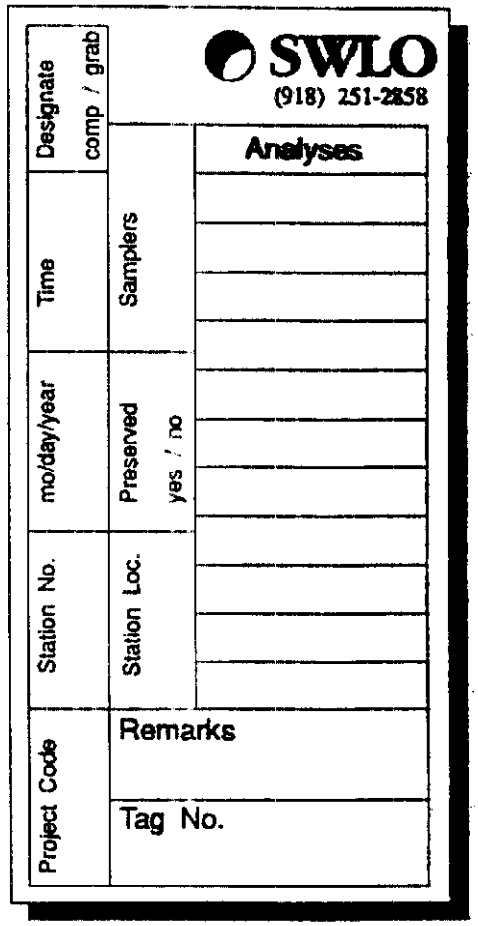

SWLO
(918) 251-2858
Designate comp / grab
Time
mo/day/year
Station No.
Project Code
Samplers
Preserved yes / no
Station Loc.
Analyses
Remarks
Tag No.

FIG. 3.1 Example of Sample Bottle Label & Sample Tag.

labeling to prevent mix-up, custody seals to prevent sample tampering, secure custody, and provide the recorded support information for potential litigation.

COC forms are used to document the integrity of all samples. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, a COC form will be filled out for each sample set at each sampling location. The COC form will contain the following information:

- Sample number (for each sample in shipment)
- Collection date (for each sample shipment)
- Time sample was obtained/or collected
- Number of containers of each sample
- Sample description (environmental matrix)
- Analyses required for each sample
- Shipment number
- Shipping address of the laboratory
- Date, time and method of shipment
- Spaces to be signed as custody is transferred.

The individual in charge of shipping samples to the laboratory is also responsible for completing the COC form. This individual will also inspect the form for completeness and accuracy. Any changes made to the COC form shall be initialed by the person making the change. An example of the COC form is presented in Figure 3.2.

Transfer of Custody and Shipment

Samples are to be accompanied by an approved COC record. When the possession of samples is transferred, the individual relinquishing the samples signs and records the date and time on the COC document. The individual receiving the samples repeats the procedure. This record represents the official documentation for all transference of the sample custody until the samples have arrived at the laboratory.

If samples are to be split with another laboratory facility or governmental agency, a separate COC record is prepared for those samples. This COC record indicates with whom the samples have been split and is appropriately signed and dated with the time of transfer of splits.

Laboratory Custody Procedures

The Sample Control program describes the laboratory custody procedures associated with sample receipt, storage, preparation, analysis and security. Sample control is maintained at SWLO through the use of several tracking systems designed to protect sample integrity. Tracking systems include the use of laboratory COC procedures, locked sample storage, sample request forms, and sample analysis requests (in the form of project sheet).

Laboratory COC procedures include sample inventory and record maintenance during sample collection, shipment and laboratory processing. The Sample Custodian (SC) manages and tracks the storage and distribution of samples after their arrival.

An overview of the sample tracking and COC procedure to be employed is presented in the Figure 3.3 flow diagram. It includes the following components:

1. Laboratory COC documentation is initiated by the SC when the sample is relinquished by the courier.
2. After sample shipment arrival, the SC begins sample inspection and log-in. Cooler temperatures are recorded for those clients requesting it, otherwise samples received warm will be noted on the Chain-of-custody. Samples are checked for preservation in the sample preparation area and recorded on Extraction/Digestion Logs. All samples are inspected: comparisons are made between the clients paperwork and that paperwork supplied by the Project Officer (i.e., Sample booking Information, Figure 3.5). Anomalies are noted in the COC form and the Client/Lab Communication sheet (Figure 3.6) as the client is notified.

CHAIN OF CUSTODY RECORD

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 W. Albany • Broken Arrow, Oklahoma 74012-1421
Office: 918-251-2858 • Fax 918-251-2599

TM

SAMPLING FIRM	CLIENT CONTACT	PHONE NUMBER

P.O. or PROPOSAL NUMBER	PROJECT NAME

SAMPLER: *(Signature)*

ANALYTICAL TESTS REQUESTED

SAMPLE NO.	DATE	TIME	COMP.	GRAB	LOCATION	MATRIX	NUMBER OF CONTAINERS									REMARKS

RELINQUISHED BY: *(Signature)*	DATE	TIME	RECEIVED BY: *(Signature)*

RELINQUISHED BY: *(Signature)*	DATE	TIME	RECEIVED BY: *(Signature)*

RELINQUISHED BY: *(Signature)*	DATE	TIME	RECEIVED FOR LABORATORY BY: *(Signature)*

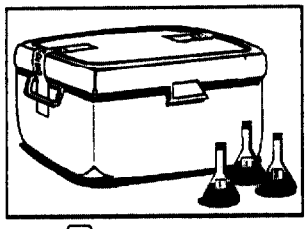
RELINQUISHED BY: *(Signature)*	DATE	TIME	RECEIVED BY: *(Signature)*

REMARKS:

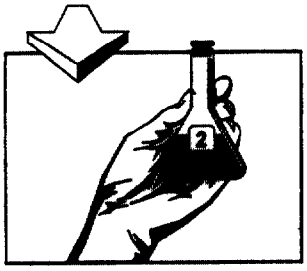
[SR012-1192-03]

FIG. 3.2 Example of Chain of Custody Record

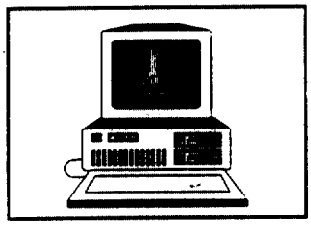
FIG. 3.3 Chain of Custody Sample Tracking Flow Diagram



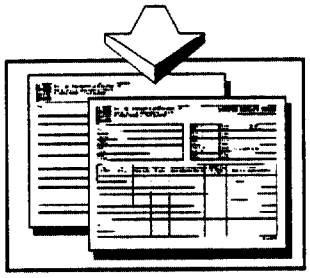
Sample Receipt



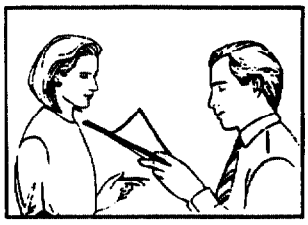
Sample Inspection
(Primary & Secondary Containers)



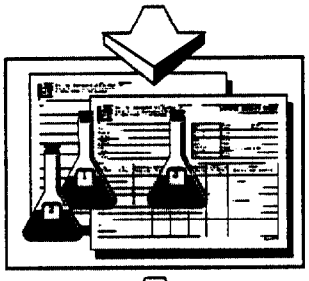
Sample Log-in
(Assigned Unique ID Number)



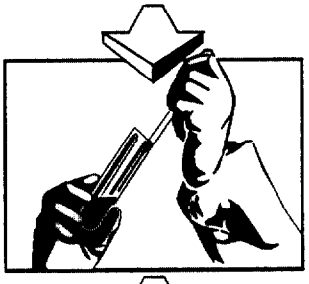
Initiate Internal Chain-of Custody Documentation



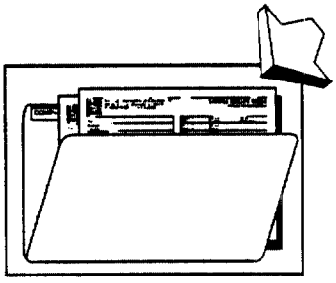
Copy of Document Returned to Appropriate Official(s)



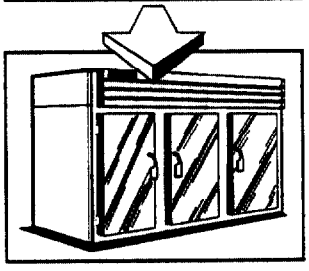
Sample Relinquished to Appropriate Lab Manager
(Sample maintained in locked storage)



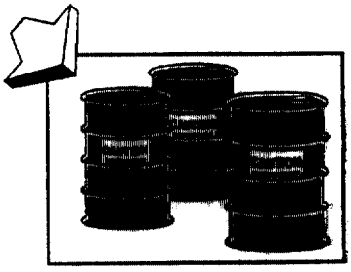
Sample Preparation and Analysis
(Sample maintained in locked storage)



Chain of Custody Document Completed and Filed with Appropriate Data in Contract File



Archive Sample/Extracts and Document Locations In Locked Freezer



Non-essential Sample Remains Disposed of
(Hazardous sample remains incinerated in controlled circumstances, or returned to client.)

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

1700 W. Albany, Suite C • Broken Arrow, Oklahoma, 74012 • Office: 918-251-2858 • Fax 918-251-2599

INITIAL CONTACT FORM

➤ Client:

➤ Client Contact:

➤ Client P.O. No:	➤ Date:
➤ Billing Instructions:	➤ Phone No:
	➤ Proposal:

➤ Analytical Requests:

➤ Method Requests

➤ Detection Limits:

➤ Additional QC:

➤ Number of Samples:	➤ Matrix/Matrices
➤ Shipping Date:	➤ VTSR:
➤ Turn-around Time:	➤ Duration of Project:
➤ Bid Price:	➤ Bid Due Date:

➤ Comments:

➤ Approximate $ Volume:

➤ Award Date:	➤ Follow-up Date:
➤ Price:	➤ SWL Contact:

➤ Additional Information:

➤ Required Qualifications:

➤ Decision Criteria:

➤ Other Bidders:

➤ Data Package:

FIG. 3.4 Project Sheet (Initial Contact Form)

3. Each sample is assigned a unique SWLO laboratory identification number which is cross-coded with the client's identification. Sample identification information is entered into the computerized laboratory data base, and the assigned number is used to track sample locations and status throughout the analytical process.
The following sample information is recorded into the computerized laboratory data base system:

   - Customer and project information
   - Date of receipt
   - Client identification
   - Date sampled
   - Matrix Type
   - Number of containers
   - Analytical requirements
   - Other pertinent comments

4. The SC logs in samples with the tests and test code information supplied by the project officer (figure 3.5 & 3.7)

5. The field COC document is completed and copies are returned to the appropriate party(s).

6. After the sample is logged in, a LIMS generated work sheet is generated (Figure 3.9).

7. The work sheet informs the analysts/departments of samples in-house.

8. This internal sample tracking sheet documents the movement of the sample from storage to sample preparation and back to sample storage.

9. While within the laboratory, sample integrity is maintained through the use of locked storage areas. Samples remain in locked storage areas except when being analyzed.

10. Based on specific contract requirements, any remaining samples are either archived in locked storage areas or disposed of properly. (See figure 3.14)

In addition to the internal and external COC documents, a computer-generated listing of the sample analysis parameters is used to control sample flow and facilitate tracking within the laboratory. Each laboratory unit is given the list of parameters and is responsible for maintaining sample integrity (holding time), fulfilling COC requirements, scheduling sample flow, and tracking sample status.

3.2 PROJECT INITIALIZATION

Sample Custodian

SC for the laboratory has duties and responsibilities that include but are not limited to:

- Receiving samples

- Inspecting sample shipping containers for presence, absence, and condition of:

  Custody seals, locks, "evidence tapes", etc.

  Container breakage and/or container integrity

- Recording the condition of both shipping containers and sample containers (bottles, jars, cans, etc.) on appropriate forms

- Signing appropriate documents shipped with samples (i.e., airbills, COC record(s), traffic reports, etc.)

- Verifying and recording agreement or non-agreement of information on sample documents (i.e., sample tags, COC records, traffic reports, airbills, etc.) on appropriate forms; if there is a variance, the Project Officer (PO) is notified immediately

- Initiating the paperwork for sample analyses on appropriate laboratory documents

- Labeling samples with laboratory sample numbers and cross-referencing laboratory numbers with client numbers and sample tags (Figure 3.8.)

- Placing samples, sample extracts, and spent samples into appropriate storage and/or secure areas

- Controlling access to samples in storage and assuring that laboratory standard operating procedures are followed during sample movement

- Monitoring sample COC in the laboratory

- Monitoring sample tags

- Monitoring storage conditions for proper sample preservation

- Returning shipping containers to sampling teams or clients.

3.3 SAMPLE RECEIPT

Upon arrival at the laboratory, all sample shipping containers are opened and inspected. Field sampling personnel are notified on the same day of any problems concerning the samples or documents associated with the shipment. If samples arrive on a Saturday and field sampling personnel are unavailable, notification is made on the next working day.

Initial Receipt

All samples will be received by one of the Sample Custodians (SC). For weekend sample receipt, a designated person shall receive the samples and store them properly for sample log-in processing the next business day.

All samples received shall be considered to be hazardous samples, and all shipping containers shall be opened in an approved exhaust hood or an approved, well-ventilated area. All personnel associated with sample receipt are required to become familiar with safety procedures for the handling of hazardous samples.

The objective of the sample receipt procedure is to ensure that all pertinent information about the condition of the sample is recorded.

Examination of Shipping Container

The SC or will examine the shipping container and shall record the following information on the COC sample log-in sheet. Only one project or sample batch may be recorded per sheet.

- Condition of container, noting any damage, etc.

- Presence/absence of COC seals and their condition

- Labeling on shipping container

Opening Shipping Container

No shipping containers should be opened except under an approved hood or in an approved, well-ventilated area. Approved hood space and/or approved, well ventilated areas shall be determined by the Laboratory's Health and Safety Officer or the Corporate Health and Safety Officer. Prior to the removal of samples, plastic-backed absorbent pads should be laid out to receive sample bottles. The SC shall note on the sample log-in form the following:

- Presence/absence of the COC record(s)

- Presence/absence of airbills and/or bills of lading documenting shipment of samples

- Necessary project and sample information enclosed with the shipment

- When samples arrive without ice or blue ice.

Sample Removal

The SC shall note on the COC form the following:

- Condition of samples (intact, broken, leaking, cold or ambient, headspace in VOA vials, etc.)

- Presence/absence of sample tags

If the sample tags are present:

- Record sample tag document control numbers

- Compare sample tags with COC record(s)
- Document whether these numbers agree
- If the sample tags are not listed on the COC record, record this fact.

If an odor is noticed after opening the shipping container prior to sample removal, it must be noted on the COC.

Sample Document Verification

The SC will compare the following documents to verify agreement among the information contained on them: (a) COC; (b) sample tags; (c) prepared project sheets; and (d) contract requirements. The SC shall document agreement among the forms and shall note any discrepancies found on the sample log-in sheet.

- If all samples recorded on the COC record were received and no problems observed, the SC will sign the COC record in the "received for laboratory by" box.
- If problems are noted, the SC will sign the COC record and note problems in the "remarks" box or reference another form that details the problems.
- If discrepancies are found, they shall be reported to the PO for clarification.

In addition, samples to be analyzed are checked for holding time requirements as listed in the Tables 2.1 and 2.2. Where sample preservation and/or sample holding time requirements are not in accordance with the table, the appropriate PO is notified.

3.4 SAMPLE LOG-IN

Following inspection of shipping containers, records, and samples, the sample information will be added to the project information on the project sheet by the SC. Should any of the project information be incomplete or any other problems arise, the sample shall be placed on hold and the problems will be noted on the Client/Laboratory Communication System Sheet (Figure 3.6). This problem sheet shall be forwarded to the PO for resolution. The samples shall remain on hold until all information necessary for log-in is received. Information concerning the sample will be entered into the laboratory data base to maintain an official record of receipt of the sample. Corrections will be made once the PO resolves all problems.

Any samples not properly preserved will be noted on the COC and the field sampling manager will be notified immediately of the problem. He will determine the necessary corrective action.

In the event holding times may be exceeded, the PO shall contact the field sampling manager or the client immediately to correct any log-in problems. In the event holding time for analysis is exceeded, the PO or SC shall notify the field sampling manager or the client and request either resampling or instruction for proceding with the analysis. If analysis is to be performed on the original samples, the PO shall note the fact that the holding time has been exceeded, and a comment to this effect shall be added to the final report.

3.5 SAMPLE SPLITTING

When clients supply their own containers or when bulk samples are received, the SC shall split the samples to provide sufficient aliquots for each analytical procedure that is to be performed. The following guidelines shall be used to determine the manner in which samples are split.

Water samples - Inorganic Parameters Only

The SC with the appropriate laboratory section manager determine the minimum sample quantities required for analysis. If insufficient sample exists to produce the aliquots needed, the SC shall contact the PO for a priority list of parameters, shall split the samples into proper containers, and shall complete the log-in procedure.

Water Samples - Organic and Inorganic Parameters

When bulk samples arrive for both inorganic and organic analysis, the SC or personnel doing volatile analyses shall split out a portion for any required volatile analysis and transfer the samples

CLIENT BOOKING SHEET

QA/QC DEPARTMENT

DATE OF CALL: _____ CLIENT: _____

CLIENT CONTACT: _____ PROJECT: _____

SHIP DATES: _____ REQUIRED TAT: _____

DELIVERABLES: CLP ☐ TAB—QC ☐ SPECIAL ☐ CONTRACT: _____

MS DEPARTMENT

VOA	BNA	DIOXIN	OTHER
W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐

GC DEPARTMENT

PEST/PCB	HERB	PAH	EXPLOS.	OTHER
W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐

INORGANIC DEPARTMENT

ICP	FURNACE	Hg-CV	CN	WET CHEM.
W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐

AATS

BTEX	TPH MOD-8015	TPH 418.1	O & G	OTHER
W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐	W ☐ S ☐ O ☐

TEST CODES/COMMENTS: _____

SOUTHWEST LABORATORY OF OKLAHOMA, INC./AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [QA010-0492-01]

FIG. 3.5 Client Booking Sheet

CLIENT/LABORATORY COMMUNICATION SYSTEM

PROJECT OFFICERS DEPARTMENT

SWL____/AATS____

TELEPHONE RECORD LOG

➤ In Reference to Case Contract/Proposal:

➤ Date of Call:

➤ Client Name:

➤ Client Contact:

➤ Call Initiated By: ☐ Client ☐ Laboratory

➤ In reference to data for the following sample number(s):

➤ Sumary of Questions/Issues Discussed:

➤ Summary of Resolution:

Signature: *Date:*

➤ Distribution: ☐ Lab Copy ☐ Client Copy ☐ Project Officer Copy

SOUTHWEST LABORATORY OF OKLAHOMA, INC. • AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [F1001-0492-01]

FIG. 3.6 Client/Laboratory Communication System

ANALYTICAL REQUEST FORM

SAMPLE RECEIVING DEPARTMENT

™

➤ Client:	➤ Code:
➤ Client Contact:	➤ Phone No.:
➤ Project Name:	➤ P.O. #:
➤ Location:.	➤ Receipt Date:

➤ Deliverables:

ANALYTICAL REQUESTS

Sample ID	Quantity.	Matrix	Code	Code	Code	Code	TAT

➤ Special Provisions

➤ Reporting Address:

➤ Billing Address:

➤ SWL Contact: ➤ Date Prepared:

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [SR002-0492-01]

FIG. 3.7 Sample Request Form/Analysis Request Form

FIG. 3.8 Sample Log-In Sheet

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 WEST ALBANY • BROKEN ARROW, OK 74012-1421
OFFICE (918) 251-2858 • FAX (918) 251-2599

SAMPLE LOG-IN SHEET

SAMPLE RECEIVING DEPARTMENT

Date:	
Custodian: *(Signature)*	
Document Control #:	
Case Number:	
Airbill Number:	

CUSTODY SEAL:	☐ Present ☐ Absent	☐ Intact ☐ Not Intact
CHAIN OF CUSTODY:	☐ Present ☐ Absent	
SAMPLE TAGS:	☐ Present ☐ Absent	
SAMPLE TAG NUMBERS:	☐ Listed ☐ Not Listed	(On Chain-of-Custody)
SMO FORMS:	☐ Present ☐ Absent	

Date Received	Time Received	Chain-of-Custody Record Number	SMO Sample Numbers	Corresponding Sample Tag Nos.	Corresponding Assigned Lab Nos	Does Info. on Custody Rec, Traffic Rept. and Sample Tags Agree?	REMARKS (Condition of Sample Shipment, etc.)

[SR005-0492-01]

SAMPLE LOG-IN SHEET

Lab Name: ______________________ Page ____ of ____

Received By (Print Name): ______________________ Log-in Date: ____________

Received By: (Signature): ______________________

Case Number: ________ Sample Delivery Group No: ________ SAS Number: ________		CORRESPONDING		
	EPA SAMPLE #	SAMPLE TAG #	ASSIGNED LAB #	REMARKS: CONDITION OF SAMPLE SHIPMENT, ETC.

REMARKS:

1. Custody Seal(s) — Present/Absent* Intact/Broken
2. Custody Seal Nos.: ________ ________
3. Chain-of-Custody Records — Present/Absent*
4. Traffic Reports or Packing List — Present/AbsentI
5. Airbill — Airbill/Sticker Present/Absent*
5. Airbill No: ________ ________
7. Sample Tags — Present/Absent

   Sample Tag Numbers — Listed/Not Listed on Chain-of-Custody
8. Sample Condition: Intact/Broken*/ Leaking
9. Does information on custody records, traffic reports, and sample tags agree? Yes/No*
10. Date Received at Lab: ________
11. Time Received ________

Sample Transfer

Fraction: ________ ________

Area #: ________ ________

By: ________ ________

On: ________ ________

* Contact SMO and attach record of resolution

Received By: ______________________

Date: ______________________

Logbook No: ______________________

Logbook Page No: ______________________

FORM DC-1

3/90

FIG. 3.8 (cont.) EPA-CLP Sample Log-In Sheet

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 W. ALBANY SUITE C
BROKEN ARROW, OK 74012-1421

Date: 10/27/93
Episode: **16075**
Client: **EPA**
Project: 21032

SAMPLE LOG-IN RECORD

SAMPLE #	DATE IN	DESCRIPTION	SDG	MA	NC	TEST	PRI	DUE	CONTAINER	DESCRIPTION	RESULTS	ANALYST	DATE/TIME
16075.01	10/25/93	FT919 ⊕A/BC		W	18	GC815	4	11/14/93	MNOPQR	PEST CLP OLM016			
										EXTRACTION		MT	10/26/93
						MS315	4	11/14/93	ABCDEF	VOA-CLP OLM01.8	_____	_____	_____
						MS515	4	11/14/93	GHIJKL	BNA CLP OLM01.8			
										EXTRACTION		TB	10/25/93
16075.02	10/25/93	FT920 (CASE#21032)		W	6	GC815	4	11/14/93	EF	PEST CLP OLM016			
										EXTRACTION		MT	10/26/93
						MS315	4	11/14/93	AB	VOA-CLP OLM01.8	_____	_____	_____
						MS515	4	11/14/93	CD	BNA CLP OLM01.8			
										EXTRACTION		TB	10/25/93
16075.03	10/25/93	FT921 (CASE#21032)		W	6	GC815	4	11/14/93	EF	PEST CLP OLM016			
										EXTRACTION		MT	10/26/93
						MS315	4	11/14/93	AB	VOA-CLP OLM01.8	_____	_____	_____
						MS515	4	11/14/93	CD	BNA CLP OLM01.8			
										EXTRACTION		TB	10/25/93
16075.04	10/25/93	FT922 (CASE#21032)		W	6	GC815	4	11/14/93	EF	PEST CLP OLM016			
										EXTRACTION		MT	10/26/93
						MS315	4	11/14/93	AB	VOA-CLP OLM01.8	_____	_____	_____
						MS515	4	11/14/93	CD	BNA CLP OLM01.8			
										EXTRACTION		TB	10/25/93

Total samples = 4

FIG. 3.9 Sample Work Sheet

	SV	PEST & PCB	OTHER
CONT. BK			
SEP-F			
SONIC.			

☐ RUSH ☐ REEXTRACT ☐ TCLP ☐ DIOXIN

SAMPLE EXTRACTION LOG

SWOK • AATS

Southwest Laboratory of Oklahoma, Inc.
American Analytical & Technical Services, Inc.

CLIENT : _____ DATE RECEIVED: _____

CASE: _____ EXTRACT DATE: _____

SAMPLE ID (EPISODE #)	CLIENT ID	MATRIX - LEVEL	SAMPLE pH	% MOISTURE	DRY WEIGHT	AMOUNT EXTRACTED	EXTRACTED VOLUME	GPC VOLUME	GPC ELUTE VOL	FLORISIL VOL CONC	FLORISIL VOL CONC	VOL SV - P	FM PROCESS VOLUME	SURROG. V/A	VOL SV - P	MATRIX SV - P	SURR. SOL CONCENTRATION	ACID SOL CONCENTRATION	COMMENTS
				%	g	g • mL	mL	mL	mL	mL	mL	mL	mL		µL	µL			

WEIGHING:	EXTRACTION:
CLEANUP:	KD:
BLOWDOWN:	
SURROG. SPIKER:	VERIFIER:
MATRIX SPIKER:	VERIFIER:
SUBMITTED BY:	REVIEWED BY:

FLORISIL CARTRIDGE #:
GPC COLUMN #:
SURROGATES ID CONC #:
MATRIX SPIKE SOL ID/CONC #(S):
MISC:

FIG. 3.10 Internal SampleTracking (Extraction Log)

VOLATILES GC/MS RUN LOG

VOLATILES GC/MS DEPARTMENT

SWOK / AATS

TM

TUNE FILE ID: _____ METHOD FILES _____

INSTRUMENT: _____ DATE _____

CB/ID FILE ID: _____ ARCHIVE TAPE #: _____

Time	File	SWOK/AATS Sample ID	Client ID	Vol.	IS Area	Surr. Rec.	Lin. Chk.	Comments	OK/ RR

Analyst Signature

SWL/AATS • 1700 West Albany • Broken Arrow, Ok 74012 [NGM008-0492-01]

FIG. 3.11 Internal SampleTracking (Volatiles GC/MS Run Log)

SWLO / AATS Sample Digestion Record

Date : 04/05/1994 Batch: 04059411 Analyst: TG
Type : NY600 ACID DIGESTION - ICP/AA Client: CLP-PRI MEH-TX Matrix: W

LAB ID	Client ID	TYP	Initial Weight	Final Weight	Color Before	Color After	Texture	pH	Comments
PBW		LB	100 ML	100 ML					
LCSW		BS	100 ML	100 ML					1.0 ML W-1,W-2,B5
17824.01	940308D00275		50 ML	50 ML	CO/CL	CO/CL		<2	
17824.01MS	940308D00275		50 ML	50 ML	CO/CL	CO/CL		<2	0.5 ML W-1,W-2,B5
17824.01MSD	940308D00275		50 ML	50 ML	CO/CL	CO/CL		<2	0.5 ML W-1,W-2,B5
17824.02	940309A05370		100 ML	100 ML	CO/CL	CO/CL		<2	
17824.03	940309A05378		100 ML	100 ML	CO/CL	CO/CL		<2	
17824.04	940309A05376		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.01	940309D00282		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.02	940309D00283		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.02MS	940309D00283		100 ML	100 ML	CO/CL	CO/CL		<2	1.0 ML W-1,W-2,B5
17836.02MSD	940309D00283		100 ML	100 ML	CO/CL	CO/CL		<2	1.0 ML W-1,W-2,B5
17836.03	940310D00284		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.04	940311A05412		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.05	940311A05413		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.06	940311A05415		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.07	940310A05394		100 ML	100 ML	CO/CL	CO/CL		<2	
17836.08	940311A05414		100 ML	100 ML	CO/CL	CO/CL		<2	
17860.01	940314D00285		50 ML	50 ML	CO/CL	CO/CL		<2	
17860.01MS	940314D00285		50 ML	50 ML	CO/CL	CO/CL		<2	0.5 ML W-1,W-2,B5
17860.01MSD	940314D00285		50 ML	50 ML	CO/CL	CO/CL		<2	0.5 ML W-1,W-2,B5
17860.02	940314D00286		100 ML	100 ML	CO/CL	CO/CL		<2	
17860.03	940314D00287		100 ML	100 ML	CO/CL	CO/CL		<2	

FIG. 3.12 Internal SampleTracking (Sample Digestion Record)

SAMPLE DISTILLATION RECORD

PAGE ____ OF BOOK ____

INORGANIC DEPARTMENT

Distillation Date _____ Distillation Batch No. _____ Analyst _____

Type of Analysis _____ Client _____ Matrix _____

Sample ID	Client ID	Initial wt/vol (g/mL)	Final Vol. (mL)	Description (Water color, Clarity, Soil color, Texture Artifacts)	pH	Sulfides Present (Y or N)	Chlorine Present (Y or N)	Comments (Spiking Solution)

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FIG. 3.13 Internal SampleTracking (Sample Distillation Record)

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

Page 1

SAMPLES READY TO BE ARCHIVED

PRODUCED ON 04/04/91

SAMPLE	CLIENT	DESCRIPTION	MATRIX	REPORTED
5447.08	RS&A	MW-2	W	04/03/91
5447.09	RS&A	MW-21A	W	04/03/91
5447.10	RS&A	MW-21B	W	04/03/91
5447.11	RS&A	MW 1B/B	W	04/03/91
5447.12	RS&A	MW-3B	W	04/03/91
5447.13	RS&A	MW-5	W	04/03/91
5447.14	RS&A	MW-3	W	04/03/91
5447.15	RS&A	MW-4	W	04/03/91
5447.16	RS&A	MW-14	W	04/03/91
5447.17	RS&A	MW-26B	W	04/03/91
5447.18	RS&A	MW-15A	W	04/03/91
5447.19	RS&A	MW-25	W	04/03/91
5447.20	RS&A	MW-34	W	04/03/91
5447.21	RS&A	TRIP BLANK	W	04/03/91
5447.22	RS&A	MW-6	W	04/03/91
5447.23	RS&A	MW-24	W	04/03/91
5447.24	RS&A	MW-23	W	04/03/91
5447.25	RS&A	MW-22A	W	04/03/91
5447.26	RS&A	MW-18B	W	04/03/91
5447.27	RS&A	MW-11B	W	04/03/91
5447.28	RS&A	MW-29	W	04/03/91
5447.29	RS&A	MW-33	W	04/03/91
5447.30	RS&A	MW-32	W	04/03/91
5447.31	RS&A	MW-30	W	04/03/91
5447.32	RS&A	EQUIP BLANK	W	04/03/91
5447.33	RS&A	MW-11A	W	04/03/91
5447.34	RS&A	MW-18T	W	04/03/91
5447.35	RS&A	MW-19	W	04/03/91
5447.36	RS&A	MW-20	W	04/03/91
5447.37	RS&A	MW-27	W	04/03/91
5447.38	RS&A	MW-28	W	04/03/91
5447.39	RS&A	TRIP BLANK	W	04/03/91
5450.01	KIMCLARK	OUTFALL001	W	04/01/91
5452.01	FHC	5-1	S	04/03/91
5452.02	FHC	5-2	S	04/03/91
5452.03	FHC	5-3	S	04/03/91
5452.04	FHC	5-4	S	04/03/91
5452.05	FHC	5-5	S	04/03/91
5452.06	FHC	6-1	S	04/03/91
5452.07	FHC	6-2	S	04/03/91
5452.08	FHC	6-3	S	04/03/91
5452.09	FHC	6-4	S	04/03/91
5452.10	FHC	6-5	S	04/03/91
5461.01	RS&ASSOC	5211.01	W	04/01/91
5466.01	ATAS	1788.01	S	04/02/91
5466.02	ATAS	1788.02	S	04/02/91
5466.03	ATAS	1788.03	S	04/02/91
5466.04	ATAS	1788.04	S	04/02/91
5467.01	ATAS	1789.16	S	04/03/91

FIG. 3.14 Sample Archive Record Sheet

to the Process Laboratory where the remainder of the organic split shall be made by the Organic Extraction Group Leader. The sample will be returned to the SC to complete samples splitting for the inorganic portion, as described above.

Sediments/Soil Samples

Every effort will be made to acquire duplicate aliquots of these matrices. The sample will be made homogeneous after any portion required for volatile analysis has been removed by one or all of the following procedures:

- Stirring
- Air drying and grinding
- Particle separation
- Quartering

The Organic Extraction Group Leader shall obtain the aliquot for organic analysis after any portion required for volatile analysis has been removed. The remainder shall be given to the Inorganic Laboratory Supervisor for further splitting. If insufficient material exists to provide minimum quantities, the PO shall provide a priority list of parameters.

3.6 SAMPLE SECURITY

Samples are in locked storage areas except during laboratory analysis. The work sheet informs the analyst of what samples are needed for sample preparation and/or analysis (Figure 3.8). Internal custody of the sample is documented in the Sample Digestion/Extraction Logs, or in the case of Volatiles, the GC/MS Run Log (see Figure 3.9 through Figure 3.12.) All laboratory personnel who receive samples are responsible for the care and custody of samples from the time each sample is received until samples (or appropriate documentation as to disposition of the empty containers) are returned to storage. All subsets (extraction, digestates, etc.) of the samples shall be kept in locked storage which is controlled by the appropriate laboratory manager. (See Appendix D, Standard Operating Procedure for Laboratory and Sample Security.)

3.7 SAMPLE STORAGE AND DISPOSAL

Once the samples have been logged into the computer system, the SC shall be responsible for the following:

Sample Storage

1. Samples and extracts shall be stored in a secure area.
2. Samples shall be removed from the shipping container and stored in their original containers unless damaged.
3. Damaged samples are to be documented and PO or the client is contacted immediately to notify him of the damaged samples.
4. Storage area is to be kept secured at all times. SC will control access to the storage area.
5. Samples removed from storage will be documented. All transfers of samples are documented in the internal COC.
6. VOA samples will be stored separately from other samples.
7. Standards are not stored with samples.

Sample Disposal

1. Upon completion of the analysis, an archive list is generated each month (Figure 3.14).
2. When sample analysis and all QC checks have been completed and a final report has been issued, the unused sample portion shall be archived for a period of not less than 60 days after the report has been issued.
3. The SC shall be responsible for returning all unused bottles, shipping containers, packing materials, blue ice packs, and if requested, the unused sample portions to the client.
4. Any sample remains shall be properly disposed of after a 120-day period, unless further instructions are received from the PO or cli-

ent. Sample disposal shall be documented on the archive list (Figure 3.14.)

5. For more information (Details on Disposal of Samples & Waste) see Appendix D-25.

3.8 FIELD DOCUMENTATION

Field Sample Identification

Sample tracking is accomplished in the field by assigning each sample a unique number as it is collected. This number is traceable back to the day, time, site, and depth (where appropriate) of collection. This is recorded on a sample label and the COC form as well as in the field logbook. All containers are labeled prior to actual sampling.

Daily Logs

Daily logs are kept during field activities by the Field Supervisor at each site. These daily logs are kept in a bound field notebook of water-resistant paper. All entries are made legibly in indelible ink, signed, and dated. Information that is to be recorded in the field notebook includes:

- Date, time, and place of sampling
- Field QC samples, as applicable
- Weather conditions at time of sampling, including ambient temperature and approximate wind direction and speed
- Data from field analyses (e.g., temperature, specific conductance, pH, and alkalinity of water samples)
- Turbidity of water samples
- Data from physical tests (sludge tests, etc.)
- Observations about site and samples (odors, appearance, etc.)
- Information about any activities, extraneous to sampling activities, that may affect the integrity of the samples (such as low-flying aircraft nearby, fossil-fueled motors being used nearby, painting operations being carried out upwind of sampling sites, etc.)
- Analyses and required preservation techniques
- Sample cooler temperature readings.

Corrections to Documentation

When it becomes necessary to make corrections to any form of documentation (e.g., sample tags, COC forms, daily logbooks), the obsolete information is crossed out with a single line and the changes are made and initialed by the person making the change.

Disposition of Documentation

Upon conclusion of the field effort at a sampling site, all field documentation (i.e., maps, well logs, logbooks, photographs) is clearly labeled and placed in the project files.

3.9 LABORATORY DOCUMENTATION

Samples Labeling/Identification

The SC shall assign laboratory sample numbers. These numbers will be listed on a document to cross-reference with the client number, sample tag number, and laboratory sample number.

Laboratory sample numbering is comprised of an "Episode" number (Episode meaning client batch) followed by .01 for the first sample, .02 designating second sample, etc. These numbers are sequentially generated by the SWLO "LIMS" system.

	SWLO ID	Client ID
Example:	3001.01	Sample A
	3001.02	Sample B
	3001.03	Sample C

This unique sample number shall be used for sample identification during storage, analysis and data reduction, data validation, and reporting.

Filling of Log-in Information

Work sheets and internal chain-of-custody are sent to the various departments (i.e. inorganics, GC/MS, GC, etc.)

The SC or a designee will log in samples. The date on the receipt form will be the date of sample receipt in the laboratory. The time, date of collection, and recipient name will be noted in the remarks column of a COC sample log-in sheet (Figure 3.8); and the original receipt documentation will be attached to the COC record.

Sample Log-in Document Storage

There will be two repositories for documents associated with a project. The first repository is the project file. This file will contain the following documents:

- Contracts, purchase orders, task order, and/or other work authorization
- Original project sheet
- Computer-generated project sheet
- Project modification forms

The second repository for related documentation is the analytical data file, which will contain a copy of the final project report/QC report and any other documents related to the project analysis (i.e. 1) signed airbill; 2) signed chain-of-custodies; 3) work sheet; 4) sample tags; 5) traffic reports; 6) bench sheets; 7) raw data).

Corrections to Documentation

When it becomes necessary to make corrections to any form of documentation (e.g., sample tags, COC forms, daily logbooks), the obsolete information is crossed out with a single line and the changes are made and initialed by the person making the change.

3.9 SAMPLE PACKAGING AND SHIPPING

Preparation of Samples for Shipment

The following is a description of the procedure followed when transporting environmental samples from the sampling site to the laboratory:

- The outer surface of all sample containers is cleaned with bottled water and paper towels.
- Sample collection points, depth increments, and sampling devices are identified and documented.
- Log book entries, sample tags, COC forms, and field record sheets with sample identification points, date, time and names or initials of all persons handling the sample in the field are completed.
- Custody tape is wrapped around the neck and cap of each container.
- Samples and trip blanks are placed into a sample cooler provided by the laboratory along with blue ice packs. After a cooler is filled, the appropriate COC form is placed inside the cooler

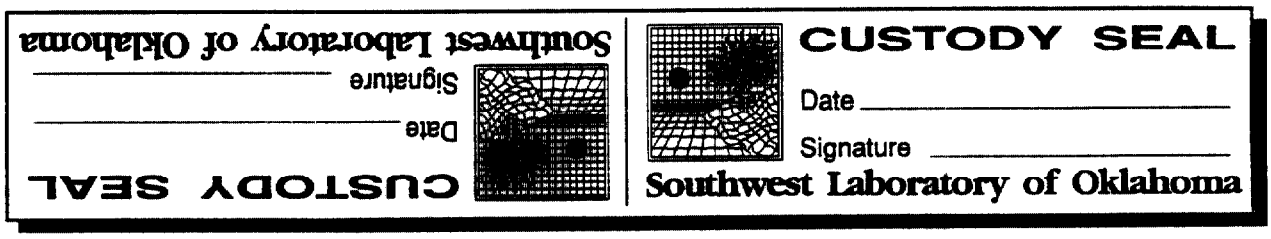

FIG. 3.15 Example Custody Seal for Sample Containers/Coolers

and the outer surface of the cooler is cleaned.

- Glass sample containers are wrapped with plastic insulating material to prevent contact with other sample containers or the inner walls of the cooler.

- Once all packaging is completed, each cooler is sealed with identifying labels/custody seals (see Figure 3.10) which are initialed by the field sampler for COC procedures. Custody seals are placed across the binding tape that secures the lid of the shipping container for both the front and back side of the container. For the back side, the custody seal is placed across the hinge, if possible.

- Samples are classified according to the Department of Transportation (DOT) regulations pursuant to Title 49 CFR.

- The laboratory is then notified prior to shipment that samples are being sent to the laboratory for analysis. This notice should be given at least 24 hours in advance of the expected sample arrival date. Notification includes shipping information (i.e., airbill number, courier company, number of shipment containers to be sent).

Shipping Containers

Samples are packaged in thermally insulated, rigid coolers, according to DOT specifications 173.510 and 172 Subparts B, C, and D, and Subparts A and B of Part 173. Sample containers are placed in a cooler that contains blue ice and absorbent packing for liquids or styrofoam packing for solids. The completed COC form is placed inside the shipping container, unless otherwise noted.

Marking and Labeling

The cooler is marked as follows:

- Proper shipping name: Hazardous substance, liquid, or solid

- Hazardous class: To be determined (label placed in upper left corner of outer container)

- Labels: "This Side Up" or arrows placed on the opposite side of the outer container if a liquid is to be shipped
- Custody tape is wrapped twice, in a single strip, around the outside of each cooler and initialed.

A hazardous material shippers certification is filled out and will accompany the shipment. The container is secured with strapping tape to prevent leakage.

Shipping Transportation/ Courier

It is recommended that an overnight express service (i.e., Federal Express) be used for sample transport. If an air freight service is used, samples can be picked up at the airport (located 20 minutes from the laboratory). When samples are scheduled to arrive at the laboratory on a Saturday, the laboratory must receive notice of this shipment at least 24 hours in advance.

4.0 CALIBRATION PROCEDURES AND FREQUENCIES

Calibration is the process for determining the correctness relative to physical or chemical standards used or assigned values in scales of measuring instruments. It establishes a reproducible reference point to which all sample measurements can be correlated. Instruments are calibrated as per method (i.e., SW846 CLP-SOW, etc.) The following are examples of those calibrations.

4.1 FIELD EQUIPMENT

All field equipment is calibrated daily prior to use, and immediately recalibrated if field personnel suspect that the calibration may have been altered. Reasons for such alteration include change of batteries, equipment being dropped or knocked around, or significant changes in temperature since the last calibration. Since instrumentation and procedures are continually being updated, field personnel are required to consult the appropriate instruction manual for calibration instructions.

Specific Conductance Meter

■ With the instrument turned off, check the meter's mechanical zero setting. Adjust the screwdriver adjustment control on the meter face if necessary to obtain a zero reading.

■ Press the power switch to on and press the battery check switch. Verify the meter needle deflects to the battery check area.

■ Connect a clean, dry probe to the instrument. Remove the instrument from its carrying case and place it on a padded surface.

■ Press the 0-2 range switch and verify that the meter reads zero. If it does not, adjust the null adjust potentiometer RB9 on the amplifier circuit board to obtain a reading as near zero as possible.

■ Press the 0-2000 range switch.

■ Immerse the probe in the 1000 mg/l sodium chloride solution. The meter should read 1990 uhos/cm. If it does not, adjust the standardization potentiometer R32.

pH Meter

■ Connect the two probes to the appropriate jacks on the instrument panel. Be sure that fill hole in the pH electrode is uncovered. The fill hole is to remain covered at all times except for calibration and pH measurement. When the electrode is not in use, slide the rubber sleeve over the fill hole.

■ Prepare pH 4 and pH 9 buffer solutions by dissolving the contents of one powder pillow of each in separate beakers containing 50 mL demineralized water.

■ Select the T(c) mode and measure the temperature of each buffer solution. Referring to the temperature coefficients table, determine the actual pH values of the buffer solutions for those temperatures. Calculate the difference between the two pH values.

■ Immerse the probes in the pH 4 buffer solution and select the pH mode. Allow approximately 30 seconds to reach equilibrium and adjust the CAL control to obtain 0.00 reading.

■ Remove the probes from the pH 4 solution and rinse thoroughly with demineralized water.

■ Immerse the probes in the pH 9 buffer solution. Allow approximately 30 seconds for the probes to reach equilibrium. Adjust the SPAN control for a reading equal to the difference value calculated above.

■ Adjust the CAL control for a reading equal to the actual pH value of the pH 9 buffer as adjusted for temperature.

■ Rinse the probes thoroughly with demineralized water.

Water Level Indicator

This instrument arrives calibrated by the manufacturer for water level measurement.

Digital Thermometer

This instrument is calibrated against an NBS thermometer at least 2 points within the anticipated range.

Geiger Counter

Geiger counters are sent annually to an independent contractor for calibration.

4.2 LABORATORY INSTRUMENTATION —INORGANIC CHEMISTRY SECTION

Atomic Absorption Spectrophotometer Systems (AAS)/Inductively Coupled Argon-Plasma Emission Spectrophotometer (ICAP)

For AAS systems (i.e., flame AA, graphite furnace AA and ICP), the instruments are calibrated daily, and each time the instrument is set-up. Appendix C lists the instrument operating parameters employed in the analysis.

Calibration standards are prepared fresh before each analysis and are discarded after use. These calibration standards are checked for traceability using NBS reference standards or EPA QC solutions. Appendix D contains a list of NBS and EPA reference standards available for laboratory use.

The following QA/QC requirements are employed for the AA calibration:

a. Initial Calibration Verification (ICV)

- The accuracy of the initial instrument calibration must be verified and documented for every analyte by the analysis of an Initial Calibration Verification solution (ICVS - i.e., an NBS, SRM or EPA QC solution). When measurements exceed the control limits of the ICVS or within the target range values supplied by the QC solution, the analysis must be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

- If the ICVS is not available, or if a certified solution of an analyte is not available from any source, analyses shall be conducted on an independent standard at a concentration other than that used for calibration, but within the calibration range. (See Appendix D for Criteria and Guidelines for Standard Traceability)

- The ICVS must be run at each wavelength used for analysis.

b. Calibration Blank

- Must be analyzed each time the instrument is calibrated.

- Must be analyzed at the beginning and the end of the run, and at a frequency of 10% during the run. It is also analyzed after a standard run or after a contaminated sample run to check for carry-over contamination.

- Blank results are to be reported down to the instrument detection limits (IDL).

- If the result is greater than method detection limit (MDL), the analysis is terminated, problem corrected, the instrument recalibrated and calibration reverified.

c. Continuing Calibration Verification (CCV)

- CCV must be performed for each analyte at a frequency of 10% or every two hours during analysis, whichever is more frequent.

- CCV must be also analyzed for each analyte at the beginning and at the end of the analysis.

- The analyte concentration in the CCV must be near the mid-range of the calibration curve.
- The same calibration standard must be used throughout the analysis for a particular case.

TABLE 4.1 INTERFERANT AND ANALYTE ELEMENTAL CON-CENTRATIONS USED FOR ICP INTERFERENCE CHECK SAMPLE

Analytes	(mg/l)	Interferants	(mg/l)
Ag	1.0	Al	500
Ba	0.5	Ca	500
Be	0.5	Fe	200
Cd	1.0	Mg	500
Co	0.5		
Cr	0.5		
Cu	0.5		
Mn	0.5		
Ni	1.0		
Pb	1.0		
V	0.5		
Zn	1.0		

■ One of the following standards can be used for continuing calibration verification:

1. EPA Solution
2. NBS SRM
3. In-house prepared solution from an independent standard

■ If the CCV results exceed the specified control limits (i.e., 95% confidence limits of the true values or the given target range values), the instrument must be recalibrated and the preceding 10 samples or less reanalyzed for the analytes affected.

d. ICP Interference Check Sample Analysis (ICS)

■ To determine if interelement and background correction is required, ICS is analyzed at the beginning and end of each sample analysis run (minimum of 2 times for every 8 hours).

■ Results must fall within the control limits of ± 20% of the EPA supplied true values for the analytes included in the ICS. (See Table 4.1 for list of analytes and interferants in the ICP check sample). If not within the control limits, the analysis is terminated, the problem is corrected, the instrument is recalibrated, and the samples are reanalyzed.

■ If an EPA ICP check sample is not available, an independent ICP check sample is prepared with the interferant and analyte concentration at the levels specified in Table 4.1. The mean value and the standard deviation is established by initially analyzing the prepared check sample at least 5 times for each parameter. Control limits are then established for the in-house prepared solution. It must fall within ± 20% of the mean value.

If an interference cannot be resolved successfully, a standard addition technique will be used for both AA and ICAP. Standards of the analytes will be added to the duplicate sample and the concentration of the analyte(s) can be determined by difference.

The following requirements are employed when using a method of standard addition for graphite furnace analysis:

■ Data must be within the linear range determined by the calibration curve.

■ The sample and the three spikes must be analyzed consecutively.

■ Only single injections are required.

- Spikes should be prepared such that:

  1. Spike 1 is approximately 50% of the sample absorbance.

  2. Spike 2 is approximately 100% of the sample absorbance.

  3. Spike 3 is approximately 150% of the sample absorbance.

Spectrophotometers

The manufacturer instructions for instrument operation are followed for proper operating procedures.

Spectrophotometers are calibrated daily prior to any sample analysis. The calibration standards are prepared from reference materials or commercial standards (traceable to EPA or NBS reference materials) at a minimum of three concentrations, including a calibration blank to cover the anticipated range of measurements. The requirement for an acceptable initial calibration is a correlation coefficient equal to or greater than 0.996 (based on statistical historical data). Before sample analysis, an initial calibration verification standard is analyzed. The response of this standard must be within 95% confidence limit of the true values or target range values provided by the QC sample. If not, the instrument must be recalibrated.

The instruments are also checked for wavelength calibration. For UV/IR instruments, polystyrene film is used to calibrate the wavelength.

All absorption cells (i.e., cuvettes, quartz cells) are kept clean, free of scratches and fingerprints, and are rinsed with the solution to be analyzed prior to use. Matched cells are checked to see that they are equivalent by placing portions of the same solution in both cells and taking several readings of the transmittance or absorbance.

Total Organic Carbon Analyzer (TOC)

For TOC calibration, a known volume of potassium hydrogen phthalates (KHP) solution is analyzed as the calibration solution on the carbon analyzer. A minimum of three calibration solutions encompassing the linear range of the carbon analyzer is prepared and analyzed. Linear regression analysis of standard concentration in ug C versus response in millivolts (mv) is done to obtain a calibration curve. The linear regression fit must be equal or greater than 0.99 (based on statistical evaluation of historical calibration data) or the standards are rerun and a new regression is calculated.

4.3 LABORATORY INSTRUMENTATION —ORGANIC PROCESSING SECTION

Gel Permeation Chromatograph (GPC)

The following procedure is employed for the calibration of the GPC system:

- Packing the column - Place 70 grams (g) of Bio Beads SX-3 in a 400 milliliter (mL) beaker. Cover the beads with 50/50 methylene chloride and allow the beads to swell overnight before packing the column. Transfer the swelled beads to the column and start pumping solvent through the column, from bottom to top, at 5.0 mL/minute. After approximately 1 hour, adjust the pressure on the column to 7-10 psi and pump an additional 4 hours to remove air from the column. Adjust the column pressure periodically as required to maintain 7-10 psi.

- Prepare the GPC calibration solutions as follows: (1) Corn oil - Add 25 mg corn oil to sufficient amount of methylene chloride to attain a final volume of 250 for a 100 mg/mL; (2) phthalate-phenol - Add 1.0 g of Bis(2-ethyl hexyl) phthalate to sufficient amount of methylene chloride for a final volume of 250 ml and a final concentration of 4 mg/ml. Add 0.15 g of neat pentachlorophenol into approximately 250 ml methylene chloride for a final concentration of 0.6 mg/ml.

■ Calibration of the column - Load 5 mL of the corn oil solution into sample loop No. 1 and 5 mL of the phthalate-phenol solution into loop No. 2. Inject the corn oil and collect 10 mL fraction (i.e., change fraction at 2-minute intervals) for 36 minutes. Inject the phthalate-phenol solution and collect 15 mL fraction for 60 minutes. Determine the corn oil elution pattern by evaporation of each fraction to dryness followed by a gravimetric determination of the residue.

■ Analyze the phthalate-phenol fractions by GC/FID on the DB-5 capillary column.

■ Plot the concentration of each component in each fraction versus total eluent volume (or time) from the injection points. Choose a "dump time" which allows $\geq$85% removal of the corn oil and $\geq$ 85% recovery of the bis(2-ethylhexyl)-phthalate.

■ Choose the "collect time" to extend at least 10 minutes after the elution of pentachlorophenol. Wash the column at least 15 minutes between samples.

■ Typical parameters selected are: Dump time = 21 minutes; collect time = 24 minutes; and wash time = 15 minutes; Elute volume collected = 120 ml.

General Laboratory Equipment

Balances are calibrated before every use with standard Class-S calibration weights and are calibrated annually by a licensed specialist. The pH/specific-ion meters are calibrated before each use with a minimum of three standard solutions. (See Appendix D, Standard Operating Procedures for pH meter, balances, and conductivity meter for discussion)

4.4 LABORATORY INSTRUMENTATION —CHROMATOGRAPHY SECTION

Gas Chromatographs (GC)

Injection of secondary standards, validated by the use of EPA or NBS reference standards, is used to adjust the sensitivity and selectivity of the analytical system for each compound being analyzed. The system is calibrated by preparing standards at a minimum of five concentration levels for each analyte. The low-level standard is at or near the established detection limit. The medium- and high-level standards are at concentrations that correspond to the expected range of concentrations found in the samples. These standards will define the working range of the GC detector. (See Appendix D, Traceability and List of EPA and NBS reference standards available)

The results of standard calibrations (low, medium, and high ranges) for each analyte are tabulated with respect to response versus concentration. The ratio between response and concentration, known as the response factor (RF), can be used to prepare a calibration curve for each compound. It is expressed in an equation as:

$$RF = \frac{\text{Area response of analyte}}{\text{Concentration of analyte in the standard}}$$

The following criteria are employed for the GC linearity calibration:

a. Initial Calibration Verification

■ % Relative Standard Deviation (RSD) cut-off for RF = $\pm$ 20% for all analytes except for problematic (i.e., poor responder) analytes (e.g., gases, endrin, DDT, DDE, DDE, DDD, etc.). RSD is calculated as:

$$\%\ RSD = \frac{s \times 100}{\text{average RF of the individual analytes in the standard solution}}$$

where s = standard deviation of the RF of each analyte

and where Average RF = mean of the RF of the analyte

■ %RSD cut-off for problematic compounds = ± 50%

■ If an analyte in the % RSD determination of the linearity standard check is greater than 20% , or 50% for problematic compounds then linear regression or a straight-line curve is used to determine linearity. (Alternatively, there is an option to use the quadratic equation or a point-to-point curve if the correlation coefficient for the linear regression is less than 0.995.)

■ If the compounds are still out of criteria after using linear regression, the quadratic equation, or a point-to-point curve, reanalyze the standard concentration that is of suspect and then recalculate % RSD.

■ If the compounds are still out of criteria after such reanalysis of the suspected standard, corrective and/or preventive maintenance should be performed to check the system. A new set of initial calibration curves is to be analyzed.

b. Continuing Calibration Verification

■ Percent Difference (% D) cut-off for RF = ± 15% for all analytes except for problematic (i.e., poor responder) analytes (e.g., gases, endrin, methoxychlor, endrin aldehyde). % D is calculated as:

$$\%D = \frac{[\text{average RF} - \text{RF (continuing calibrationstandard)}] \times 100}{\text{mean of average RF}}$$

■ % D cut-off problematic compounds = ± 50%

■ If 20% of the analytes in the % D determination of the standards for linearity check have values greater than 35%, then linear regression or a straight-line curve is used to determine linearity. (Alternatively, there is an option to use the quadratic equation or a point-to-point curve if the correlation coefficient for the linear regression is less than 0.995.)

■ If the compounds are still out of criteria after using linear regression, the quadratic equation, or a point-to-point curve, reanalyze the continuing calibration standard concentration and recalculate % D.

■ If the compounds are still out of criteria after such reanalysis, corrective and/or preventive maintenance should be performed to check the system.

■ A new set of initial calibration curves is to be analyzed.

c. The continuing calibration standard is analyzed every 12 hours during sample analysis.

d. A solvent blank using solvent (Pesticide grade) suitable for the detector is used to check system contamination and is also analyzed after a standard run or after a contaminated sample has been analyzed to check for carry-over contamination.

NOTE: Cut-off criteria for initial calibration and continuing calibration are interim guidelines. The GC laboratory will set new criteria based on historical data obtained from previous calibration standards used for the various analytical methods.

High Performance Liquid Chromatographs (HPLC)

The system is calibrated by preparing standards at a minimum of five concentration levels for each analyte. The low-level standard is at or near the established detection limit. The medium- and high-level standards are at concentrations that correspond to the expected range of concentrations found in the samples. These standards will define the working range of the HPLC. Continuing calibration is analyzed after every 10 samples and at the end of run. Criteria for % RSD for the initial calibration is within 20% or a linear regression or a straight-line curve is used to determine linearity. If the correlation coefficient is less than 0.995, corrective and/or preventive maintenance is done, and a new set of calibration curves is analyzed. Criteria for % D for continuing calibration is within 15% or a new standard is analyzed and % D recalculated.

Ion Chromatographs (IC)

The calibration procedure for the system is the same as the HPLC.

4.5 LABORATORY INSTRUMENTATION—MASS SPECTROMETRY SECTION

Procedures for calibration and instrument tuning for sensitivity and selectivity are somewhat similar to those for gas chromatography method. The primary difference between GC and GC/MS methods is concerned with the validation of the mass spectrometer as the detector. GC detectors generally operate by sensing a change in an electrical field (e.g., GC-EC, GC-FID, Hall); whereas, mass spectrometers sense a change in charge with reference to the mass of the compound. Further, the charge molecule ion will fragment reproducibly into an array of ions. The result is a characteristic mass spectrum of the compound. The first step in the calibration of the GC/MS system is to demonstrate the ionization and fragmentation of standard mass spectral tuning compounds. This is accomplished, as well as a sensitivity check, with the use of two EPA-specified compounds injected. Those compounds are: 4-Bromofluorobenzene (BFB) for volatiles and Decafluorotriphenylphosphine (DFTPP) for semivolatiles. These standards are run daily to validate the GC/MS system tune. (See Tables 4.2 and 4.3, for Tune Criteria)

Calibration of the GC/MS, like that of GC calibration, is established and validated by the injection of EPA traceable standards at a minimum of five concentration levels over the range of likely sample concentrations. An internal calibration procedure is used: in addition to surrogate recovery compounds, sample extracts are spiked with internal calibration standards that span the retention time range of the analytes of interest. The concentration of the analytes is calculated with reference to the RF of the internal standards for each sample. RF is defined as:

$$RF = \frac{(A_x)\ (C_{is})}{(A_{is})\ (C_x)}$$

where:

A_x = area of the characteristic ion for the measured compound

A_{is} = area of the characteristic ion for the specific internal standard

C_{is} = concentration of the internal standard (ng/μL)

TABLE 4.2 BFB KEY IONS AND ABUNDANCE CRITERIA

MASS	ION ABUNDANCE CRITERIA
50	15.0 - 40.0 percent of the base peak
75	30.0 - 60.0 percent of the base peak
95	base peak, 100 percent relative abundance
96	5.0 - 9.0 percent of base peak
173	less than 2.0 percent of mass 174
174	greater than 50.0 percent of the base peak
175	5.0 - 9.0 percent of mass 174
176	greater than 95.0 percent but less than 101.0 percent of mass 174
177	5.0 - 9.0 percent of mass 176

TABLE 4.3 DFTPP KEY IONS AND ABUNDANCE CRITERIA

MASS	ION ABUNDANCE CRITERIA
51	30.0 - 60.0 percent of mass 198
68	less than 2.0 percent of mass 69
70	less than 2.0 percent of mass 69
127	40.0 - 60.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 1.00 percent of mass 198
441	present but less than mass 443
442	greater than 40.0 percent of mass 198
443	17.0 - 23.0 percent of mass 442

C_x = concentration of the measured compound (ng/μL)

Further precision, accuracy, and continuing calibration are demonstrated with the use of repeated analyses of spiked and duplicate spiked samples and EPA check samples. Reagent blanks are analyzed in each batch of semivolatile analyses and are analyzed daily for volatile organic analyses.

The QA/QC requirements employed for the GC/MS calibration are discussed in the following subsections.

Instrument Tuning

■ EPA-CLP (2/88 SOW) tune criteria for BFB and DFTPP are used before any sample analysis for VOA and BNA. (See Tables 4.2 and 4.3, BFB and DFTPP Tune Criteria)

■ Other tuning criteria can be used for CLP 3/90 SOW or the Superfund Method for Low Concentration Water.

■ A tune criteria is required every 12 hours during sample analysis.

Initial Instrument Calibration

■ For EPA-CLP (2/88 SOW) and EPA SW846 Method 8240 and 8270 the criteria for VOA and BNA calibration check compounds (CCC) and system performance check compounds (SPCC) is employed.

■ BNA and VOA CCC are:

BNA CCC	VOA CCC
Phenol	Vinyl Chloride
1,4-Dichlorobenzene	Chloroform
2-nitrophenol	1,2-Dichloropropane
Hexachlorobutadiene	Toluene
4-Chloro-3-Methylphenol	Ethylbenzene
2,4,6-Trichlorophenol	
Acenaphthene	
N-Nitrosodiphenylamine	
Pentachlorophenol	
Fluoranthene	
Di-n-octyl phthalate	
Benzo(a)pyrene	

% RSD is calculated for all compounds. It should be within ± 30% for all CCC compounds and should be within ± 30% for all other compounds.

■ BNA and VOA SPCC are:

BNA SPCC	VOA SPCC
N-Nitroso-di-n-Propylamine	Chloromethane
Hexachlorocyclopentadiene	1,1-Dichloroethane
2,4-Dinitrophenol	Bromoform
4-Nitrophenol	1,1,2,2-Tetrachloroethane
	Chlorobenzene

The average RF is calculated for all compounds. RF for both BNA and VOA SPCC compounds must be at least 0.300 except for bromoform which must be at least 0.250. The RF for all other BNA and VOA compounds must be at least 0.05.

For EPA-CLP 3/90 SOW all compounds must meet a minimum Relative Response Factor (RRF). most compounds must meet a maximum %RSD (20.5%) criteria.

Continuing Calibration

■ Same list of CCC and SPCC for BNA and VOA analysis.

■ CCC and SPCC criteria

1. % D must be less than 25% for all CCC and should be less than 25% for all other compounds for BNA and VOA analysis.

2. The RF is calculated for all compounds. RF for all other BNA and VOA SPCC compounds must be at least 0.300, except for bromoform which must be at least 0.250. The RF for all other BNA and VOA compounds must be at least 0.05.

■ Continuing calibration must be performed after tune criteria is met.

■ Continuing calibration must be performed before beginning sample analysis and must be done every 12 hours during analysis for BNA and VOA.

■ For EPA-CLP 3/90 SOW all compounds must meet a minimum RRF. Most compounds must meet a maximum %Difference (25%) criteria.

Internal Standard

Internal standard areas are monitored as a measure of the GC/MS instrument calibration. The areas of each internal standard in each sample are compared to the internal standard areas in the continuing calibration standard associated with the samples. If the samples are analyzed under the same tune as the initial or continuing calibration, the areas in each sample are compared to those in the VOA or BNA continuing calibration standard in the initial or continuing calibration.

■ The area and retention time for each internal standard from the calibration standard and the upper and lower limits of the EICP area should be within -50% to +100%.

■ When the retention time of any internal standard changes by more than 30 seconds, the system must be inspected and corrections made.

■ The EICP area of each internal standard must fall within the limits of the 12 hour standard.

5.0 ANALYTICAL PROCEDURES

5.1 FIELD TESTING AND SCREENING

During multimedia sampling activities, selected physical and chemical parameters in the air, water, and soil at the site are measured. Equipment and general procedures for analysis of field samples are listed below. Because field instrumentation and analytical methodology is continually being updated, field personnel are required to consult each manufacturer's instruction manual for operating procedures.

Measurements of pH

Measurements of pH are taken on water purged from wells prior to sampling. Groundwater samples are collected after a stable pH is achieved to ensure that conditions are representative of the formation. Measurements for pH also are taken on surface water samples. A Orion Model 231 Digital pH meter or equivalent is used for field analyses using the procedure described below.

Rinse the probes thoroughly with ASTM Type II reagent water to prevent any carryover. Make certain that the pH electrode fill hole is uncovered and the mode switch is set to pH. Immerse the probes in the test sample and take the reading. Allow 30 seconds for the reading to stabilize. After pH measurements are conducted, slide the rubber sleeve over the fill hole.

Specific Conductance

Conductivity measurements are taken on purge water and all groundwater and surface water samples using a Hach Model 16300 portable conductivity meter according to the procedure described below.

Connect the probe to the PROBE INPUT connector on the front panel. Press the POWER switch on and perform a battery check. Press the switch for the highest range and immerse the probe in a beaker containing the sample solution. Shake or tap the probe on the bottom of the beaker to ensure that no air bubbles are trapped near the electrode. Allow about 10 seconds for the probe to stabilize before taking the reading. If the meter indicator falls in the lowest 10 percent of the range, switch to the next lower range. Repeat until the proper range is selected. Dilute if necessary. Rinse the probe with ASTM Type II water between each use.

Temperature

Temperature data is used in conjunction with the chemical data for groundwater and surface water characterization. Temperature measurements are taken on purge water and all groundwater and surface water samples using a mercury thermometer or the conductivity meter, which is equipped to measure temperature, according to the procedure described below.

Connect the temperature probe and select the T(c) mode. Immerse the probe in the test sample and allow 30 seconds for equilibration. Take the reading. Rinse the probe with ASTM Type II reagent water after each use.

5.2 LABORATORY METHODS

References

The laboratory follows analytical procedures based on EPA-approved methods for both inorganic and organic analyses of multimedia environmental samples. Methods used for inorganic and organic analysis of routine samples are based on 40 CFR part 136 as published in the Federal Register (October 26, 1984), the EPA's Test Methods for Evaluating Waste (SW-846, 3rd edition), and Standard Methods for the Examination of Water and Wastewater, 16th Edition 1985. Unless otherwise notified by the client, the above methods shall be followed. Appendix A, provides a listing of analytical protocols utilized by the laboratory. A listing of our most utilized methods is found in Appendix B & Appendix E.

If typical methods are rendered ineffective by matrix interferences or if analytical parameters of detection limits, precision, specificity, etc., would require method variance (i.e., modification of the method), the Project Officer will notify the client/contractor of the method modification. A copy of the variance will be sent to the client/contractor to seek approval of the method change. The modification request must show that the conditions for the laboratory variance are similar to the expected conditions (i.e., sampling and handling techniques, environmental matrix concentration range, interferences, etc.) in the EPA approved methods.

Changes in operations prior to instrumental analysis (e.g., sample preparation and storage) must be documented.

Documentation

The objective of document control is to assure that all documents for a given program are accountable and traceable. It includes chain-of-custody records, all logbooks, graphs, and other miscellaneous items.

Record-Keeping

Documentation in the laboratory is initiated by the SC who receives samples, assigns laboratory numbers and generates COC forms which document sample movement in the laboratory. Each shipment of samples received is given a unique batch number (project number). A batch consists of a number of samples carried through the entire analytical procedure, along with samples and standards. All work performed on a sample batch is documented in a bound laboratory logbook which is described as follows:

1. Sample Receiving Logbook: It is a compilation of computer-generated sample summary forms which were entered into the laboratory sample data base on a sample receipt basis. It is compiled on a monthly basis to document sample receipt information.

2. Instrument Maintenance Logbook: To record the maintenance performed on the analytical instruments. It is maintained for each GC, GC/MS, AA, or other analytical instrument.

3. Standards Logbook: To record the preparation and use of all standards in the laboratory. It shall indicate standard traceability to EPA or NBS standards. It shall note date of preparation, concentration and by whom, as well as date of expiration of the stock standards or reagents.

4. Chemist's Notebook: To record the raw data and final data of every batch. It is used to document all activities associated with the analytical process. Laboratory notebook of each staff is a functional record and is prenumbered.

5. Instrument Benchsheet Logbook: To record sample run sequence or injections done in a day's or shift's run.

Rules Governing the Use of Logbooks

a. Bound logbooks with pre-numbered pages are the preferred record-keeping forms. Loose sheets are not to be used unless permanently affixed to the logbooks.

b. Only assigned laboratory notebooks or logbooks are used for record-keeping related to project work.

c. All writing must be legible and shall be completed in ink. All numbers must be clear. Corrections should be made by drawing one line through the incorrect entry, entering the correct information, and initialing the change.

d. Complete information should be entered so that in an examination it can be determined what was done, when, and what the results were.

e. If any data are determined to be invalid, reasons are indicated.

f. All relevant information is included (e.g., the manufacturer and lot number of a chemical, the specific procedure used for sample preparation and analysis, instrumental conditions, etc.).

INORGANICS DOCUMENTS

- File inventory
- Chain-of-custody record(s)
- Sample tag(s)
- Airbill(s)
- Inorganics Traffic Report(s)
- Inorganics Analysis Data Summaries
- Copies of analysts' notebook pages and/or benchsheets
- Worksheets
- ICAP and AA instrument logbook pages
- Sample tracking documents
  - Sample receipt log pages
  - Internal custody records
- Copies of instrument printouts
- QA/QC data reports
- Duplicate, blank, etc., analyses results
- Related correspondence and memos
- All other related documents

FIG. 5.1 Inorganics Document Inventory Check List

g. When work is continued in another notebook or logbook, the number of the first notebook is written in the first page of the second notebook and vice-versa.

Document Control

Document control is accomplished through the use of a centralized repository document inventory and a Data Clerk with purview over all the documents generated in conjunction with the project or contract. All project files and analytical data files and related documentation to sample analysis are maintained by the Data Clerk.

Document Handling

The Data Clerk is responsible for the collection, organization, maintenance and security of all documents. The Data Clerk will establish a client/contract file for all documentation regarding a project or a contract.

A client/contract file is generated when the project file (i.e., sample receipt and log-in documents) are transferred by the SC to the Data Clerk for custody. Within a project file, subfiles are established for each major element of the contract. These files are stored in a locked file cabinet in the Data Clerk's office.

Each file contains the following type of documents:

a. Project File: All documentation relating to sample receipt and log-in. This also contains project sheet information as well as contract information, etc.

b. Analytical File: This contains the final data/QC report and raw data relating to sample analysis. The order of filing within the analytical file would consist of final data/QA report, raw data (i.e., chromatograms, RIC/Quan, strip charts, etc., or any instrument's data recording output).

c. Miscellaneous File: This will contain the instrument benchsheets, all documents associated with sample preparation (i.e., analysis request form), analyst's notes, etc. In the case of laboratory notebooks and instrument benchsheets, photocopies will be used in place of the originals being maintained by the analyst.

Consistency of Documentation

Before releasing analytical results, the laboratory assembles and cross-checks the information on sample tags, custody records, laboratory benchsheets, personal and instrument logs and other relevant data to ensure that data pertaining to each particular sample or case is consistent throughout the record. (See Data Collection, Validation and Reporting Section for details)

Document Inventory

Document tracking and control are facilitated through the use of an inventory checklist for document tracking. Figures 5.1 and 5.2 show the checklist for both inorganic and organic parameters.

DOCUMENT INVENTORY LIST - FORMAT

SECTION I
Narrative

SECTION II
QC Summary

SECTION III
Sample Data
Traffic Reports
One-entry for each Sample

SECTION IV
Lab Detection Limits
VOA Initial Calibration Data Form VI
VOA Continuing Calibration Data Form VII
BNA Initial Calibration Data Form VI
BNA Continuing Calibration Data Form VII
Pesticide Data Summary Forms VIII-X
VOA Initial Calibration Raw Data
VOA Continuing Calibration Raw Data
BNA Initial Calibration Raw Data
BNA Continuing Calibration Raw Data
Pesticide Raw Data

SECTION V
DFTPP Raw Calibration Data
BFB Raw Calibration Data
Method Blank Data
Matrix Spike Data
Matrix Spike Duplicate Data

SECTION VI
Airbill/Shipping Manifest
Field Chain-of-Custody Document
Sample Receipt Form

SECTION VII
Lab Notebook Pages
GC Injection Log Pages
GC/MS Injection Log Pages
Miscellaneous File
Pesticide Raw Data File

FIG. 5.2 Organics Document Inventory List

Handling Confidential Documents

All documents received with a group of samples and/or generated in the course of analysis shall be kept confidential. Documents specifically marked confidential that may accompany the samples, are to be treated separately from other case-related documents.

The following procedures are employed for handling documents marked CONFIDENTIAL:

1. Client/contractor is contacted to assure that receipt of these documents is correct and required for analysis, and returned as directed by client/contractor.

2. If the documents are necessary to begin the sample analyses, the documents are placed in a secured file separate from the regular files and under the control of the Data Clerk. The Data Clerk keeps these documents secured at all times and only authorized personnel have access to them.

Document/Data Package Shipping.

The delivery schedule of the data package depends on the contract requirements. The date of shipping is documented and a list of data/documents shipped is retained for record. A copy of the data package sent is kept by the laboratory to be filed for future reference in case of client's future request for information.

Standard Operating Procedures

The laboratory maintains SOPs for each laboratory section that describe standard procedures used by each laboratory section for use of logbook,

benchsheets, traceability of standards, instrumentation, sample and environmental data.

The laboratory maintains Standard Operating Procedures (SOPs) for every major analytical procedure. These procedures detail use of logbooks, benchsheets, traceability of standards, instrumentation, sample, and environmental data. SOPs are updated yearly with any changes from previous revisions approved by the Section Manager/Supervisor and/or QC Officer. All SOPs within the laboratory are the current revision which are dated and controlled by the use of a sign-off sheet documenting who has the procedure and which revision they have. Out of date material is "retired" by removal from circulation and maintained in a locked file and used for reference material only.

Document Control, Review, & Approval

Documents are updated for any revision made. Changes made in documentation shall reflect the actual procedures being followed. Before any revision is made, analyst concerned for revision of such documents shall submit to the Section Supervisor or the Project Officer (PO) the proposed revisions.

If the revision is justified for the changes to be done, the Section Supervisor or the PO submits the proposed revision of the standard operating procedure (SOP) to the QA Officer for approval.

Document revision shall also include policy changes which could substantially impact the QA/QC plan. They are as follows:

- Personnel changes relating to QA/QC responsibilities
- Method changes

All Document revisions are reviewed by two supervisors (i.e., managers, QA Officer, etc.). Approval signatures are on the cover with revision numbers and date of revision. Each copy is given a document control number.

Outdated documents are collected, and the latest revision issued. The outdated document is "retired," and entered into the retired document log. Copies are maintained for historical purposes.

Standards Preparation

All inorganic and organic analytical standards utilized for instrument/methodological calibration and preparation of QC samples are traceable to SRMs. Primary standards are obtained from reliable, certifiable source, and of highest possible purity. Prepared commercial standards are verified against SRMs from EPA or NBS for traceability. Appendix IV contains Standard Operating Procedures for Standard Traceability, Expiration, and Criteria and Guidelines used by the laboratory for standard preparation.

5.3 TYPES OF DETECTION LIMITS

Instrumental Detection Limit (IDL)

It is defined as the smallest signal above background noise that an instrument can detect reliably. It does not address possible blank contaminants or matrix interferences.

IDL for each analyte in a given method is determined for each analytical instrument used. It is quarterly updated to verify instrument sensitivity changes. The following procedure is used to determine IDL:

- Using EPA or NBS supplied SRMs, if available, perform seven consecutive measurements of standards for all components being measured at 3 - 5 times the required detection limit concentrations [i.e. MDL or contract required detection limits (CRQL) on three nonconsecutive days.

- These analyses are performed using the instrumental working conditions specified in the method, on standards in appropriate solvent for base/neutrals, acids, and pesticides/PCBs; standards diluted into reagent water for volatile organics; and trace metal analytes in reagent water.

- IDL is determined by multiplying 3 times the average of the standard deviations of the measured values.

Limit of Detection (LOD)

LOD is the lowest concentration level of an analyte that the analytical process can reliably detect. Sometimes, the IDL and LOD are operationally the same since an indication of whether an analyte signal exceeds peak-to-peak noise. LOD accounts for blank contamination but not for matrix complexity and interferences. It is also numerically equivalent to the MDL as the value for blank approaches zero. The recommended value for LOD is 3s where s is the standard deviation of the difference between total value measured for the sample and value measured for the blank. It is expressed in an equation as:

$$S_T - S_B > 3s$$

where
S_T = Total value of the analyte measured in the sample
S_B = Value of the analyte measured in the blank
s = Standard deviation for these measurements ($S_T - S_B$)

Method Detection Limit (MDL)

MDL is defined as the minimum concentration of an analyte that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero. It also refers to the minimum concentration of an analyte that a method can detect reliably in either a given sample matrix or blank.

It is expressed in an equation as:

$$MDL = \frac{Ks}{M}$$

where:
K = 3
s = Standard deviation of average noise level
m = Slope of the calibration curve

Practical Quantitation Limits (PQL)

PQL is the lowest level that can be reliably achieved within the laboratory control limits of precision and accuracy during routine laboratory operating conditions. It is expressed in an equation as

PQL = [MDL x factor]

For nonaqueous samples, the factor is on a wet-weight basis. (See Table 5.1)

Methods for Which Limits of Detection Are to Be Developed

The laboratory periodically reevaluates the MDLs for the analytical methods used.

MDL established by the laboratory for EPA approved methods (i.e. Federal Register 600 series, SW-846 "7000" series, and Methods of Chemical Analysis of Water and Wastes) shall be compared against the MDL defined in these methods to determine if in-house quality control procedures are effective. In instances where an EPA method is used in analysis, the MDL shall be that indicated by the EPA method. For parameters that are not

TABLE 5.1 PRACTICAL QUANTITATION LIMITS (PQL) FOR VARIOUS MATRICES

MATRIX	FACTOR[1]
ground water	10
low-level soil	200
water miscible liquid waste	50
high-level soil and sludge	10,000
non-water miscible waste	100,000

[1]PQL = [PQL for ground water] X [Factor]. For non-aqueous samples, the factor is on a wet-weight basis.

Reference: USEPA SW-846, 3rd Edition, September 1986

comparable with the defined MDL in the EPA methods (i.e. laboratory cannot achieve the MDL set by the method), the laboratory MDL shall be used. For contracts/projects requiring the use of non-EPA approved methods, the laboratory shall establish detection limits according to the contract requirements and protocol.

Approach to Establishing Limits of Detection

The laboratory shall employ the procedure based on EPA Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater Appendix A (Appendix B) for the development of MDL. For contracts/project requiring non-EPA methods, the laboratory shall establish limits according to contract requirements and protocol.

6.0 DATA REDUCTION, VALIDATION, AND REPORTING

6.1 FIELD AND TECHNICAL DATA

The collected data are divided into field data and technical documentation. Technical documentation is combined field and analytical data and enables definitive characterization of the extent and magnitude of specific contaminants at each site. Field data contains data from all measurements performed on-site including well stability measurements, well logging, water level measurements, soil gas readings, and PID measurements. Technical data includes all field and analytical data plus the results of the field and laboratory QC samples and are incorporated into the final report.

Field and Technical Data Reduction

All field measurements and observations are recorded in project log books, field data records, or similar types of record-keeping books. Field measurements include pH, temperature, conductivity, alkalinity, water flow, and certain air quality parameters. All data are recorded directly and legibly in field logbooks with all entries signed and dated. If entries must be changed, the change should not obscure the original entry. The reason for the change should be stated, and the correction and explanation should be signed and dated or identified at the time the correction is made. Field data records are organized into standard formats whenever possible and retained in permanent files.

All laboratory data are cross-referenced to the appropriate trip blank, field blank, equipment blank, method blank, field duplicate or replicate, matrix spike, and matrix spike duplicate. In addition, all pertinent dates (dates collected, received by the laboratory and analyzed) for each laboratory analysis applicable to the contract or project are referenced against their respective holding times.

Field and Technical Data Validation

Validation of field data is performed on two different levels. First, all data are validated at the time of collection by following standard procedures and QC checks specified in Section 10. Second, data are validated by the Field Supervisor, who reviews the data to ensure the correct codes and units have been included. After data reduction into tables or arrays, the Field Supervisor reviews data sets for anomalous values. Any inconsistencies discovered shall be resolved immediately, if possible, by seeking clarification from the field personnel responsible for data collection. The Field Supervisor is also responsible for ensuring that defensible and justifiable data was obtained by following the field objectives described below:

- Adherence to the project work plan
- Equipment and instruments properly calibrated and in working order
- Sample collection according to standard operating procedures
- Sufficient sample volume collected to maintain sample integrity and conduct all required analyses
- Properly preserved samples
- All applicable blanks and field QC samples are provided with each sample set
- Complete COC documentation is kept throughout the duration of the field sampling effort and copies are included with each sample shipment
- Field samples arrive at the laboratory in good condition.

Random checks of sampling and field conditions are made by the Field Supervisor, who checks recorded data at that time to confirm observa-

tions. Whenever possible, peer review also is incorporated into the data validation process in order to maximize consistency between field personnel.

Once both field and analytical data have been combined, the resulting technical documentation is validated against the following criteria:

- Stated objectives of the work plan
- Stated QA objectives of the Quality Assurance Project Plan (QAPP)
- Analysis date versus the applicable holding times
- Percentage of QA analyses conducted
- Field and laboratory blank contamination
- Laboratory accuracy (percent recovery versus control limits)
- Laboratory and field precision (RPD versus control limits).

Descriptive statistic for completeness is calculated and reported.

Field and Technical Data Reporting

Description of the type and format for technical reports to be produced for the project is based on contract requirements and QAPP.

6.2 LABORATORY DATA

All bench chemists document sample preparation activities in bound laboratory notebook. These serve as the primary record for subsequent data reduction. The data for GC/MS, AA, ICP, and GC analyses are generated by stand-alone computers. The data for Mercury analysis is conducted using a strip chart to record absorbance expressed in peak height units. Results of each analysis are transcribed manually onto analytical results forms specific to the particular analysis. All data are checked for accuracy and precision at the bench and instrument operator/analyst level, the laboratory manager's level and the QAO's level. The QAO's review shall consist of comparing spike recovery and/or relative percent difference to control limits established for the parameter analyzed. Concentration of the analytes found in the analysis are expressed according to the required units, depending on the sample matrix (i.e., ug/L for aqueous samples for ug/Kg for soil samples).

Laboratory Data Reduction

Gas Chromatograph Results—Calculations are performed for each analyte after its identification is determined. Identification is based on retention time of the suspect peak compared to the retention time of the internal standard. The concentration of the analyte is determined by using the calibration curve and the peak area of the analyte. A response factor is determined from the calibration curve and used to calculate the concentration. Final results will be rounded to the nearest 0.1 ug/L (or two significant figures, whichever is smaller). (See Appendix D, Significant Figures)

Gas Chromatograph/Mass Spectrometry Results—Qualitative identifications are determined by obtaining extracted ion current profiles (EICPs) for the primary ion mass to charge ratio (m/z) and the secondary masses for each analyte. Positive identification is based on the following criteria:

- The intensity of the three characteristic masses of each analyte must maximize in the same ratio (±20%), within one scan of each other
- The retention time must fall within ± 30 seconds of the retention time of the authentic compound
- The relative peak heights of the three characteristic masses in the EICPs must fall within ± 20 percent of the relative intensities of these masses in a reference mass spectrum (standard analysis or reference library).

Structural isomers to be listed as separate analytes must have an acceptable resolution. Acceptable resolution is achieved if, in a standard mix, the baseline to valley height between the isomers is less

than 25 percent of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

The calculation for the concentration for the suspect peak is made using the RF for each analyte.

$$\text{Concentration} = \frac{(A_s)(C_{is})}{(A_{is})(RF)}$$

where:

A_s = Area of characteristic m/z for the analyte to be measured
A_{is} = Area of characteristic m/z for the internal standard
C_{is} = Concentration of the internal standard, in $\mu g/L$
RF = Average response factor as calculated from the area formed on an intensity plot of the ion of interest.

Inductively Coupled Plasma (ICP)—The theory of emission spectrometry is based upon excitaton of gaseous atoms of an element resulting in the electrons being raised to high energy state. The frequency of the emitted radiatoin depends on the difference in energy of the two states of the atom. While the intensity is relative to the concentration of the element.

$$E_2 - E_1 = hv = hc/w$$

E2 = to the energy of the higher excited state
E1 = to the energy of the ground state
h = Planck's constant
v = frequency of emitted light
c = speed of light
w = wavelength (lambda)

The purpose of the ICP is to measure concentrations of elements in a sample. This is accomplished by measuring the emission intensity produced when a sample containing these elements is aspirated into the plasma exciting the electrons to a higher state. The measurement of intensity if performed by allowing the light leaving the plasma through each exit slit to fall on a photomultiplier tube. This tube converts light energy into an electrical current. At the end of the integration time the total current produced is measured and is proportional to the intensity and the concentration of the element being analyzed. This total current value is sent to the computer for data reduction. The final calculations are done by the computer system by comparing intensity of unknown against intensity of known standards.

Interelement correction is performed by measuring the light intensity of interfering elements and mathematically correcting for the additional emitted intensity.

Atomic Absorption Spectrophotometry Results—Photometric absorbance is governed by the relationship:

$$\text{Absorbance} = \log(100/\%T) = 2 - \log \%T$$

where:
% T = 100 - % absorption

Percent Absorption is based on the amount of light of a particular wavelength absorbed by a specific metal. Its calculation is based on the loss of light after a beam of light of a particular wavelength is passed through a flame into which a solution containing metals of interest has been aspirated.

Calibration curves establishing the absorbance relationship with concentration are generated at various concentrations. From these curves, a comparison is made with absorbance from sample measurement. Since absorbance is directly related to concentration, a plot of the two parameters is linear in certain operable ranges and allows for determination of unknown concentrations in solutions (direct samples or extracts) after measurement of absorbance.

Atomic absorption spectrophotometry is based on the principle that if light of a resonance wavelength is passed through a flame containing atoms of an element to be measured, then part of the light is absorbed and the extent of absorption is proportional to the number of atoms present in the flame. Because of the sophistication of current instrumentation, the partial application of this technique for the measurement of metal concentration in liquids relies on a Beer's absorption law approach, comparing absorbance from an unknown against the linear correlation between absorbance and concentration in standards.

In many spectrophotometric measurements, interferences occur in the absorption of light confusing

the Beer's Law relationship between absorption and concentration; this is especially true for atomic absorption. To alleviate this problem, a technique known as the "method of standard additions" is used in which sequential known amounts of the component being analyzed for are added to a sample of unknown concentration. By making an initial absorbance measurement and measurement after each addition, the effects of interference present in the analytic matrix can be accounted for.

Laboratory Data Validation and Data Reporting

Data validation is performed by the QA Officer and the PO. Validation is accomplished through routine audits of the data collection and flow procedures and by monitoring of QC sample results.

Validation Requirements

The minimum requirements for each analytical run are:

- At least three point calibrations and one calibration check standard
- Continuing calibration check using an EPA or NBS reference, if available
- Laboratory control samples/QC sample included in each analysis whenever available
- One reagent blank per matrix and per concentration level for every sample batch analyzed (i.e., one per 20 samples)
- Matrix spike duplicate and matrix spikes per concentration level and per matrix for every sample batch analyzed (i.e., one set per 20 samples)

For GC/MS data, in addition to the requirements mentioned:

- DFTPP or BFB key ions and abundance criteria
- Percent recovery of surrogate spike run on all samples
- Internal standard area monitoring for samples analyzed (-50% to +100%) of the internal standard area of the calibration standard
- RIC/Quan, standard curves and printouts of samples analyzed

Data Collection and Flow Audits

Data collection and flow audits include the following:

- Review of sample documents for completeness by the analyst(s) at each step of analysis
- Daily review of instrument logs, performance test results, and analyst performance by the laboratory manager
- Daily review of performance indicators such as blanks, surrogate recoveries, duplicate/matrix spike duplicate analyses, matrix spike analyses, etc.
- Random calculation checks
- Review of all reports prior to and subsequent to data entry
- Review and approval of the final report of the QA Officer

Data Review

The review of data quality involves several levels of evaluation. In general, the analysts and the laboratory manager are responsible for reviewing the data relative to instrument calibration, standard preparation, method blanks, raw data, calculations and transcriptions. The analyst normally reviews 100% of the raw analytical data generated, including the calibration data and all calculations. Upon completion of the analyst process, a second level of review of the raw data is performed by either the laboratory manager or Program Manager. At this level, 25 - 100% of the data quality indicators (i.e., method blanks, replicate analyses and spike recovery data) are reviewed relative to the acceptance criteria described in the analytical procedures.

At the next level of data quality review, the QA Officer is generally responsible for a complete review of about 20% of the data generated. The emphasis is on the data acceptability relative to the data quality indicators and on the accuracy of the final data summaries.

All analytical problems encountered during sample analysis are properly addressed to provide explanations for data users.

Review Checklists

See figure6-1 and 6-2.

REPORT REVIEW

CLIENT: **PROJECT:** **SDG/EPISODE:**

ITEM	CHECK	✓	REMARKS/CORRECTIONS
Case Narrative	Typographical		
	Names		
	Ref IDs/Text IDs		
	Receipt Dates		
	Single/Plural Spl		
	VOA-Gold Sheet		
	BNA-Extract Log		
	QC Inorg Notes		
Chain of Custody	Original		
	Copy		
Cooler Receipt Form	Yes		
	No		
Report - Headers	Dates		
	Date Sampled		
	Date Extracted		
	Date Analyzed		
	Sample IDS		
	Client		
	Lab		
	Proj Ref Consistant		
	Method Reference		
	Dilution Factors		
Report - Data Review	Units of Measure		
	Values Transcribed		
	Flags Correct		
	Surrogate Recoverie		
	% OK		
	Range to Matrix		
QC Section	Header Information		
	Units of Measure		
	Values Transcribed		
	Surrogate Recoverie		
	% OK		
	Range to Matrix		
Diskette	CBDF		
	Directory CK		
	Detection Lmts		
	Spike Amounts		
	QC Check		
REVIEWER:	**DATE:**		**CORRECTED (Initials/Date):**

Instructions

A check mark in the appropriate column indicates that the reviewer has reviewed and verified the item next to it. If a check is not marked please refer to "REMARKS/CORRECTIONS column for report numbers which need correction or additional comments from the reviewer. CORRECTED Initials/Date indicate that corrections were made and verified.

Figure 6-1 Report Review Sheet

DATA REVIEW CHECKLIST

PROJECT OFFICERS DEPARTMENT

CLIENT/PROJECT:

EPISODE:

REVIEW DATE:

™

Client Name/Address/Contact are all correct? Yes ☐ No☐

Sample I.D.s are as specified on client chain-of-custody? Yes ☐ No☐

If No: Is the I.D. change documented in a client phone log and in the case narrative? Yes ☐ No☐

Do all samples reflect the proper matrix? Yes ☐ No☐

Are all units reported reflecting the proper matrix? Yes ☐ No☐

Are the proper method references listed? Yes ☐ No☐

Do the results on the worksheets agree with the LIMS entered result? Yes ☐ No☐

Do the results from the raw data agree with reported results? Yes ☐ No☐

Are Dilution Factors/Calculations carried out correctly? Yes ☐ No☐

Are all parameters addressed in the QC section? Yes ☐ No☐

Do they have the following QC information tabulated?

1. Method &/or TCLP Blank Results? .... Yes ☐ No☐
2. Blank Spike Results? ..... Yes ☐ No☐
3. Laboratory Control Spike (LCS)? ..... Yes ☐ No☐
4. Matrix Spike/Matrix Spike Duplicate Results? ..... Yes ☐ No☐
5. Duplicate Sample Results? ..... Yes ☐ No☐

Are Diskette Deliverables Required? ..... Yes ☐ No☐

If Yes:

Is the requested format supplied? ..... Yes ☐ No☐

Are all the fields filled out? ..... Yes ☐ No☐

Are CLP/"CLP-Like" Packages required by client? Yes ☐ No☐

If Yes: Are the following Items supplied?

ORGANICS:

1. QC Summary (i.e., Surrogate, MatrixSpike/ Matrix Spike Duplicate Summary, Method Blank Summary) ..... Yes ☐ No☐
2. Sample Results? ..... Yes ☐ No☐
3. Sample raw Data? ..... Yes ☐ No☐
4. All Pertinent Calibration Summaries (Initial & Continuing)? ..... Yes ☐ No☐
5. All Pertinent Calibration Raw Data? .. Yes ☐ No☐
6. All Tuning Summaries (BFB & DFTPP)? ..... Yes ☐ No☐
7. All Tuning Raw Data? ..... Yes ☐ No☐
8. Method Blank Raw Data? ..... Yes ☐ No☐
9. MS/MSD Raw Data? ..... Yes ☐ No☐

INORGANICS:

1. Sample Results? ..... Yes ☐ No☐
2. QC Summary (i.e., Initial & Continuing Calibration Verification, CRDL Standard for AA & ICP, Blanks, ICP Interference Check Sample, Spike Sample Recovery, Post Digestion Spike Sample Recovery, Duplicates Laboratory Control Sample, Standard Addition Results, ICP Serial Dilutions, Preparation Log, Analysis Run Log)? ..... Yes ☐ No☐
3. Quarterly Verification of:
   - Instrument Parameters? ..... Yes ☐ No☐
   - Instrument Detection Limits? ..... Yes ☐ No☐
   - ICP Interelement Correction Factors? Yes ☐ No☐
   - ICP Linear Ranges? ..... Yes ☐ No☐
4. Raw Data? ..... Yes ☐ No☐

ADDITIONAL COMMENTS:

Project Officer Signature:

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Figure 6-2 Data Review Checklist

7.0 EXTERNAL AND INTERNAL QUALITY CONTROL CHECKS

7.1 EXTERNAL QUALITY CONTROL CHECKS

EPA CLP Performance Evaluation and On-Site Audits

Quarterly Performance Evaluation (PE) samples consisting of one to three sets of PE samples are analyzed by the laboratory to demonstrate its ability to perform CLP requirements. This provides evidence that the laboratory personnel involved fully understand the required analytical methods and that these methods can be performed satisfactorily by the laboratory personnel using the laboratory equipment and instrumentation. It also provides evidence that the laboratory understands the documentation and reporting requirements of the contract.

An on-site audit is done annually to demonstrate the laboratory has in place and operating, all the personnel, equipment and internal standard operating procedures needed for performance of contract requirements.

EPA Water Pollution (WP) /Water Supply (WS) Performance Evaluation

The laboratory receives sets of quarterly PE samples for the analyses of water pollution and water supply parameters to provide interlaboratory evaluation of data results for reproducibility and comparability. It also provides "feedback" of the QC procedures used by the laboratory.

Performance Evaluation of Contracts/Project Proposals

A set of PE samples is received by the laboratory prior to pre-award of contract/project proposal bids. PE results obtained demonstrate the data reliability of sample analyses performed under a contract/project.

Field Quality Control Checks

Collection and analysis of field blanks, equipment washes, trip blanks, and field replicates are intended as QC checks on the integrity of sample collection and handling procedures and equipment decontamination procedures.

Field blanks, equipment blanks, and trip blanks are prepared using ASTM Type II reagent water and sample bottles randomly selected from the bottles prepared for environmental samples. ASTM Type II reagent water is used to prepare these field check samples, regardless of the environmental medium being sampled, because:

- It mimics the physical characteristics of groundwater and surface water
- No reproducible, affordable material is available that mimics the clay and organic portion of soils and sediments
- An organic or aqueous reservoir is necessary for the absorption, dissolution, or solvation of organic and inorganic contaminants.

Field blanks (ambient conditions blanks) are prepared at the beginning of each sampling event, at each discrete sampling site, by pouring ASTM Type II reagent water into prepared sample bottles. These sample bottles are randomly selected from the supply of prepared sample bottles; a sample container is selected that is appropriate for each type of analysis for which environmental samples are being collected. The field blanks are handled and analyzed in the same manner as environmental samples. Because field blanks and environmental samples are collected under the same conditions, field blank analyses are used to indicate the presence of external contaminants that may have been introduced into samples during collection. Field blanks also may become contaminated during transport, but this may be assessed by the simultaneous use of trip blanks, which is discussed below.

Equipment blanks (bailer washes) are prepared for manual and small automated sampling equipment used to collect environmental samples (i.e., equipment blanks are not prepared for drill rig sampling equipment). Equipment blanks are collected during the sampling day by pouring ASTM Type II reagent water into/through/over a clean piece of sampling equipment, such as bailers, shovels and trowels, and then dispensing it into prepared sample bottles. These sample bottles are randomly selected from the supply of prepared sample bottles, selecting a sample container appropriate for each type of analysis for which environmental samples are being collected. Analyses of bailer washes are used to assess the efficiency of equipment decontamination procedures in preventing cross-contamination between samples.

Trip blanks are prepared at the beginning of the sampling trip by pouring ASTM Type II reagent water into prepared sample bottles. These sample bottles are randomly selected from the supply of prepared sample bottles. Sample containers are filled to yield an appropriate sample volume for each type of VOC analysis, resulting in a complete trip blank for the sampling event. These trip blanks are prepared at the laboratory, shipped to the facility to be sampled (with the unused sample bottles), stored with the unused sample bottles, transported to the sampling site, and then shipped for analysis with the samples collected during the sampling event. The water used to prepare each batch of trip blanks is analyzed for VOCs. The results of the trip blank analyses are reported along with the associated environmental and QC samples. The trip blanks remain unopened throughout the sampling event. Analysis of trip blanks is used to assess contamination of sample containers during transport to and storage at the site, and contamination of samples during transport back to the laboratory. One trip blank will be included in each shipping container containing samples for VOC analysis.

All sample containers provided are shipped with COC records. These records are completed by the field personnel and returned with the samples. The following QC samples are collected for each day of sampling:

- One trip blank per cooler per sampling team for every batch of VOC samples.

- One field blank per field sampling team for every VOC sampling round at a particular site or zone.

- One set of equipment blanks for every day of groundwater sampling. All parameters are to be analyzed.

- One field replicate for every 20 soil/sediment samples is collected at a preselected monitoring point. (More frequent replication can be accomodated.) Field replicates are collected at the same time and in the same manner as the other environmental samples. Field replicates are not the same as laboratory duplicates, because they are separate samples obtained from the same field monitoring point. As such, results of the field replicate analyses are used to assess the precision of the field sampling methods, not that of the analytical techniques.

- One field duplicate for every 20 water samples is collected at a preselected monitoring point. (More frequent replication can be accomodated.) A duplicate sample is collected independently at a sampling location during a single act of sampling. Field duplicates are labeled indistinguishable from other analytical samples so that personnel performing the analyses are not able to determine which samples are duplicates. Field duplicates are used to evaluate the reproducibility of sampling techniques.

7.2 LABORATORY QUALITY CONTROL CHECKS

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

MS/MSD is used to check for precision and accuracy. These are replicate samples spiked with a known spike concentration that are taken through the whole sample preparation process. MS/MSD analyses are performed on one sample in each group of 20 samples (20%), and/or on each type of sample matrix per concentration. Table 7.2 shows a list of matrix spike compounds routinely employed by the laboratory.

The sample analysis process and the spike sample process differ in the adding of known amounts of the substances to be analyzed to the aliquot of the replicate sample. The amount of spike added varies according to the working range of the analytical instrument.

After value of the sample is determined, the value of the sample spike is determined. Should the sample also have a value of the spike analyte, the value of the sample is subtracted from the value of the spike and the percent (%) recovery of the spike is calculated using the following equation:

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result}) \times 100}{\text{Spike Added}}$$

At times the sample value is outside the operating range of the analytical instrument. In such cases it is impossible to know the magnitude of the analyte before the spike is added. Occasionally, the sample and the spike sample require dilution to perform sample analysis within the linear range of the instrument. This dilution adjusts the analyte in the sample to the proper concentration, but it will sometimes also dilute the spike added below the range of detection. In this case, it is not possible to report spike recovery for that particular analyte.

The lack of spike recovery data for an analyte that has been diluted to levels outside the working concentration of the instrument is supplemented by the periodic analysis of spiked QC check sample and other additional sample data.

The calculated % recoveries are then used to assess data precision expressed as relative percent deviation (RPD). It is calculated using the following equation:

$$RPD = \frac{(\text{MS Result} - \text{MSD Result}) \times 100}{\text{Mean of MS and MSD Results}}$$

where MS denotes Matrix Spike.

RPD can also be measured by duplicate sample analysis of one sample. In this case the (2) sample results take the place of the MS and MSD values in the above equation.

Method Blanks

Method blanks, also known as reagent blanks, are analyzed for each matrix and each batch of sample analyses. An aliquot of equal volume or weight to the sample is used for method blank analysis. The method blank, like that of duplicate and spike samples, is taken through the whole analytical process. The method blank must be blank of any substances being analyzed, or interferences.

Calibration Blank/System Blank

A calibration blank/system blank is prepared by analyzing the same matrix used for the preparation of the calibration standards. It is used to establish the analytical curve by taking into account background responses during the calibration process. It is also used to check for carry-over contamination after a standard run or after a contaminated sample run.

Laboratory Control Samples (LCS)

Laboratory Control Samples (LCS) are obtained from USEPA Quality Assurance Branch, Environmental Monitoring and Support Laboratory (EMSL), and NBS. The quality control samples are prepared for analysis in strict accordance with the procedures provided with the materials. LCS are analyzed each day for every sample batch run to check proficiency of the analysis in terms of working standards preparation, monitor standard degradation, and check traceability of the prepared standards from commercial reference materials to EPA reference materials. A measure of comparability between batches is established with the analysis of the LCS. It is also used to check efficiency of both the digestion/extraction, and the instrumental analysis. Check results must be within the target range values (i.e. 95% confidence limits of the given values) of the LCS or within the 95% confidence limits of the true value of the check standard as determined from running replicate analyses of the check standard. (See Appendix D for Standard Traceability)

Surrogate Spike Analyses

Where applicable, an analytical process includes the addition, subsequent detection, and recovery calculation of surrogate spiking compounds. Surrogate compounds are analyte compound substitutes, (i.e., compounds not specifically requested to be determined as analytes in a particular scope of work) which most often do not occur naturally. Surrogate compounds are added to samples for analysis after sample aliquots have been measured out and are taken through the whole sample preparation process. Surrogate compounds, to be useful in QC analysis, must not interfere with the determination of the analytes of interest. Surrogates must also be chemically similar to the analytes of interest and capable of emulating the analyte response.

Surrogate standard determinations are performed on all samples and blanks. All samples and blanks are spiked with surrogate spiking compounds before purging or extraction in order to monitor preparation and analysis of samples. Table 7.1 shows a list of surrogate spike compounds routinely employed by the laboratory.

Method of Standard Addition

A method of standard addition is used to check the accuracy of the analysis method under optimum conditions, excluding chemical interference from sample matrix. (See Section 4.2.1.1 for details)

ICP Interference Check Sample (ICS) Analysis

ICP interference check sample verifies interelement and background correction factors of the ICP instrument. (See Section 4.2.1.1 for details)

EPA, NBS and/or Commercial Reference Standards

These standards are analyzed routinely for the parameter of interest. Commercial standards are checked for standard traceability.

Internal Standards Analysis

Internal standard areas are monitored as a measure of instrument calibration. Internal standard determinations are performed on all samples and blanks to monitor instrumental efficiency and also used as a reference retention time indicator to check retention time shifts of peaks of interest.

A known amount of internal standard concentration is added to a sample extract prior to instrumental analysis. Like the surrogate standard, it must not interfere with the determination of the analytes of interest. It must also be chemically similar to the analytes of interest and capable of emulating the analyte response.

Calibration Standards

Calibration standards are used to quantitate the amount of analytes present in the sample. These are analyzed to initiate any type of analyses. (See Section 4.0, Calibration and Frequencies)

Tuning Requirements (BFB and DFTPP)

See Section 4.5, Table 4.2, and Table 4.3.

Control Charts

The performance of a measurement system can be demonstrated by the measurement of homogeneous and stable control samples in planned repetitive process. The data generated is plotted as a control chart to indicate whether the system is measuring the control sample adequately to provide confidence in the measurement process. It warns the laboratory of possible deviation from 95% confidence level by identifying systematic errors, drifts, or other types of problems.

The use of control charts are summarized as follows:

■ They provide graphic assessment of accuracy and precision for the analysis of each analyte and instant detection of erroneous data.

■ They allow efficient observation of recovery trends for a particular analysis, and they provide a long-term mechanism for self-evaluation of analytical output.

■ They provide assessment of the analytical capability of the staff chemists with regard to the output of valid analytical data.

■ They allow observations of deviations from control trends. It has been noted that:

√ A system must be established to be in control, in order to be maintained in control.

√ A system is not in control if it is observed to produce unexpected data more than once every 20 runs.

√ Control limits usually become tighter once a process is under a controlled protocol (i.e. the original limits were based on data produced by an uncontrolled operation).

TYPES OF CONTROL CHARTS USED

Four charts are used to monitor the laboratory data:

Surrogate Spike Recoveries vs. Sample Analyzed (see fig 7.1)

Laboratory Control Standard (LCS) Concentration vs. Date Analyzed (see fig 7.2)

Percent Matrix Spike Recovery vs. Date Analyzed (see fig. 7.3)

Relative Percent Difference of Matrix Spike/MS Duplicates or Duplicate Analyses vs. Date Analyzed (see fig. 7.4)

The preparation of a control chart is based on Shewhart's theory of control charts (EPA Handbook for Analytical Quality Control Water and Wastewater Laboratories, Chapter 6).

APPROACH TO CONTROL CHART INTERPRETATION

For each parameter and method, a data base of percent recovery (%R) for QC reference samples or spiked samples is collected. The arithmetic mean and standard deviation of this set is calculated. From this information, warning and control limits of a run are determined. These are defined as:

■ Warning limits are defined as x ±2s, where s is standard deviation.

■ Control Limits are defined as x ±3s, where s is standard deviation. The %R of each QC sample or spike sample is plotted on a control chart and compared with the statistically based control limits.

■ Data precision is evaluated based on results of the samples analyzed in duplicate. The range is calculated and then divided by the average of the two analyses, then multiplied by 100. This value equals percent difference (%D). The %D of duplicates in each data set is compared with the values previously found in the laboratory. Calculations for warning and control limits are the same as above.

■ Interpretation of control charts for out-of-control:

■ One or more points outside the control limit (3s).

■ A run of two or more consecutive points outside warning limits (2s).

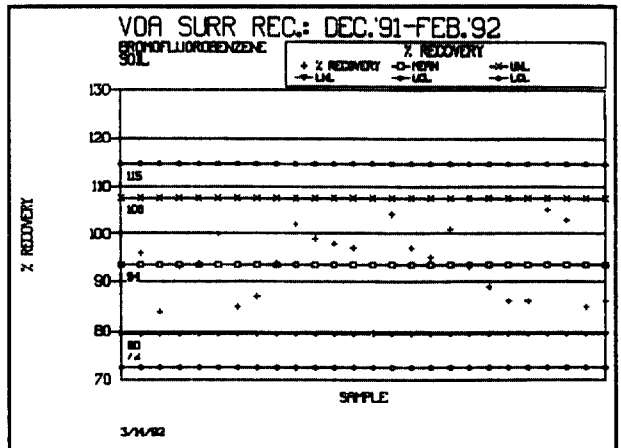

Figure 7.1
Example Control Chart

■ A run of seven or more points above or below x, indicating trends or shifts.

■ Cycles or non-random patterns in the data chart (six consecutive points increasing or decreasing).

■ See figure 5.4 for examples of some of these outliers/trends.

■ Control charts are routed to the various departments where trends are noted and corrective actions are made to alleviate these patterns.

Laboratory Control Limits

Appendix E shows table of laboratory control limits for some parameters. Data outside of the laboratory control limits are flagged and discussed with the client. As the laboratory gathers a large enough data base, it will be able to establish its own criteria for 95% confidence level for both inorganic and organic parameters.

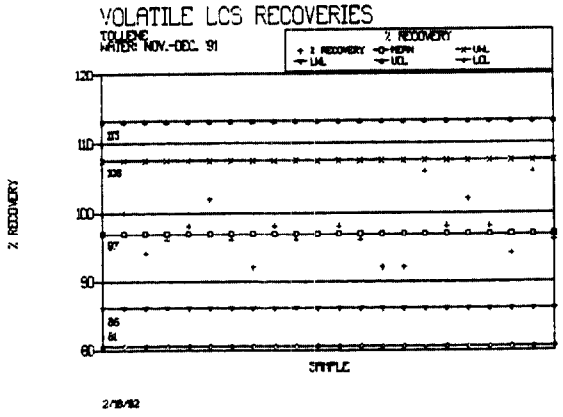

Figure 7.2
Example Control Chart

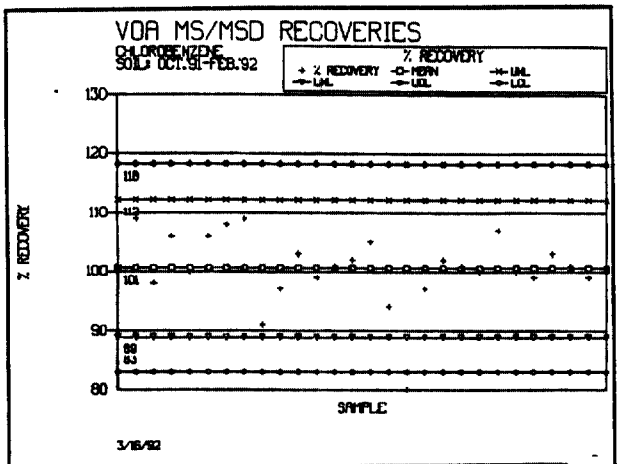

Figure 7.3
Example Control Chart

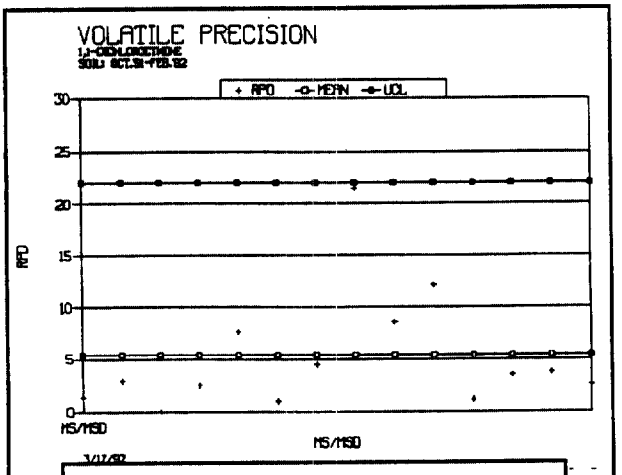

Figure 7.4
Example Control Chart

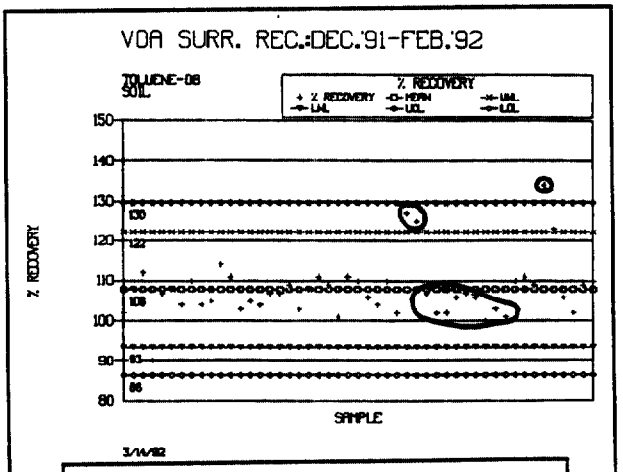

Figure 7.5
Example Control Chart

TABLE 7.1 LIST OF SURROGATES SPIKING STANDARDS FOR ORGANIC ANALYSIS

SURROGATES

Method 601/602/8010/8020 (GC Purgeables):
- Bromochloromethane
- Bromofluorobenzene

Method 608/8080/IFB (Pest/PCB)
- Dibutyl Chlorendate (DBC)

Method 624/8240/IFB (GC/MS Purgeables)
- 1,2 Dichloroethane-d4
- Bromofluorobenzene
- Toluene-d8

Method 625/8270/IFB (Semivolatiles)
- Nitrobenzene-d5
- Phenol-d5
- 2-Fluorobiphenyl
- 2-Fluorophenol
- 2,4,6-Tribromophenol
- Terphenyl-d14

TABLE 7.2 LIST OF MATRIX SPIKING STANDARDS FOR ORGANIC ANALYSIS

MATRIX SPIKES

Method 601/602/8010/8020 (GC Purgeables)
- 1,1-Dichloroethene
- Trichloroethene
- Chlorobenzene
- Toluene
- Benzene

Method 608/8080/IFB (Pest/PCB)
- Gamma-BHC
- Heptachlor
- Aldrin
- Endrin
- PP'-DDT
- PCB-1260 or PCB-1254

Method 615/8150 (Herbicides)
- 2,4-D
- 2,4,5-TP (Silvex)

Method 624/8240/IFB (GC/MS Purgeables)
- 1,1-Dichloroethene
- Trichloroethene
- Chlorobenzene
- Toluene
- Benzene

Method 625/8270/IFB (Semivolatiles)

BASE/NEUTRALS	ACIDS
1,2,4-Trichlorobenzene	Phenol
Acenaphthene	Pentachlorophenol
2,4-Dinitrotoluene	4-Chloro-3-Methylphenol
Pyrene	2-Chlorophenol
N-Nitroso-di-N-Propylamine	4-Nitrophenol
1,4-Dichlorobenzene	

8.0 PERFORMANCE AND SYSTEM AUDITS

Audit is defined as systematic check to determine the quality of operation of laboratory activities. It is comprised of the following:

- Performance audit
- System audit

8.1 FIELD PERFORMANCE AUDITS

Field performance audits are performed on an ongoing basis during the project as field data are generated, reduced, and analyzed. All numerical analyses, including manual calculations, are documented. All records of numerical analyses are legible, of reproduction-quality, and supporting complete to permit logical reconstruction by a qualified individual other than the originator.

Other indicators of the level of field performance are the analytical results of the blank, duplicate and replicate samples. Each blank analysis is an indirect audit of effectiveness of measures taken in the field to ensure sample integrity (e.g., field decontamination procedures). The results of the field duplicate and replicate analyses are an indirect audit of the ability of each field team to collect representative sample portions of each matrix type.

8.2 LABORATORY PERFORMANCE AUDIT

Procedures used to assess the effectiveness of the quality control system are as follows:

Internal Performance Audits

These are accomplished by the laboratory through the use of control samples, replicate measurements and use of reference materials.

Sample analysis systems are conducted by the QA Officer and include the following:

- Verification of written procedures and analyst(s) understanding
- Verification and documentation of procedures and documents
- Review of analytical data and calculations

External Performance Audits

These are accomplished by the laboratory through interlaboratory checks such as:

- Participation in various state laboratory evaluation programs.
- Participation in WP & WS studies from EPA.
- Participation in Environmental Resource Assoc (ERA) WP & WS studies.
- Analysis of split samples and comparing results with the other laboratory.
- Participation in the U.S. EPA CLP program.
- Participation in the U.S. Army Corps of Engineers DERA certification program.

8.3 LABORATORY SYSTEM AUDIT

An on-site inspection is done by EPA audit team or laboratory certification personnel to review the laboratory quality control system which covers sample handling, sample analysis, records control, preventive maintenance, and proficiency testing. When EPA or laboratory certification personnel initiate a system audit of the laboratory, any recommendations made or deficiencies identified will be considered for implementation and corrective actions taken to correct deficiencies.

LABORATORY AUDIT CHECKLIST

QA/QC DEPARTMENT

DATE:

BY:

SAMPLE RECEIVING:

1. Was the sample paperwork & laboratory paperwork in agreement?* Yes ☐ No ☐
2. Was a sample log-in sheet filled out? Yes ☐ No ☐
   If so, were all items completed? Yes ☐ No ☐
3. Was the worksheet and appropriate paperwork sent out to the analytical requred sections of the laboratory (i.e., Extractions, Gc/MS, & Inorganics)? Yes ☐ No ☐
4. Were there any revisions made to the paperwork and notes/phone logs describing why the revisions were made? Yes ☐ No ☐
5. Were samples storage areas monitored for appropriate temperatures? Yes ☐ No ☐
6. Any temperatures outside of control limits? Yes ☐ No ☐
   If so, were corrective actions made? Yes ☐ No ☐

COMMENTS:

*Make copy of paperwork to verify that it is in agreement with other parts of the laboratory.

ANALYTICAL LABORATORIES:

1. Does log-in of sample/extracts to the analytical lab agree with the Sample Receiving paperwork (i.e., analytical run logs I.D. samples correctly)? Yes ☐ No ☐
2. Are samples analyzed within holding times? Yes ☐ No ☐
3. Are standards used in analysis traceable back to US EPA standards? Yes ☐ No ☐
4. Are calibrations performed correctly? Yes ☐ No ☐
5. Is the analytical run sequence in agreement with the requested methodology? Yes ☐ No ☐
6. Were there any corrective actions/maintenance performed to the instrument during analysis of the samples in question? Yes ☐ No ☐
7. Are these corrective actions/maintenance documented in the instrument maintenance logs? Yes ☐ No ☐

COMMENTS:

REPORTING:

1. Does the Sample Receiving paperwork agree with the reporting paperwork (i.e., sample number, sample ID's, turnaround time, matrix, etc.) Yes ☐ No ☐
2. Have revisions been made to the paperwork? Yes ☐ No ☐
3. Are notes/phone logs describing revisions included in the reporting files? Yes ☐ No ☐
4. Are problems in the analysis reported in the case narrative?* Yes ☐ No ☐
5. Was the reporting requirements in agreement with what the client requested? Yes ☐ No ☐
6. Were there any resubmissions or submissions of late data? Yes ☐ No ☐
7. Were the reasons for these submissions documented in the subsequent case narratives? Yes ☐ No ☐
8. Were requested methodologies reported to the client? Yes ☐ No ☐
9. Was all appropriate QC (Quality Control) reported? Yes ☐ No ☐

COMMENTS:

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FIGURE 8-1 Laboratory Audit Checklist

LABORATORY CORRECTIVE ACTION

QA/QC DEPT.

➤ **Contract/Project/Episode Number:**

DESCRIPTION OF EVENT

➤ Date Recognized: ➤ By:

➤ Date Occurred: ➤ By:

➤ Date Corrected: ➤ By:

ANALYTICAL METHOD

➤ Analyte: ➤ Method:

➤ Analyst: ➤ Lab Manager:

➤ Samples Affected (Lab ID):

➤ Description of problem encountered:

➤ Corrective/Preventive Action Taken:

➤ **SIGNATURES:**

Analyst: *Date:*

Supervisor *Date:*

QA Officer *Date:*

FOLLOW UP

➤ Follow up Investigation/Discussion:

➤ **SIGNATURES:**

QA Officer: *Date:*

Laboratory Director: *Date:*

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FIGURE 8-2 Laboratory Corrective Action

9.0 PREVENTIVE MAINTENANCE

Preventive maintenance is defined as an orderly program of positive actions for preventing failure of equipment and ensuring that the equipment is operating with the reliability required for quality results. The actions include specification checks, calibrating, cleaning, lubricating, reconditioning, adjusting and checking.

9.1 FIELD EQUIPMENT

Preventive maintenance is carried out on all field equipment prior to being shipped to the sampling site. This preventive maintenance includes regular battery checks and maintaining a sufficient stock of spare parts and supplies. Field personnel are strongly cautioned that these instructions are for general purpose only. Should equipment break down in the field and field crews are unable to repair the equipment within a reasonable amount of time, the operations manager in the laboratory is notified. A replacement is shipped immediately via overnight courier. Whenever possible, duplicates of all equipment are initially sent to the field. For specific preventive maintenance procedures, the appropriate instrument manual should be consulted.

pH Meter

The following is a description of the preventive maintenance procedures for the field pH meters:

- Charging Batteries

After the initial charge when first placing the instrument in operation, the batteries are recharged after each 30 hours of operation. Allow the batteries to charge 16 hours to restore them fully. Exceeding the 16-hour period will not damage the batteries. Overnight charging is recommended, and periods of operation between charges should not exceed 30 hours. With proper charging practices, a set of batteries should last for more than 300 charge cycles.

- Battery Replacement

When batteries no longer hold a charge for a reasonable length of time, they should be replaced. This unit requires six AA size nickel-cadmium batteries. Replace them as follows:

- Remove the accessories from the foam insert above the instrument panel
- Remove the four screws securing the panel in the case
- Lift the panel from the case and place it face down on a padded surface
- Pry the batteries from their clips with a screwdriver and replace all six batteries
- Replace the panel in the case, and replace the accessories in the foam insert
- Connect the charge unit to the instrument and allow the batteries to charge for 15 hours.

- pH Electrode Care Storage

When the electrode is not in use, the wetting cap with filling solution-soaked cotton should be reinstalled over the tip, and the fill hole cover should be placed over the hole. This will prevent loss of filling solution through evaporation. Always maintain the filling solution level just below the fill hole.

- pH Electrode Cleaning

Normal cleaning of the electrode can be performed in the following manner:

- Immerse the electrode tip in 0.1N HCl followed by immersion in 0.1N NaOH and again in 0.1N HCl, each for a 2 minute period. Rinse with ASTM Type II reagent water and soak in pH 7 buffer solution for 30 minutes.
- If the electrode is slow to respond or readings are unstable and the connection cannot

be remedied with normal cleaning, the reference junction may be clogged. Clean the junction for 10 minutes in dilute potassium chloride solution. First dilute a saturated potassium chloride solution about 1:10 with water. Place the electrode tip in the boiling solution for about 10 minutes.

• Remove heat and allow the electrode to cool while immersed in the solution. Then rinse with ASTM Type II reagent water and soak in pH 7 solution before testing again.

If these steps fail to improve electrode response, replace the electrode. If the pH bulb becomes contaminated or left dry, it may be reconditioned by following the cleaning procedure above.

Specific Conductance Meter

The following is a description of the preventive maintenance procedures for the field specific conductivity meters:

- Battery Replacement

Low battery condition is indicated by an arrow on the display. When the arrow appears, the battery should be replaced.

Thermometer

After each use, the thermometer probe should be rinsed with ASTM Type II reagent water. Should the sample contain oils or other heavy hydrocarbon mixture, the probe should be washed with laboratory-grade detergent and rinsed with ASTM Type II reagent water.

9.2 LABORATORY INSTRUMENTATION

A preventive maintenance program for the instrumentation ensures fewer interruptions of analyses, personnel efficiency, and lower repair costs. It eliminates premature replacement of parts, and reduces discrepancy among test results. It increases reliability of results.

The laboratory has established the following preventive maintenance program:

1. Each type of equipment/instrument has a written Standard Operating Procedure (SOP) which describes the methods for routine inspection, cleaning, maintenance, testing, calibration, and/or standardization of the equipment. Instrument operating manuals are kept near the instrument or where analysts have easy access.

2. Analysts using the instruments are properly trained and develop trouble-shooting skills in equipment failure to reduce dependence upon outside servicing agencies. In complicated cases, the servicing agency or supplier is called to solve the problem.

3. Written equipment records are kept to document all inspection, maintenance, trouble-shooting, calibration, or modifications. Whenever maintenance is performed on an instrument, it is properly documented in a preventive maintenance logbook, which is kept near the equipment to monitor the adequacy of maintenance schedules. The records contain the date (month, day, year), description of the maintenance done, the actual findings, the name of the person doing the maintenance and a statement of whether the maintenance operations were routine, and if those operations followed the written SOP.

4. Performance criteria is established for judging when data from instrument performance checks indicate the need to make adjustments in the instrument operating conditions. (See Section 4.0, Calibration Procedures and Frequency for details)

Chromatographic Instruments

Preventive maintenance is done through a daily performance check and calibration of standards. Parameters such as retention time and response factors are observed and back-checked with prior operational performance.

In addition, the following are done:

- GC detectors are cleaned whenever performance degradation (i.e., calibration criteria are not met, retention time shifts, noisy baseline, etc.) is observed by the analyst.

- Septa are replaced as needed.

- Incoming gas drying cartridges are changed whenever the color of the adsorbent is noticed.

- Effluent adsorbent traps are changed every month.

- Columns (GC and HPLC) are checked by performance and operating conditions when in use or prior to use.

- Oven performance checked daily prior to use.

(See Appendix D for SOP for GC Preventive Maintenance for more detailed discussion)

Gas Chromatography/Mass Spectroscopy (GC/MS)

The preventive maintenance includes:

Maintenance Requirements	Frequency
Clean filters on cooling fans	Monthly
Check cooling fan for proper operation	Monthly
Check line voltage	Monthly
Clean CDC disc drive pre-filter	Monthly
Check cool-flow level	Monthly
Change mechanical pump oil	Every 4 months
Clean source and rods	Every 4 months
Check power supplies in QEM Box	Every 4 months
Clean printer inside and outside	Every 4 months
General cleaning of instrument	Every 4 months
All items from monthly maintenance schedule	Every 4 months
Change primary filters on CDC disc drive	Every 6 months
Sensitivity analysis through BFB and DFTPP tune criteria	Every 12-hour clock

Atomic Absorption Spectrophotometers/ICP

Preventive maintenance is done for atomic absorption through the following checks:

- Minimum warm-up period of 30 minutes

- Alignment of hollow cathode tube to produce the maximum emitted light to the detector

- For flameless AA, the inert gas flow inside the furnace is optimized to ensure maximum sensitivity

- Digital readout values obtained for the standard curve of each element are checked to ensure linearity

- If readings are low, the operator checks the gas flows, burner or cell alignment, wavelength, slit width, photomultiplier voltage and lamp intensity prior to analysis

General Laboratory Equipment

Analytical balances of various capacities and operational modes are calibrated annually by a licensed specialist and officially recorded as verification of performance.

Balances are calibrated with standard Class S calibration weights before usage. The pH/specific-ion meters are calibrated before use with a minimum of two standard solutions. All combination pH electrodes will be stored in pH 4 buffer solutions. Appendix D shows SOPs used for some instrumentation and equipment.

10.0 DATA ASSESSMENT PROCEDURES

10.1 FIELD DATA

Precision

Duplicate and replicate samples analyzed by the laboratory assess the precision of the sampling effort. Control limits for duplicate/replicate RPDs are set at 0-20% to provide interim guideline. Once a sufficient amount of replicate data becomes available, field precision control charts are constructed similar to the laboratory precision charts. For any given concentration, the mean and the standard deviation(s) of the replicates are calculated. The mean is the centerline of the control chart. Data from each sample set are pooled with the previous sample sets to generate control and warning limits for the next set. Warning and control limits for water samples are set at ±2s and ±3s, respectively. Control limits for solid samples are more liberally established due to matrix heterogeneity. Data outside any control limit are subject to QA review.

Accuracy

Field instruments are calibrated daily or more frequently, if needed, to ensure accuracy of the measurement of field parameters. Specifically, the pH measurement must be accurate to ±0.1 unit, temperature must be to ±0.5°C, and specific conductance must be ±10 umhos/cm. Each will be purged until the above parameters are stable within the specified limits.

All blanks associated with each sample set are to be analyzed and evaluated for cross-contamination. Blank contamination and the resulting corrective action are assessed on an individual basis.

Completeness

The Field Supervisor is responsible for ensuring that all field instrumentation and equipment is functioning properly and calibrated according to set procedures, and that all data are recorded accurately and legibly. In addition, the Field Supervisor must ensure all sites are sampled for all of the specified analyses, that sufficient sample volume has been provided to complete those analyses, and that all of the QA samples have been included with each sample set. The goal for completeness for each sample set shipped to the laboratory is 100 percent. The minimum acceptable completeness limit is 95 percent.

10.2 LABORATORY DATA

Accuracy

Data accuracy is a reflection of the efficiency of the analytical procedure. It is determined by use of spiked samples and standard reference materials or laboratory control samples performed at the rate of one set every 20 samples. A control chart is generated using historical laboratory data where warning and control limits are established to assess data accuracy. (See Appendix E for Laboratory Control Limits)

Precision

Precision is based upon the results of the relative percent differences as calculated from the percent recoveries of the matrix spike and duplicate samples. The control limits for precision are based on historical laboratory data. (See Appendix E for Laboratory Control Limits)

Completeness

Completeness is expressed as the percentage of the amount of valid data obtained to the amount of data expected. For a set of data to be considered complete, it must include all QC data verifying its accuracy and precision. (See Section 6.2, Laboratory Data, for details.)

Comparability

Comparison of results from one batch of samples to another is established by the analysis of the Laboratory Control Samples (LCS).

11.0 CORRECTIVE ACTION

11.1 FIELD CORRECTIVE ACTION

The initial responsibility for monitoring the quality of field measurements lies with the field personnel. The Field Supervisor is responsible for verifying that all QC procedures are followed. This requires that the Field Supervisor assess the correctness of the field methods, the ability to meet QA objectives, and to make a value judgement of the impact a procedure has upon the field objectives and subsequent data quality. If a problem occurs that might jeopardize the integrity of the project, cause a QA objective not to be met, or impact data quality, the Field Supervisor will immediately notify the PO and the Technical Operations Manager if appropriate. Corrective action measures are then decided upon and implemented. The PO is notified if the situation warrants it. The Field Supervisor documents the situation, the field objective affected, the corrective action taken, and the results of that action.

11.2 LABORATORY CORRECTIVE ACTION

Procedures for Determining and Reporting Out-of-Control Events

Out-of-Control Event:
An out-of-control event is defined as any occurrence failing to meet the QA/QC plan.

Criteria Used for Determination of an Out-of-Control Event:
Factors that affect data quality (failure to meet calibration criteria, inadequate record keeping, improper storage, or preservation of samples) require investigation and corrective actions.

Some factors can be easily assessed through the use of control chart interpretation. Control charts can reveal shifts, trends, biases, and conditions where parts of the analytical system are out-of-control. One or more of the data points in the control chart are out-of-control when:

- One or more data points fall outside the control limits (3s)
- A run of two or more data points outside the warning limits (±2s)
- A run of seven or more successive data points above x or below x indicating trends or shifts
- A run of five successive data points in the same direction
- A cyclical pattern or non-random pattern appears in the control chart data

The detection of one of these conditions is an indication that the analytical system is out-of-control. The out-of-control value(s) is placed on the control chart and circled. The QA Officer is notified and both the analyst and QAO investigate and determine whether the condition indicates a procedure that is truly out-of-control or a possible random error. The QAO shall document corrective actions taken (i.e. whether the sample run was repeated or whether the data was received and released for reporting to the client) on the corrective action form.

Responding to an Out-of-Control Event

Roles and Responsibilities:
When an out-of-control event is recognized, each individual involved with the analysis in question has an interactive role and responsibility, these are as follows:

■ **The Analyst:** He must be able to recognize QC failure and immediately notify the Laboratory Supervisor and work with the QAO to solve the problem.

■ **The Laboratory Supervisor:** He must review all analytical and QC data for reasonableness, accuracy, and clerical errors; also responsible to monitor QC charts (in terms of control limits). In an out-of-control event, the laboratory manager works with the analyst and QAO to solve the problem and prevents the reporting of suspect data by stopping work on the analysis in question and ensuring that all results that are suspect are repeated, if possible, after the source of the error is determined and remedied.

■ **QA Officer:** In the event an out-of-control situation occurs that is unnoticed at the bench or supervisory level (i.e., performance failure on a QC sample), the QAO will notify the laboratory manager, help identify and solve the problem where applicable, and ensure the work is stopped on the analysis and no suspect data is reported.

Procedures for Stopping Analysis

Whenever the analytical system is out-of-control, investigation/ correction efforts are initiated by all concerned personnel.

If the problem is instrumental or specific only to preparation of that sample batch, samples prepared after the out-of-control event are processed after the instrument is repaired and recalibrated, provided holding times are not exceeded.

If a sample batch is still out-of-control after reanalysis, all method-related activities shall stop immediately. A detailed laboratory-wide investigation shall be conducted to isolate and correct faulty operations. Sample security, integrity of standards, reagents, glassware, laboratory notebooks, instrument performance and adherence to the methods shall be included in the investigation.

All actions shall be documented and placed in their respective case/contract file.

Corrective Action

The need for corrective action comes from several sources: equipment malfunction; failure of internal QA/QC checks; failure of performance of system audits; and noncompliance with QA requirements.

When measurement equipment or analytical methods fail QA/QC, the problems will immediately be brought to the attention of the PO and QAO. Corrective measures to be taken will depend entirely on the type of analysis, the extent of the error, and whether the error is determinant or not. The corrective action to be taken is determined by either the Technical Operations Manager, the analyst, the PO or the QA officer or by all of them in conference.

A corrective action can be as extensive as replacing a complete lot of contaminated extraction solvent, the reextracting and analyzing of a complete batch of samples due to reagent blank contamination, or as simple as recalculating a series of results because a wrong dilution factor was applied. Furthermore, the right corrective action must be determined on a case by case basis. Appendix D outlines a list of potential analytical problems that might be encountered in the laboratory.

If failure is due to equipment malfunction, the equipment will be repaired, precision and accuracy will be reassessed, and the analysis will be rerun. All attempts will be made to reanalyze all affected parts of the analysis so that in the end, the product is not affected by failure of QA requirements.

When a result in a performance audit is unacceptable, the laboratory will identify the problems and implement corrective actions immediately. A step-by-step analysis and investigation to determine the cause of the problem shall take place as part of the corrective action program. If the problem cannot be controlled, the laboratory will analyze what the impact will be on the data results.

When a system audit reveals an unacceptable performance, work shall be suspended until corrective action has been implemented and performance has been proven to be acceptable.

All corrective actions will be documented on the Laboratory Corrective Action Report Form. These Reports are discussed weekly by the supervisors, managers, QA Officer, and Laboratory Director.

A follow-up review is then performed on each corrective action to ensure that the response taken has indeed been incorporated into the laboratory operation, minimizing a reoccurrence of the problem.

LABORATORY CORRECTIVE ACTION

➤ **Contract/Project/Episode Number:**

DESCRIPTION OF EVENT

➤ Date Recognized: ➤ By:

➤ Date Occurred: ➤ By:

➤ Date Corrected: ➤ By:

ANALYTICAL METHOD

➤ Analyte: ➤ Method:

➤ Analyst: ➤ Lab Manager:

➤ Samples Affected (Lab ID):

➤ Description of problem encountered:

➤ Corrective/Preventive Action Taken:

➤ **SIGNATURES:**

Analyst: *Date:*

Supervisor *Date:*

QA Officer *Date:*

FOLLOW UP

➤ Follow up Investigation/Discussion:

➤ **SIGNATURES:**

QA Officer: *Date:*

Laboratory Director: *Date:*

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FIG. 11.1 Laboratory Corrective Action Form

Remedial Actions

Remedial Actions are taken when a sample has to be reextracted due to poor surrogate recovery, improper level of extraction, etc. The Remedial Action Form is filled out by the analytical chemist and submitted to the section supervisor. The supervisor review the problem and signs the form, then sends it on to the extraction lab for the remedial action.

REMEDIAL ACTION RECORD

GC/MS DEPARTMENT

Initiated by:_____ **Project*:**_____

Date:_____ **Client*:**_____

Sample ID's:_____ **Case*:**_____

*if applicable

DESCRIPTION OF PROBLEM (list dates):

Supervisor's Signature:_____

DESCRIPTION OF ACTIONS TAKEN (list dates):

Supervisor's Signature:_____

Copies: **Case File,** _____, _____, _____, _____

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FIG. 11.2 Remedial Action Record

12.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

12.1 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Data from formal performance audits of the laboratory's activities are reviewed directly by the QAO, Laboratory Director, and Laboratory Manager.

Should any significant quality assurance problem arise, it will be internally discussed among the QAO, Laboratory Director, and Laboratory Manager at a weekly meeting.

13.0 REFERENCES

1. 40 CFR, Part 136, Federal Register, Volume 49, Number 209, Friday October 26, 1984.

2. Handbook for Analytical Quality Control in Water and Wastewater Laboratories, U.S. EPA 600/4-79-019, March 1979.

3. Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, USEPA, EPA-600/4-82-057, July 1982, and as subsequently amended.

4. "Principles of Environmental Analysis," Analytical Chemistry Volume 55, pp. 2210-2218, December 1983.

5. Quality Assurance Handbook of Air Pollution Measurement Systems, USEPA 600/9-76-005, December 1984.

6. Statement of Work: Multi-Media USEPA Contract Laboratory Program USEPA, 1987.

7. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, USEPA SW-846, 3rd Edition, September 1986.

8. USATHAMA QA Program, 2nd Edition, March 1987.

9. A Compendium of Superfund Field Operations Methods, USEPA, EPA/540/P-87/001, December 1987.

APPENDIX A

ANALYTICAL PROTOCOLS UTILIZED AT THE SWOK LABORATORY

1. Standard Methods for the Examination of Water and Wastewater: APHA, AWWA, and WPCG; 16th Edition, 1985,

2. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act., USEPA.

3. 40 CFR, Part 136, Federal Register, Volume 49, Number 209, Friday, October 26, 1984.

4. Methods for Chemical Analysis of Water and Wastes, USEPA, EPA-600/4-79-020, March 1979 and as amended December, 1982 (EPA-600/482-055)

5. Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, USEPA, EPA-600/4-82-057, July 1982 and as subsequently amended.

6. Pesticide Analytical Manual, Volume I, Food and Drug Administration, Revised September, 1977.

7. Recommended Methods of Analysis for the Organic Components Required for AB1803, State of California, 5th Edition, April 1986.

8. NIOSH Manual of Analytical Methods, U.S. Department of Health and Human Services, 3rd Edition, February, 1984.

9. Statement of Work: Multi-Media USEPA Contract Laboratory Program, USEPA, 1990.

10. Statement of Work: Multi-Media High Concentration, USEPA Contract Laboratory Program, July 1986.

11. 500 Series Methods-Drinking Water Test Methods, USEPA Compendium of Methods.

12. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, USEPA, EPA-600/4-84-041, April 1984.

13. Annual Book of ASTM Standards, Water and Environmental Technology, ASTM, 1987, Volume 11.01 and 11.02

14. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, USEPA SW-846, 3rd Edition, September, 1986.

APPENDIX B

DEFINITION AND PROCEDURE FOR THE DETERMINATION OF THE METHOD DETECTION LIMIT

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero and determined from analysis of a sample in a given matrix containing analyte.

Scope and Application

This procedure is designed for applicability to a wide variety of sample types ranging from reagent (blank) water containing analyte to wastewater containing analyte. The MDL for an analytical procedure may vary as a function of sample type. The procedure requires a complete, specific and well defined analytical method. It is essential that all sample processing steps of the analytical method be included in the determination of the method detection limit.

The MDL obtained by this procedure is used to judge the significance of a single measurement of a future sample.

The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this, the procedure was made device- or instrument-independent.

Procedure

1. Make an estimate of the detection limit using one of the following:

   (a) The concentration value that corresponds to an instrument signal/noise ratio in the range of 2.5 to 5. If the criteria for qualitative identification of the analyte is based upon pattern recognition techniques, the last abundant signal necessary to achieve identification must be considered in making the estimate.

   (b) The concentration value that corresponds to three times the standard deviation of replicate instrumental measurements for the analyte in reagent water.

   (c) The concentration value that corresponds to the region of the standard curve where there is a significant change in sensitivity at low analyte concentrations, i.e., a break in the slope of the standard curve.

   (d) The concentration value that corresponds to known instrumental limitations. It is recognized that the experience of the analyst is important to this process. However, the analyst must include the above considerations in the estimate of the detection limit.

2. Prepare reagent (blank) water that is as free of analyte as possible. Reagent or interference free water is defined as a water sample in which analyte and interferant concentrations are not detected at the method detection limit of each analyte of interest. Interferences are defined as systematic errors in the measured analytical signal of an established procedure caused by the presence of interfering species (interferant). The interferant concentration is presupposed to be normally distributed in representative samples of a given matrix.

3. (a) If the MDL is to be determined in reagent water (blank), prepare a laboratory standard (analyte in reagent water) at a concentration which is at least equal to or in the same concentration range as the estimated MDL. (Recommend between 1 and 5 times the estimated MDL.) Proceed to Step 4.

   (b) If the MDL is to be determined in another sample matrix, analyze the sample. If the measured level of the analyte is in the recommended range of one to five times the estimated MDL proceed to Step 4.

   If the measured concentration of analyte is less than the estimated MDL, add a known

amount of analyte to bring the concentration of analyte to between one and five times the MDL in the case where an interference is co-analyzed with the analyte.

If the measured level of analyte is greater than five times the estimated MDL, there are two options:

(1) Obtain another sample of lower level of analyte in same matrix if possible.

(2) The sample may be used as is for determining the MDL if the analyte level does not exceed 10 times the MDL of the analyte in reagent water. The variance of the analytical method changes as the analyte concentration increases from the MDL, hence the MDL determined under these circumstances may not truly reflect method variance at lower analyte concentrations.

4. (a) Take a minimum of seven aliquots of the sample to be used to calculate the MDL and process each through the entire analytical method. Make all computations according to the defined method with final results in the method reporting units. If blank measurements are required to calculate the measured level of analyte, obtain separate blank measurements for each sample aliquot analyzed. The average blank measurements is subtracted from the respective sample measurements.

(b) It may be economically and technically desirable to evaluate the estimated MDL before proceeding with 4a. This will: (1) prevent repeating this entire procedure when the costs of analyses are high, and (2) ensure that the procedure is being conducted at the correct concentration. It is quite possible that an incorrect MDL can be calculated from data obtained at many times the real MDL even though the background concentration of analyte is less than five times the calculated MDL. To ensure that the estimate of the MDL is a good estimate, it is necessary to determine that a lower concentration of analyte will not result in a significantly lower MDL. Take two aliquots of the sample to be used to calculate the MDL and process each through the entire method, including blank measurements as described above in 4a. Evaluate these data:

(1) If these measurements indicate the sample is in the desirable range for determining the MDL, take five additional aliquots and proceed. Use all seven measurements to calculate the MDL.

(2) If these measurements indicate the sample is not in the correct range, reestimate the MDL, obtain new sample as in 3 and repeat either 4a or 4b.

5. Calculate the variance (S^2) and standard deviation (S) of the replicate measurement as follows:

$$S2 = \left[\frac{1}{n-1} \left(\sum_{i=1}^{n} X_i^2 - \sum_{i=1}^{n} X_i \right) \Big/ {}^{2}n \right]$$

$$S = (S^2)^{1/2}$$

where the X_1, i = 1 to n are the analytical results in the final method reporting units obtained from the n sample aliquots and

$$\sum_{i=1}^{n} X_i^2$$

refers to the sum of the X values from i = 1 to n.

6. (a) Compute the MDL as follows:

$$MDL = t_{(n-1\ 1-o=99)}\ (S)$$

where MDL = the method detection

$t_{(n-1\ 1-o=\ 99)}$ =the analyst's "t" value appropriate for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom. See Table.

S = standard deviation of the replicate analyses.

(b) The 95% confidence limits for the MDL derived in 6a are computed according to the following equations derived from percentiles of the chi square over degrees of freedom distribution (X^2/df) and calculated as follows:

$MDL_{LCL} = 0.69\ MDL$
$MDL_{UCL} = 1.92\ MDL$

where MDL_{LCL} and MDL_{UCL} are the lower and upper 95% confidence limits respectively based on seven aliquots.

7. Optional iterative procedure to verify the reasonableness of the estimated MDL and calculated MDL of subsequent MDL determinations.

   (a) If this is the initial attempt to compute MDL based on the estimated MDL in Step 1, take the MDL as calculated in Step 6, spike in the matrix at the calculated MDL and proceed through the procedure starting with Step 4.

   (b) If the current MDL determination is an iteration of the MDL procedure for which the spiking level does not permit qualitative identification, report the MDL as that concentration between the current spike level and the previous spike level which allows qualitative identification.

   (c) If the current MDL determination is an iteration of the MDL procedure and the spiking level allows qualitative identification, use S^2 from the previous MDL calculation to compute the F ratio.

$$\text{if} \quad \frac{S^2_A}{S^2_B} < 3.05$$

   then compute the pooled standard deviation by the following equation:

$$S_{pooled} = \left[\frac{6S^2_A - 6S^2_B}{12} \right]^{1/2}$$

$$\text{if} \quad \frac{S^2_A}{S^2_B} < 3.05$$

   re-spike at the last calculated MDL and proceSS the samples through the procedure starting with step 4.

   (c) Use the S_{pooled} as calculated in 7b to compute the final MDL according to the following equation:

$$MDL = 2.681\ (S_{pooled})$$

   where 2.681 is equal to $t_{(n-1\ 1-o=99)}$ (S).

   (d) The 95% confidence limits for MDL derived in 7c are computed according to the following equations derived from percentiles of the chi squared over degrees of freedom distribution.

$$MDL_{LCL} = 0.72\ MDL$$
$$MDL_{UCL} = 1.65\ MDL$$

   where LCL and UCL are the lower and upper 95% confidence limits respectively based on 14 aliquots.

Reporting

The analytical method used must be specifically identified by number or title and the MDL for each analyte expressed in the appropriate method reporting units. If the analytical method permits options which affect the method detection limit, these conditions must be specified with the MDL value. The sample matrix used to determine the MDL must also be identified with MDL value. Report the mean analyte level with the MDL. If a laboratory standard or a sample that contained a known amount analyte was used for this determination, report the mean recovery, and indicate if the MDL determination was iterated.

If the level of the analyte in the sample matrix exceeds 10 times the MDL of the analyte in reagent water, do not report a value for the MDL.

Reference

Glaser, J.A., Foerst, D.L., McKee, G.C., Quave, S.A., and Budde, W.L., "Trace Analysis for Wastewaters", Environmental Science and Technology, 15, 1426 (1981)

TABLE B.1 ANALYST'S VALUES AT THE 99 PERCENT CONFIDENCE LEVEL

Number of Replicates	Degrees of Freedom (n-1)	$t_{[n-1 1-\alpha=99]}$
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602
21	20	2.528
26	25	2.485
31	30	2.457
61	60	2.390
		2.326

TABLE B.2 METHOD DETECTION LIMITS

PARAMETERS	METHOD REFERENCE	MDL	
		WATER (mg/L)	SEDIMENT (mg/Kg)
TOTAL PETROLEUM HYDROCARBONS	E418.1	0.011	.379
TOTAL DISSOLVED SOLIDS	E160.1	9.00	
CHLORIDE	E300.0	0.16	
FLUORIDE		0.07	
SULFATE		0.35	
NITRATE		0.07	
ORTHO-PHOSPHATE		0.45	
NITRATE	E353.2	0.01	
NITRITE	E354.1	0.02	
ARSENIC	SW7060	0.0015	.30
LEAD	SW7421	0.0007	.14
MERCURY	SW7470	0.0001	.02
SELENIUM	SW7740	0.0039	.78
THALLIUM	SW7841	0.0015	.30
ALUMINUM	SW6010	0.008	1.60
ANTIMONY		0.032	6.50
ARSENIC		0.021	4.20
BARIUM		0.007	1.40
BERYLLIUM		0.0002	.04
CADMIUM		0.002	.34
CALCIUM		0.246	49.00
CHROMIUM		0.003	.68
COBALT		0.003	.68
COPPER		0.013	2.60
IRON		0.003	.58
LEAD		0.041	8.20
MAGNESIUM		0.135	27.00
MANGANESE		0.0009	0.18
MOLYBDENUM		0.005	1.10
NICKEL		0.005	1.00
POTASSIUM		0.312	62.00
SELENIUM		0.060	12.00
SILVER		0.002	0.46
SODIUM		0.172	34.00
THALLIUM		0.021	4.20
VANADIUM		0.002	0.40
ZINC		0.002	0.44
CYANIDE	SW9012	0.0005	0.27

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL	
		WATER (μg/L)	SEDIMENT (mg/Kg)
BENZENE	SW8020	.08	.0001
TOLUENE		.12	.0001
CHLOROBENZENE		.07	.0001
ETHYLBENZENE		.09	.0001
m,p-XYLENE		.08	.0001
o-XYLENE		.06	.0001
1,3-DICHLOROBENZENE		.05	.0001
1,4-DICHLOROBENZENE		.06	.0001
1,2-DICHLOROBENZENE		.05	.0001
CHLOROMETHANE	SW8010	.13	.0001
VINYL CHLORIDE		.11	.0001
BROMOMETHANE		.23	.0002
CHLOROETHANE		.15	.0001
TRICHLORO FLUOROMETHANE		.12	.0001
1,1-DICHLOROETHANE		.05	.0001
METHYLENE CHLORIDE		.10	.0001
trans-1,2-DICHLOROETHENE		.04	.0001
1,1-DICHLOROETHANE		.05	.0001
cis-1,2-DICHLOROETHENE		.05	.0001
CHLOROFORM		.08	.0001
1,1,1-TRICHLOROETHANE		.07	.0001
CARBON TETRACHLORIDE		.06	.0001
1,2-DICHLOROETHANE		.04	.0001
TRICHLOROETHENE		.06	.0001
1,2-DICHLOROPROPANE		.04	.0001
BROMODICHLOROMETHANE		.05	.0001
2-CHLOROETHYL VINYL ETHER		.35	.0004
cis-1,3-DICHLOROPROPENE		.03	.0001
trans-1,3-DICHLOROPROPENE		.03	.0001
TETRACHLOROETHENE		.08	.0001
DIBROMOCHLOROMETHANE		.04	.0001
CHLOROBENZENE		.05	.0001
BROMOFORM		.04	.0001
1,1,2,2-TETRACHLOROETHANE		.03	.0001
para-CHLOROTOLUENE		.37	.0004
1,3-DICHLOROBENZENE		.03	.0001
1,4-DICHLOROBENZENE		.07	.0001
1,2-DICHLOROBENZENE		.04	.0001

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL WATER (µg/L)	MDL SEDIMENT (µg/Kg)
NDMA	SW8280M	0.05	
DICHLORVOS	SW8140	0.096	3.17
MEVINPHO		0.277	9.14
ETHOPROP		0.165	5.45
NALED		0.106	3.50
PHORATE		0.099	3.27
DEMETON-S		0.227	7.49
DIAZINON		0.397	13.10
DISULFOTON		0.142	4.69
METHYL PARATHOIN		0.014	0.46
RONNEL		0.181	5.97
MALATHION		0.050	1.65
FENTHION		0.079	2.61
CHLORPYRIFOS		0.223	7.36
STIROPHOS		1.28	42.20
MERPHOS		0.249	8.22
FENSULFOTHION		2.29	75.60
BOLSTAR		0.137	4.52
AZINPHOS METHYL		1.16	38.30
COUMAPHOS		1.07	35.30

PARAMETERS	METHOD REFERENCE	MDL WATER (µg/L)	MDL SEDIMENT (mg/Kg)
ALPHA-BHC	SW8080	.004	.00027
BETA-BHC		.004	.00027
DELTA-BHC		.004	.00017
GAMMA-BHC(LINDANE)		.003	.00029
HEPTACHLOR		.008	.00102
ALDRIN		.004	.00029
HEPTACHLOR EPOXIDE		.003	.00034
ENDOSULFAN I		.004	.00030
DIELDRIN		.006	.00049
4,4-DDE		.007	.00049
ENDRIN		.009	.00053
ENDOSULFAN II		.007	.00066
4,4-DDT		.009	.00052
ENDRIN KETONE		.008	.00066
ENDRIN ALDEHYDE		.009	.00046
METHOXYCHLOR		.034	.00318
ALPHA-CHLORDANE		.004	.00031
GAMMA-CHLORDANE		.004	.00036
TOXAPHENE		.069	.0051
AROCHLOR-1016		.070	.0044
AROCHLOR-1221		.072	.0060
AROCHLOR-1232		.146	.0034
AROCHLOR-1242		.089	.005
AROCHLOR-1248		.067	.0028
AROCHLOR-1254		.038	.0048
AROCHLOR-1260		.096	.0034

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL WATER (µg/L)	MDL SEDIMENT (µg/Kg)
ETHYLENE DIBROMIDE	E504.1	.005	.400
NAPHTHALENE	SW8310	.90	60.30
ACENAPHTHYLENE		.20	13.40
ACENAPHTHENE		.90	60.30
FLUORENE		.10	6.70
PHENANTHRENE		.04	2.68
ANTHRACENE		.01	0.67
FLUORANTHENE		.02	1.34
PYRENE		.07	4.69
BENZO(A)ANTHRACENE		.02	1.34
CHRYSENE		.06	4.02
BENZO(b)FLUORANTHENE		.02	1.34
BENZO(k)FLUORANTHENE		.01	0.67
BENZO(a)PYRENE		.01	0.67
DIBENZO(a,h)ANTHRACENE		.20	13.40
BENZO(g,h,i)PERLYENE		.20	13.40
INDENO(1,2,3-cd)PYRENE		.10	6.70
DALAPON	SW8150	.182	2.33
DICAMBA		.077	1.79
MCPP		65.900	1173.00
MCPA		54.300	1034.00
DICHLOROPROP		.142	3.08
2,4-D		.104	2.43
2,4,5-TP		.051	1.28
2,4,5-T		.046	1.05
DINOSEB		.031	0.860
2,4-DB		.358	6.37
HMX	SW8330	7.55	57.5
RDX		6.66	63.1
TNB		5.66	67.6
TETRYL		8.06	436.0
DNB		1.63	76.9
TNT		2.17	59.3
NITROBENZENE		2.27	71.5
26DNT		6.10	52.8
24DNT		3.81	42.1
2NT		7.58	80.3
4NT		14.30	51.7
3NT		7.90	17.2

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL WATER (µg/L)	MDL SEDIMENT (µg/Kg)
	SW8270		
Acenaphthene		4.22	1.39
Acenaphthylene		4.14	1.64
Anthracene		1.43	2.94
Benzo(A)Anthracene		2.89	1.68
Benzo(B)Fluoranthene		7.14	3.21
Benzo(K)Fluoranthene		15.21	2.24
Benzo(G,H,I)Perylene		7.76	4.72
Benzo(A)Pyrene		2.05	1.73
Benzyl Alcohol		14.05	9.03
Bis(2-Chloroethoxy)Methan		3.98	2.14
Bis(2-Chloroethyl)ether		5.14	2.24
Bis(2-chloroisopropyl)ether		9.93	2.65
Bis(2-Ethylhexyl)Phthalate		4.71	5.10
4-Bromophenylphenylether		1.30	1.17
Butylbenzylphthalate		2.30	2.59
4-Chloroanaline		21.14	8.58
2-Chloronaphthalene		9.44	1.55
4-Chlorophenyl-Phenylethe		2.80	1.85
Chrysene		6.94	2.29
Dibenz(A,H)Anthracene		6.92	4.77
Dibenzofuran		3.14	1.81
Di-N-Butylphthalate		4.02	1.94
1,2-Dichlorobenzene		5.75	1.47
1,3-Dichlorobenzene		4.71	2.22
1,4-Dichlorobenzene		4.58	2.00
3,3'-Dichlorobenzidine		22.66	21.13
Diethylphthalate		3.58	1.36
Dimethylphthalate		6.40	0.96
2,4-Dinitrotoluene		6.28	2.96
2,6-Dinitrotoluene		3.35	2.09
Di-N-Octylphthalate		5.78	11.33
Fluoranthene		6.28	4.38
Fluorene		1.91	1.31
Hexachlorobenzene		2.00	1.98
Hexachlorobutadiene		11.43	2.95
Hexachlorocyclopentadiene		0.00	3.79
Hexachloroethane		4.51	2.45
Indeno(1,2,3-CD)Pyrene		6.33	9.63
Isophorone		2.33	1.79
2-Methylnaphthalene		5.44	2.34
Naphthalene		16.24	2.65
2-Nitroaniline		8.01	6.08
3-Nitroaniline		7.64	22.06
4-Nitroaniline		33.47	38.70
Nitrobenzene		4.25	1.42
N-Nitrosodiphenylamine		2.38	2.46
N-Nitroso-di-n-propylamine		5.24	2.88
Phenanthrene		3.42	1.90

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL	
		WATER (µg/L)	SEDIMENT (µg/Kg)
	SW8270 (cont.)		
Pyrene		4.07	2.61
1,2,4-Trichlorobenzene		15.40	2.76
Benzonic Acid		47.61	2.88
4-Chloro-3-Methylphenol		2.58	3.60
2-Chlorophenol		2.88	1.49
2,4-Dichlorophenol		2.11	4.36
2,4-Dimethylphenol		7.35	2.31
4,6-Dinitro-2-Methylphenol		19.93	14.81
2,4-Dinitrophenol		15.16	29.81
2-Methylphenol		4.60	1.60
4-Methylphenol		4.60	1.87
2-Nitrophenol		2.92	3.41
4-Nitrophenol		20.05	14.91
Pentachlorophenol		7.23	14.60
Phenol		6.97	3.16
2,4,5-Trichlorophenol		3.66	1.27
2,4,6-Trichlorophenol		3.77	2.35
2-Fluorophenol		12.39	4.51
2-Fluorobiphenyl		4.89	2.55
2,4,6-Tribromophenol		10.65	6.50
Carbazole		2.58	3.35
Aniline		0.36	1.46
1-Methylnaphthalene		0.54	0.43

TABLE B.2 METHOD DETECTION LIMITS (continued)

PARAMETERS	METHOD REFERENCE	MDL	
		WATER (µg/L)	SEDIMENT (µg/Kg)
	SW8240		
Acetone		3.18	7.03
Benzene		0.67	0.23
Bromodichloromethane		0.57	0.11
Bromoform		0.78	0.59
Bromomethane		1.20	0.16
2-Butanone (MEK)		6.38	2.15
Carbon Disulfide		0.59	0.31
Carbon Tetrachloride		1.56	0.24
Chlorobenzene		0.71	0.20
Chloroethane		0.89	0.95
2-Chloroethyl vinyl ether		2.95	-
Chloroform		0.46	0.16
Chloromethane		1.17	0.41
Dibromochloromethane		0.81	0.19
1,1-Dichloroethane		0.64	0.22
1,2-Dichloroethane		0.98	1.17
1,1-Dichloroethene		0.86	0.17
cis-1,2-Dichloroethene		0.87	0.14
trans-1,2-Dichloroethene		0.67	0.17
1,2-Dichloropropane		0.76	0.28
cis-1,3-Dichloropropene		0.74	0.31
trans-1,3-Dichloropropene		0.51	0.83
Ethylbenzene		0.75	0.33
Freon 113		0.56	0.64
2-Hexanone		1.75	2.34
Methylene Chloride		0.60	0.24
4-Methyl-2-Pentanone (MIBK)		2.25	1.85
Styrene		0.65	0.25
1,1,2,2-Tetrachloroethane		2.00	0.73
Tetrachloroethene		1.72	0.40
Toluene		0.91	0.24
1,1,1-Trichloroethane		1.27	0.24
1,1,2-Trichloroethane		1.43	1.24
Trichloroethene		1.37	0.22
Vinyl Acetate		0.92	2.15
Vinyl Chloride		0.91	0.33
o-Xylene		0.74	0.29
M,P,Xylene		1.68	2.15
1,3 Dichlorobenzene		1.65	0.34
1,4 Dichlorobenzene		1.63	0.33
1,2 Dichlorobenzene		1.61	0.37

APPENDIX C
Instrument Operations Conditions

INDUCTIVELY COUPLED ARGON PLASMA (ICAP) OPERATING CONDITIONS

Start Up:

1. Check that the argon tank main valve is open and the pressure is set to at least 60 psi.
2. Check the plasma work coil coolant water and exhaust vents.
3. Check that the drain tube is inserted into a plastic water bottle containing at least 8 inches of water and drain line is below surface.
4. On the R.F. generator control panel, turn the forward power manual control rheostat knob counter clockwise to the off position.
5. Check that the white power lamp is illuminated on the RF generator.
6. Turn the torch gas toggle switch on and adjust flow meter to 18, turn the auxiliary flow on to 0.5 and the sample gas flow to 0.6.
7. Purge the torch surfaces, the capillary tube and teh drainage tube of air for at least 3 minutes.
8. Check that the blue R.F. off lamp on the generator is illuminated.
9. Turn the Automatic Power Control switch to the manual position.
10. Press the red R.F. on button.
11. Turn the sample gas flow toggle switch to OFF position.
12. To ignite, slowly turn the forward power manual control rheostat knob clockwise until the forward power meter reads 0.5 KW.
13. Press the ignitor button on the front panel of the generator. You should see a faint filamentary plasma swirling in the outer tube of the torch. Gradually increase the forward power until the plasma ignites.
14. Once the plasma is lit, rotate the forward power rheostat knob until the forward power meter reading is 1.0 - 1.1 KW.
15. Turn the automatic power control switch to the automatic position.
16. Introduce the rinse solution into the plasma by slowly turning on toggle switch.
17. Turn off auxiliary flow toggle switch.

GAS CHROMATOGRAPH (GC) OPERATING CONDITIONS

The following are the gas chromatograph analytical conditions. The conditions are recommended unless otherwise noted.

Carrier Gas:	Helium (Hydrogen may be used)
Column Flow:	5mL/min.
Make-up Gas:	P-5/P-10 or N_2 (required)
Injector Temperature	$\geq$ 200°C
Injection:	On-column
Injection Volume:	1 or 2 μL
Injector:	Grob-type, splitless
Initial Temperature:	150°C
Initial Hold Time:	1/2 min.
Temperature Ramp:	5°C to 6°C/min.
Final Temperature:	275°C
Final Hold Time:	Until after Decachlorobiphenyl has eluted (approximately 10 minutes)

Optimize GC conditions for analyte separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, samples, blanks, and MS/MSD's.

GC/MS SEMIVOLATILE OPERATING CONDITIONS

The following instrumental parameters are required for all performance tests and for all sample analyses:

Electron Energy: .....70 volts (nominal)
Mass Range:.....35 to 500 amu
Scan Time:.....1 second per scan
Initial Column
  Temperature Hold: .....40°C for 1 minute
Column Temperature
  Program:.....40-300°C at 8°/min.
Final Column
  Temperature Hold: .....300°C for 5 minutes
Injector Temperature:.....280°C
Transfer Line
  Temperature: .....380°C
Source Temperature: .....According to manufacturer's specifications
Injector: .....Grob-type, splitless
Sample Volume:.....2 μL

VOLATILE GC/MS OPERATING CONDITIONS

These performance tests require the following instrumental parameters:

Electron Energy:	70 Volts (nominal)
Mass Range:	35-300
Scan Time:	to give at least 5 scans per peak, not to exceed one second per scan.

Column conditions:	DB-624, 75m, 0.53mm ID
Film Thickness:	3 um
Flow Rate:	30 mL/min. (glass jets) 10-15mL min. (microjets)
Column Temperature:	Isothermal at 45°C for 5 min., then programmed at 5°C/min. to 105°C. Further programmed at 10°C/min. to 180°C

Adjust the purge gas (helium) flow rate to 35 ± 3 mL/min.

TABLE 1.
Instrument Operating parameters and Standard Conditions for Metals Analyzed by Graphite Furnace Atomic Absorption Spectrophotometry

Element	Wave Length (mn)	Slit Opening (mm)	HCL Lamp Current (mA)	EDL Lamp Watts (w)	Gas Setting Time/Rate	Furnace Conditions Dry [5]C/ Seconds	Char [6]C/ Seconds	Atomiz [6]C/ Sec.(ppm)
Arsenic	193.7	4 (1.0)	—	6.5	Ar(Normal/3 sec./20	110/22	400/22	2700/7
Lead	283.3	4 (1.0)	10	—	Ar(Normal/3 sec./20)	110/22	750/22	2300/7
Selenium	196.0	—	—	6.5	Ar(Normal/3 sec./20)	110/22	1200/22	2700/7
Thallium	276.8	4 (1.0)	20	—	Ar(Normal/3 sec./20)	110/22	400/22	2300/7

Element	Injection Volume (ul)	Linear Working Range(ppb)	Sensitivity ppb/ 0.0044 Abs	Maximum Scale Expansion	Additional Elements			
Arsenic	20	4-300	5	5	O_2 Correction Ni $(NO_3)_2$ matrix			
Lead	20	0.3-100	2	30	O_2 Correction			
Selenium	20	4-300	5	5	O_2 Correction Ni $(NO_3)_2$ matrix			
Thallium	20	0.5-100	3	20	O_2 Correction			

APPENDIX D
Related Standard Operating Procedures

LABORATORY AND SAMPLE SECURITY

Samples received at SWLO are considered to be physical evidence and are handled according to procedural safeguards established by the EPA. Because of the legal nature of the work, the laboratory provides complete security for samples, analysis and data.

To assure complete security for samples and analytical procedures during sample analyses, the following steps are taken:

- Sensitive Materials Containment Laboratory/ Process and Instrument Laboratories be locked at all times except when in actual use.

- Analytical sample should always be in the custody of an individual technician assigned to do the task.

The following security measures are employed:

- Doors to the laboratory are closed and secured at all times.

- Only authorized personnel and visitors under escort shall have access to the chemistry lab.

- All laboratory personnel should be aware of the need to question and determine legitimacy of a stranger's presence in the laboratory.

- Deliveries are to be escorted to the laboratory from the main reception area or from the receiving area.

TRACEABILITY OF STANDARDS

All inorganic and organic analytical standards utilized for instrument/methodological calibration and preparation of quality control samples shall be traceable to standard reference materials. Primary standards must be obtained from reliable certifiable source and be of the highest possible purity. Standards are purchased from approved commercial vendors such as Chem Services, Inc., Fisher Scientific, Supelco, etc., for the use in all laboratory analyses. Commercial standards prepared are verified against certified standard reference materials (SRM). Within the USEPA, the three sources of SRM that will be considered acceptable for traceability are:

a. Quality Assurance Materials Bank (QAMB)

b. Pesticides and Industrial Chemical Repository

c. Toxic and Hazardous Materials Repository

Whenever possible, SRM received from one of the three EPA repositories will be utilized directly for generation of control samples and analytical standards. However, if such reference materials are unavailable for routine use, standards will be definitively traceable to such reference materials.

For inorganic analytes, calibration standards and control samples shall be traceable to a standard reference material supplied by the National Bureau of Standards (NBS) or the USEPA's Toxic and Hazardous Materials Repository.

All standards must be stored under conditions and in containers that provide the greatest protection against deterioration and/or contamination.

Stock and working standards solutions must be made fresh as often as required by their stability and must be checked regularly for signs of deterioration (i.e., discoloration, formation of precipitates and changes in concentration). Standard solutions are properly labeled as to compound name, concentration, solvent, date and preparer.

(See Criteria and Guidelines of Analytical Standards and QC Samples for the Evaluation of Traceability.)

STANDARD EXPIRATION PROCEDURE

DEFINITIONS:

1. *Primary Compound* - A liquid or solid compound in a pure form obtained from an

approved commercial distributor. (It could have a certain % purity that can be used to correct standard concentration.)

2. *Stock Standard* - Standard prepared/or obtained directly from the primary compound (i.e., liquid or solid) at a high concentration. (Most commercially-prepared standards are convenient to be used as stock solutions.)
3. *Working Standards* - Standards used in the calibration and quantitation of the compounds of interest.

Expiration or Holding Time Criteria:

All standards obtained/or purchased from approved commercial vendors such as Chem Services, Inc., Fisher, Supelco, etc., as well as standard reference materials procured from EPA or NBS are dated upon receipt. Date of expiration is also noted and if not available will be obtained from the supplier or manufacturer; if no information is available from the supplier, the lab holding time or shelf-life for the materials obtained shall be half the normal shelf-life (i.e., assuming 1 year for most compounds, then it would be 6 months shelf-life).

Standards prepared as stock/or working standards are properly labeled as to name of compound mixture, concentration, solvent/medium, date and preparer.

Laboratory control sample (LCS) or an independent check standard available from EPA or NBS or standard reference materials (SRM) are used to monitor standard degradation. Check results of the LCS or the check standard are checked against the given target range values (i.e., it should be within the 95% confidence limits of the given values).

All working standards prepared from stock solution commercially obtained or prepared in-house must be checked against LCS or NBS or any certified reference material. Check results must be within the target range values (i.e., 95% confidence limits of the given values) of the LCS, NBS, or SRM or within 95% confidence limits of the true value of the check standard as determined from replicate analyses (assuming normal instrument sensitivity) previously determined. (See Criteria and Guidelines for the Preparation of Analytical Standards and Quality Samples.)

All standards used in the laboratory will have the following expiration or holding time criteria:

INORGANIC:

a. Stock Standards: Expiration date of commercially obtained standards is checked weekly to identify and purge outdated stock solutions

b. Working Standards: Standards are prepared at the following frequency depending on standard concentration:

   1. 1-5 ppm: remake every three weeks
   2. 0.1-1 ppm: remake every two weeks
   3. less than 0.1 ppm: remake every week

   Note: These standards can be prepared following the frequency stated above or sooner if comparison with a check standard indicates a problem. All working standards are evaluated by a check standard or LCS on a daily basis.

ORGANIC:

a. For liquid or solid stock standard:

Maximum holding time of 1 year from date of receipt if no expiration date is indicated by the manufacturer.

b. For commercially obtained prepared stock standards:

Prepare or obtain once a month or sooner if comparison with a check standard of LCS indicates a problem. (This would be based from the check results of the working standards prepared from this stock against the LCS or check standard.)

c. For working standards:

Prepare fresh weekly or sooner if comparison with a check standard or LCS indicates a problem. (This would be based from the check results of the working standards prepared from this stock against the LCS or check standard.)

CRITERIA AND GUIDELINES FOR THE PREPARATION OF ANALYTICAL STANDARDS AND QUALITY CONTROL SAMPLES

All standards obtained or purchased from approved commercial vendors shall be evaluated for traceability using standard reference materials (SRM) obtained from NBS and/or EPA reference materials.

A. CRITERIA FOR TRACEABILITY

Traceability to certified SRM shall be performed through statistical evaluation of the control sample or analytical standard relative to NBS and/or EPA reference material.

Criteria set for traceability shall be as follows:

1. The new standard solution/calibration standard is considered to be acceptable for sample quantification if the RPD (relative percent difference) is less than or equal to 10%.

   The general procedure used for this evaluation involves:

   a. Triplicate analysis of the certified SRM.

   b. Triplicate analysis of the newly prepared analytical standard or spiking solution within the same time frame.

   c. Mean and standard deviation statistics are calculated on each set of triplicate analyses.

   d. Relative Standard Deviation (RSD) of less than 10% must be obtained on each set of triplicate analyses for acceptability.

   e. The two sets of data (i.e., newly prepared standard or calibration standard solution) is then compared with the SRM to determine acceptability using criteria mentioned.

$$RPD = \frac{\text{Mean SRM value - Mean proposed standard value}}{\text{average of the Mean value}}$$

2. If SRM are not available, laboratory control samples (LCS) obtained from EPA shall be used for traceability. Working standards prepared from the stock solution (i.e., newly prepared standard) are used as calibration standards for the quantification of the LCS. Check results must be within the target range values (i.e., 95% confidence limits of true values) provided with the LCS.

3. If SRM and EPA LCS are not available, check results of the newly prepared standard must be within 95% confidence limits of the historical values obtained from replicate analysis of the same standard concentration previously determined (assuming normal instrument sensitivity).

B. GUIDELINES

The laboratory has established guidelines for the preparation of analytical standards used as spiking solutions and/or calibration standards which are as follows:

1. Laboratory technicians experienced in calibration and use of analytical measurement tools are assigned to do standard preparation tasks.

2. Analytical reagent grade materials, in solution or neat form, are utilized in the preparation of analytical/control sample standards. Whenever possible, guaranteed assay materials with supporting chromatograms are requested from the manufacturers.

3. Solvents used for dilution of standards are checked for background contamination. Contamination for dilution solvents is required in all phases of standard preparation. (See Solvent Check SOP)

4. Analytical measuring tools such as balance, volumetric glasswares, syringe, etc., are calibrated to obtain accurate measurements. (See Laboratory Equipment SOP)

5. All data generated (i.e., weights of standard used, volume aliquot taken, lot number, solvent used, date of preparation, concentration of the solution, etc.) are documented immediately in a standard preparation logbook.

6. A sequential standard log number (SL#) is assigned to the newly prepared standard solution. This standard identification code must be noted in the standard log, on all chromatograms generated from the instrument analysis of the solution for traceability evaluation, and on any storage uses which are used to contain the original

solution or any aliquots of the solution prepared.

7. Standards are analyzed prior to use for any analytical measurement by use of detection (i.e., GC detectors-FID, EC, and GC/MS) system it was intended for.

8. A standard of the same material obtained from NBS or EPA is used as quality control traceability reference standard. (See Criteria)

9. Both the new standard solution and the reference standard are analyzed on the same instrument and within the same time frame to maximize analytical precision.

10. The new standard solution is quantified against the reference standard as an unknown to determine its acceptability.

11. Once the standard solution has passed QC evaluation for traceability, it is aliquoted appropriately, flame sealed and stored at -4°C to maintain its integrity until required.

LIST OF EPA AND NBS REFERENCE STANDARDS

PARAMETERS		REFERENCE STANDARD
Inorganics		
Trace Metals	EPA:	ICAP QC Water Pollution QC Water Supply QC
	NBS:	SRM "3100" Series Spectrometric Solutions; SRM 1646 Estuarine Sediment SRM 1577a Bovine Liver
Organics		
Total Inorganic/ Organic Carbon	NBS:	SRM 191a, 192a, 84j
Volatile Organics	EPA:	Water Pollution QC Water Supply VOC I, II, IV,V, VI & VII Water Supply Trihalomethanes
Base/Neutrals/Acids	EPA:	Water Pollution QC GC/MS Acids Water Pollution QC GC/MS Base Neutral I, II, III
Pesticides	EPA:	Water Pollution QC GC/MS Pesticide I Water Pollution Chlorinated HC Pesticide I,II, III Water Supply Chlorinated HC Pesticide I, II
PCBs	EPA:	Water Pollution QC PCB 1016, 1260, 1248, 1254
EP Toxicity	EPA:	Water Pollution QC EP Extracts for Pesticides and Herbicides
Herbicides	EPA:	Water Supply QC

NOTE: Analytical reference standards for most organic parameters are obtained from EPA Quality Assurance Materials Bank, Pesticides and Industrial Chemical Repository and Toxic and Hazardous Materials Repository.

PREPARATION AND QA/QC PROCEDURE FOR THE LABORATORY WATER SUPPLY

The quality control of water used as reagent water or laboratory water involves consideration and control of the many variables that affect the production of reliable data. It should be free from interferences and other contaminants. Failure to prepare water properly and to use water suitably may account for the poor performance of some analytical methods.

The laboratory employs a high-purity ion-exchange system through the use of Millipore system that produces an ASTM Type II grade water. It consists of disposable cartridges for pre-filtration, organic absorption, deionization and Millipore filtration. The MilliQ water generated is checked for total dissolved solids not to exceed 0.1 mg/L. A new deionizing and filtration cartridge will be installed if purity falls below 12 megohms/cm.

The following preparation of laboratory water is employed for the different analyses done in the laboratory:

1. For trace metals and other general chemistry analyses

Deionized water generated by the ion-exchange system is used for trace elements and other inorganic work.

The presence of inorganic analytes is checked when the prepared reagent water is analyzed as reagent blank and/or calibration blank. For calibration blank analysis, any analyte concentration found should be less than the method detection limit (MDL) or required contract detection limit (CRDL). For preparation of blank analysis, if any analyte concentration in the blank is above the MDL or CRDL, the lowest concentration of that analyte in the associated samples must be 10X the blank concentration.

2. For volatile analysis

Reagent water is prepared by filtering deionized water through a carbon filter.

The presence of organic volatiles is chedked when the prepared reagent water is run as a method blank and/or system blank. When organic volatiles found (i.e., common laboratory solvents - methylene chloride, acetone and toluene), it should be <5x detection limit and no analytes in the Hazardous Substances List detected.

3. For organic extractions

Reagent water used for sample preparations as well as method blanks is preextracted bottled water or ASTM Type II water. The water is preextracted with a solvent of choice, i.e., depending on the method of extraction to be used. Most of the time the solvent used is methylene chloride or hexane (nanograde). The water is then used for method blank preparation as well as sample preparation for a given extraction method.

The presence of organic semivolatiles/pesticides is checked when the prepared reagent water is analyzed as a method blank. When organic semivolatiles/pesticides are found (i.e., common phthalate esters), there should be <5x detection limit and no analytes in the Hazardous Substances List detected.

To determine whether organic impurities are present in the bottled water, the solvent used for the pre-extraction is then concentrated to a suitable volume (~0.5 mL) and analyzed by chromatographic techniques, GC-FID or GC-ECD for the presence of organic contaminants. If peaks present in the GC-FID chromatogram are greater than 10% full scale deflection (FSD), the polished water is again re-extracted with the solvent of choice and reanalyzed for organic impurities.

NOTE: All calibration blank, system blank, preparation or method blank data are to be kept together with the associated samples analyzed.

STANDARD OPERATING PROCEDURE FOR CHECKING REAGENTS, SOLVENTS, AND GASES

A. Scope

Chemical reagents aside from the primary standard reagents, solvents, and gases are carefully selected to conform to specifications defined in the method of analyses. Selection is based on the required priority for parameters being measured, sensitivity of the method, and specificity of the detection system (i.e., AA, ICAP, GC-ECD, GC/MS).

B. Reagents

Laboratory reagents obtained from approved commercial vendors shall meet ACS standards and are labeled indicating contents, date of receipt or preparation, and expiration. Hazardous reagents are adequately labeled and stored segregated from the rest of the reagents to indicate type and degree of hazard.

C. Solvents

Solvent quality is also routinely monitored and checked for contamination prior to use by concentration (volume reduction) and GC analysis. All solvents are distilled-in-glass reagents which are purchased in large single lots (20-100 cases) and stored to enhance consistency. Solvent quality is checked each time a new lot is purchased and prior to use on all significant contracts. The following procedure is routinely employed to assess solvent quality:

1. A suitable volume of solvent (500mL) is accurately measured and placed in a 500mL KD flask with a 4mL receiver.
2. The solvent is reduced in volume using standard KD concentration techniques to a final volume which will produce a concentration factor of 100x (200uL) for a 500mL initial volume.
3. The concentrated solvent is then analyzed by both GC/ECD and GC/FID to evaluate the degree of contamination.
4. Any solvent producing extraneous peaks subject to interference with components of interest is discarded and replaced with solvent of adequate quality.
5. Solvent check chromatograms of the solvent lot number are kept in a file by the QA Officer for documentation.
6. Each lot of solvent is recorded in a solvent check logbook along with the date received, date of concentration, the analyst, and the results of the check (whether or not the lot has been approved.

D. Gases

Gases used in inorganic and organic analyses are of commercial grade or are laboratory supplied gases. For organic analyses, the type of detection (i.e., GC/ECD, Hall, GC/FID, GC/MS) used affects gas quality requirement. Molecular sieves, carrier-gas filters, and drying tubes are required on combustion gases to improve quality. Gas cylinders are immediately replaced when the pressure falls to 100-200 pounds per square inch (psi) to minimize detector contamination that will affect sensitivity of the detector.

STANDARD OPERATING PROCEDURE FOR GLASSWARE AND LABWARE CLEANING

To ensure the integrity of the samples, steps must be taken to minimize contamination from the containers the are stored in and through the glasswares or labwares used during sample analysis. If the analyte(s) to be determined is organic in nature, the container is preferably made of glass. If the analyte(s) is inorganic, then the container should be plastic or polyethylene.

When both organic and inorganic substances are to be analyzed, the following procedures should be taken when cleaning glassware or labwares that are to be used for sample analysis:

A. Metals Analysis Labware Washing Procedures

1. Wear safety glasses and polyethylene gloves.
2. Rinse with tap water to remove sample residue or reagents.
3. Wash with warm tap water and prepared "Microsoap".
4. Rinse with tap water followed by deionized water.
5. Soak labware in 3N HNO_3. (Be sure to thoroughly wet the entire inside.)
6. Rinse with tap water.
7. Soak labware in (deionized) water.
8. Allow labware to dry, covered with lab wipers at ambient laboratory temperature.
9. Store each labware in polyethylene bags and place in assigned storage area.

   <u>NOTE</u>: If a labware has been in storage for at least 2 weeks, the following procedures are taken before usage:

   a. Rinse labware in 3N HNO_3.
   b. Rinse at least twice with (deionized) water.
   c. Repeat the above steps 8-9.

B. Bottles for Hg Analysis: Cleaning Procedures.

1. Rinse with tap water.
2. Wash with prepared "Microsoap" and warm tap water.
3. Rinse with tap water.
4. Rinse with 20% $SnCl_2$ solution (made in 4N HCl).
5. Rinse with tap water followed by deionized water.
6. Soak in 3N HNO_3.
7. Rinse with deionized water.
8. Soak in (deionized) water for.
9. Rinse with (deionized) water after soaking.
10. Allow bottles to dry covered with lab wipers.
11. Put caps on bottles and place in polyethylene bags for storage in assigned areas.

    NOTE: 3N HNO_3 soaking solution should be changed once a month.

C. Organic Analysis Glassware Preparation

Although procedures for glassware vary somewhat according to the type of apparatus involved, the protocol for most apparatus involves thorough washing, solvent rinsing and high temperature oxidation. This procedure has been proven extremely effective for elimination of contamination in trace level organic analyses. The glassware preparation procedure for non-volumetric glassware is as follows:

1. Rinse 1-2x with acetone or methanol to help remove residue.
2. Thoroughly wash in deionized water (DI) and detergent (Alconox) to remove particulate matter and gross contamination.
3. Rinse extensively with DI water.
4. Air dry.
5. Cover open ends and exposed portion of ground glass joints with aluminum foil and place in kiln at 200° C for 2 hours.

The following procedure is utilized for preparation of volumetric glassware:

1. Rinse 1-2x with acetone or methanol to help remove residue.
2. Thoroughly wash in DI water and Alconox to remove particulate matter and gross contamination.
3. Rinse extensively with DI water.
4. Submerge in concentrated "Nochromic"/ sulfuric acid bath for 2-4 hours and then rinse 5x with DI water (optional).
5. Rinse 2x with acetone or methanol.
6. Oven drying.
7. Cap with aluminum foil.
8. Rinse 3x with solvent of choice before using.

D. Segregation of Potentially Contaminated Glassware

When a sample is suspected of containing a high contaminant level, disposable glassware will be used as much as possible and discarded after use. Any non-disposable glassware that is used will be washed and prepared separately using the SOP for glassware preparation.

Glassware suspected of gross contamination will be rinsed with methylene chloride three times, the rinsate concentrated to a final volume of 0.5 mL, and analyzed by chromatographic techniques to check for residual contamination. Glassware checks exhibiting detectable peaks will be discarded.

SIGNIFICANT FIGURES *

The term "significant figure" is used, sometimes rather loosely, to describe a judgment of the reportable digits in a result. When the judgment is not soundly based, meaningful digits are reported. On the other hand, proper use of significant figures gives an indication of the reliability of the analytical method used.

* From "Handbook for Analytical Quality Control in Water and Wastewater Laboratories"*be done within the limits of the given laboratory operations to improve these values. If more significant figures are needed, a further improvement in method or selection of another method will be required.

Once the number of significant figures obtainable from a type of analysis is established, data resulting from such analyses are reduced according to set rules for rounding off.

The following discussion describes the process of retention of significant figures.

A number is an expression of quantity. A figure or digit is any of the characters 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, which, alone or in combination, serve to express a number. A significant figure is a digit that denotes the amount of the quantity in the particular decimal place in which it stands. Reported analytical values should contain only significant figures. A value is made up of significant figures when it contains all digits known to be true and one last digit in doubt. For example, if a value is reported as 18.8 mg/l, the 18 must be firm while the 0.8 is somewhat uncertain, but presumably better than one of the values 0.7 or 0.9 would be.

The number zero may or may not be a significant figure depending on the situation.

Final zeros after a decimal point are always meant to be significant figures. For example, to the nearest milligram, 9.8 g is reported as 9.800 g.

Zeros before a decimal point with nonzero digits preceding them are significant. With no preceding nonzero digit, a zero before the decimal point is not significant.

If there are no nonzero digits preceding a decimal point, the zeros after the decimal point but preceding other nonzero digits are not significant. These zeros only indicate the position of the decimal point.

Final zeros in a whole number may or may not be significant. In a conductivity measurement of 1,000 umho/cm, there is no implication by convention that the conductivity is 1,000 ± 1 umho. Rather, the zeros only indicate the magnitude of the number.

A good measure of the significance of one or more zeros interspersed in a number is to determine whether the zeros can be dropped by expressing the number in exponential form. If they can, the zeros may not be significant. For example, no zeros can be dropped when expressing a weight of 100.08 g in exponential form; therefore the zeros are significant. However, a weight of 0.0008 g can be expressed in exponential form as 8×10^{-4} g so the zeros are not significant. Significant figures reflect the limits in accuracy of the particular method of analysis. It must be decided whether the number of significant digits obtained for resulting values is sufficient for interpretation purposes. If not, there is little that can

Rounding Off Numbers

Rounding off of numbers is a necessary operation in all analytical areas. It is automatically applied by the limits of measurement of every instrument and all glassware. However, when it is applied in chemical calculations incorrectly or prematurely, it can adversely affect the final results. Rounding off should be applied only as described in the following sections.

Rounding-Off Rules

If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45.

If the figure following those to be retained is 5, and if there are no figures other than zeros beyond 5, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42.

STANDARD OPERATING PROCEDURES FOR ELECTRONIC BALANCES

Summary

Analytical balances of various capacities and operational mode are calibrated annually by a licensed specialist and officially recorded as verification of performance.

Stickers documenting the calibration are placed on the balance noting the calibration date as well as the date of the next calibration. Certificates of calibration are maintained in the QA/QC department.

Balances are checked with known calibration weights before using. If the values of the calibration are not within limits, the balance will be calibrated per manufacturers instructions. Two examples are provided

The following is a list of check weights used to verify accuracy.

A. Electronic toploaders, (example, Ohaus GT400)

1. Allow a warm up time of 30 to 60 minutes after plugging in the balance.
2. Center bubble level indicator of top loader using the leveling screws.
3. Using kimwipe and/or balance brush, remove any particulates from balance pan.
4. Turn power switch to "1"; the toploader will run through an "auto check".
5. A small green circle "o" appears in the bottom left corner if the system checks out.
6. Press tare once. The display will read 0.00g.
7. Calibration
   a. Calibrate using weights which span the anticipated weighing episode.
   b. Place calibration weight in center of pan using forceps (never touch weights with fingers).
   c. Read and record reading from balance.
   d. Repeat steps "a" and "b" using a second weight.
   e. Document all readings in the daily calibration log.

      NOTE: Reading is stable when "g" appears in the display.
   f. Note control limits recorded in the balance log. Should the weights be outside the control limits, stop the calibration and notify your supervisor or QA Officer.
8. Top loader is now ready to use.
   a. Keep pan as clean as possible.
   b. To tare:

      After reading is stable, press tare and display will read all zeros.

B. Electronic Analytical Balance, OHAUS Model AS120 (reference OHAUS Operating Manual for further detail).

1. If balance has been unplugged, allow 60 minutes for warm-up.
2. Check and center bubble level using leveling screws. 3. Briefly press ON/TARE to tare balance; first 8.8.8.8.8.8.8.8. then 0.0000 will appear.
4. Holding down control bar, allow instrument to display program setting.
   a. Settings for Stringflow are:

mg	160
Int.	2
ASd	2

      Any variation should be noted and balance reprogrammed to the above settings.
5. ***Calibration of Balance:***
   a. Calibrate using weights which span the specified capacity of balance
   b. Remove all objects from pan and close doors.
   c. Hold down ON/TARE until CAL appears.
   d. Release ON/TARE; SPAN will appear
      (1) Press OFF MODE and display will show LIN.
      (2) Press ON/TARE to start the linearity calibration procedure. When ON/TARE is released, C θ gwill be displayed, indicating that no weight should be in the pan.
      (3) Press ON/TARE. The display will show -C- followed by the value of the weight which must be placed on the pan.
      (4) Place required weight in pan.

(5) Press ON/TARE. The display will show -C- momentarily, then C followed by the next weight to be placed on the pan. Do not disturb balance when -C- is displayed.

(6) Place required weight on the pan, then press ON/TARE. The display will show -C- while the balance recalibrates. When the weight on the pan is displayed along with the current indicator, the balance is recalibrated.

(7) Repeatedly press OFF mode until END is displayed.

(8) Press ON/TARE. When released, the balance will return to normal weighing opterations.

6. *Taring*
   a. Place container on pan.
   b. Press control bar once to tare, all zeros will appear. Balance is now ready for weighing.

Maintenance for the balances is documented with a sticker on the balance dating the service and the next service due date.

STANDARD OPERATING PROCEDURES FOR PH METER (ORION 720)

A. Preliminary Operation

1. General
   a. Allow instrument sufficient time to warm up after turning it on (minimum 15 minutes).
   b. Ensure that all electrode connectors are securely fastened.
   c. Place instrument on **"standby"** when not in use.
   d. Allow samples and buffers to reach uniform temperature before taking measurements.
   e. Stir both buffer and sample solutions •while measurement is being made.
   f. Rinse electrode with DI water between measurements.
   g. Allow time for stabilization of reading, try to maintain same time frame for each sample and buffer.
   h. Calibrate unit.
2. Probe care:
   a. Check and, as needed, add filling solution.
   b. Blot dry only; never wipe.
   c. Store electrode in holding solution when not in use.

B. Calibration:

1. 2-buffer standardization with manual temperature compensation: This step should be done prior to sample analysis, once per day.
   a. Engage "standby" push button (if not on).
   b. With laboratory thermometer, take temperature reading of buffer (pH-7).
   c. Adjust "temperature degree C" control to temperature of buffer solution.
   d. Place electrode in buffer (pH-7).
   e. Engage "pH" push button and place "slope" control in the off position.
   f. Disengage "standby" push button.
   g. Adjust zero controls until digital display reads value of 7.000.
   h. Engage "standby" push button.
   i. Rinse and place electrode in second standard buffer. (This must bracket sample pH value and may not exceed ±3 pH units in range).
   j. Note control limits recorded in the balance log. Should the weights be outside the control limits, stop the calibration and notify the supervisor or QA Officer.
   k. Repeat step "h" using a 2nd weight.
   l. Note % slope reading in notebook (acceptable limit 100% ± 15%).

C. General Information and Documentation

1. pH meter log is to be updated daily when meter is used

2. Maintenance should be dated and noted under "comments" in the pH meter log (see attached example).
3. Aliquots of pH buffers should be replaced at a minimum once per week.
4. pH buffers commercially obtained are dated upon receipt and date of expiration documented.
5. pH buffers commercially obtained must show traceability to NBS standard buffer.

STANDARD OPERATING PROCEDURE FOR CONDUCTIVITY METER (HACH 2711)

A. Preliminary Operation

1. General

a. Adjust meter zero (if necessary) by turning the bakelite screw on meter face so that the meter needle lines up with the zero on the conductivity scale when meter is in **"off"** position.

b. Turn the "mode" control to redline, adjusting the "redline" control so the meter needle lines up with the redline on the meter face. If you cannot line up the needle with the redline, replace the batteries.

c. Cell check - turn "mode" control to 100x or 10x scale and depress cell button, meter reading should be <2%.

d. Sample depth must be sufficient to cover temperature probe.

e. At time of standard preparation, an aliquot of the Reagent water used should be saved for calibration, (reference step 2.c below)

<u>NOTE</u>: Conductivity will increase with time and exposure to air.

f. Allow standard and samples to reach uniform temperature before taking reading.

g. Always leave meter "off" when not in use to conserve battery.

B. Probe

1. Use

a. Do not touch the electrodes inside probe.

b. Avoid obstructions and when possible, allow 2 inches of clearance from solids.

c. Avoid metallic objects (minimum 6 inches if possible).

d. To ensure flow of sample over electrodes, gently raise and lower the probe several times while taking reading.

2. Cleaning and Maintenance

a. Rinse well with DI water between samples

b. Store probe in DI water when not in use

c. Soak probe in 10 parts isopropyl alcohol/ 10 parts water/1 part concentrated HCl solution for 5 minutes and rinse with DI water once a month, or whenever cell test indicates high reading. If reading is still high, consult reference manual.

3. Calibration

a. Meter: Reference A.1 section a, b, and c

b. Temperature reading: check internal thermometer daily using a second thermometer (i.e., calibrated thermometer) acceptable difference <1°.

(1) Calculation

(I-E) = difference

I = internal thermometer reading in C°

E = 2nd thermometer reading in C°

c. Conductivity reading for accuracy check:

(1) Place probe in Reagent water aliquot stored at time of standard preparation (see A.1.e).

(2) Measure and set temperature using internal thermometer located in probe.

(3) Read conductivity using 1x scale (fresh Reagent water should have conductivity reading of 0, if >20, prepare new standard and Reagent Water aliquot).

(4) Rinse probe and place in 0.745 g KCl/kg Reagent Water standard solution.

(5) Take conductivity reading

* Conductivity reading to be taken on lowest scale

Example: Use X1 scale for less than 500

Use X10 scale for 500 thru 5000

(6) Subtract Reagent water reading from KCl standard reading.

(7) Match temperature and compare actual reading to attached table.

(8) If reading is not within ± 1.5%, notify the Laboratory Manager.

(a) Calculation of percent:

$$\frac{C^T - CR \times 100}{CT}$$

CT = Conductivity in umhos/am from table

CR = Conductivity in umhos/am read from meter

C. *General Information and Documentation*

1. Conductivity log is to be updated daily whenever meter is used.
2. Maintenance should be dated and noted under "comments" in the conductivity log.

STANDARD OPERATING PROCEDURES FOR MISCELLANEOUS EQUIPMENT

A. *Refrigerators/Freezers*

1. The temperature in all the refrigerators shall be maintained at 4° C (± 2 degrees). In cases where temperatures are out of these limits, the thermostat will be adjusted accordingly with the laboratory manager's approval. If a power failure or some mechanical problem (i.e., compressor) causes the limit to be exceeded, the following actions shall be taken:

   a. <u>If due to power failure ("brown-out")</u>

   Pack all refrigerators with frozen blue ice and/or dry ice* and keep doors closed until the power is restored.

   *Dry ice can be purchased from local supplier.

   b. <u>If due to a mechanical problem</u>

   For repair service, notify a contractor to have it repaired.

   Notify Laboratory Manager. Pack refrigerators with frozen blue ice and/or dry ice, if necessary, until repairs are completed.

2. Temperature must be read daily for all refrigerators and freezers and recorded in the appropriate refrigerator log.

B. *Ovens*

1. Oven temperatures will be maintained at the required temperature ± 2° C at the operating range of 60-300°C. Above 300°C, temperature will be maintained ± 10°C. If the temperature is found to be out-of-control during analysis, the results of that analysis will not be reported. The analysis will be repeated after the oven has stabilized for 8 hours.

   If stable oven temperature cannot be maintained because of electrical problems, the following should be done:

   a. Notify Laboratory Manager, or if not available;

   b. Call an electrical contractor and arrange for service.

2. Ovens that are set at a specific temperature must have their temperatures read and recorded daily while in use.

C. Desiccator

1. Desiccant must be checked daily and changed when initial color change is first noted (i.e., blue to pink).

D. Fume Hoods

1. Fume hoods flow rates are checked every four months at nine points in each hood for one minute at each point. If the flow rates drop for any reason, the filters for the hoods will be checked and replaced.

E. Steam Baths

1. Steam baths are maintained daily by keeping water level at a certain level and using DI water at all times. Generally they are drained and cleaned weekly.

STANDARD OPERATING PROCEDUREFOR GEL PERMEATION CHROMATOGRAPH (GPC) MAINTENANCE

A. Gel Permeation Chromatograph Autoprep 1002A Maintenance

Routine maintenance is employed by each concerned personnel prior to use (i.e., sample batch run). The following clean-up procedures are followed to help minimize laboratory contamination.

1. Disconnect the GPC column from the system. Seal-off the GPC column to keep Biobeads SX-3 in a moist state by connecting the inflow and outflow tubings together.
2. Solvent Cycle Clean-up:

   The following solvents are pumped to the GPC system (i.e., 23 loops) for a period of 30 minutes per loop to flush away residues built-up in the system. It is pumped through the GPC system in the order of:

   a. Chlorobutane for purging
   b. Acetone (pesticide grade)
   c. Methylene Chloride (Pesticide Grade)
3. If the GPC column appears to be dirty, repack the column.

STANDARD OPERATING PROCEDURE FOR SONICATOR TUNING

Each time a new converter, probe, cup horn, tip, microtip, or accessory is used, the power supply is tuned using the following procedure:

1. Move the switch above the tuning control to the DOWN POSITION.
2. Ensure that the probe or microtip is not immersed in the solution and that it does not come in contact with anything. If a cup horn or flow through cell is used, make sure that it does not contain any water.
3. Set TIMER to HOLD.
4. Set OUTPUT CONTROL to "10" (to "4" when using a microtip or extender).
   CAUTION When using a microtip, never allow the tip to vibrate in air for more than 10 seconds, and do not set the OUTPUT CONTROL above "5". Ignoring these instructions will cause the microtip to fracture.
5. Momentarily hold down ON/OFF/TUNE switch to TUNE and rotate the tuning control clockwise or counterclockwise until a **minimum** (not maximum) reading (usually less than 20) is obtained on the power monitor. If minimum reading (sometimes referred to as null) cannot be obtained, the probe, cuphorn, tip, microtip, or accessory is loose or out of resonance, or the power supply or convertor requiring servicing. A loose probe will usually generate a loud piercing sound.

   NOTE If minimum reading cannot be obtained, check unit without the probe to ascertain whether the power supply or probe is at fault.
6. Set OUTPUT CONTROL to "4".
7. Release ON/OFF/TUNE Switch.
8. With a dual 500 watt Ultrasonic Processor, if two converters are going to be used simultaneously, connect the second converter cable to connector.
9. Document all tuning in the Sonicator Tuning Log.

STANDARD OPERATING PROCEDURE FOR CALIBRATING THERMOMETERS

Thermometers are calibrated quarterly against an NBS thermometer using the following procedure:

1) Install the NBS in the same environment as the thermometer in question (i.e., cold storage refrigerator, oven, etc.)

2) Should the thermometer in the cold storage be in glycerin, verify that the NBS thermometer is in the same solution.

3) Allow the thermometers to equilibrate.

4) Read both thermometers and record in the calibration log.

5) Verify that the thermometer in question is within the ±0.2 acceptance limit.

6) Should the temperature be outside this limit, the thermometer should be replaced with a new calibrated thermometer.

LABORATORY CORRECTIVE ACTION PLAN FOR POTENTIAL ANALYTICAL PROBLEMS

In the following paragraphs,
P = Problem, and
A = Action to be taken

Sample Receipt, Log-in, and Labeling

P: Sample containers received broken and/or seal not intact.

A: Notify Project Officer

P: Sample cannot be located (i.e., misplaced) either intra- or interlaboratory.

A: Notify Project Officer

P: Samples received without proper refrigeration or preservation.

A: Notify Project Officer

P: Illegible sample numbers or label missing from sample containers.

A: Notify Project Officer

P: No instructions received with samples (i.e., list of analytes/analyses to be performed).

A: Notify Project Officer

P: Samples received in nonprotected containers (i.e., not in proper sample containers, samples for VOA analysis not contained in septum top vials.

A. Notify Project Officer

P: Physical characteristics different than those on sampling sheets (i.e., two phases instead of one)

A: Notify Project Officer

P: Shipment container received damaged upon arrival

A: Notify Project Officer

P: Chain-of-Custody document does not match information indicated on sample label and containers received.

A: Notify Project Officer

P: Samples received past the holding time requirement (e.g., nitrates—24 hours).

A: Notify Project Officer

Sample Refrigeration and Preservation

P: Field chain-of-custody sheet indicated that samples were preserved contrary to the protocol or analytical plan.

A: Notify Project Officer

P: No indication on the chain-of-custody or sample containers that the sample was preserved, or how.

A: Notify Project Officer

P: Drastic change in physical characteristics upon preservation in the laboratory.

A: Notify Project Officer and QA Officer

P: Discovery of sample storage (i.e., refrigeration) malfunction

A: Notify Project Officer and QA Officer

P: Discovery that sample has frozen with or without breakage.

A: Notify Project Officer and QA Officer

Analytical Method

P: If at any time you are not in agreement with the method to be used or some portion of the method.

A: Notify Project Officer and QA Officer.

Sample Preparation

P: Loss of sample or unusual behavior during pH adjustment.

A: Notify Project Officer and Supervisor.

P: Knowledge of making incorrect spike.

A: Notify Project Officer and Supervisor.

P: Portion of solvent lost during sample concentration (i.e., KD or N_2 blowdown).

A: Notify Project Officer and Supervisor

P: Sample or extract loss due to glassware breakage

A: Notify Project Officer and Lab Manager

P: A lower than expected percentage of the solvent is recovered after extraction (<85%).

A: Notify Project Officer and Supervisor

P: Unable to reduce the extract volume to desired level or final volume

A: Notify Project Officer and Supervisor

Extract Storage

P: Noticable loss of solvent after storage

A: Notify Project Officer and QA Officer

P: Extract storage is past holding time for analysis (i.e., past 40 days for BNA/Pesticide).

A: Notify Project Officer and QA Officer

P: Noticeable change in physical characteristic.

A: Notify Project Officer, QA Officer, and Lab Manager

P: Label or labels have come off of the storage container.

A: Notify Lab Manager

P: Not enough information is on the label

A: Notify Project Officer and Lab Manager

Standard Preparation

P: Doubt as to purity of the standard material

A: Notify Lab Manager or QA Officer

P: Material does not appear to go completely into solution

A: Notify Project Officer, Lab Manager, or QA Officer

P: Confusion over whether the right compound was added or not

A: Start over from the step you are sure of.

P: Question whether standard (stock or working) is "too old" (expired).

A: Check expiration of the standard, if available. If not, check SOP on standard expiration. ALSO notify Lab Manager or QA Officer

P: Confusion over some dilution from the standard stock solution

A: Start over from the step you are sure of.

Instrumental Analysis

P: Injection of solvent blank produces erratic baseline and/or noise

A: 1) Reinject another solvent blank, if due to bad injection. 2) Check instrument operating conditions. 3) Do corrective maintenance.

P: Injection of multiple components standard produce poor separation or fewer peaks elute than components added.

A: 1) Check column for degradation. 2) Check instrument operating conditions. 3) Do corrective maintenance.

P: Chromatographic peaks ahve severe tailing.

A: 1) Check column for degradation. 2) Check instrument operating conditions. 3) Do corrective maintenance.

P: Multiple standard injections indicate poor instrument and/or analyst precision

A: 1) Check column for degradation. 2) Check instrument operating conditions. 3) Do corrective maintenance.

P: Calibration curve is not linear.

A: 1) Redo calibration with the problematic standard concentration. 2) Redo standard prepration. 3) Recalibrate.

P: Loss of greater than 10% of the sensitivity during the work day is experienced.

A: Check instrument operating conditions.

P: Knowledge that a bad injection has been made.

A: Mark the chromatogram and inject the sample again.

P: Calibration has been performed too infrequently.

A: Notify Lab Manager and QA Officer

P: Retention items begin to change.

A: 1) Check instrument operating conditions. 2) Do column maintenance. 3) Rerun the standard. 4) Recalibrate.

Data Review

P: The recovery of material from spiked water or a QA/QC sample is not within the limits set prior to analysis.

A: Notify the Project Officer.

P: The data is contrary to that expected (historical background does not agree).

A: Notify QA Officer

P: Data review is not done within a day of the analysis, so the corrective changes can be quickly made

A: Notify Lab Manager, Project Officer, or QA Officer

P: Calibration mistake is discovered after data have been reported.

A: Notify Lab Manager and Project Officer or QA Officer.

CHROMATOGRAPHY SECTION — PREVENTIVE MAINTENANCE

MAINTENANCE	FREQUENCY
GASES	
• molecular-sieve filters, adsorbent cartridges	as needed
• moisture traps/oxygen traps	as needed
• gas pressure level (psi)	when column maintenance performed
• regulators	as needed
• copper line connections, check for gas leaks	whenever cylinder changed or work is done on gas lines/traps
• purity of gases used	upon receipt of gas order
• gas supplies	daily

COLUMNS

- change of glasswool inserts for packed column ...as needed or when column head re-packed
- bake-out temperature frequency .....at end of analysis sequence
- when to change to a new column (i.e., previous column to a new column whether packed or capillary) .....as needed

AUTOSAMPLERS

- flushing of compressed air linesfor the autosampler ..... daily
- alignment of the autoinjector syringe to GC inlet as needed/when syringe is replaced
- autoinjector syringe check for needle/or plunger needle/or plunger ..... as needed
- lubrication of gears .....not required
- replacement of solvent vials used for solvent flush .....as needed
- discard or removal of sample vials that were injected .....daily

AUTOSAMPLER (TEKMAR ALS)

- check gas flow connections .....at installation and when any hardware is .....replaced or changed
- check connection to the GC .....at installation
- check for leaks - glassware mounts of th esampler, fitting, unions sample valve .....at installation and when hardware .....is replaced or changed
- cleaning of the samplers (i.e., fritted disc, sampler, needle spargers, purging device .....every six months or as needed.

RECORDERS/INTEGRATORS

- check supplies (ink, printheads, chart paper) ....weekly
- replacement of printhead/ink .....as needed
- cleaning of pen carriage rods .....as needed

HALL 700A SYSTEM

- check all dials, lights (vent light), and controls for proper function .....daily
- solvent module .....daily
- solvent replacement frequency .....every six months or as needed
- solvent level check .....weekly
- solvent flow rate (solventreplacement, pump shut down) .....when maintenance performed
- motor pump for proper function .....daily
- ion exchange resin .....monthly
- frequency of packing or replacement .....yearly
- replacement of nickel reaction tube .....as needed

PHOTOIONIZATION DETECTOR (PID MODEL 703)

- cleaning of lamp window ..... as needed
- cleaning of detector .....as needed
- replacement of detector lamp .....as needed

GAS CHROMATOGRAPHS

1. Check for gas leaks

- gas lines/column connections .....at installation, during routine maintenance
- column joint with injection port .....at installation, during routine maintenance
- GC connection to gas lines .....at installation and when gas lines are changed .....to the instrument
- septum (auto-injection port) replacement .....as needed

2. Injection port

- cleaning ..... as needed
- replacement of glass liner insert ..... as needed
- replacement of charcoal tube filter for exhaust/vent monthly
- replacement of brass seal (swagelok/ferrules) for column connection ..... as needed
- gas flow checks ..... at time of routine column\injection ..... port maintenance
- temperature checks ..... daily

3. Detectors

- cleaning/rebuilt ..... as needed
- radioactive leak check (wipe test) ..... every six months
- column pressure (psi) ..... at time of routine column\injection ..... port maintenance
- check panels, light, dials, controls for proper function ..... daily

GENERAL

- cleaning and maintenance of bench tops ..... monthly
- check supplies ..... weekly
- logbook entries for maintenance and temperature programs, injection logs, etc. ..... as required

Solvent Disposal

Solvents from sample extraction or sample prep shall be disposed of by incineration through the use of a properly licensed/permitter facility. All drums shall be manifested for transportation; it is essential to have the waste segregated by type.

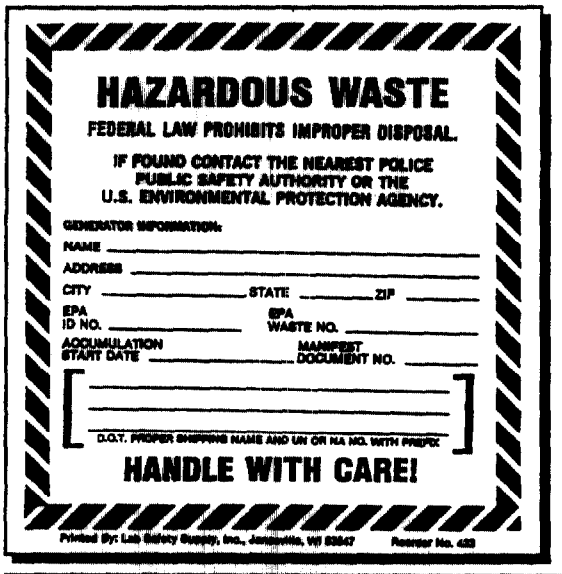

FIGURE D.2
Hazardous Waste Drum Sticker

A. Chlorinated solvents i.e., Freon/Methylene Chloride

B. Hydrocarbons - Toluene/Hexane/Cyclohexane Segregation shall begin within laboratory, small two gallon containers shall be placed within each laboratory area. These shall be of proper type to receive solvent and properly labeled as to type and with any hazard codes.

At the end of each work day these containers shall be emptied into a fifty gallon drum located in a secure area behind the walk-in. All waste solvent cans shall have a minimum of *two gallon* capacity and have a self closing lid to reduce the amount of volatile loss. The only time the lids are to be opened are when the can is in use. Each container shall be equipped with a integral flame arrestor and a pressure relief mechanism. One suggested supplier is Lab Safety *catalog number 0891.*

A log shall be maintained (see Figure D.1) on each drum as to the date it was put into service and when it is full. This log shall become part of the manifest and a copy maintained with the lab for record of disposal. Each drum shall be of the proper type required and labeled with type of waste/hazard codes and our name and address, date that was in service and a unique sequential identification (see Figure D.2). These drums shall be used only for solvent disposal. Records of solvent disposed shall be the responsibility of the extraction lab supervisor. Any deviation from procedure or problems associated with disposal of solvent shall be documented with a corrective action report. All waste drums shall meet DOT requirements and be lined with plastic or coated with phenolic resin. The use of this type of drum is to reduce potential leaking from corrosion if water or corrosive material are inadvertently added to the drums. Drums shall be ground at all times when being filled as well as the waste solvent can to prevent static sparks(see figure D.3). After each use drums shall be closed using a non-sparking wrench (see figure D.4)(Lab Safety Supply Catalog number C4762). After tightening bungs, place cover (Lab Safety supply catalog number C 2367) over drum to prevent rain water from accumulating in top of drum (see figure D.5). It is mandatory this secure area be kept organized and locked.

The waste stream needs to be periodically characterized by analysis and accurate record maintenance. Based upon our knowledge of the waste stream and the analysis all manifest shall be completely filled out.

The secured area shall be deemed such and sign posted (Labeled Hazardous Waste, No Smoking and Emergency Phone Number—See figure D.6). Any noncompatible waste should be stored as far away from each other as possible.

All drums should be moved using an approved drum dolly (see figure D.7) (Lab Safety supply catalog number C4087) protective eyewear and gloves should be worn when filling or transporting any of the waste.

Emergency Spill Kit containing vermiculite should be available as an absorbent in case of spill along with Spill Dikes (Lab Safety Supply catalog number C7412-2) to contain any spill in a localized area (see figure D.8).

An emergency response kit shall be maintained near or in the containment area. This kit shall contain protective gloves, respirator with assorted cartridges (i.e., solvent vapor and gas) protective clothing and goggles.

HAZARDOUS WASTE STORAGE & INSPECTION PROCEDURE

Scope:

Southwest Laboratory of Oklahoma, Inc. utilizes this procedure to assure proper storage identification and correction of hazardous waste hazards and compliance with all hazardous waste SOP's. It is the responsibility of Management to assure that this procedure is followed.

Procedure:

1. Waste are stored in a designated containment area until periodic removal by waste hauler.
2. Inspections should be completed weekly.
3. The hazardous waste inspection form will be used as a check-list and for documentation of the inspection (see Figure D.9).
4. The inspection form is divided into four sections:
   - General; signs, housekeeping, SOP's followed.
   - Containers; odors present, caps on tight, leaking.
   - Labeling; DOT labels present, hazardous waste label present, flammable label present, drums marked properly, accumulation start date.
   - Safety; necessary safety equipment accessible.
5. The inspection form will be used as a tool for corrective action and follow-up.
6. The inspection form will be filed by the Hazardous Waste Manager.

FIGURE D.3
Drum Storage Cabinet

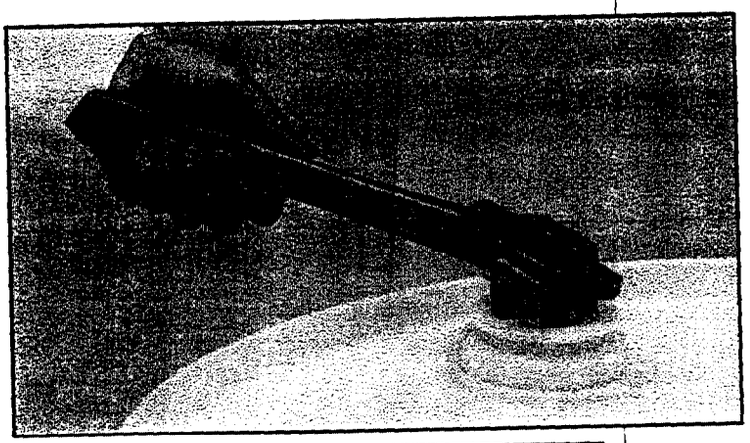

FIGURE D.4
Non-Sparking Drum Plug Wrench

HAZARDOUS WASTE MANIFEST

Scope:

Southwest Laboratory of Oklahoma, Inc. utilizes this procedure to assure that all hazardous waste shipments are manifested properly and in accordance with DOT and Hazardous Waste regulations. It is the responsibility of Management to assure that this procedure is followed.

HAZARDOUS WASTE DISPOSAL RECORD

CAN #:_____ DATE TRANSFERRED:_____

CHLORINATED: ☐ NON-CHLORINATED: ☐ BARREL #:_____

Date	Amount (mls)	Description, Amt of each Constituent	Initials

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599

FIGURE D.1 Hazardous Waste Disposal Record

Procedure:

1. A Hazardous Waste manifest must be completed according to the instructions on the manifest before the wastes can be picked-up for transportation to the disposal site (see Figure D.10).
2. The truck driver must sign and leave two copies of the manifest with us.
3. One copy of the manifest is retained in the Hazardous Waste Manger's file and the other is mailed immediately to the state receiving the waste.
4. Manifest records are maintained for a minimum of three years.

HAZARDOUS WASTE REPORTING REQUIREMENTS

Scope:

Southwest Laboratory of Oklahoma, Inc. utilizes this procedure to assure that all hazardous waste reports are generated according to applicable regulations. It is the responsibility of management to assure that this procedure is followed.

Procedure:

1. All completed manifest shall be filed quarterly with the State. No report is required to be filed with the USEPA.
2. If the completed manifest is not received from the disposal site within 30 days from the date accepted by the initial transporter, and "Exception Report" must be filed with the State within 45 days from the date of shipment. This report must contain the action taken to determine the status of the shipment.

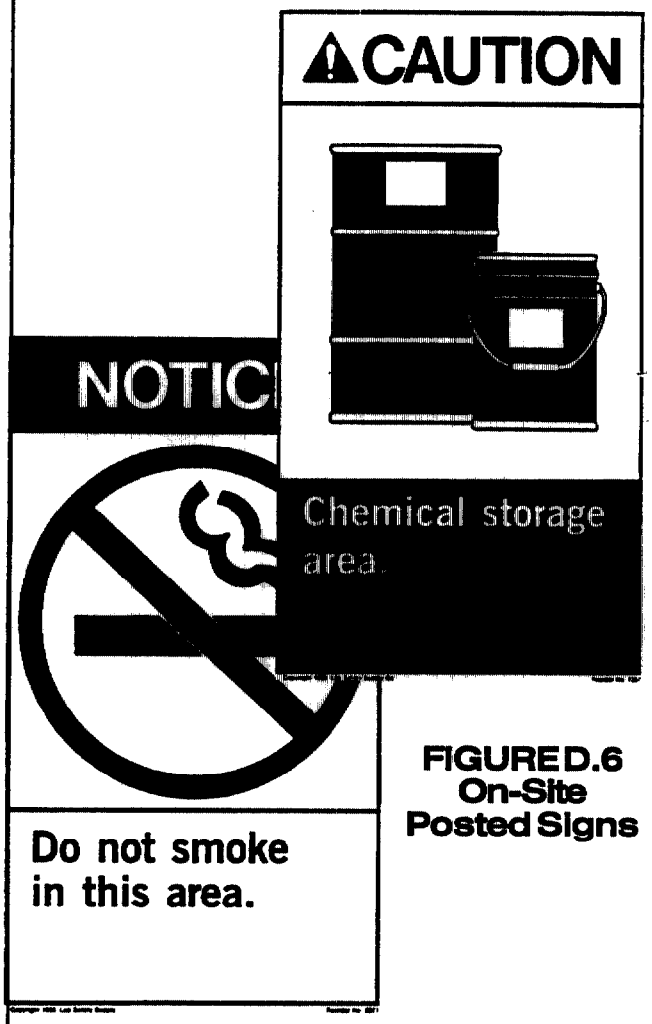

FIGURE D.6
On-Site Posted Signs

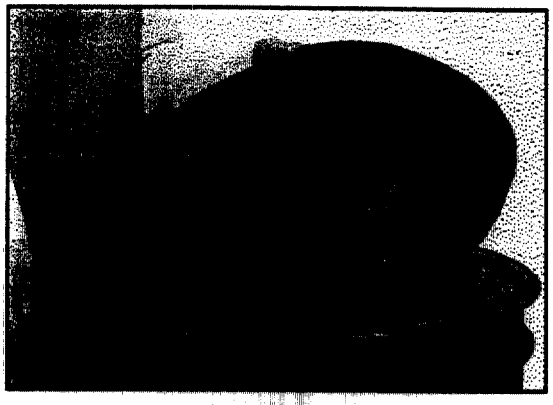

FIGURE D.5
Drum Cover

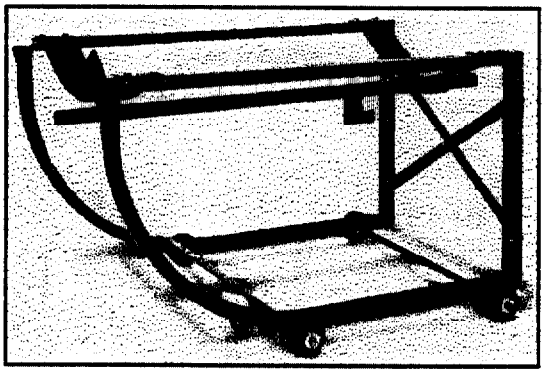

FIGURE D.7
Approved Drum Dolly

FIGURE D.8
Spill Dike

HAZARDOUS WASTE INSPECTION FORM

DATE: _____

TIME: _____

AREA INSPECTED

SATELLITE ☐ BULK STORAGE ☐

AREA INSPECTED	OBSERVATIONS/REQUIRED ACTIONS	DATE CORRECTED
GENERAL		
Housekeeping		
SOP's		
Signs		
CONTAINERS		
Odors		
Caps Sealed		
Leaking?		
LABELS		
DOT/Hzd Wst		
Markings		
Accum Date		
SAFETY		
Signs		
Equipment		
COMMENTS		

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599

FIGURE D.9 Hazardous Waste Inspection Form

STATE OF ARKANSAS
Department of Pollution Control and Ecology
P. O. Box 8913 Little Rock, Arkansas 72219-8913
Telephone 501-562-7444

1

Please print or type. *(Form designed for use on elite (12-pitch) typewriter.)*

Form Approved OMB No. 2050-0039. Expires 9-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. | Manifest Document No | 2. Page 1 of | Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address

A. State Manifest Document Number: AR- 494389

B. State Generator's ID

4. Generator's Phone ( )

5. Transporter 1 Company Name | 6. US EPA ID Number | C. State Transporter's ID PC ____ H ___

D. Transporter's Phone

7. Transporter 2 Company Name | 8. US EPA ID Number | E. State Transporter's ID PC ____ H ___

F. Transporter's Phone

9. Designated Facility Name and Site Address | 10. US EPA ID Number | G. State Facility's ID

H. Facility's Phone

11. US DOT Description *(Including Proper Shipping Name, Hazard Class, and ID Number)*	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
a.					
b.					
c.					
d.					

J. Additional Descriptions for Materials Listed Above

K. Handling Codes for Wastes Listed Above

EMERGENCY RESPONSE INFORMATION:

if no alternate TSDF, return to generator

15. Special Handling Instructions and Additional Information

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations and Arkansas state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name | Signature | Month Day Year

GENERATOR

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

TRANSPORTER

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name | Signature | Month Day Year

FACILITY

EPA Form 8700-22 (Rev. 9-88) Previous edition is obsolete.

NOTICE: THE ORIGINAL AND NOT LESS THAN TWO (2) COPIES MUST MOVE WITH THE HAZARDOUS WASTE SHIPMENT. ONCE DELIVERED, THE TREATMENT/STORAGE/DISPOSAL FACILITY MUST RETURN THIS ORIGINAL COPY TO THE GENERATOR.

930-021 (11-90) ST-90-5011 General Business Forms, Inc. - Bentonville, AR 72712 501-273-2486 7-4804

FIGURE D.10 Uniform Hazardous Waste Manifest

Appendix E
Laboratory Control Limits

PARAMETER	METHOD REFERENCE	SW846 METHOD LIMITS	CLP METHOD LIMITS	LABORATORY LIMITS % REC	LABORATORY (MAX RPD) WATER/SOIL
VOLATILE ORGANICS	624/8240				
• **Surrogate Spikes**	**EPA/SW846**			*	
Toluene d-8 (water)		88-110	88-110	88-110	
Toluene d-8 (soil)		81-117	84-138	81-117	
Bromofluorobenzene (water)		86-115	86-115	86-115	
Bromofluorobenzene (soil)		74-121	59-113	74-121	
1,2-Dichloroethane-d4 (water)		76-114	76-114	76-114	
1,2-Dichloroethane-d4 (soil)		70-121	70-121	70-121	
• **Laboratory Control Spikes**		**water/soil**		**water/soil**	**water/soil**
Acetone		53-146/30-160		53-146/30-160	50/59
Bromodichloromethane		48-164/71-124		48-164/71-124	20/14
Benzene		70-134/79-128		70-134/79-128	46/13
Bromoform		34-151/58-119		34-151/58-119	52/37
Bromomethane		50-191/46-161		50-191/46-161	23/36
Chlorobenzene		72-135/80-125		72-135/80-125	14/10
Carbon Disulfide		50-162/52-129		50-162/52-129	31/29
cis-1,2-Dichloroethene		54-153/80-128		54-153/80-128	24/20
cis-1,3-Dichloropropene		34-199/63-123		34-199/63-123	33/29
Chloroethane		32-212/-44-154		32-212/-44-154	28/54
Chloroform		57-152/79-129		57-152/79-129	9/177
Chloromethane		32-161/21-170		32-161/21-170	28/18
Carbon Tetrachloride		37-182/65-140		37-182/65-140	49/21
2-Chloroethylvinyl-ether		73-156/D-146		73-156/D-146	61/45
Dibromochloromethane		43-157/68-120		43-157/68-120	21/25
1,3-Dichlorobenzene		52-164/64-121		52-164/64-121	37/24
1,1-Dichloroethene		54-161/60-141		54-161/60-141	32/16
1,2-Dichloropropane		40-182/81-122		40-182/81-122	32/17
Ethylbenzene		55-147/82-123		55-147/82-123	17/19
2-Hexanone		27-176/20-181		27-176/20-181	97/60
Methylene Chloride		52-168/77-141		52-168/77-141	43/21
4-Methyl-2-Pentanone		23-208/33-163		23-208/33-163	62/54
m,p-Xylene		55-151/81-125		55-151/81-125	16/21
o-Xylene		68-144/72-126		68-144/72-126	29/14
Styrene		64-147/71-129		64-147/71-129	27/13
Trichloroethene		67-149/71-134		67-149/71-134	38/21
Trichlorofluoromethane		39-181/70-132		39-181/70-132	28/25
trans-1,2-Dichloroethene		74-162/72-133		74-162/72-133	35/21
trans-1,3-Dichloropropene		10-164/48-141		10-164/48-141	42/41
Toluene		75-140/80-122		75-140/80-122	15/11
Tetrachloroethene		61-141/80-125		61-141/80-125	24/21
Vinyl Acetate		22-122/17-153		22-122/17-153	60/72
Vinyl Chloride		65-167/31-168		65-167/31-168	25/26
1,1-Dichloroethane		55-159/75-129		55-159/75-129	22/19
1,1,1-Trichloroethane		38-179/66-140		38-179/66-140	51/45
1,1,2,2-Tetrachloroethane		14-157/49-127		14-157/49-127	95/78
2-Butanone		42-173/16-130		42-173/16-130	29/91
1,2-Dichlorobenzene		62-135/53-120		62-135/53-120	39/16
1,2-Dichloroethane		59-151/81-132		59-151/81-132	26/19
1,1,2-Trichloroethane		40-179/68-120		40-179/68-120	31/28
1,4-Dichlorobenzene		51-172/63-112		51-172/63-112	46/32

*CLP Limits used due to excessive in-house generated limits.

LCL-1193-01

PARAMETER	METHOD REFERENCE	SW846 METHOD LIMITS	CLP METHOD LIMITS	LABORATORY LIMITS % REC	LABORATORY (MAX RPD) WATER/SOIL
• **Matrix Spike/Duplicate (RPD)***				**water*/soil**	*
1,1-Dichloroethane		59-155	61-145/59-172	61-145/77-135	14/22
Trichloroethene		71-157	71-120/61-137	71-120/79-100	14/24
Benzene		37-151	76-127/66-142	76-127/77-135	11/21
Toluene		47-150	76-125/59-139	76-125/77-134	13/21
Chlorobenzene		37-160	75-130/60-133	75-130/92-115	13/21
BTEX	8020				
• **Surrogate Spike**	EPA SW-846				
Bromofluorobenzene		65-135		65-135	
• **Matrix Spike/Duplicate (RPD)**					
Benzene		39-150		39-150	20
Toluene		46-148		46-148	20
Ethyl benzene		32-160		32-160	20
Xylenes		77-145		77-145	20
BNA	625/8270				
• **Surrogate Spikes**	EPA/SW846			**water/soil**	
Nitrobenzene-d5		35-114/23-120	35-114/23-120	47-102/40-98	
2-fluorobiphenyl		43-116/30-115	46-116/30-115	46-86/34-125	
p-terphenyl-d14		33-141/18-137	33-141/18-137	66-100/18-137*	
Phenol-d5		10-94/24-113	10-110/24-113	46-86/33-96	
2-fluorophenol		21-100/25-121	21-110/25-121	21-100*/32-82	
2,4,6-Tribromophenol		10-123/19-122	10-123/19-122	43-115/19-122*	
2-Chlorophenol-d4			33-110/20-130		
1,2-Dichlorobenzene-d4			16-110/20-130		
• **Laboratory Control Spikes**		**water/soil**		**water/soil**	**water/soil**
Phenol		28-104/35-115		28-104/35-115	40/37
2-Chlorophenol		21-106/34-115		21-106/34-115	29/38
1,4-Dichlorobenzene		14-110/33-201		14-110/33-102	29/38
n-Nitroso-di-n-propylamine		19-128/36-124		19-128/36-124	29/40
1,2,4-Trichlorobenzene		17-109/43-106		17-109/43-106	27/37
4-Chloro-3-mehtylphenol		23-115/30-124		23-115/30-124	33/33
Acenaphthene		26-137/41-113		26-137/41-113	27/37
4-Nitrophenol		20-135/25-147		20-135/25-147	33/38
2,4-Dinitrotoluene		28-129/38-122		28-128/38-122	28/28
Pentachlorophenol		25-134/28-133		25-134/28-133	46/39
Pyrene		28-139/26-126		28-139/26-126	16/46
• **Matrix Spike/Duplicate (RPD)***				**water*/soil**	*
1,2,4-Trichlorobenzene		44-142	39-98/38-107	39-98/58-93	28/23
Acenaphthene		47-145	46-118/31-137	46-118/59-89	31/19
2,4-Dinitrotoluene		39-139	24-96/28-89	24-96/56-97	38/47
Pyrene		52-115	26-127/35-142	26-127/44-109	31/36
N-Nitroso-Di-n-Propylamine		13.6-197.9	41-116/41-126	41-116/45-116	38/38
1,4-Dichlorobenzene		20-124	36-97/28-104	36-97/33-75	28/27
Pentachlorophenol		14-176	9-103/17-109	9-103/31-167	50/47
Phenol		5-112	12-110/26-90	12-110/50-71	42/35
2-Chlorophenol		23-134	27-123/25-102	27-123/39-83	40/50
4-Chloro-3-Methylphenol		22-147	23-97/26-103	23-97/60-87	42/33
4-Nitrophenol		0-132	10-80/11-114	10-80/73-102	50/50

*CLP Limits used due to excessive in-house generated limits.

LCL-1193-01

PARAMETER	METHOD REFERENCE	SW846 METHOD LIMITS	CLP METHOD LIMITS	LABORATORY LIMITS % REC	LABORATORY (MAX RPD) WATER/SOIL
PESTICIDE/PCB	608/8080				
• **Surrogate Spike**	EPA/SW846				
Dibutylchlorendate (water)			60-150/60-150	—	
Dibutylchlorendate (soil)			60-150/60-150	—	
Tetrachloro-m-xylene			60-150/60-150	—	
Decachlorobiphenyl			60-150/60-150	—	
• **Laboratory Control Spikes**		**water/soil**		**water/soil**	
Aldrin		38-123/22-119		38-123/22-119	
Dieldrin		40-123/20-123		40-123/20-123	
Endrin		42-145/25-138		42-145/25-138	
g-BHC		34-143/21-153		34-143/21-153	
Heptachlor		39-128/21-145		39-128/21-145	
4,4'-DDT		36-126/45-131		36-126/45-131	
a-BHC		31-142/20-160		31-142/20-160	
b-BHC		43-133/22-147		43-133/22-147	
d-BHC		24-125/23-104		24-125/23-104	
Endrin Aldehyde		47-178/27-160		47-178/27-160	
Endrin Ketone		49-161/23-147		49-161/23-147	
Endosulfan I		46-134/24-121		46-134/24-121	
Endosulfan II		41-149/24-142		41-149/24-142	
Endosulfan Sulfate		36-150/22-126		36-150/22-126	
g-Chlordane		40-137/21-118		40-137/21-118	
Heptachlor Epoxide		39-124/20-119		39-124/20-119	
Methoxychlor		34-141/26-140		34-141/26-140	
4,4'-DDD		70-133/57-160		70-133/57-16	
4,4'-DDE		70-122/50-117		70-122/50-117	
• **Matrix Spike/Duplicate**			**water/soil**	*	*
Gamma-BHC			56-123/46-127	56-123/46-127	15/50
Heptachlor			40-131/35-130	40-131/35-130	20/31
Aldrin			40-120/34-132	40-120/34-132	22/43
Dieldrin			52-126/31-134	52-126/31-134	18/38
Endrin			56-121/42-139	56-121/42-139	21/45
4,4-DDT			38-127/23-134	38-127/23-134	27/50
TRACE METALS (ICP)*	200.7/6010 EPA/SW846				
Aluminum		75-125	75-125	75-125	20
Barium		75-125	75-125	75-125	20
Boron		75-125	75-125	75-125	20
Calcium		75-125	75-125	75-125	20
Cobalt		75-125	75-125	75-125	20
Iron		75-125	75-125	75-125	20
Magnesium		75-125	75-125	75-125	20
Manganese		75-125	75-125	75-125	20
Molybdenum		75-125	75-125	75-125	20
Potassium		75-125	75-125	75-125	20
Silicon		75-125	75-125	75-125	20
Sodium		75-125	75-125	75-125	20
Vanadium		75-125	75-125	75-125	20

*CLP Limits used due to excessive in-house generated limits.

LCL-1193-01

PARAMETER	METHOD REFERENCE	SW846 METHOD LIMITS	CLP METHOD LIMITS	LABORATORY LIMITS % REC	LABORATORY (MAX RPD) WATER/SOIL
TRACE METALS (FURANCE AA)	*7000 Series SW846				
Arsenic		75-125	75-125	75-125	20
Lead		75-125	75-125	75-125	20
Selenium		75-125	75-125	75-125	20
Thallium		75-125	75-125	75-125	20
Mercury (CV)*	7470 SW846	75-125	75-125	75-125	20
WET CHEMISTRY					
Carbonate	E310.0			80-120	20
Bicarbonate	E310.0			80-120	20
Hydroxide	E310.0			80-120	20
TDS	E160.1				20
Chloride	E300.0			80-120	20
Fluoride	E300.0			80-120	20
Sulfate	E300.0			80-120	20
Nitrate	E300.0			80-120	20
Ortho-Phosphate	E300.0			80-120	20
Nitrate	E352.1			80-120	20
Nitrite	E354.1			80-120	20

*CLP Limits used due to excessive in-house generated limits.

NAVY QUALITY CONTROL LEVELS

As detailed in the Naval Energy & Environmental Support Activity (NEESA) Document 20.2—047B here are different levels of Quality Control that meet the requirements of the Data Quality Objectives (DQOs) for varios remedial actions. The following table details these levels and the Quality control needed to support them.

TABLE E.1 OVERALL PLAN FOR QC BASED ON TYPE OF SITE

DQO Levels[1]	Type of Site	QC Requirements						
3	Major Non-NPL Level C	PE sample	Laboratory[2] audit	QA Plan review	Use EPA-approved method[3]	Monthly review	10% field duplicates	Review of final data
4	NPL Level D	PE sample	Laboratory[2] audit	QA Plan review	Use CLP procedures	Monthly review	10% field duplicates	CLP validation
5	Non-NPL Level E	PE sample	Laboratory[2] audit	QA Plan review	Use EPA-approved methods.[3] Non-EPA methods for tissue and explosives.	Monthly review	5% Field duplicates	Review of final data

[1]QC criteria for DQO Levels 1 and 2 has not been defined.
[2]All laboratory audits will be performed by the NCR.
[3]Includes methods from SW 846, Amercian Society for Testing Materials, and Federal Register.

CLP = Contract laboratory protocol
PE = Performance evaluation samples
DQO = Data quality objective

R1-8/88

ATTACHMENT B
TO QUALITY ASSURANCE PROJECT PLAN

LABORATORY STANDARD OPERATING PROCEDURES

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF VOLATILE ORGANICS NEW PROTOCOL 3/90

MS315

REV 3.2 — 4/7/95

Document Control #SWL-MS315- 008

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GC/MS ANALYSIS OF PURGEABLE ORGANICS

I. SUMMARY OF METHOD/HOLDING TIMES

A. An inert gas, helium, is bubbled through a 5 mL sample contained in a specifically designed purging chamber at ambient temperature. The purgeables are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the purgeables are trapped. After purging is completed, the sorbent column is heated and backflushed with the helium to desorb the purgeables onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the purgeables which are then detected with a mass spectrometer.

B. An aliquot of the sample is diluted with reagent water when dilution is necessary. A 5 mL aliquot of the dilution is taken for purging.

C. If the amount of TCL compound detected is outside the linear range of the instrument, then a smaller sample size is analyzed.

D. Water and soil samples are analyzed within 10 days of Verified Time of Sample Receipt (VTSR).

II. APPARATUS AND MATERIALS

A. *Micro syringes* — 10 μL and larger, 0.006 inch ID needle.

B. *Syringe valve* — two-way, with Luer ends (three each), if applicable to the purging device.

C. *Syringe* — 5 mL, gas tight.

D. *Balance* — Analytical, capable of accurately weighing 0.0001 g. and a top-loading balance capable of weighing 0.1 g.

E. *Glassware:*

1. Bottle — 40 mL, screw cap, with Teflon cap liner.

F. *Purge and trap device* — The purge and trap device consists of three separate pieces of equipment; the sample purger, trap and the desorber. (Tekmar 2000 with 2016 and 2032 autosamplers). A heating blanket is added to the Tekmar autosamplers when low level soils are analyzed.

III. GC/MS SYSTEM

A. *Gas chromatograph* — An analytical system complete with a temperature programmable gas chromatograph suitable for on-column injection and all required accessories including syringes, analytical column, and gases.

B. *Column* — DB624, 75m, 0.53mm ID, 3.0 um (J&W Scientific Cat. No. 125-1334) or equivalent.

C. *Jet Separator* — Glass (SIS Cat. No. 113505).

D. *Mass spectrometer* — Capable of scanning from 35 to 300 amu every three seconds, utilizing seventy volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all the criteria when 50 ng of 4-bromofluorobenzene (BFB) is injected through the gas chromatograph inlet (see Table 4).

E. Calibration requirements can be found in Tables 8 and 9.

IV. REAGENTS

A. *Reagent water* — Produced by filtering tap water through an organic filtration system containing activated charcoal prior to use.

B. *Methanol* — Pesticide quality or equivalent.

C. *Stock standard solutions*— Stock standard solutions are purchased and are traceable to EPA supplied standards. These solutions are stored in Teflon sealed screwcap bottles at 10°C to 20°C.

D. *Secondary dilution standards* — Using stock standard solutions, prepare secondary dilution standards in methanol that contain the compounds of interest, either singly or mixed together. (See GC/MS Calibration in Exhibit E). Secondary dilution standards should be stored with minimal headspace and should be checked frequently for signs of degradation or evaporation especially just prior to preparing calibration standards from them.

E. *Surrogate Standard Spiking Solution* — Prepare stock standard solutions for toluene-d_8, p-bromofluorobenzene, and 1,2-dichloroethane-d_4 in methanol. Prepare a surrogate standard spiking solution from these stock standards at a concentration of 25 μg/mL in methanol.

F. *Purgeable Organic Matrix Standard Spiking Solution* — Prepare a spiking solution in methanol that contains the following compounds a concentration of 25 μg/mL: 1,1-dichloroethene, trichloroethene, chlorobenzene, toluene, benzene. Matrix spikes also serve as duplicates; therefore, add an aliquot of this solution to each of two portions from one sample chosen for spiking.

G. *Internal Standard Solution* — The three internal standards are Bromochloromethane, 1,4-difluorobenzene and chlorobenzene-d_5. Prepare a spiking solution containing each of the internal standards. It is recommended that the secondary dilution standard be prepared at concentration of 25 μg/mL of each internal standard compound. The addition of 10 μL of this standard to 5.0 mL of sample or calibration standard would be equivalent of 50 μg/L.

V. GC/MS OPERATING CONDITIONS

A. These performance test require the following instrumental parameters:

1. Electron Energy: 70 Volts (nominal)
2. Mass Range: 35-300
3. Scan Time: to give at least 5 scans per peak, not to exceed one second per scan

B. *Sample Analysis*

1. All samples and standard solutions must be allowed to warm to ambient temperature before analysis.
2. Recommended operating conditions for the gas chromatograph - Column Conditions: DB-624, 75m, 0.53mm ID, 3 um film thickness or equivalent at a flow rate of 30 mL/min. for Glass jets. Column temperature is isothermal at 45°C for five minutes, then programmed at 5°C per minute to 105°C. further programmed at 10°C/min. to 180°C.
3. Adjust the purge gas (helium) flow rate to 35 ± 3 mL/min. Variations from this flow rate may be necessary to achieve better purging and collection efficiencies for some compounds, particularly chloromethane and bromoform.

VI. GC/MS VOLATILES RUN LOG:

A. All of the following items are recorded in the Volatiles GC/MS Run Log (see fig. 1.)

VII. CALIBRATION

A. *Tune*

1. Before analysis of samples can begin, the instrument must meet all calibration criteria. The first step in the calibration of Volatiles GC/MS system is to demonstrate the ionization and fragmentation of standard mass spectral tuning compounds. This is accomplished, as well as sensitivity check, with the use of 4-Bromofluorobenzene, an EPA specified compound. This standard is run daily to validate the GC/MS system and to begin the 12-hour clock. BFB is analyzed by direct injection of a 50ng aliquot into the instrument.
2. When the analysis is complete, the tune is checked against standard criteria (See Table 3 for Tune Criteria). EPA-CLP tune criteria for BFB is used for all volatile test codes, and before any other calibration standards or sample analysis is performed.
3. If the tune fails to meet the criteria, rerun BFB. If it fails again, the instrument must be retuned through "Auto Tune" or "Manual Tune." BFB should be run again. If it meets criteria, continue with the calibration sequence. If it fails again, contact your supervisor. Instrument maintenance such as source cleaning may be required.

B. *Initial Calibration*

1. Once BFB has met its tune criteria, calibration may begin. Initial calibration of the GC/MS is established and validated by the analysis of EPA traceable standards at five concentration levels which are 10, 20, 50, 100, and 200 ppb. These standards are made up in 5mL of reagent water and purged on the Tekmar before analysis by GC/MS. The internal standard calibration procedure is used. In addition to surrogate recovery compounds, standards and sample extracts are spiked with internal standards that span the retention time range of the analytes of interest.

2. The Response Factors (RF) for the analytes in the standard are calculated and stored in a Target Method File. The concentration of the analytes during sample analysis is calculated using the RF of each analyte determined in each day's calibration. These equations are shown in Table 13.

3. The calibration standards are prepared by filling a syringe with 5mL of reagent water and spiking with the standards as shown below.

Internal Std. (µL)	Surrogate (µL)	25ppm Stock Std. (µL)	Int. Std. Final conc. (ng/mL)	Stock Std. Final conc. (ng/mL)
10	2	2	50	10
10	4	4	50	20
10	10	10	50	50
10	20	20	50	100
10	40	40	50	200

4. Attach the syringe to the syringe valve assembly on the Tekmar. Open the syringe valve and inject the sample into the purging chamber. Close the purging device valve. Low level soil calibrations must be heated to 40°C before purging. Water, medium level soils, and high level soils purge at ambient temperature. Purge the sample for 8.0/min. At the conclusion of the purge time, introduce the trapped materials to the GC column by the Desorb Mode where the trap is rapidly heated to 180°C for four minutes.

5. While the trap is being desorbed into the GC, you may empty the purging chamber. After desorbing the sample for four minutes, bake the trap for four minutes at 225°C. After bake, allow the trap to cool to less than 30°C making it ready to purge the next standard or sample.

6. The standard will automatically be quantitated into a report from which concentrations, areas, response factors, standard deviations, and percent differences are calculated.

7. EPA-CLP criteria is employed for Volatiles Calibration Check Compounds (CCC) and System Performance Check Compounds (SPCC). This criteria is shown in Tables 8 & 9. The operator is allowed to have two items out of limits, either minimum RRF or Maximum % RSD. However, the RRF's for those two compounds must be greater than or equal to 0.010, and the %RSD of those two compounds must be less than or equal to 40.0% for the initial calibration to be acceptable.

8. If the five-point does not meet criteria, check to see if a standard needs to be rerun. The standards could have been added at the wrong amount or the purge may have been bad. If reanalyzing a standard will not solve the problem, contact your supervisor. It could be related to purge chambers, multiplier, flows, etc.

9. If the five-point does meet criteria, and there is time remaining in the 12-hour time period, samples may be run. The 50ppb Standard's response factors are used to calculate the concentrations in samples of TCL (Target Compound List) compounds.

VIII. CONTINUING CALIBRATION

1. A continuing calibration of the GC/MS uses the same EPA traceable standards, but at only one level. This level is 50ppb. The analysis is performed in the same manner as stated before the initial calibration. The continuing calibration checks the same CCC and SPCC compounds as the initial calibration. The CCC compounds must have a %Difference (%D) of less than 25% .

2. This CCC criteria, as well as the SPCC criteria, is shown in Tables 8 & 9. The operator is allowed to have two items out of limits, either minimum RRF or Maximum % Difference. However, the RRF's for those two compounds must be greater than or equal to 0.010, and the % Difference must be less than or equal to 40.0% for the continuing calibration to be acceptable.

3. If the criteria is not met, the standard must be rerun. It is possible it was not prepared correctly, or that there was a bad purge. However, if the second standard still doesn't meet criteria, an initial calibration must be run or corrective action must be performed.

4. The continuing calibration is performed after BFB.

IX. QC SAMPLES

A. *Method Blank*

1. The method blank is analyzed once the calibration has been met, whether it be an initial or continuing calibration. The method blank, called the "VBLK", consists of loading a syringe with 5mL of reagent water spiked with 10μL of Internal Standard and 10μL of Surrogate which yields a concentration for both of 50 ppb. It is used to establish the analytical curve by taking into account any background responses during the calibration process. It is also used to check for carryover contamination after a standard run or after a contaminated sample run.

2. An acceptable blank must meet the internal standard criteria stated in the "Sample Analysis" section and the surrogate recoveries in Table 4. It must also contain less than or equal to five times the Contract Required Quantitation Limits (CRQL) of Methylene Chloride, Acetone, and 2-Butanone. For all other TCL compounds, the blank must contain less than or equal to the CRQL of any single TCL analyte.

3. If a blank exceeds this criteria, corrective measures must be taken immediately. This action first consists of immediately reanalyzing the blank. If it still exceeds criteria, consult your supervisor immediately.

B. *Laboratory Control Spike (LCS)*

1. The Laboratory Control Spikes (LCS) is the last analysis of the calibration sequence. It is used as an internal QA/QC check. The LCS is analyzed daily following the method blank to check the proficiency of the analysis in terms of working standards preparation, to monitor standard degradation, and to check traceability of the prepared standards from commercial reference materials to EPA reference materials. These results are also used to create our laboratory control charts.
2. It consists of loading a syringe with 5 mL of reagent water spiked with 10 μL of Internal Standard, 10 μL of Surrogate, and 10 μL of Matrix Spike. This yields a final concentration for all three standards of 50 ppb.
3. The LCS compounds and their limits may be found in Table 6. The LCS must meet these limits, as well as the surrogate and internal standard criteria. If these criteria are not met, corrective action must be taken immediately. This includes rerunning the LCS. If the compounds are still out of limits, a new standard should be prepared. LCS limits are advisory like Matrix Spike Compounds, but since they are internal QC limits set forth by our laboratory, every effort should be made to meet these limits.
4. The LCS/LCSD are not analyses required by the method. These analyses, however, are used to set internal QC limits and are submitted to clients that do not request and/or assign MS/MSDs.

X. SAMPLE ANALYSIS

A. *Water Samples*

1. Note any headspace in the bottle before opening. Open the sample bottle which has been allowed to come to ambient temperature, and carefully fill the sample into the syringe barrel to just short of overflowing, and adjust the sample volume to 5.0 mL. This process of taking an aliquot destroys the validity of the sample for future analysis. Care must also be taken to prevent air from leaking into the syringe.
2. Add 10 μL of the Surrogates spiking solution and 10 μL of the internal standard spiking solution through the valve bore of the syringe. The Surrogates and internal standards may be mixed and added as a single spiking solution to 5 mL of sample, and is equivalent to a concentration of 50 μg/L of each Surrogates standard.
3. Water samples are loaded in the following manner to ensure the proper sample is placed into its designated purge chamber on the Tekmar Autosampler:
   a. A test tube rack is filled with the samples' 40 mL VOA vials. The syringes to be used are placed in front of the samples.
   b. All sample purge tubes are labeled with the SWLO ID number and autosampler position. Each analyst verifies as he/she loads each sample into the purge chambers that the syringe matches the ID on the purge tube.

   Follow the same purging method as stated during calibration.
4. For water samples requiring matrix spike and matrix spike duplicates, add 10 μL of the matrix spike solution to the 5 mL of the sample to be purged. Disregarding any dilutions, this is equivalent to a concentration of 50 μg/L of each matrix spike standard.

5. Once the sample aliquots have been taken from the VOA vials, the pH of the water samples are determined and logged onto a pH log (figure 2.) The purpose of the pH determination is to ensure that all VOA samples were acidified in the field. Test the pH by placing one or two drops of sample on pH paper and record it on the log. This data is reported by placing the log directly behind the SDG Case Narrative in the data package.

B. *Soil Sample Analysis — Low Level*

1. The low level method is based on purging a heated sediment/soil mixed with reagent water containing the surrogate and internal standards.
2. The sample (for volatile organics) consists of the entire contents of the sample container. Do not discard any supernatant liquids. Mix the contents of the sample with a narrow spatula. Weigh the sample into a disposable test tube. Use 5 grams of sample, unless a dilution is required in which 1 - 4 grams of sample is used. Use a top loading balance. Note and record the actual weight to the nearest 0.1g.
3. Immediately after weighing the sample into the test tube, load it onto the Tekmar ALS. Remove the plunger from a 5 mL Luerlock syringe and fill to overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust the volume to 5.0mL. Add 10 μL each of the surrogate spiking solution and the internal standard solution to the syringe. This addition to the soil is equivalent to 50 μg/Kg of each standard. Add this spiked reagent water to the test tube. Heat the sample to 40°C and begin purging. The samples follow the same purge method as stated in the calibration.
4. For soil samples requiring matrix spike and matrix spike duplicates, add 10 μL of the matrix spike solution to the 5 mL of the reagent water being added to the soil. Disregarding any dilutions, this is equivalent to 50 μg/Kg of each matrix spike standard.

C. *Soil Sample Analysis — Medium Level*

1. The medium level method is based on extracting the sediment/soil sample with methanol. An aliquot of the methanol extract is added to reagent water containing the internal standards. The surrogate is spiked directly into the extract, thus making the addition directly into the reagent water unnecessary. The samples are purged at ambient temperature. If peaks are saturated or compounds are out of linearity range at 1g, the medium level extract is the next dilution needed.
2. The medium level extract is prepared by weighing 4g of the sample into the scintillation vial. Use a top loading balance. Note and record the actual weight to the nearest 0.1g. Add 9900 μL of methanol and 100 μL of the surrogate standard. Cap and shake by hand for 2 minutes. The extract should be made up quickly in order to avoid loss of volatile organics.
3. The sample is loaded in the following manner. Fill a syringe just short of overflowing, and adjust the sample volume to 4.9mL. Adjust the plunger to 5mL to allow for the addition of the extract and standards. Add 10 μL of internal standard solution. Also add the volume of the methanol extract and the volume of methanol, if needed, to total 100 μL.
4. Load the sample into the purging device (Tekmar) and follow the same purging method as stated during the calibration.
5. For samples requiring matrix spike and matrix spike duplicates, prepare an extract in the same manner as stated above, but add only 9800 μL of methanol, 100 μL of medium concentration surrogate, and 100 μL of medium concentration matrix spike solution. Load and analyze them in the same manner as the samples.

6. Samples requiring medium level extractions are analyzed by a water calibration. If both waters and medium level soils are both ran under the same calibration, a method blank for each matrix is required.
7. The method blank for medium level soils must be analyzed in the same manner as waters, but it is prepared differently. The method blank consists of a 4g purified solid matrix spike with the surrogates made up to a total volume of 10 mL. An acceptable blank must contain less than or equal to five times the CRQL of Methylene Chloride, Acetone, and 2-Butanone, and less than or equal to the CRQL of any other volatile target compound. It must meet criteria or corrective action must be taken immediately.
8. With all matrices, all dilutions should keep the response of the major constituents (previously saturated peaks) in the upper half of the linear range of the curve.
9. An estimated concentration for Non-TCL components tentatively identified shall be quantified by the internal standard method. For quantification, the nearest internal standard free of interferences shall be used.
10. The formula for calculating concentrations is found in Table 13. Total area counts from the total ion chromatograms are to be used for both the compound to be measured and the internal standard. A response factor (RF) of one (1) is to be assumed. The value from this quantitation shall be qualified as estimated. This estimated concentration should be calculated for all tentatively identified compounds as well as those identified as unknowns.
11. Xylenes (o,m, & p - isomers) are to be reported as total Xylenes. The concentration of all Xylene isomers must be added together to give the total.
12. All soil samples must have their percent moisture determined. This is performed by the Extractions Department and submitted to the Volatiles Data Clerk for reporting. The percent moistures may also be obtained from the LIMS database.

XI. ANALYSIS/REPORT CRITERIA

A. A sample is acceptable when it meets the following criteria:
   1. The internal standards' EICP areas are within a factor of 2(-50%/+100%) of the calibration's internal standards.
   2. The internal standards' retention times are within +/-30 seconds of the calibration's internal standards.
   3. Surrogate recoveries are within the limits stated in Table 4.
   4. Any TCL compounds found in the sample are within the linearity range, with any dilutions showing compounds in an acceptable range of linearity. If a sample analysis contains any target compounds above the linear range, all subsequent samples will be reviewed for those target compounds. The target compounds must be below CRQL to be acceptable; otherwise they must be reanalyzed.
   5. Chromatogram shows no signs of carryover or instrument deficiencies.

B. If sample does not meet internal standards' or surrogates' criteria, it must be reanalyzed. If the reanalysis meets all criteria, it is submitted. If the reanalysis duplicates the results from the first analysis, both analyses are submitted.

C. A sample report is complete when it contains all of the following in order:
   1. Chromatogram
   2. Quant Report
   3. Manual Integrations
   4. Spectra of any TCL compounds, excluding internal standards and surrogates.
   5. Tentatively Identified Compounds (TICs)
   6. Internal Standards/Surrogates

XII. DATA ARCHIVAL

A. Instrument data is stored in two separate locations before being archived to ensure data does not become erased or corrupt. Data is stored on both the instrument's Chemstation and the Unix-based processing system. Data is archived from the Unix-based system using the "TAR" format onto 60 M DAT tapes. No more than two months worth of data is archived onto the same tape. Once a tape contains two months of data, a tape directory is printed and bound for permanent storage. Each tape is labeled with the instrument ID and the date range of data contained on the tape.

XIII. REFERENCES

A. U.S. EPA Contract Laboratory Program Statement of Work (SOW) for Organic Analysis, OLMO1.0, March, 1990, and OLMO1.8, Revision.

VOLATILES GC/MS RUN LOG

VOLATILES GC/MS DEPARTMENT

SWOK / AATS

TM

TUNE FILE ID: _____ METHOD FILES _____

INSTRUMENT: _____ DATE _____

CB/ID FILE ID: _____ ARCHIVE TAPE #: _____

Time	File	SWOK/AATS Sample ID	Client ID	Vol.	IS Area	Surr. Rec.	Lin. Chk.	Comments	OK/ RR

_____
Analyst Signature

SWL/AATS • 1700 WEST ALBANY • BROKEN ARROW, OK 74012 [VGM008-0492-01]

FIGURE 1

Volatiles GC/MS pH Log

VOLATILES GC/MS DEPARTMENT

TM

CASE _____ SAS _____ SDG# _____

AATS/SWLO ID	EPA SAMPLE ID	pH	ANALYST	DATE TESTED

COMMENTS: _____

SOUTHWEST LABORATORY OF OKLAHOMA, INC. • AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 WEST ALBANY • BROKEN ARROW, OK 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [VGM001-0492-01]

FIGURE 2

TABLE 1.

Characteristic Ions for System Monitoring Compunds and Internal Standards for Volatile Organic Compounds

Compound	Primary Ion	Secondary Ion(s)
SURROGATES		
4-Bromofluorobenzene	95	174, 176
1,2-Dichloroethane d-4	65	102
Toluene d-8	98	70, 100
INTERNAL STANDARDS		
Bromochloromethane	128	49, 130, 51
1,4-Difluorobenzene	114	63, 88
Chlorobenzene d-5	117	82, 119

TABLE 2.

Characteristic Ions for Volatile TCL Compounds

Parameter	Primary Ion	Secondary Ion(s)
Chloromethane	50	52
Bromomethane	94	96
Vinyl chloride	62	64
Chloroethane	64	66
Methylene chloride	84	49, 51, 86
Acetone	43	58
Carbon disulfide	76	78
1,1-Dichloroethene	96	61, 98
1,1-Dichloroethane	63	65, 83, 85, 98, 100
1,2-Dichloroethene (total)	96	61, 98
Chloroform	83	85
1,2-Dichloroethane	62	64, 100, 98
2-Butanone	43*	57, 72
1,1,1-Trichloroethane	97	99, 117, 119
Carbon tetrachloride	117	119, 121
Bromodichloromethane	83	85, 129
1,1,2,2-Tetrachloroethane	83	85, 131, 133, 166
1,2-Dichloropropane	63	65, 114
trans-1,3-Dichloropropene	75	77
Trichloroethene	130	95, 97, 132
Dibromochloromethane	129	208, 206
1,1,2-Trichloroethane	97	83, 85, 99, 132, 134
Benzene	78	
cis-1,3-Dichloropropene	75	77
Bromoform	173	171, 175, 250, 252, 254, 256
2-Hexanone	43	58, 57, 100
4-Methyl-2-pentanone	43	58, 100
Tetrachloroethene	164	129, 131, 166
Toluene	91	92
Chlorobenzene	112	114
Ethyl Benzene	106	91
Styrene	104	78, 103
Total Xylenes	106	91

*The 43 ion is used for quantitation, but the 72 ion must be present.

TABLE 3.

BFB Key Ions and Abundance Criteria

Mass	Ion Abundance Criteria
50	8.0 - 40.0 percent of mass 95
75	30.0 - 66.0 percent of mass 95
95	base peak, 100 percent relative abundance
96	5.0 - 9.0 percent of mass 95
173	less than 2.00 percent of mass 174
174	50.0 - 120.0 percent of mass 95
175	4.0 - 9.0 percent of mass 174
176	93 - 101.0 percent of mass 174
177	5.0 - 9.0 percent of mass 176

TABLE 4.

System Monitoring Compound Recovery Limits

Fraction	Surrogate	Water	Soil
Volatile	Toluene-d_8	88-110	84-138
Volatile	4-Bromoflourobenzene	86-115	59-113
Volatile	1,2-Dichloroethane-d_4	76-114	70-121

TABLE 5.

Matrix Spike Recovery Limits

Fraction	Matrix Spike Compound	Water	Soil
Volatile	1,1-Dichloroethene	61-145	59-172
Volatile	Trichloroethene	71-120	62-137
Volatile	Chlorobenzene	75-130	60-133
Volatile	Toluene	76-125	59-139
Volatile	Benzene	76-127	66-142

TABLE 6.

LCS Recoveries — New Protocol

Compound	Soil QC Limits	Water QC Limits
Acetone	60-167	50-176
Bromodichloromethane	62-150	67-134
Benzene	67-139	74-133
Bromoform	49-154	46-149
Bromomethane	39-167	39-167
Chlorobenzene	72-130	72-128
Carbon Disulfide	58-112	55-138
cis-1,2-Dichloroethene	81-115	77-128
cis-1,3-Dichloropropene	63-124	68-134
Chloroethane	70-145	63-142
Chloroform	41-140	78-124
Chloromethane	69-141	21-169
Carbon Tetrachloride	71-162	69-132
Dibromochloromethane	54-152	62-138
1,1-Dichloroethene	46-160	54-161
1,2-Dichloropropane	66-144	67-141
Ethylbenzene	83-117	82-121
2-Hexanone	35-165	26-194
Methylene Chloride	60-125	76-134
4-Methyl-2-Pentanone	47-157	33-195
o-Xylene	82-117	80-127
Styrene	80-120	78-123
Trichloroethene	64-142	73-131
trans-1,2-Dichloroethene	75-117	75-128
trans-1,3Dichloropropene	46-138	45-166
Toluene	74-130	75-130
Tetrachloroethene	71-147	75-147
Vinyl Chloride	35-150	37-155
1,1-Dichloroethane	68-117	76-130
1,1,1-Trichloroethane	75-158	71-130
1,1,2,2-Tetrachloroethane	45-158	38-158
2-Butanone	54-158	40-179
1,2-Dichloroethane	84-141	79-124
1,1,2-Trichloroethane	53-147	64-144
m,p-Xylene	81-125	55-151

TABLE 7.

Volatile Internal Standards with Corresponding
TCL Analytes Assigned for Quantitation

Bromochloromethane	1,4-Difluorobenzene	Chlorobenzene-d_5
Chloromethane	1,1,1-Trichloroethane	2-Hexanone
Bromomethane	Carbon Tetrachloride	4-Methyl-2-Pentanone
Vinyl Chloride	Bromodichloromethane	Tetrachloroethene
Chloroethane	1,2-dichloropropane	1,1,2,2-Tetrachloroethane
Methylene Chloride	trans-1,3-Dichloropropene	Toluene
Acetone	Trichloroethene	Chlorobenzene
Carbon Disulfide	Dibromochloromethane	Ethylbenzene
1,1-Dichloroethene	1,1,2-Trichloroethane	Styrene
1,1-Dichloroethane	Benzene	Xylene (total)
1,2-Dichloroethene (total)	cis-1,3-Dichloropropene	Bromofluorobenzene
Chloroform	Bromoform	(Sys. Monitoring Comp.)
1,2,-Dichloroethane		Toluene-d_8 (System
2-Butanone		Monitoring Compound)
1,2-Dichloroethane-d_4,(System Monitoring Compound)		

TABLE 8.

Relative Response Factor Criteria for Initial and
Continuing Calibration of Volatile Organic Compounds

Volatile Compound	Minimum RRF	Maximum %RSD	Maximum %Diff
Bromomethane	0.100	20.5	25.0
Vinyl chloride	0.100	20.5	25.0
1,1-Dichloroethene	0.100	20.5	25.0
1,1-Dichloroethane	0.200	20.5	25.0
Chloroform	0.200	20.5	25.0
1,2-Dichloroethane	0.100	20.5	25.0
1,1,1-Trichloroethane	0.100	20.5	25.0
Carbon tetrachloride	0.100	20.5	25.0
Bromodichloromethane	0.200	20.5	25.0
cis-1,3-Dichloropropene	0.200	20.5	25.0
Trichloroethene	0.300	20.5	25.0
Dibromochloromethane	0.100	20.5	25.0
1,1,2-Trichloroethane	0.100	20.5	25.0
Benzene	0.500	20.5	25.0
trans-1,3-Dichloropropene	0.100	20.5	25.0
Bromoform	0.100	20.5	25.0
Tetrachloroethene	0.200	20.5	25.0
1,1,2,2-Tetrachloroethane	0.500	20.5	25.0
Toluene	0.400	20.5	25.0
Chlorobenzene	0.500	20.5	25.0
Ethylbenzene	0.100	20.5	25.0
Styrene	0.300	20.5	25.0
Xylenes (total)	0.300	20.5	25.0
Bromofluorobenzene	0.200	20.5	25.0

TABLE 9.

Minimum Relative Response Criteria for Initial and Continuing Calibration of Volatile Organic Compounds

Acetone	1,2-Dichloropropane
2-Butanone	2-Hexanone
Carbon disulfide	Methylene chloride
Chloroethane	4-Methyl-2-pentanone
Chloromethane	Tolune-d_8
1,2-Dichloroethene (total)	1,2-Dichloroethane-d_4

TABLE 10.

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)

		Quantitation Limits	
Volatiles	CAS Number	Water Low µg/L	Soil/Sediment µg/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	10	10
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	10	10
8. 1,1-Dichloroethene	75-35-4	10	10
9. 1,1-Dichloroethane	75-34-3	10	10
10. 1,2-Dichloroethene (total)	540-59-0	10	10
11. Chloroform	67-66-3	10	10
12. 1,2-Dichloroethane	107-06-2	10	10
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	10	10
15. Carbon Tetrachloride	56-23-5	10	10
16. Bromodichloromethane	7527-4	10	10
17. 1,2-Dichloropropane	78-87-5	10	10
19. cis-1,3-Dichloropropene	10061-01-5	10	10
20. Trichloroethene	79-01-6	10	10
21. Dibromochloromethane	124-48-1	10	10
22. 1,1,2-Trichloroethane	79-00-5	10	10
23. Benzene	71-43-2	10	10
24. trans-1,3,-Dichloropropene	10061-02-6	10	10
25. Bromoform	75-25-2	10	10
26. 4-Methyl-2-Pentanone	108-10-1	10	10
27. 2-Hexanone	591-78-6	10	10
28. Tetrachloroethene	127-18-4	10	10
29. 1,1,2,2-Tetrachloroethane	79-34-5	10	10
30. Chlorobenzene	108-90-7	10	10
31. Ethyl Benzene	100-41-4	10	10
32. Styrene	100-42-5	10	10
33. Xylenes (Total)	1330-20-7	10	10
34. Toluene	108-88-3	10	10

*Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL compounds are 125 times the individual Low Soil/Sediment CRQL and recorded to two significant figures.

TABLE 11.

Standards Preparation

Compound or Standard Mix	Begin Conc. µg/mL	Aliquot µL	Total Vol.	Final Conc. µg/mL	Volume to be used
Restek Internal Standard					
VOA Internal Std. Mix	2,500	200	20 mL	25	10µL/5mL
Restek Surrogate					
VOA Surrogate Spike Mix	2,500	200	20 mL	25	10µL/5mL
Restek Calibration Mix					
VOA Calibration Mix 1	5,000	100		25	
VOA Calibration Mix 2	2,000	250		25	
VOA Calibration Mix 3	2,000	250		25	
VOA Calibration Mix 4	2,000	250		25	
VOA Calibration Mix 5	2,000	250	20 mL	25	10µL/5mL
* Trichlorofluoromethane	5,000	100		25	
* 1,3-Dichlorobenzene	5,000	100		25	
* 1,4-Dichlorobenzene	5,000	100		25	
* 1,2-Dichlorobenzene	5,000	100		25	
* 2-Chloroethyl Vinyl ether	10,000	5	2 mL	25	10µL/5mL
Restek VOA Matrix Spike Mix	2,500	40	4 mL	25	10µL/5mL
MEDIUM LEVEL SOIL SPIKES					
Restek VOA Surrogate Spike Mix	2,500	500	5 mL	250	100µL/10 mL
Restek Matrix Spike Mix	2,500	500	5 mL	250	100µL/10mL

* Compound contained in calibration standard, but not required by OLMO1.8 protocol.

TABLE 12
Instrument Paramenters

PARAMETERS	INSTRUMENT C	I	K	L	N	R	U
Tune File	CTUNE	KTUNE	ITUNE	LANTUNE	NTUNE	RTUNE	UTUNE
Method Files	BFB VOA	BFB VOA	IBFB IVOA	BFB VOA	BFBN VOAN	BFBR VOAR	BFBU VOAU
Software	Target 3.0	Target 3.0	Target 3.0	Target 3.0	Target 3.0	Target 3.0	Target 3.0
Data System	HP 710	HP 715	HP HP710	HP HP710	HP715715	HP HP715	HP715
Tekmar LCS 2000 Method	1	1	1	1	1	1	1
Standby	30°C	30°C	30°C	30°C	30°C	30°C	30°C
Purge	8 min.	8 min.	8 min.	8 min.	8 min.	8 min.	8 min.
Preheat	—	—	—	—	—	—	—
Sample	—	—	—	—	—	—	—
Desorb Preheat	175°C	175°C	175°C	175°C	175°C	175°C	175°C
Desorb	4 min/180°C	4 min/180°C	4 min/180°C	4 min/180°C	4 min/180°C	4 min/180°C	4 min/180°C
Bake	4 min/225°C	4 min/225°C	4 min/225°C	4 min/225°C	4 min/225°C	4 min/225°C	4 min/225°C
Auto Drain	On	Off	Off	On	Off	Off	Off
Bake Gas Bypass	Off	On	On	Off	On	On	On
BGB Delay	—	—	—	—	—	—	—
Valve	185°C	150°C	150°C	100°C	150°C	150°C	150°C
Line	200°C	200°C	150°C	150°C	200°C	200°C	200°C
Mount	45°C	40°C	40°C	40°C	40°C	40°C	40°C
Aux. Heaters	—	—	—	—	—	—	—
2016 Valve	165°C	150°C	150°C	150°C	150°C	150°C	150°C
Line	150°C	175°C	150°C	150°C	175°C	175°C	175°C
2032 Valve	150°C	150°C	150°C	150°C	150°C	150°C	150°C
Line	150°C	175°C	150°C	150°C	175°C	175°C	175°C
Purge Pressure (PSI)	20	20	20	20	20	20	20

TABLE 13.

Response Factor and Concentration Calculation

$$RF = \frac{(A_x)(C_{is})}{(A_{is})(C_x)} \quad \text{and} \quad conc_x = \frac{(A_x)(C_{is})}{(A_{is})(RF_x)}$$

Where:

A_x = Area of characteristic ion for the measured compound.
A_{is} = Area of the characteristic ion for the specified internal standard
C_{is} = Concentration of the internal standard (ng/μL)
C_x = Concentration of the measured compound (ng/μL)
RF_x = Response Factor of the measured compound.

Surrogate Recovery:

$$\% \text{ Surrogate Recovery} = \frac{Qd}{Qa} \times 100\%$$

Where:

Qd = Quantity determined by analysis
Qa = Quantity added to sample

Matrix Spike Recovery and RPD:

$$\text{Matrix Spike Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where:

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

$$\text{Matrix Spike RPD} = \frac{|MSR - MSDR|}{(1/2)(MSR + MSDR)} \times 100$$

Laboratory Control Spike (LCS) Recovery:

$$\text{LCS Spike Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where:

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF SEMIVOLATILE ORGANICS

MS515

REV 5.1 — 11/16/93

DOCUMENT CONTROL #SWL-MS515A-_____

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I. SUMMARY

A. *Method Summary*

1. A measured volume of sample or a measured weight of sample (soil/sediment) is extracted with methylene chloride. For water samples the pH is adjusted, if needed, to 2. The methylene chloride extract is dried and concentrated to a volume of 1.0 ml. Chromatographic conditions are described which permit the separation and measurement of the parameters in the extract. Qualitative identification is performed using the retention time and the relative abundance of three characteristic ions. Quantitative analysis is performed using internal standard techniques with a single characteristic ion.

II. GC/MS ANALYSIS OF EXTRACTABLES (BASE/NEUTRALS AND ACIDS)

A. *GC/MS System*

1. Column - 30 m x 0.25 mm ID (or 0.32 mm) bonded-phase silicone coated fused silica capillary column (J & W Scientific DB-5 or equivalent). A film thickness of 1.0 micron is recommened because of its larger capacity. A film thickness of 0.25 microns may be used.

2. GC/Mass Spectrometer - capable of scanning from 35 to 500 amu every 1 second or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all required criteria when 50 ng of decafluorotriphenylphosphine (DFTPP) is injected through the GC inlet.

   NOTE: *DFTPP criteria (QA/QC SOP) must be met before any sample extracts and/or standards are analyzed.*

B. *Reagents*

1. Internal Standards —1,4-dichlorobenzene-d_4, napthalene-d_8, acenaphthene-d_{10}, phenanthrene-d_{10}, chrysene-d_{12}, perylene-d_{12}. An internal standard solution can be prepared by dissolving 100 mg of each compound in 50 ml of methylene chloride. The resulting solution will contain each standard at a concentration of 2000 ng/μL. A 10 μL portion of this solution should be added to each 1 mL of sample extract. This will give a concentration of 40 ng/2 μL of each constituent.

C. *GC/MS Operating Conditions*

1. The following instrumental parameters are required for all performance tests and for all sample analyses:

   a. *Electron Energy:* 70 volts (nominal)

   b. *Mass Range:* 35 to 500 amu

   c. *Scan Time:* 1 second per scan

D. Calibration

1. An Initial Calibration must be performed prior to the analysis of any samples and blanks, and after the DFTPP performance check criteria has been met. The concentration of the initial calibration standard 20, 50, 80, 120, 160 ng/2μL injection. The calibration must be checked against the criteria outlined in Table 8, with allowance for up to four target and surrogate compounds. If time remains in the 12 hour time period after the initial calibration has been performed, samples may be analyzed. Quantify the samples using the response factors from the 50 ng/2μL standard.

2. A continuing calibration must be analyzed each 12 hour time period to check the calibration curve. The criteria in Table 8 must be met prior to the analysis of any blanks or samples, and after the DFTPP Performance Check. As with the initial calibration, up to four target compounds may fail the criteria. The concentration of the continuing calibration standard is 50 μg/2μL.

E. Sample Analysis

1. Sample extracts from the Sample Extraction/Analysis Log (figure 1) are logged into the GC/MS section using the GC/MS Extract Receipt Log (figure 2). Internal standard solution is added to each sample extract. For water and/or medium soil extracts, add 10 μL of internal standard solution to each accurately measured 1.0 mL of sample extract. Analyze the 1.0 mL extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows:

   a. *Initial Column Temperature Hold:* 40°C for 1 minutes

   b. *Column Temperature Program:* 40-300°C at 8°C/min.

   c. *Final Column Temperature Hold:* 300°C for 5 minutes

   d. *Injector Temperature:* 280°C

   e. *Transfer Line Temperature:* 380°C

   f. *Source Temperature:* according to manufacturer's specifications

   g. *Injector:* Grob-type, splitless

   h. *Sample Volume:* 2 μL

F. Daily Semivolatile Laboratory Procedures

1. Take out standards and extracts from refrigerator and set out to equilibriate to room temperature.

2. The operator who removes the standards is also responsible for recording the temperature of the refrigerator into the temperature log.

3. Check the data (surrogate recoveries, internal standard areas linearity) for all of the samples analysed on the previous day. Complete the instrument log (figure 3). The details of the QC criteria are described in the SOP attached. The raw data for all of the good data along with DFTPP and calibrations should be kept in "black bins". Complete the instrument run log.

4. Make a list of all reanalysis and reextractions. Fill out corrective action form (Figure 4) and get it approved by your supervisor and send the form to extration lab for further action.

5. Change the septum and liner. Check for air leaks.

6. Inject 50 ng DFTPP. Check the spectrum by averaging ± 1 and background subtracting. If the spectrum meets the criteria, then proceed further. If the criteria is not met, then reanalyze DFTPP or retune the instrument with PFTBA and reanalyse DFTPP. If problem still exists, then check with your supervisor for cleaning of the source. Make a RR file for DFTPP (RR,>datafile,,,=390D,,!P).

7. While the standard is running, makeup a batch file sequence for the samples to be analysed. Record all of the samples on the instrument run log.

8. Add 10 μL of internal standard mix (2000ppm) to 1 mL of sample extract. Mark the septum of the vial with blue ink to indicate that the internal standard has been added. Take out about 100 μL in the autosampler vial and seal the vial. The sample extract is ready for injection by autosampler.

9. Load the autosampler making sure that the extract is placed exactly in the same location as reported in the sequence file. Make a hard copy of the sequence file to check that all of the header information is correct.

10. Setup to run "FITIC" program to run "TICS" for the samples analysed on previous day.

11. Replace the standards and sample extracts exactly in the same place in the refrigerator.

12. Tables 1 through 10 give a quick reference to the QC requirements.

G. *Quantitation*

1. TCL components identified shall be quantified by the internal standard method. The internal standard used shall be the one nearest the retention time to that of a given analyte. The EICP area of characteristic ions of analytes listed in Tables 4, 5, and 6 are used. The response factor (RF) from the daily standard analysis is used to calculate the concentration in the sample. Secondary ions may be used if interferences are present. The area of a secondary ion cannot be substituted for the area of a primary ion unless a response factor is calculated using the secondary ion.

2. Calculate the concentration in the sample using the response factor (RF) and the following equation:

   a. *Water*

$$\text{Concentration } (\mu g/L) = \frac{(A_x)\,(I_s)\,(V_t)\,(Df)}{(A_{is})\,(RF)\,(V_o)\,(V_i)}$$

A_x = Area of the characteristic ion for the compound to be measured.
A_{is} = Area of the characteristic ion for the internal standard.
I_s = Amount of internal standard injected in nanograms (ng).
V_o = Volume of water extracted in millimeters (mL).
V_i = Volume of extract injected (μL).
V_t = Volume of concentrated (μL) extract.
Df = Dilution factor. If no dilution is performed, Df = 1.0

   b. *Sediment/Soil*

$$\text{Concentration } (\mu g/Kg) = \frac{(A_x)\,(I_s)\,(V_t)\,(Df)(2.0)}{(A_{is})\,(RF)\,(V_i)\,(W_s)\,(D)}$$

(Dry weight basis)
A_x, I_s, A_{is}=Same as given for water, above.
V_t = Volume of low level concentrated extract.
V_i = Volume of extract injected (μL).
$D = \frac{100 - \%\text{ moisture}}{100}$
W_s = Weight of sample extracted (grams).
Df = Dilution factor. If no dilution is performed, Df = 1.0.

3. The factor of 2.0 is used to account for extract not recovered from the GPC cleanup.

4. An estimated concentration for Non-TCL components tentatively identified shall be quantified by the internal standard method. For quantification, the nearest internal standard free of interferences shall be used.

5. Calculate surrogate standard recovery on all samples, blanks and spikes. Determine if recovery is within limits and reoprt on appropriate form.

III. OPERATOR DATA VALIDATION, GC/MS DEPARTMENT

A. *Operator Validation Tasks*

1. Label the internal standards and surrogates on the total ion chromatograms, with abbreviations IS-1, SS-A1, SS-B1, etc.
2. Verify that surrogate recoveries are within the limits listed in Table 2 and enter values on the appropriate surrogate recovery forms. (Form II).
3. Output dual display for TCL compounds and library search (ESFLS or FITIC) for non-TCL compounds.
4. After output of the library search for the non-TCL compounds, account for all major peaks in the chromatogram (as either TCL compuond or non-TCL compound).
5. Complete the instrument log entirely on daily basis. (Copies of logbook pages are sent to EPA, they must be complete).
6. Complete forms V (DFTPP) including the analyses performed versus a particular DFTPP tune. Percent abundances must be recorded using three significant figures.
7. Verify that matrix spike compounds are within the limits listed in Table 3 and record values on the matrix spike sumary form (Form III).
8. Verify that there are no saturated TCL Compounds in the run.
9. Verify that all internal standard areas are within a factor of two of the most recent continuing calibration areas.
10. After data review has been completed, make up the appropriate files to be transferred to the PC for diskette deliverables. The files made up and their names must be written in the instrument logbook at the top where it says "other" below the header information.
11. Hard copies of all the manual integrations must be submitted along with the raw data.
12. Make copies of Initial and Continuing Calibration as the calibration may be used for several cases and file them away in your QC file cabinet for the appropriate month.
13. Complete the extraction logs for BNA runs. Initials, date of analysis and QLF.

B. *Remedial Action If Criteria Are Not Met.*

1. If peaks are saturated, the sample must be diluted and reanlyzed. If saturation still persists, the sample must be extracted at a higher level (i.e. medium) and reanalyzed. (IS intensities should be at least 20% or greater in the sample for correct dilution).
2. If a sample is analyzed at medium level, matrix spike and blanks analyses must also be performed for that level.
3. If a surrogate recovery for semivolatiles in any sample is less than 10%, the sample must be reextracted and reanalyzed. If two acid surrogates or two base surrogates are out of spec in

any sample, the sample must be reextracted and reanalyzed. Before a sample is reextracted, make sure your surrogate spike check is analyzed to ensure that there are no problems with the spiking solution itself. No surrogates can be out of the criteria limits for VOAs or for the blanks for semivolatiles.

IV. INSTRUMENT MAINTENANCE

A. Maintenance Schedule

1. Change septum every day.
2. Change liners if dirty samples were run the previous day.
3. Cut colum if dirty samplees were analysed the previous day ~ 10 cm to ~1 ft. in length.
4. Change columns when poor chromatography is exhibited by the performance check solution.
5. Clean the source if the septum gets dirty based on your tune and sensitivity.
6. Use the spare source and clean the source from your system as soon as possible.
7. Pump oil will be changed every quarter by HP maintenance (service people).
8. Data system — Heads will be cleaned by HP service and filters changed for disc drives.
9. If there is any other system problems, check with your supervisor.

METHOD	SV	PEST • PCB	OTHER
CONT. EX.			
SEP-F			
SONIC.			

☐ RUSH ☐ REEXTRACT ☐ TCLP ☐ DIOXIN

SAMPLE EXTRACTION LOG
SWOK • AATS
Southwest Laboratory of Oklahoma, Inc.
American Analytical & Technical Services, Inc.

CLIENT: _____ DATE RECEIVED: _____

CASE: _____ EXTRACT DATE: _____

SAMPLE ID (EPISODE #)	CLIENT ID	MATRIX - LEVEL	SAMPLE pH	% MOISTURE	DRY WEIGHT	AMOUNT EXTRACTED	EXTRACTED VOLUME	GPC VOLUME	GPC ELUTE VOL	FLORISIL FIN VOL CONC	FLORISIL FIN VOL CONC	VOL SV - P	FIN PROCESS VOLUME	SCREEN Y/N	MS SV - P	SURR SV - P	BASE pH CONFIRMATION	ACID pH CONFIRMATION	COMMENTS
				%	g	g • mL	mL	mL	mL	mL	mL	mL	mL		µL	µL			

INITIALS	
WEIGHING:	EXTRACTION:
CLEANUP:	KD:
BLOWDOWN:	
SURROG. SPIKER:	VERIFIER:
MATRIX SPIKER:	VERIFIER:
SUBMITTED BY:	REVIEWED BY

ID NUMBERS
FLORISIL CARTRIDGE #:
GPC COLUMN #:
SURROGATES ID CONC #:
MATRIX SPIKE SOL ID/CONC #(S):
MISC:

COMMENTS

(EX013-0392-01)

33050

Figure 1. Sample Extraction Log

EXTRACT RECEIPT LOG

GC/MS SEMIVOLATILE LABORATORY

TM

DATE	TIME	SWOK / AATS SAMPLE ID	CLIENT ID	EXTRACTION CHEMIST INITIALS	GC/MS SPL. CUSTOD. INITIALS	COMMENTS

SOUTHWEST LABORATORY OF OKLAHOMA, INC. • AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [SGM004-0792-01]

Figure 2. GC/MS Extract Receipt Log

SEMIVOLATILE GC/MS RUN LOG

SEMIVOLATILES GC/MS DEPARTMENT

SWOK / AATS

BOOK_____ PAGE_____

CLIENT: _____ DATE (MO/DAY/YR): _____

CASE: _____ INSTRUMENT ID (A,B,C, etc.): _____

SAS: _____

METHOD NO: _____ COLUMN NO: _____

EMV: _____ TUNE FILE ID: _____

OTHER: _____

TIME	INIT	CLIENT SAMPLE ID	LAB ID	FILE ID	SAMPLE AMOUNT			DIL. FACT.	AUTO INJ POS	ARCH TAPE NO	RUN NO
					wt	vol	inj				
											1
											2
											3
											4
											5
											6
											7
											8
											9
											10
											11
											12
											13
											14
											15

Analyst Signature

PART I SWL/AATS, BROKEN ARROW, OK [SGM002A-0492-01]

Figure 3a. Semivolatile GC/MS Run Log (page 1 of 2)

SEMIVOLATILE GC/MS RUN LOG

SEMIVOLATILES GC/MS DEPARTMENT

SWOK / AATS

BOOK_____PAGE_____

(Check appropriate box. All major maintenance should be recorded in maintenance logbook.)

ROUTINE MAINTENANCE: ☐ MAJOR MAINTENANCE: ☐ in Book____Page____.

DATE: _____ TIME: _____

COMMENTS: _____

INTERNAL STANDARD AREAS							
Cpd.	IS #1	IS #2	IS #3	IS #4	IS #5	IS #6	
Std. RT							Run # =
NO.	m/z=	m/z=	m/z=	m/z=	m/z=	m/z=	Comment
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

_____
Analyst Signature

PART II SWL/AATS, BROKEN ARROW, OK [SGM002a-0492-01]

Figure 3b. Semivolatile GC/MS Run Log (page 2 of 2)

REMEDIAL ACTION RECORD

Initiated by:_____ **Project*:**_____

Date:_____ **Client*:**_____

Sample ID's:_____ **Case*:**_____

*if applicable

DESCRIPTION OF PROBLEM (list dates):

Supervisor's Signature:_____

DESCRIPTION OF ACTIONS TAKEN (list dates):

Supervisor's Signature:_____

Copies: **Case File,** _____, _____, _____, _____

SOUTHWEST LABORATORY OF OKLAHOMA, INC./AMERICAN ANALYTICAL & TECHNICAL SERVICES, INC.
1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599

Figure 4. Remedial Action Record

TABLE 1.
DFTPP Key Ions and Abundance Criteria

Mass	Ion Abundance Criteria
51	30.0 - 80.0 percent of mass 198
68	less than 2.0 percent of mass 69
69	Present
70	less than 2.0 percent of mass 69
127	25.0 - 75.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 0.75 percent of mass 198
441	present but less than mass 443
442	40.0 - 110.0 percent of mass 198
443	15.0 - 24.0 percent of mass 442

TABLE 2.
Surrogate Spike Recovery Limits

Fraction	Surrogate Compound	Water	Low/Medium Soil
BNA	Nitrobenzene-d_5	35-114	23-120
BNA	2-Flourobiphenyl	43-116	30-115
BNA	p-Terphenyl-d_{14}	33-141	18-137
BNA	phenol-d_5	10-94	24-113
BNA	2-Flourophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122
BNA	2-Chlorophenol-d4	33-110	20-130 (Advisory)
BNA	1,2-Dichlorobenzene-d4	16-110	20-130 (Advisory)

TABLE 3.
Matrix Spike Recovery Limits

Fraction	Matrix Spike Compound	Water	Soil/Sediment
BN	1,2,4-Trichlorobenzene	39-98	38-107
BN	Acenaphthene	46-118	31-137
BN	2,4-Dinitrotoluene	24-96	28-89
BN	Pyrene	26-127	35-142
BN	N-Nitroso-Di-n-Propylamine	41-116	41-126
BN	1,4-Dichlorobenzene	36-97	28-104
Acid	Pentachlorophenol	9-103	17-109
Acid	Phenol	12-110	26-90
Acid	2-Chlorophenol	27-123	25-102
Acid	4-Chloro-3-Methylphenol	23-97	26-103
Acid	4-Nitrophenol	10-80	11-114

TABLE 4.
Characteristic Ions for Semivolatile TCL Compounds

Parameter	Primary Ion	Secondary Ion(s)
Phenol	94	65, 66
bis (-2-Chloroethyl) Ether	93	63, 95
2-Chlorophenol	128	64, 130
1,3-dichlorobenzene	146	148, 113
1,4-Dichlorobenzene	146	148, 113
1,2-Dichlorobenzene	146	148, 113
2-Methylphenol	108	107
2,2'-oxybis(1-Chloropropane)	45	77, 79
4-Methylphenol	108	107
N-Nitroso-Di-Propylamine	70	42, 101, 130
Hexachloroethane	117	201, 199
Nitrobenzene	77	123, 65
Isophorone	82	95, 138
2-Nitrophenol	139	65, 109
2,4-Dimethylphenol	107	121, 122
bix (-2-Chloroethoxy) Methane	93	95, 123
2,4-Dichlorophenol	162	164, 98
1,2,4-Trichlorobenzene	180	182, 145
Naphthalene	128	129, 127
4-Chloroaniline	127	129
Hexachlorobutadiene	225	223, 227
4-Chloro-3-methylphenol	107	144, 142
2-methyl(napthalene)	142	141
Hexachlorocyclopatadiene	237	235, 272
2,4,6-Trichlorophenol	196	198, 200
2,4,5-Trichlorophenol	196	198, 200
2-Chloronaphthalene	162	164, 127
2-Nitroaniline	65	92, 138
Dimethyl Phthalate	163	194, 164
Acenaphthylene	152	151, 153
3-Nitroaniline	138	108, 92
Acenaphthene	153	152, 154
2,4-Dinitrophenol	184	63, 154
4-Nitrophenol	109	139, 65
Dibenzofuran	168	139
2,4-Dinitrotoluene	165	63, 182
2,6-Dinitrotoluene	165	89, 121
Diethylphthalate	149	177, 150
4-Chlorophenyl-phenylether	204	206, 141
Fluorene	166	165, 167
4-Nitroaniline	138	92, 108
4,6-Dinitro-2-Methylphenol	198	182, 77
N-Nitrosodiphenylamine	169	168, 167
4-Bromophenyl-phenylether	248	250, 141
Hexachlorobenzene	284	142, 249
Pentachlorophenol	266	264, 268
Phenanthrene	178	179, 176
Anthracene	178	179, 176

(Table 4 continued on following page)

TABLE 4.
(Continued)

Parameter	Primary Ion	Secondary Ion(s)
Carbazole	167	166, 139
Di-N-Butylphthalate	149	150, 104
Fluoranthene	202	101, 100
Pyrene	202	101, 100
Butylbenzyphthalate	149	91, 206
3,3-Dichlorobenzidine	252	253, 125
Benzo (a) Anthracene	228	229, 226
bis (2-Ethylhexyl) Pthalate	149	167, 279
Chrysene	228	226, 229
Di-N-Octyl Phthalate	149	—
Benzo (b) Fluoranthene	252	253, 125
Benzo (k) Fluoranthene	252	253, 125
Benzo (a) Pyrene	252	253, 125
Indeno (1,2,3-cd) Pyrene	276	138, 227
Dibenz (a,h) Anthracene	278	139, 279
Benzo (g,h,i) Perylene	276	138, 277

TABLE 5.
Characteristic Ions for Pesticides/PCBs

Parameter	Primary Ion	Secondary Ion(s)
Alpha-BHC	183	181, 109
Beta-BHC	181	183, 109
Delta-BHC	183	181, 109
Gamma-BHC (Lindane)	183	181, 109
Heptachlor	100	272, 274
Aldrin	66	263, 220
Heptachlor Epoxide	353	355, 351
Endosulfan I	195	339, 341
Dieldrin	79	263, 279
4,4'-DDE	246	248, 176
Endrin	263	82, 81
Endrin aldehyde	67	250, 345
Endosulfan II	337	339, 341
4,4'-DDD	235	237, 165
Endosulfan sulfate	272	387, 422
4,4'-DDT	235	237, 165
Methoxychlor	227	228
Chlordane (alpha and/or gamma)	373	375, 377
Toxaphene	159	231, 233
Aroclor-1016	222	260, 292
Aroclor-1221	190	222, 260
Aroclor-1232	190	222, 260
Aroclor-1242-	222	256, 292
Aroclor-1248	292	362, 326
Aroclor-1254	292	362, 326
Aroclor-1260	360	362, 394
Endrin Ketone	317	67, 319

TABLE 6.
Characteristic Ions for Surrogate and Internal Standards for Semivolatile Organic Compounds

Compound	Primary Ion	Secondary Ion(s)
SURROGATE STANDARDS		
Phenol-d_5	99	42, 71
2-Fluorophenol	112	64
2,4,6-Tribromophenol	330	332, 141
d-5 Nitrobenzene	82	128, 54
2-Flourobiphenyl	172	171
Terphenyl	244	122, 212
2-Chlorophenol-d_4	132	68, 134
1,2-Dichlorobenzene-d_4	152	115, 150
INTERNAL STANDARDS		
1,4-Dichlorobenzene-d_4	152	115
Naphthalene-d_8	136	68
Acenapthene-d_{10}	164	162, 160
Phenanthrene-d_{10}	188	94, 80
Chrysene-d_{12}	240	120, 236
Perylene-d_{12}	264	260, 265

TABLE 7.
Semivolatile Internal Standards with Corresponding TCL Analytes Assigned for Quantitation

1,4-Dichlorobenzene-d_4	Napthalene-d_8	Acenaphthene-d_{10}
Phenol bis (2-Chloroethyl) ether 2-Chlorophenol 1,3-Dichlorobenzene 1,4-Dichlorobenzene 1,2-Dichlorobenzene 2-Methylphenol 2,2'-oxybis-(1-chloropropane) 4-Methylphenol N-nitroso-Di-n-propylamine Hexachloroethane 2-Fluorophenol (surr) Phenol-d6 (surr) 2-Chlorophenol-d_4 (surr) 1,2-Dichlorobenzene-d_4 (surr)	Nitrobenzene Isophorone 2-Nitrophenol 2,4-Dimethylphenol bis (2-Chloroethoxy) methane 2,4-Dichlorophenol 1,2,4-Trichlorobenzene Naphthalene 4-Chloroaniline Hexachlorobutadiene 4-Chloro-3-methylphenol 2-Methylnaphthalene Nitrobenzene-d_5 (surr)	Hexachlorocyclopentadiene 2,4,6-Trichlorophenol 2,4,5-Trichlorophenol 2-Chloronaphthalene 2-Nitroaniline Dimehtyl Phthalate Acenaphthylene 2,4-Dinitrophenol 4-Nitrophenol Dibenzofuran 3-Nitroanatine 1-cenaphthene 2,4-Dinitrotoluene 2,6-Dinitrotoluene Diethyl Phthalate 4-Chlorophenyl phenyl ether Fluorene 4-Nitroaniline 2-Fluorobiphenyl (surr) 2,4,6-Tribromo Phenol (surr)
Phenanthrene-d_{10}	**Chrysene-d_{12}**	**Perylene-d_{12}**
4,6-Dinitro-2-methylphenol N-nitrosodiphenylamine 4-Bromophenyl Phenyl Ether Hexachlorobenzene Pentachlorophenol Penanthrene Carbazole Anthracene Di-n-butyl Phthalate Fluoranthene	Pyrene Butylbenzylphthalate 3,3'-Dichlorobenzidine Benzo (a) anthracene bis(2-ethylhexyl) Phthalate Chrysene Terphenyl-d_{14} (surr)	Di-n-octyl Phthalate Benzo (b) fluoranthene Benzo (k) fluoranthene Benzo (a) pyrene Indeno (1,2,3-cd) pyrene Dibenz (a,h) anthracene Benzo (g,h,i) perylene

Surr = surrogate compound

TABLE 8.
Relative Response Factor Criteria for Initial and Continuing Calibration of Semivolatile Target Compounds

Semivolatile Organic Compounds	Minimum RRF	Maximum %RSD	Maximum %Diff
Phenol	0.800	20.5	25.0
bis(-2-Chloroethyl)ether	0.700	20.5	25.0
2-Chlorophenol	0.800	20.5	25.0
1,3-Dichlorobenzene	0.600	20.5	25.0
1,4-Dichlorobenzene	0.500	20.5	25.0
1,2-Dichlorobenzene	0.400	20.5	25.0
2-Methylphenol	0.700	20.5	25.0
4-Methylphenol	0.600	20.5	25.0
N-Nitroso-Di-propylamine	0.500	20.5	25.0
Hexachloroethane	0.300	20.5	25.0
Nitrobenzene	0.200	20.5	25.0
Isophorone	0.400	20.5	25.0
2-Nitrophenol	0.100	20.5	25.0
2,4-Dimethylphenol	0.200	20.5	25.0
bis(-2-Chloroethoxy)methane	0.300	20.5	25.0
2,4-Dichlorophenol	0.200	20.5	25.0
1,2,4-Trichlorobenzene	0.200	20.5	25.0
Napthalene	0.700	20.5	25.0
4-Chloro-3-methylphenol	0.200	20.5	25.0
2-Methylnaphthalene	0.400	20.5	25.0
2,4,6-Trichlorophenol	0.200	20.5	25.0
2,4,5-Trichlorophenol	0.200	20.5	25.0
2-Chloronapthalene	0.800	20.5	25.0
Acenaphthylene	1.300	20.5	25.0
2,6-Dinitrotoluene	0.200	20.5	25.0
Acenaphthene	0.800	20.5	25.0
Dibenzofuran	0.800	20.5	25.0
2,4-Dinitrotoluene	0.200	20.5	25.0
4-Chlorophenyl-phenylether	0.400	20.5	25.0
Fluorene	0.900	20.5	25.0
4-Bromophenyl-phenylether	0.100	20.5	25.0
Hexachlorobenzene	0.100	20.5	25.0
Pentachlorophenol	0.050	20.5	25.0
Penanthrene	0.700	20.5	25.0
Anthracene	0.700	20.5	25.0
Fluoranthene	0.600	20.5	25.0
Pyrene	0.600	20.5	25.0
Benzo(a)anthracene	0.800	20.5	25.0
Chrysene	0.700	20.5	25.0
Benzo(b)fluoranthene	0.700	20.5	25.0
Benzo(k)Fluoranthene	0.700	20.5	25.0
Benzo(a)pyrene	0.700	20.5	25.0
Ideno(1,2,3-cd)pyrene	0.500	20.5	25.0
Dibenzo(a,h)anthracene	0.400	20.5	25.0
Benzo(g,h,i)perylene	0.500	20.5	25.0
Nitrobenzene-d_5	0.200	20.5	25.0
2-Fluorobiphenyl	0.700	20.5	25.0
Terphenyl-d_{14}	0.500	20.5	25.0
Phenol-d_f	0.800	20.5	25.0
2-Fluorophenol	0.600	20.5	25.0
2-Chlorophenol-d_4	0.800	20.5	25.0
1,2-Dichlorobenzene-d_4	0.400	20.5	25.0

Initial calibration 20, 50, 80, 120, and 160 ng.

Eight compounds: 2,4-Dinitrophenol, 2,4,5-Trichlorophenol, 2-Nitroaniline, 3, Nitroaniline, 4-Nitroaniline, 4-Nitrophenol, 4,6-Dinitro-2-Methylphenol, and Pentachlorophenol will only require a four-point initial calibration at 50, 80, 120 and 160 total nanograms since detection at less than 50 nanograms per injection is difficult.

TABLE 9.
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment ug/kg
1. Phenol	108-95-2	10	330
2. bis(2-Chloroethyl)ether	111-44-4	10	330
3. 2-Chlorophenol	95-57-8	10	330
4. 1,3-Dichlorobenzene	541-73-1	10	330
5. 1,4-Dichlorobenzene	106-46-7	10	330
6. 1,2-Dichlorobenzene	95-50-1	10	330
7. 2-Methylphenol	95-48-7	10	330
9. 2,2'-oxybis(chloropropane)	108-60-1	10	330
9. 4-Methylphenol	106-44-5	10	330
10. N-Nitroso-di-n-propylamine	621-64-7	10	330
11. Hexachloroethane	67-72-1	10	330
12. Nitrobenzene	98-95-3	10	330
13. Isophorone	78-59-1	10	330
14. 2-Nitrophenol	88-75-5	10	330
15. 2,4-Dimethylphenol	105-67-9	10	330
16. bis(2-Chloroethoxy)methane	111-91-1	10	330
17. 2,4-Dichlorophenol	120-83-2	10	330
18. 1,2,4-Trichlorobenzene	120-82-1	10	330
19. Naphthalene	91-20-3	10	330
20. 4-Chloroaniline	106-47-8	10	330
21. Hexachlorobutadiene	87-68-3	10	330
22. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
23. 2-Methylnaphthalene	91-57-6	10	330
24. Hexachlorocyclopentadiene	77-47-4	10	330
25. 2,4,6-Trichlorophenol	88-06-2	10	330
26. 2,4,5-Trichlorophenol	95-95-4	25	800
27. 2-Chloronaphthalene	91-58-7	10	330
28. 2-Nitroaniline	88-74-4	25	800
29. Dimethylphthalate	131-11-3	10	330
30. Acenaphthylene	208-96-8	10	330
31. 2,6-Dinitrotoluene	606-20-2	10	330
32. 3-Nitroaniline	99-09-2	25	800
33. Acenaphthene	83-32-9	10	330
34. 2,4-Dinitrophenol	51-28-5	25	800
35. 4-Nitrophenol	100-02-7	10	800
36. Dibenzofuran	132-64-9	25	330
37. 2,4-Dinitrotoluene	121-14-2	25	330
38. Diethylphthalate	84-66-2	10	330
39. 4-Chlorophenyl-phenyl ether	7005-72-3	10	330
40. Fluorene	86-73-7	10	330

(Table 9 continued on following page)

TABLE 9.
(Continued)

Semivolatiles	CAS Number	Quantitation Limits** Water µg/L	Low Soil/Sediment[b] µg/kg
41. 4-Nitroaniline	100-01-6	25	800
42. 4,6-Dinitro-2-methylphenol	534-52-1	25	00
43. N-nitrosodiphenylamine	86-30-6	10	330
44. 4-Bromophenyl-phenyl ether	101-55-3	10	330
45. Hexachlorobenzene	118-74-1	10	330
46. Pentachlorophenol	87-86-5	25	800
47. Phenanthrene	85-01-8	10	330
48. Anthracene	120-12-7	10	330
49. Carbazole	86-74-8	10	330
50. Di-n-butylphthalate	84-74-2	10	330
51. Fluoranthene	206-44-0	10	330
52. Pyrene	129-00-0	10	330
53. Butylbenzylphthalate	85-68-7	10	330
54. 3,3'-Dichlorobenzidine	91-94-1	10	330
55. Benzo(a)anthracene	56-55-3	10	330
56. Chrysene	218-01-9	10	330
57. bis(2-Ethylhexyl)phthalate	117-81-7	10	330
58. Di-n-octylphthalate	117-84-0	10	330
59. Benzo(b)fluoranthene	205-99-2	10	330
60. Benzo(k)fluoranthene	207-08-9	10	330
61. Benzo(a)pyrene	50-32-8	10	330
62. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
63. Dibenz(a,h)anthracene	53-70-3	10	330
64. Benzo(g,h,i)perylene	191-24-2	10	330

b Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for SemiVolatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achieveable.

** Quantitation limits ilsted for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

TABLE 10.
Standards Preparation

Compound	Conc. ug/mL	Aliquot uL	Total Vol.	Conc. ug/mL	Volume used/uL
Supelco Internal Std. Mix	2000	2000	4 mL	1000	40
STOCK STANDARD					
Phenolic Mix	2000	400		200	-
Haz. Subst. Mix	2000	400		200	-
Haz. Subst. Mix	2000	400		200	-
PAH Mix	2000	400		200	-
B-N Mix-1	2000	400	4 mL	200	-
B-N Mix-2	2000	400		200	-
Benzidine Mix	2000	400		200	-
Acid Surr. Mix	2000	400		200	-
B-N Surr. Mix	1000	800		200	-
Stock Std.	200	750		50	-
IS Mix	1000	120	3mL	50	-
Stock Std.	200	400		80	-
IS Mix	200	40	1mL	80	-
Stock Std.	200	600		120	-
IS Mix	1000	40	1mL	120	-
Stock Std.	200	800		160	-
IS Mix	1000	40	1mL	160	-
Stock Std.	200	100		20	-
IS Mix	1000	40	1mL	20	-

These standards are verified with EPA standards regularly. Every time a standard is made, it is recorded in the current standards logbook.

OFFICIAL COPY RED STAMP INDICATES ORIGINAL

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE EXTRACTION OF SEMIVOLATILE ORGANICS

MS515X

REV 3.2 — 11/16/93

DOCUMENT CONTROL # SWL-MS515X-_____

APPROVALS BY:

Name: Chuck Hoover **Title:** QC Officer

Signature: Chuck Hoover

Name: SEYMOND H. FOSTER **Title:** ORG. EXTR. LAB. SUPERVI

Signature:

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I. SUMMARY

A. *Summary of Method*

1.A measured volume of sample or a measured weight of sample (soil/sediment) is extracted with methylene chloride. For water samples the pH is adjusted if needed to 2. The methylene chloride extract is dried and concentrated to a volume of 1.0 mL. Chromatographic conditions are described which permit the separation and measurement of the parameters in the extract. Qualitative identification is performed using the retention time and the relative abundance of three characteristic ions. Quantitative analysis is performed using internal standard techniques with a single characteristic ion.

II. EXTRACTION OF BASE NEUTRAL/ACIDS FROM WATER

A. *Extraction Procedure*

1. Shake bottle well.
2. Prerinse all glassware and apparatus used with the extraction solvent to be used.
3. Make sure enough sample is retained for pH determination.
4. A one liter portion of sample water is measured out and put into a continuous liquid-liquid extractor (see note 1). Record the volume on the extraction data sheet.
5. All solutions are pH adjusted to 2, checking the pH with pH paper. To all solutions is added 0.5 mL of surrogate spiking solution and to the matrix and matrix duplicate samples is added 0.5 mL of the matrix standard spiking solution. Record amount and ID of spiking solutions on extraction sheets when added (see note 2).

B. *Continuous Extractor*

1. When a continuous extractor is used, 250 mLs of methylene chloride is added to the continuous extractor and 200 mLs to the boiling flask. Adjust the pH of the solutions to 2 and extract for 18 hours. Turn off the continuous extractor and label as Base Neutral/Acid fraction. In transferring the extract to the distillation flask tilt the extractor allowing the solvent to flow into the flask. Prevent water or sediment from being transferred in this step. Disconnect the flask from the extractor. Place a glass funnel with S&S #595 filter paper and 10 grams of Na2SO4 into a KD flask. Add the solvent from the distillation flask to the funnel with the Na2SO4 Rinse the flask with 3, 10 mL portion of solvent and put these rinses through the Na2SO4 and collect all in the KD.
2. Add one clean boiling bead and attach a three-ball Snyder column. Prewet it with about 1 mL of methylene chloride. Put the concentrator in a hot water bath (about 75°C) so that the concentrator tube is partially immersed in the water and the entire lower rounded surface is bathed with hot vapor.
3. The position of the water bath and its temperature should be such that the concentration is completed in 10-15 minutes. The balls of the column should actively chatter and the chambers should not flood with condensed solvent. When the apparent volume of liquid

reaches 10 mL, remove from water bath and allow the apparatus to drain and cool for at least 10 minutes. Remove the column and rinse the flask and lower joint into the concentrator tube with 1-2 mLs of methylene chloride.

4. Place the concentrator tube on the nitrogen evaporator and evaporate the solvent volume to just below 1 mL with rinsing down of the inside wall of the tube several times with about 1 mL of methylene chloride. The final volume is brought to 1 mL with methylene chloride. During evaporation, the tube must never be allowed to become dry. Transfer these 1 mL extracts to the appropriate vials labeled for base neutral / acid fractions. Also include on the label the date and beginning amount of sample and the final volume. All data is to be recorded on the extraction data sheet (see figure 1) which follows the sample to the actual analysis, and in the extraction lab record book.

   Note 1. If the sample is in a 1 liter bottle mark the menicus before transfer of the sample. After transferring the sample fill the bottle with tap water to the mark. Transfer this to a 1 liter graduate to determine sample volume.

   Note 2. To ensure spiking solutions are added mark extraction vessels with a check mark for each spiking solution added.

III. EXTRACTION OF BN/A FRACTIONS FROM SOIL/SEDIMENTS (LOW LEVEL)

A. *Sample Preparation Procedure*

1. Homogenize sample before taking sub samples.

2. Determine pH and moisture content of each sample. If the pH is less than 5 or >11, then report to the supervisor.

3. Calibrate the balance before weighing samples. Weigh about 30 grams of the sample to the nearest 0.1 gram into a 400 mL beaker and add 60 grams of preextracted anhydrous sodium sulfate. Mix well with glass rod. Immediately add 100 mLs of 1:1 methylene chloride/ acetone.

4. Add 0.5 mL of BNA surrogate standard to the B/N/A samples.

5. For BNA matrix spike samples, add 0.5 mL of the BNA matrix spike. These are the BNA matrix spike and the BNA matrix spike duplicate. Record volume and spiking ID on the extraction data sheet at this time.

6. Sonicate the samples one at a time using the 3/4" probe held about 1/2" below the liquid surface but 1/2" above the sediment level. Use full power and a 50% pulse for 3 minutes. Decant and filter the extracts through a filter paper in a glass funnel, collecting the extracts in a 500 mL K D flask. Repeat the extraction 2 more times with 2 more 100 mL portions of the 1:1 methylene chloride/acetone. Decant the solvent after each sonication, pouring the entire sample into the funnel the last time. Rinse the beaker and soil/sediment with about 100 mLs more extraction solution.

7. After each of the "soils" have been extracted, dry the extract over Na_2SO_4. Concentrate in the K D assembly consisting of a 10 mL concentrator tube and a 500 mL evaporative flask.

Add one or two clean boiling chips and attach a 3-ball Snyder column. Wet the column with 1 mL methylene chloride. Evaporate the solution in the manner given in the BNA from water procedure until there is an apparent volume of 5 mL. Remove the K D assembly from the heat and allow it to cool and drain for 10 minutes. Rinse the flask and lower joint with 1-2 mLs of methylene chloride. Make the final volume to 1.0 mL with methylene chloride for BNA. Use the nitrogen blowdown apparatus with new pipettes to avoid contamination.

8. Label the 2 mL. vial with the EPA ID, LAB ID, CASE # and date. Store all vials in a rack in the extract storage refrigerator and give the extraction data sheets to the GC/MS operator .

9. For GPC cleanup, dilute the 1 mL extract to 10 mL and load into the GPC. Calibrate the GPC before loading any samples. Collect the required fraction and concentrate to 1 mL by N2 blow down technique. Record all activity in the GPC log (see figure 2).

IV. EXTRACTION OF BN/A FRACTIONS FROM SOILS/SEDIMENTS (MEDIUM LEVEL)

A. Sample Preparation Procedure

1. At this time a moisture determination should be done since concentrations of individual analytes will be reported relative to the dry weight of sediment. Also at this time, the pH should be determined. (See section V and VI below for pH and moisture determination..)

2. In a fume hood, open the sample container and mix the sample discarding any foreign objects such as sticks, leaves and rocks. Transfer approximately 1 gram (record to the nearest 0.1 g) of sample to a 20 mL vial. Clean off the vial mouth, weigh and cap.

3. Add 0.5 mL of B/N/A surrogate spiking standard to each vial. Add 0.5 mL of Matrix standard spiking solution to two of the sample vials (label them).

4. Add 2 grams preextracted sodium sulfate to each vial.

5. Prepare a blank using reagents used in sample extraction.

6. Immediately add 9.5 mL methylene chloride to the blank and plain sample and 9 mls to the matrix and matrix duplicate and disrupt the sample by ultra sonic probe for two minutes at 100 watts power.

7. Loosely pack disposable Pasteur pipets with 2-3 cm glass wool plugs. Filter the extract through these tubes collecting 5 mls in a concentrator tube. Concentrate to 1 mL on the nitrogen evaporator. Transfer the 1 mL to a sample vial, label this with EPA ID, LAB #, CASE #, and DATE (see proper labeling in diagram).

8. For GPC cleanup use 10 mL of the extract.

V. PH DETERMINATION OF SOIL AND WATER SAMPLES

A. *Water Samples*

1. The pH meter is to be calibrated before use and calibration data recorded in the pH meter log book.

2. Shake the Sample. Transfer approximately 50 mls of the sample to a clean beaker. Add a magnetic stirring bar and place on the stir plate and adjust the speed to give a good mixing action but not to aerate the sample. Place the probe into the liquid and allow the meter to obtain a stable reading. Record this answer on the sample data sheet and in the extraction lab record book.

B. *Soil Samples*

1. The pH meter is to be calibrated before use and calibration data recorded in the pH meter log book.

2. Homogenize the Sample. Weigh 50 grams of sample into a clean beaker and add 50 mls of DI water. Add a magnetic stir bar and place on the stir plate and allow to mix for one hour. Do not agitate fast enough as to entrain air in the sample. While the sample is mixing, keep it covered with a plastic film or aluminum foil. After 1 hour, place probe in the slurry and record the value on the data sheet and in the record book.

VI. MOISTURE DETERMINATION:

A. *Procedure*

1. Weigh 5-10 grams of the sediment into a tared crucible. Determine the percent moisture by drying overnight at 105°C. Allow to cool in a desiccator before weighing. Concentration of individual analytes will be reported relative to the dry weight of sediment.

$$\text{Percent Moisture} = \frac{\text{gm of sample - gm of dry sample}}{\text{gm of sample}} \times 100$$

VI. STANDARDS PREPARATION FOR EXTRACTIONS LABORATORY

A. *Working Surrogate BNA Spiking Solution*

1. BNA Surrogate spiking solution is prepared from ampules received from vendor. Base-Neutral compounds are at a concentration level of 1000 μL/mL. Acid compounds are at a concentration level of 1500 μL/mL. Working standards are prepared in Methanol at a concentration of 100 μL/mL for the Base Neutral compounds and 150 μL/mL for the Acid compounds. This solution is prepared in either 250 mL or 100 mL volumetric flasks. The solution is verified by the GC/MS department prior to use.

2. *FOR 100 mL VOLUME:*

COMPOUND	Primary Conc	µL Used	Final Volume	Final Conc.
2-Chlorophenol-d_4	1500 µL/mL	10000	100	150 µL/mL
Phenol-d_6	1500 µL/mL	10000	100	150 µL/mL
2,4,6-Tribromophenol	1500 µL/mL	10000	100	150 µL/mL
2-Fluorophenol	1500 µL/mL	10000	100	150 µL/mL
Nitrobenzene-d_5	1000 µL/mL	10000	100	100 µL/mL
Terphenyl-d_{14}	1000 µL/mL	10000	100	100 µL/mL
2-Fluorobiphenyl	1000 µL/mL	10000	100	100 µL/mL
1,2-Dichlorobenzene-d_4	1000 µL/mL	10000	100	100 µL/mL

3. *FOR 250 mL VOLUME:*

COMPOUND	Primary Conc	µL Used	Final Volume	Final Conc.
2-Chlorophenol-d_4	1500 µL/mL	25000	250	150 µL/mL
Phenol-d_6	1500 µL/mL	25000	250	150 µL/mL
2,4,6-Tribromophenol	1500 µL/mL	25000	250	150 µL/mL
2-Fluorophenol	1500 µL/mL	25000	250	150 µL/mL
Nitrobenzene-d_5	1000 µL/mL	25000	250	100 µL/mL
Terphenyl-d_{14}	1000 µL/mL	25000	250	100 µL/mL
2-Fluorobiphenyl	1000 µL/mL	25000	250	100 µL/mL
1,2-Dichlorobenzene-d_4	1000 µL/mL	25000	250	100 µL/mL

B. BNA Matrix Spiking Solutions

1. BNA Matrix Spiking Solutions are prepared using ampules from Supelco, Inc.. These solutions are made in Methanol at a concentration of 100 µL/mL for Base/Neutral compounds and 150 µL/mL for Acid compounds.

2. *FOR 250 mL VOLUME:*

COMPOUND	Primary Conc	µL Used	Final Volume	Final Conc.
1,2,4-Trichlorobenzene	1000 µL/mL	25000	250	100 µL/mL
Acenaphthene	1000 µL/mL	25000	250	100 µL/mL
2,4-Dinitrotoluene	1000 µL/mL	25000	250	100 µL/mL
Pyrene	1000 µL/mL	25000	250	100 µL/mL
N-Nitroso-di-N-Propylamine	1000 µL/mL	25000	250	100 µL/mL
1,4-Dichlorobenzene	1000 µL/mL	25000	250	100 µL/mL
Pentachlorophenol	1500 µL/mL	25000	250	150 µL/mL
Phenol	1500 µL/mL	25000	250	150 µL/mL
2-Chlorophenol	1500 µL/mL	25000	250	150 µL/mL
4-Chloro-3-Methylphenol	1500 µL/mL	25000	250	150 µL/mL
4-Nitrophenol	1500 µL/mL	25000	250	150 µL/mL

3. *FOR 100 mL VOLUME:*

COMPOUND	Primary Conc	µL Used	Final Volume	Final Conc.
1,2,4-Trichlorobenzene	1000 µL/mL	10000	100	100 µL/mL
Acenaphthene	1000 µL/mL	10000	100	100 µL/mL
2,4-Dinitrotoluene	1000 µL/mL	10000	100	100 µL/mL
Pyrene	1000 µL/mL	10000	100	100 µL/mL
N-Nitroso-di-N-Propylamine	1000 µL/mL	10000	100	100 µL/mL
1,4-Dichlorobenzene	1000 µL/mL	10000	100	100 µL/mL
Pentachlorophenol	1500 µL/mL	10000	100	150 µL/mL
Phenol	1500 µL/mL	10000	100	150 µL/mL
2-Chlorophenol	1500 µL/mL	10000	100	150 µL/mL
4-Chloro-3-Methylphenol	1500 µL/mL	10000	100	150 µL/mL
4-Nitrophenol	1500 µL/mL	10000	100	150 µL/mL

VII. GC/MS ANALYSIS OF EXTRACTABLE ORGANIC COMPOUNDS (BASE/NEUTRALS AND ACIDS)

A. *GC/MS System*

1. Column - 30 m x 0.25 mm ID (or 0.32 mm) bonded-phase silicone coated fused silica capillary column (J & W Scientific DB-5 or equivalent). A film thickness of 1.0 micron is recommended because of its larger capacity. A film thickness of 0.25 microns may be used.

2. GC/Mass Spectrometer - capable of scanning from 35 to 500 amu every 1 second or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum which meets all required criteria when 50 ng of decafluorotriphenylphosphine (DFTPP) is injected through the GC inlet.

3. NOTE: DFTPP criteria (QA/QC SOP) must be met before any sample extracts and/or standards are analyzed.

B. *Reagents*

1. Internal Standards —1,4-Dichlorobenzene-d4, Napthalene-d8, Acenaphthene-d10, Phenanthrene-d10, Chrysene-d12, Perylene-d12. An internal standard solution can be prepared by dissolving 100 mg of each compound in 50 mL of methylene chloride. The resulting solution will contain each standard at a concentration of 2000 ng/µL. A 10 µL portion of this solution should be added to each 1 mL of sample extract. This will give a concentration of 40 ng/2 µL of each constituent.

C. GC/MS Operating Conditions

1. The following instrumental parameters are required for all performance tests and for all sample analyses:

   a. Electron Energy — 70 volts (nominal)

   b. Mass Range — 35 to 500 amu

   c. Scan Time — 1 second per scan

D. Calibration

1. An Initial Calibration must be performed prior to the analysis of any samples and blanks, and after the DFTPP performance check criteria has been met. The concentration of the initial calibration standard 20, 50, 80, 120, 160 ng/2μL injection. The calibration must be checked against the criteria outlined in Table 8, with allowance for up to four target and surrogate compounds. If time remains in the 12 hour time period after the initial calibration has been performed, samples may be analyzed. Quantify the samples using the response factors from the 50 ng/2μL standard.

2. A continuing calibration must be analyzed each 12 hour time period to check the calibration curve. The criteria in Table 8 must be met prior to the analysis of any blanks or samples, and after the DFTPP Performance Check. As with the initial calibration, up to four target compounds may fail the criteria. The concentration of the continuing calibration standard is 50 μg/2μL.

E. Sample Analysis

1. Internal standard solution is added to each sample extract. For water and/or medium soil extracts, add 10 μL of internal standard solution to each accurately measured 1.0 mL of sample extract. Analyze the 1.0 mL extract by GC/MS using a bonded-phase silicone-coated fused silica capillary column. The recommended GC operating conditions to be used are as follows:

   a. Initial Column Temperature Hold — 45°C for 4 minutes

   b. Column Temperature Program — 45-300°C at 12 °C/min.

   c. Final Column Temperature Hold — 300°C for 10 minutes

   d. Injector Temperature — 280°C

   e. Transfer Line Temperature — 300°C

   f. Source Temperature — according to manufacturer's specifications

   g. Injector-Grob-type, splitless Sample Volume — 2 μL

F. Daily Semivolatile Laboratory Procedures

1. Take out standards from refrigerator and set out to equilibrate to room temperature.

2. The operator who removes the standards is also responsible for recording the temperature of the refrigerator into the temperature log.

3. Check the data (surrogate recoveries, internal standard areas linearity) for all of the samples analyzed on the previous day. Complete the instrument log. The details of the QC criteria are described in the SOP attached. The raw data for all of the good data along with DFTPP and calibrations should be kept in "black bins". Complete the instrument run log.

4. Make a list of all reanalysis and reextractions. Fill out corrective action form (copy is attached) and get it approved by your supervisor and send the form to extraction lab for further action.

5. Change the septum and liner. Check for air leaks.

6. Inject 50 ng DFTPP. Check the spectrum by averaging + 1 and background subtracting. If the spectrum meets the criteria, then proceed further. If the criteria is not met, then reanalyze DFTPP or retune the instrument with PFTBA and reanalyze DFTPP. If problem still exists, then check with your supervisor for cleaning of the source. Make a RR file for DFTPP (RR,>datafile,,,=DFTPP,,1P).

7. While the standard is running, makeup a batch file sequence for the samples to be analyzed. Record all of the samples on the instrument run log.

8. Add 10 μL of internal standard mix (2000ppm) to 1 mL of sample extract. Mark the septum of the vial with blue ink to indicate that the internal standard has been added. Take out about 100 μL in the autosampler vial and seal the vial. The sample extract is ready for injection by autosampler.

9. Load the autosampler making sure that the extract is placed exactly in the same location as reported in the sequence file. Make a hard copy of the sequence file to check that all of the header information is correct.

10. Setup to run "FITIC" program to run "TICS" for the samples analyzed on previous day.

11. Replace the standards and sample extracts exactly in the same place in the refrigerator.

12. Tables No. 1 to 11 give a quick reference to the QC requirements.

G. Quantitation

1. TCL components identified shall be quantified by the internal standard method. The internal standard used shall be the one nearest the retention time to that of a given analyte. The EICP area of characteristic ions of analytes listed in Tables 4, 5, and 6 are used. The response factor (RF) from the daily standard analysis is used to calculate the concentration in the sample. Secondary ions may be used if interferences are present. The area of a secondary ion cannot be substituted for the area of a primary ion unless a response factor is calculated using the secondary ion.

2. Calculate the concentration in the sample using the response factor (RF) and the following equation:

3. Water

$$\text{Concentration } (\mu g/L) = \frac{(A_x)\,(I_s)\,(V_t)\,(Df)}{(A_{is})\,(RF)\,(V_o)\,(V_i)}$$

A_x = Area of the characteristic ion for the compound to be measured.
A_{is} = Area of the characteristic ion for the internal standard.
I_s = Amount of internal standard injected in nanograms (ng).
V_o = Volume of water extracted in millimeters (mL).
V_i = Volume of extract injected (μL).
V_t = Volume of concentrated (μL) extract.
Df = Dilution factor. If no dilution is performed, Df = 1.0 Sediment/Soil

$$\text{Concentration } (\mu g/Kg) = \frac{(A_x)\,(I_s)\,(V_t)\,(Df)(2.0)}{(A_{is})\,(RF)\,(V_i)\,(W_s)\,(D)}$$

(Dry weight basis)

A_x, I_s, A_{is}=Same as given for water, above.
V_t = Volume of low level concentrated extract.
V_i = Volume of extract injected (μL).
$D = \frac{100 - \%\ \text{moisture}}{100}$
W_s = Weight of sample extracted (grams).
Df = Dilution factor. If no dilution is performed, Df = 1.0.

4. The factor of 2.0 is used to account for extract not recovered from the GPC cleanup.

5. An estimated concentration for Non-TCL components tentatively identified shall be quantified by the internal standard method. For quantification, the nearest internal standard free of interferences shall be used.

6. Calculate surrogate standard recovery on all samples, blanks and spikes. Determine if recovery is within limits and report on appropriate form.

VIII. OPERATOR VALIDATION, GC/MS DEPARTMENT

A. *GC/MS Operator Validation*

1. Label the internal standards and surrogates on the total ion chromatograms, with abbreviations IS-1, SS-A1, SS-B1, etc.
2. Verify that surrogate recoveries are within the appropriate limits and enter values on the appropriate surrogate recovery forms. (Form II).
3. Output dual display for TCL compounds and library search (ESFLS or FITIC) for non-TCL compounds.
4. After output of the library search for the non-TCL compounds, account for all major peaks in the chromatogram (as either TCL compound or non-TCL compound).
5. Complete the instrument log entirely on daily basis. (Copies of logbook pages are sent to EPA, they must be complete).
6. Complete forms V (DFTPP or BFB) including the analyses performed versus a particular DFTPP or BFB tune. Percent abundances must be recorded using three significant figures.
7. Verify that matrix spike compounds are within the appropriate limits and record values on the matrix spike summary form (Forms III).
8. Verify that there are no saturated TCL Compounds in the run.
9. Verify that all internal standard areas are within a factor of two of the most recent continuing calibration areas.
10. After data review has been completed, make up the appropriate files to be transferred to the PC for diskette deliverables. The files made up and their names must be written in the instrument logbook at the top where it says "other" below the header information.
11. Hard copies of all the manual integrations must be submitted along with the raw data.
12. Make copies of Initial and Continuing Calibration as the calibration may be used for several cases and file them away in your QC file cabinet for the appropriate month.
13. Complete the extraction logs for BNA runs. Initials, date of analysis and QLF.

B. *Remedial Action If Criteria Are Not Met.*

1. If peaks are saturated, the sample must be diluted and reanalyzed. If saturation still persists, the sample must be extracted at a higher level (i.e. medium) and reanalyzed. (IS intensities should be at least 20% or greater in the sample for correct dilution).
2. If a sample is analyzed at medium level, matrix spike and blanks analyses must also be performed for that level.
3. If a surrogate recovery for semivolatiles in any sample is less than 10%, the sample must be reextracted and reanalyzed. If two acid surrogates or two base surrogates are out of

specifications in any sample, the sample must be reextracted and reanalyzed. Before a sample is reextracted, make sure your surrogate spike check is analyzed to ensure that there are no problems with the spiking solution itself. No surrogates can be out of the criteria limits for VOAs or for the blanks for semivolatiles.

IX. INSTRUMENT MAINTENANCE PROCEDURES

A. Procedures

1. Change septum every day.
2. Change liners if dirty samples were run the previous day.
3. Cut column if dirty samples were analyzed the previous day ~ 10 cm to ~1 ft. in length.
4. Change columns when poor chromatography is exhibited by the performance check solution.
5. Clean the source if the septum gets dirty based on your tune and sensitivity.
6. Use the spare source and clean the source from your system as soon as possible.
7. Pump oil will be changed every quarter by HP maintenance (service people).
8. Data system — Heads will be cleaned by HP service and filters changed for disc drives.
9. If there is any other system problems, check with your supervisor.

METHOD	SV	PEST • PCB	OTHER
CONT. EX.			
SEP-F			
SONC.			

☐ RUSH ☐ REEXTRACT ☐ TCLP ☐ DIOXIN

CLIENT: _____ DATE RECEIVED: _____

CASE: _____ EXTRACT DATE: _____

SAMPLE EXTRACTION LOG
SWOK • AATS
Southwest Laboratory of Oklahoma, Inc.
American Analytical & Technical Services, Inc.

SAMPLE ID (EPISODE #)	CLIENT ID	MATRIX - LEVEL	SAMPLE pH	% MOISTURE	DRY WEIGHT	AMOUNT EXTRACTED	EXTRACTED VOLUME	GPC VOLUME	GPC ELUTE VOL	FLORISIL VOL CONC	FLORISIL FW VOL CONC	VOL SV - P	FW PROCESS VOLUME	SCREEN Y/N	MS SV - P	SURR SV - P	BASE pH CONFIRMATION	ACID pH CONFIRMATION	COMMENTS
				%	g	g • mL	mL	mL	mL	mL	mL	mL	mL		µL	µL			

INITIALS	
WEIGHING:	EXTRACTION:
CLEANUP:	KD:
BLOWDOWN:	
SURROG. SPIKER:	VERIFIER:
MATRIX SPIKER:	VERIFIER:
SUBMITTED BY:	REVIEWED BY:

ID NUMBERS
FLORISIL CARTRIDGE #:
GPC COLUMN #:
SURROGATES ID CONC #:
MATRIX SPIKE SOL ID/CONC #(S):
MISC.

COMMENTS

(EX013-0393-01)

33050

Figure 1. Sample Extraction Log

GEL PERMEATION CHROMATOGRAPHY

EXTRACTIONS DEPARTMENT

BENCHMATE:	
COLUMN ID:	
CLIENT:	
FRACTION:	
PROTOCOL:	
CYCLE:	
CASE NUMBER:	

OPERATOR	DATE	TIME	POSITION #	SAMPLE I.D.

COMPOUND	INITIAL R.T.	FINAL R.T.	% DIFFERENCE
PHTHALATE			
METHOXYCHLOR			
PERYLENE			

SWL/AATS • 1700 W. ALBANY • BROKEN ARROW, OKLAHOMA 74012 • OFFICE (918) 251-2858 • FAX (918) 251-2599 [EX002-0492-01]

Figure 2. Gel Permeation Chromatography (GPC) Log

TABLE 1.
DFTPP Key Ions and Abundance Criteria

Mass	Ion Abundance Criteria
51	30.0 - 80.0 percent of mass 198
68	less than 2.0 percent of mass 69
69	Present
70	less than 2.0 percent of mass 69
127	25.0 - 75.0 percent of mass 198
197	less than 1.0 percent of mass 198
198	base peak, 100 percent relative abundance
199	5.0 - 9.0 percent of mass 198
275	10.0 - 30.0 percent of mass 198
365	greater than 0.75 percent of mass 198
441	present but less than mass 443
442	40.0 - 110.0 percent of mass 198
443	15.0 - 24.0 percent of mass 442

TABLE 2.
Surrogate Spike Recovery Limits

Fraction	Surrogate Compound	Water	Low/Medium Soil
BNA	Nitrobenzene-d_5	35-114	23-120
BNA	2-Flourobiphenyl	43-116	30-115
BNA	p-Terphenyl-d_{14}	33-141	18-137
BNA	phenol-d_5	10-94	24-113
BNA	2-Flourophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122
BNA	2-Chlorophenol-d4	33-110	20-130 (Advisory)
BNA	1,2-Dichlorobenzene-d4	16-110	20-130 (Advisory)

TABLE 3.
Matrix Spike Recovery Limits

Fraction	Matrix Spike Compound	Water	Soil/Sediment
BN	1,2,4-Trichlorobenzene	39-98	38-107
BN	Acenaphthene	46-118	31-137
BN	2,4-Dinitrotoluene	24-96	28-89
BN	Pyrene	26-127	35-142
BN	N-Nitroso-Di-n-Propylamine	41-116	41-126
BN	1,4-Dichlorobenzene	36-97	28-104
Acid	Pentachlorophenol	9-103	17-109
Acid	Phenol	12-110	26-90
Acid	2-Chlorophenol	27-123	25-102
Acid	4-Chloro-3-Methylphenol	23-97	26-103
Acid	4-Nitrophenol	10-80	11-114

TABLE 4.
Characteristic Ions for Semivolatile TCL Compounds

Parameter	Primary Ion	Secondary Ion(s)
Phenol	94	65, 66
bis (-2-Chloroethyl) Ether	93	63, 95
2-Chlorophenol	128	64, 130
1,3-dichlorobenzene	146	148, 113
1,4-Dichlorobenzene	146	148, 113
1,2-Dichlorobenzene	146	148, 113
2-Methylphenol	108	107
2,2'-oxybis(1-Chloropropane)	45	77, 79
4-Methylphenol	108	107
N-Nitroso-Di-Propylamine	70	42, 101, 130
Hexachloroethane	117	201, 199
Nitrobenzene	77	123, 65
Isophorone	82	95, 138
2-Nitrophenol	139	65, 109
2,4-Dimethylphenol	107	121, 122
bix (-2-Chloroethoxy) Methane	93	95, 123
2,4-Dichlorophenol	162	164, 98
1,2,4-Trichlorobenzene	180	182, 145
Naphthalene	128	129, 127
4-Chloroaniline	127	129
Hexachlorobutadiene	225	223, 227
4-Chloro-3-methylphenol	107	144, 142
2-methyl(napthalene)	142	141
Hexachlorocyclopatadiene	237	235, 272
2,4,6-Trichlorophenol	196	198, 200
2,4,5-Trichlorophenol	196	198, 200
2-Chloronaphthalene	162	164, 127
2-Nitroaniline	65	92, 138
Dimethyl Phthalate	163	194, 164
Acenaphthylene	152	151, 153
3-Nitroaniline	138	108, 92
Acenaphthene	153	152, 154
2,4-Dinitrophenol	184	63, 154
4-Nitrophenol	109	139, 65
Dibenzofuran	168	139
2,4-Dinitrotoluene	165	63, 182
2,6-Dinitrotoluene	165	89, 121
Diethylphthalate	149	177, 150
4-Chlorophenyl-phenylether	204	206, 141
Fluorene	166	165, 167
4-Nitroaniline	138	92, 108
4,6-Dinitro-2-Methylphenol	198	182, 77
N-Nitrosodiphenylamine	169	168, 167
4-Bromophenyl-phenylether	248	250, 141
Hexachlorobenzene	284	142, 249
Pentachlorophenol	266	264, 268
Phenanthrene	178	179, 176
Anthracene	178	179, 176

(Table 4 continued on following page)

TABLE 4.
(Continued)

Parameter	Primary Ion	Secondary Ion(s)
Carbazole	167	166, 139
Di-N-Butylphthalate	149	150, 104
Fluoranthene	202	101, 100
Pyrene	202	101, 100
Butylbenzyphthalate	149	91, 206
3,3-Dichlorobenzidine	252	253, 125
Benzo (a) Anthracene	228	229, 226
bis (2-Ethylhexyl) Pthalate	149	167, 279
Chrysene	228	226, 229
Di-N-Octyl Phthalate	149	—
Benzo (b) Fluoranthene	252	253, 125
Benzo (k) Fluoranthene	252	253, 125
Benzo (a) Pyrene	252	253, 125
Indeno (1,2,3-cd) Pyrene	276	138, 227
Dibenz (a,h) Anthracene	278	139, 279
Benzo (g,h,i) Perylene	276	138, 277

TABLE 5.
Characteristic Ions for Pesticides/PCBs

Parameter	Primary Ion	Secondary Ion(s)
Alpha-BHC	183	181, 109
Beta-BHC	181	183, 109
Delta-BHC	183	181, 109
Gamma-BHC (Lindane)	183	181, 109
Heptachlor	100	272, 274
Aldrin	66	263, 220
Heptachlor Epoxide	353	355, 351
Endosulfan I	195	339, 341
Dieldrin	79	263, 279
4,4'-DDE	246	248, 176
Endrin	263	82, 81
Endrin aldehyde	67	250, 345
Endosulfan II	337	339, 341
4,4'-DDD	235	237, 165
Endosulfan sulfate	272	387, 422
4,4'-DDT	235	237, 165
Methoxychlor	227	228
Chlordane (alpha and/or gamma)	373	375, 377
Toxaphene	159	231, 233
Aroclor-1016	222	260, 292
Aroclor-1221	190	222, 260
Aroclor-1232	190	222, 260
Aroclor-1242-	222	256, 292
Aroclor-1248	292	362, 326
Aroclor-1254	292	362, 326
Aroclor-1260	360	362, 394
Endrin Ketone	317	67, 319

TABLE 6.
Characteristic Ions for Surrogate and Internal Standards for Semivolatile Organic Compounds

Compound	Primary Ion	Secondary Ion(s)
SURROGATE STANDARDS		
Phenol-d_5	99	42, 71
2-Fluorophenol	112	64
2,4,6-Tribromophenol	330	332, 141
d-5 Nitrobenzene	82	128, 54
2-Flourobiphenyl	172	171
Terphenyl	244	122, 212
2-Chlorophenol-d_4	132	68, 134
1,2-Dichlorobenzene-d_4	152	115, 150
INTERNAL STANDARDS		
1,4-Dichlorobenzene-d_4	152	115
Naphthalene-d_8	136	68
Acenapthene-d_{10}	164	162, 160
Phenanthrene-d_{10}	188	94, 80
Chrysene-d_{12}	240	120, 236
Perylene-d_{12}	264	260, 265

TABLE 7.
Semivolatile Internal Standards with Corresponding TCL Analytes Assigned for Quantitation

1,4-Dichlorobenzene-d_4	Napthalene-d_8	Acenaphthene-d_{10}
Phenol	Nitrobenzene	Hexachlorocyclopentadiene
bis (2-Chloroethyl) ether	Isophorone	2,4,6-Trichlorophenol
2-Chlorophenol	2-Nitrophenol	2,4,5-Trichlorophenol
1,3-Dichlorobenzene	2,4-Dimethylphenol	2-Chloronaphthalene
1,4-Dichlorobenzene	bis (2-Chloroethoxy) methane	2-Nitroaniline
1,2-Dichlorobenzene	2,4-Dichlorophenol	Dimehtyl Phthalate
2-Methylphenol	1,2,4-Trichlorobenzene	Acenaphthylene
2,2'-oxybis-(1-chloropropane)	Naphthalene	2,4-Dinitrophenol
4-Methylphenol	4-Chloroaniline	4-Nitrophenol
N-nitroso-Di-n-propylamine	Hexachlorobutadiene	Dibenzofuran
Hexachloroethane	4-Chloro-3-methylphenol	3-Nitroanatine
2-Fluorophenol (surr)	2-Methylnaphthalene	1-cenaphthene
Phenol-d6 (surr)	Nitrobenzene-d_5 (surr)	2,4-Dinitrotoluene
2-Chlorophenol-d_4 (surr)		2,6-Dinitrotoluene
1,2-Dichlorobenzene-d_4 (surr)		Diethyl Phthalate
		4-Chlorophenyl phenyl ether
		Fluorene
		4-Nitroaniline
		2-Fluorobiphenyl (surr)
		2,4,6-Tribromo Phenol (surr)
Phenanthrene-d_{10}	**Chrysene-d_{12}**	**Perylene-d_{12}**
4,6-Dinitro-2-methylphenol	Pyrene	Di-n-octyl Phthalate
N-nitrosodiphenylamine	Butylbenzylphthalate	Benzo (b) fluoranthene
4-Bromophenyl Phenyl Ether	3,3'-Dichlorobenzidine	Benzo (k) fluoranthene
Hexachlorobenzene	Benzo (a) anthracene	Benzo (a) pyrene
Pentachlorophenol	bis(2-ethylhexyl) Phthalate	Indeno (1,2,3-cd) pyrene
Penanthrene	Chrysene	Dibenz (a,h) anthracene
Carbazole	Terphenyl-d_{14} (surr)	Benzo (g,h,i) perylene
Anthracene		
Di-n-butyl Phthalate		
Fluoranthene		

Surr = surrogate compound

TABLE 8.
Relative Response Factor Criteria for Initial and Continuing Calibration of Semivolatile Target Compounds

Semivolatile Organic Compounds	Minimum RRF	Maximum %RSD	Maximum %Diff
Phenol	0.800	20.5	25.0
bis(-2-Chloroethyl)ether	0.700	20.5	25.0
2-Chlorophenol	0.800	20.5	25.0
1,3-Dichlorobenzene	0.600	20.5	25.0
1,4-Dichlorobenzene	0.500	20.5	25.0
1,2-Dichlorobenzene	0.400	20.5	25.0
2-Methylphenol	0.700	20.5	25.0
4-Methylphenol	0.600	20.5	25.0
N-Nitroso-Di-propylamine	0.500	20.5	25.0
Hexachloroethane	0.300	20.5	25.0
Nitrobenzene	0.200	20.5	25.0
Isophorone	0.400	20.5	25.0
2-Nitrophenol	0.100	20.5	25.0
2,4-Dimethylphenol	0.200	20.5	25.0
bis(-2-Chloroethoxy)methane	0.300	20.5	25.0
2,4-Dichlorophenol	0.200	20.5	25.0
1,2,4-Trichlorobenzene	0.200	20.5	25.0
Napthalene	0.700	20.5	25.0
4-Chloro-3-methylphenol	0.200	20.5	25.0
2-Methylnaphthalene	0.400	20.5	25.0
2,4,6-Trichlorophenol	0.200	20.5	25.0
2,4,5-Trichlorophenol	0.200	20.5	25.0
2-Chloronapthalene	0.800	20.5	25.0
Acenaphthylene	1.300	20.5	25.0
2,6-Dinitrotoluene	0.200	20.5	25.0
Acenaphthene	0.800	20.5	25.0
Dibenzofuran	0.800	20.5	25.0
2,4-Dinitrotoluene	0.200	20.5	25.0
4-Chlorophenyl-phenylether	0.400	20.5	25.0
Fluorene	0.900	20.5	25.0
4-Bromophenyl-phenylether	0.100	20.5	25.0
Hexachlorobenzene	0.100	20.5	25.0
Pentachlorophenol	0.050	20.5	25.0
Penanthrene	0.700	20.5	25.0
Anthracene	0.700	20.5	25.0
Fluoranthene	0.600	20.5	25.0
Pyrene	0.600	20.5	25.0
Benzo(a)anthracene	0.800	20.5	25.0
Chrysene	0.700	20.5	25.0
Benzo(b)fluoranthene	0.700	20.5	25.0
Benzo(k)Fluoranthene	0.700	20.5	25.0
Benzo(a)pyrene	0.700	20.5	25.0
Ideno(1,2,3-cd)pyrene	0.500	20.5	25.0
Dibenzo(a,h)anthracene	0.400	20.5	25.0
Benzo(g,h,i)perylene	0.500	20.5	25.0
Nitrobenzene-d_5	0.200	20.5	25.0
2-Fluorobiphenyl	0.700	20.5	25.0
Terphenyl-d_{14}	0.500	20.5	25.0
Phenol-d_6	0.800	20.5	25.0
2-Fluorophenol	0.600	20.5	25.0
2-Chlorophenol-d_4	0.800	20.5	25.0
1,2-Dichlorobenzene-d_4	0.400	20.5	25.0

Eight compounds: 2,4-Dinitrophenol, 2,4,5-Trichlorophenol, 2-Nitroaniline, 3, Nitroaniline, 4-Nitroaniline, 4-Nitrophenol, 4,6-Dinitro-2-Methylphenol, and Pentachlorophenol will only require a four-point initial calibration at 50, 80, 120 and 160 total nanograms since detection at less than 50 nanograms per injection is difficult.

Initial calibration 20, 50, 80, 120, and 160 ng.

TABLE 9.
Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)

Semivolatiles	CAS Number	Quantitation Limits** Water µg/L	Low Soil/Sediment[b] µg/Kg
1. Phenol	108-95-2	10	330
2. bis(2-Chloroethyl)ether	111-44-4	10	330
3. 2-Chlorophenol	95-57-8	10	330
4. 1,3-Dichlorobenzene	541-73-1	10	330
5. 1,4-Dichlorobenzene	106-46-7	10	330
6. 1,2-Dichlorobenzene	95-50-1	10	330
7. 2-Methylphenol	95-48-7	10	330
9. 2,2'-oxybis(chloropropane)	108-60-1	10	330
9. 4-Methylphenol	106-44-5	10	330
10. N-Nitroso-di-n-propylamine	621-64-7	10	330
11. Hexachloroethane	67-72-1	10	330
12. Nitrobenzene	98-95-3	10	330
13. Isophorone	78-59-1	10	330
14. 2-Nitrophenol	88-75-5	10	330
15. 2,4-Dimethylphenol	105-67-9	10	330
16. bis(2-Chloroethoxy)methane	111-91-1	10	330
17. 2,4-Dichlorophenol	120-83-2	10	330
18. 1,2,4-Trichlorobenzene	120-82-1	10	330
19. Naphthalene	91-20-3	10	330
20. 4-Chloroaniline	106-47-8	10	330
21. Hexachlorobutadiene	87-68-3	10	330
22. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
23. 2-Methylnaphthalene	91-57-6	10	330
24. Hexachlorocyclopentadiene	77-47-4	10	330
25. 2,4,6-Trichlorophenol	88-06-2	10	330
26. 2,4,5-Trichlorophenol	95-95-4	25	800
27. 2-Chloronaphthalene	91-58-7	10	330
28. 2-Nitroaniline	88-74-4	25	800
29. Dimethylphthalate	131-11-3	10	330
30. Acenaphthylene	208-96-8	10	330
31. 2,6-Dinitrotoluene	606-20-2	10	330
32. 3-Nitroaniline	99-09-2	25	800
33. Acenaphthene	83-32-9	10	330
34. 2,4-Dinitrophenol	51-28-5	25	800
35. 4-Nitrophenol	100-02-7	10	800
36. Dibenzofuran	132-64-9	25	330
37. 2,4-Dinitrotoluene	121-14-2	25	330
38. Diethylphthalate	84-66-2	10	330
39. 4-Chlorophenyl-phenyl ether	7005-72-3	10	330
40. Fluorene	86-73-7	10	330

(Table 9 continued on following page)

TABLE 9.
(Continued)

Semivolatiles	CAS Number	Quantitation Limits** Water µg/L	Low Soil/Sediment[b] µg/Kg
41. 4-Nitroaniline	100-01-6	25	800
42. 4,6-Dinitro-2-methylphenol	534-52-1	25	00
43. N-nitrosodiphenylamine	86-30-6	10	330
44. 4-Bromophenyl-phenyl ether	101-55-3	10	330
45. Hexachlorobenzene	118-74-1	10	330
46. Pentachlorophenol	87-86-5	25	800
47. Phenanthrene	85-01-8	10	330
48. Anthracene	120-12-7	10	330
49. Carbazole	86-74-8	10	330
50. Di-n-butylphthalate	84-74-2	10	330
51. Fluoranthene	206-44-0	10	330
52. Pyrene	129-00-0	10	330
53. Butylbenzylphthalate	85-68-7	10	330
54. 3,3'-Dichlorobenzidine	91-94-1	10	330
55. Benzo(a)anthracene	56-55-3	10	330
56. Chrysene	218-01-9	10	330
57. bis(2-Ethylhexyl)phthalate	117-81-7	10	330
58. Di-n-octylphthalate	117-84-0	10	330
59. Benzo(b)fluoranthene	205-99-2	10	330
60. Benzo(k)fluoranthene	207-08-9	10	330
61. Benzo(a)pyrene	50-32-8	10	330
62. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
63. Dibenz(a,h)anthracene	53-70-3	10	330
64. Benzo(g,h,i)pervlene	191-24-2	10	330

b Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for SemiVolatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

* Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achieveable.

** Quantitation limits ilsted for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

TABLE 10.
Standards Preparation

Compound	Conc. µg/mL	Aliquot µL	Total Vol.	Conc. µg/mL	Volume used/µL
Supelco Internal Std. Mix	2000	2000	4 mL	1000	40
STOCK STANDARD					
Phenolic Mix	2000	400		200	-
Haz. Subst. Mix	2000	400		200	-
Haz. Subst. Mix	2000	400		200	-
PAH Mix	2000	400		200	-
B-N Mix-1	2000	400	4 mL	200	-
B-N Mix-2	2000	400		200	-
Benzidine Mix	2000	400		200	-
Acid Surr. Mix	2000	400		200	-
B-N Surr. Mix	1000	800		200	-
Stock Std.	200	750		50	-
IS Mix	1000	120	3mL	50	-
Stock Std.	200	400		80	-
IS Mix	200	40	1mL	80	-
Stock Std.	200	600		120	-
IS Mix	1000	40	1mL	120	-
Stock Std.	200	800		160	-
IS Mix	1000	40	1mL	160	-
Stock Std.	200	100		20	-
IS Mix	1000	40	1mL	20	-

These standards are verified with EPA standards regularly. Every time a standard is made, it is recorded in the current standards logbook.

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE
FOR THE ANALYSIS OF

METALS

REV 2.1 — 4/18/94

Document Control# SWL-MT910-____

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SECTION 1.0 INDUCTIVELY COUPLED ARGON PLASMA

I. INTRODUCTION

A. This method is used for the determination of dissolved, suspended or total metals in a variety of matrices. Table I lists elements for which this method applies with current wavelengths used and laboratory detection limits. Elements and wavelengths will be added as new methods are developed. Detection limits are updated quarterly.

B. This method describes the technique for the simultaneous multi-element determination of trace metals in solution using a Thermal-Jarrel Ash ICAP-61. The basis of this method is the measurement of atomic emission by an optical spectroscopic technique. Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by photomultiplier tubes. The photo currents from the photomultiplier tubes are processed and controlled by a computer system.

TABLE I. ELEMENTS ANALYZED BY ICP AND THEIR CORRESPONDING WAVELENGTHS AND DETECTION LIMITS.

Element	Wavelength (nm)	Detection Limits, ug/L
Aluminum	308.215	36.0
Antimony	217.581	25.8
Arsenic	193.606	32.1
Barium	493.409	16.1
Beryllium	313.042	0.7
Boron	249.678	42.0
Cadmium	228.802	2.8
Calcium	317.933	207.0
Chromium	267.716	1.9
Cobalt	228.616	7.6
Copper	324.754	3.9
Iron	249.940	27.0
Lead	220.353	17.4
Magnesium	279.079	126.0
Manganese	257.610	2.5
Mercury	194.220	50.0
Molybdenum	202.030	32.9
Nickel	221.604	6.2
Osmium	225.585	—
Phosphorus	214.914	100.0
Potassium	766.491	453.0
Selenium	196.026	27.7
Silicon	288.158	100.0
Silver	328.068	9.0
Sodium	588.995	287.0
Thallium	190.864	32.4
Tin	189.989	80.0
Titanium	334.941	80.0
Vanadium	292.402	6.0
Zinc	213.856	4.0

II. INTERFERENCES

A. Spectral Interferences

1. Overlap of a spectral line from another element compensated by interelement correction by instrument.

2. Unresolved overlap of molecular band spectra may require selection of an alternate wavelength.

3. Background contribution from continuous or recombination phenomena.

4. Background contribution from stray light from the line emission of high concentration elements.

Note: Number 3 and 4 effects can usually be compensated by a background correction adjacent to the analyte line.

B. Physical Interferences - affects associated with the sample nebulization and transport processes. Dilution may be necessary.

III. APPARATUS

A. Thermal-Jarrel Ash ICAP-61 optical emission spectrophotometer.

B. IBM PC/AT computer with ThermoSPEC operating software. Automated background correction and interelement corrections.

C. Radio frequency power supply with 2500 watts capacity.

D. Liquid argon supply, 4300 cu.ft.

E. Gilson - 240 Autosampler with 240 sample positions and 14 QA/QC position.

IV. OPERATING CONDITIONS

A. Start-Up

1. Check that the argon tank main valve is open and the pressure is set to at least 60 psi.

2. Turn on the plasma work coil coolant water and exhaust vents.

3. Check that the drain tube is inserted into a plastic water bottle containing at least 8 inches of water.

4. On the R.F. generator control panel, turn the forward power manual control rheostat knob counter clockwise to the off position.

5. Turn the line and control circuit breaker switches on. The white power on lamp should be illuminated.

6. Turn the torch gas toggle switch on and adjust flow meter to 18, turn the auxiliary flow on to 0.5 and the sample gas flow to 0.6.

7. Purge the torch surfaces, the capillary tube and the drainage tube of air for at least 3 minutes.
8. Check that the blue R.F. off lamp on the generator is illuminated.
9. Turn the Automatic Power Control switch to the manual position.
10. Press the red R.F. on button.
11. Turn the sample gas flow control knob counter clockwise until the flowmeter ball stops falling.
12. To ignite, slowly turn the forward power manual control rheostat knob clockwise until the forward power meter reads 0.5 KW.
13. Press the ignitor button on the front panel of the generator. You should see a faint filamentary plasma swirling in the outer tube of the torch. Gradually increase the forward power until the plasma ignites.
14. Once the plasma is lit, rotate the forward power rheostat knob until the forward power meter reading is 1.0 - 1.1 KW.
15. Turn the automatic power control switch to the automatic position.
16. Introduce the rinse solution into the plasma by rotating the sample gas control knob to a reading of 0.6.

B. Shutdown

1. Press the R.F. OFF button on the R.F. generator control panel.
2. Turn off the gas at the tank while the toggle switches are still open. When both gauges on the tank read 0, turn OFF the toggle switches.
3. Turn off the torch coolant water.
4. Turn the R.F. generator line and control circuit breakers off.

V. REAGENTS AND STANDARDS

A. Nitric Acid, conc.: Baker Instra-analyzed for trace metal Analysis.

B. Nitric Acid (1:1): Add 500 mL conc. HNO_3 to 400 mL ASTM Type II water and dilute to 1 liter.

C. Hydrochloric Acid, conc.: Baker Instra-analyzed for trace metal analysis.

D. Hydrochloric Acid (1:1): Add 500 mL conc HCl To 400mL ASTM Type II water and dilute to 1 liter.

E. Hydrogen Peroxide, 30%: Method Control Blank meets ACS Standards.

F. Standard Stock Solutions

1. Inorganic Ventures, Inc. - use high purity inorganics as starting materials. Place into

solution with purified acids and 18 mega-ohm double deionized water. All standards are traceable to national standards.

2. Spex Industries, Inc. - prepared from 99.995% - 99.999% pure elements assayed by wet chemical methods dissolved in 18 mega-ohm, double deionized water and electronic grade acids. Date solutions are received and opened are posted on each bottle.

G. Blank Solutions

1. Calibration blanks - dilute 2.0 mL of (1:1) HNO_3 and 10.0 mL of (1:1) HCL to 100 mL with ASTM Type II water. This blank is used in establishing the analytical curve and to flush the system between standards and samples.

2. Preparation Blank - contains all the reagents and in the same volumes as used in the processing of the samples. The preparation blank is carried through the complete digestion procedures and contains the same acid concentration in the final solution as the sample solution.

H. Calibration Check Standard: A standard made from a different stock solution as that used for the calibration standards and analyzed immediately after calibration to validate calibration. Concentration of the calibration check standard is approximately at the mid-point of the calibration curve.

VI. SAMPLE PREPARATION

A. Separate operating procedures are written for the digestion of samples to be analyzed by the ICP depending on the matrix of the sample.

VII. ANALYSIS

A. Set up the instrument with proper operating parameters already established. The instrument must be allowed to become thermally stable before beginning. This usually requires at least 30 minutes of operation prior to calibration.

B. Initiate appropriate method file configuration on computer.

C. Calibrate the ICP starting with the highest mixed standard. Flush the system with the calibration blank between each standard. Use at least three replicate exposures for both standardization and sample analysis.

D. Begin the sample run by analyzing the calibration blank and calibration verification check samples. Analyze the blank and calibration check samples every 10 samples. Flush the system with the calibration blank between each sample.

E. Record the analytical sequence on the ICPrun log.

VIII. CALCULATION

A. If dilutions were performed, the appropriate factor must be applied to sample values.

B. Data should be reported in ug/L up to three significant figures.

C. When rounding off values, use guidelines specified in EPA "Handbook for Analytical Quality Control in Water and Wastewater Laboratories".

IX. QUALITY CONTROL

A. Initial Calibration Verification

1. Immediately after the ICP has been calibrated, the accuracy of the initial calibration is verified and documented for every analyte by the analysis of EPA Initial Calibration Verification Solution at each wavelength used for analysis. If the measurements exceed the control limits of 90 - 110% of the true value, the analysis must be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

B. Continuing Calibration Verification

1. To ensure calibration verification during the analysis run, a continuing calibration verification standard is analyzed for every analyte at each wavelength at a frequency of 10% or every 2 hours during an analysis run, whichever is more frequent. The standard is also analyzed for every wavelength used for analysis at the beginning of the run and after the last analytical sample. The same continuing calibration standard must be used throughout the analysis runs for a case of samples received. If the measurements exceed the control limits of 90-110% of the true value, the instrument must be recalibrated and the preceding samples analyzed since the last good calibration verification must be reanalyzed.

C. CRDL Standard

1. To verify linearity near the CRDL an ICP standard at two times the CRDL or two times IDL, whichever is greatest, is analyzed at the beginning and end of each sample analysis, or a minimum of twice per 8 hour working shift, whichever is more frequent. This standard is run for every wavelength used for analysis except these for Aluminum, Barium, Calcium, Iron, Magnesium, Sodium, Potassium. No control limits for this standard have been set at this time.

D. Initial and Continuing Calibration Blank

1. A calibration blank is analyzed at each wavelength used for analysis immediately after each every initial and continuing calibration verification, at a frequency of 10% or every 2 hours during the run, whichever is more frequent. If the absolute value of the blank exceeds the CRDL, terminate analysis, correct the problem, recalibrate and reanalyze all analytical samples analyzed since the last good calibration blank.

E. Preparation Blank

1. At least one preparation blank must be prepared and analyzed with every Sample Delivery Group (SDG), or with each batch of samples digested, whichever is more

ICP RUN LOG

ANALYST: _____ DATE _____

INSTRUMENT: _____ CALIBRATION STD: SOURCE _____

Client ID	SWLO ID	Time	Percent Recovery	Dilution Factor	Analytes (circle)
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn
					Ag, Al, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, V, Zn

frequent. This blank is used to ascertain whether sample concentrations reflect contamination in the following manner:

a. If the absolute value of the blank is less than or equal to the CRDL no corrective action is necessary.

b. If any analyte concentration in the blank is above the CRDL, the lowest concentration of that analyte in the associated samples must be 10x the blank concentration. If not, all samples less than 10x the blank concentration and above the CRDL, must be redigested and reanalyzed for that analyte.

c. If the concentration of the blank is below 10x CRDL, all samples associated with the blank must be redigested and reanalyzed.

F. Interference Check Sample (ICS)

1. To verify interelement and background correction factors an ICP interference check sample is analyzed at the beginning and end of each analysis run or a minimum of twice per 8 hour working shift, whichever is more frequent. The ICS is obtained from EPA and consists of two solutions. Solution A consists of the interferants and solution AB consists of the analytes mixed with the interferants. An ICS analysis consists of analyzing both solutions consecutively for all wavelengths used. Results for the analyses of solution AB must fall within the control limits of $\pm$ 20% of the true value for the analytes. If not, terminate the analysis, correct the problem, recalibrate and reanalyze the analytical samples analyzed since the last good ICS.

G. Matrix Spike Sample

1. The spike solution is added before digestion to provide information about the effect of the sample matrix on the digestion and measurement methodology. At least one spike analysis is performed on each group of samples of a similar matrix type and concentration or for each Sample Delivery Group (SDG), whichever is more frequent.

2. Samples identified as field blanks cannot be used for spiked sample analysis.

3. If the spike recovery is not within the limits of 75-125% the data of all samples received associated with that spike sample and determined by the same analytical method will be flagged with the letter "N". An exception to this is when the sample concentration exceeds the spike concentration by a factor of four or more.

H. Post Digested Spike

1. When the pre-digested spike recovery falls outside the control limits and the sample result does not exceed 4x the spike added, a post-digested spike is performed except for Silver.

2. Spike the unspiked aliquot of the sample at 2x the indigenous level or 2x CRDL whichever is greater.

I. Duplicate Sample

1. One duplicate sample is analyzed from each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent.

2. Samples identified as field blanks cannot be used for duplicate sample analysis.

3. A control limit of 20% for relative percent difference (RPD) is used for original and duplicate sample values greater than or equal to 5x CRDL. A control limit of ± CRDL is used for sample values less than 5x CRDL.

J. Laboratory Control Sample (LCS)

1. Aqueous and solid LCS are analyzed for each analyte using the same sample preparations, analytical methods and QA/QC procedures employed for the samples. The aqueous LCS is obtained form EPA (or use the initial calibration verification solution). One aqueous LCS is prepared and analyzed for every group of aqueous samples in a Samples Delivery Group, or for each batch of aqueous samples digested, whichever is more frequent. If the percent recovery for the aqueous LCS falls outside the control limits of 80-120% (exception: Ag and Sb), the analyses must be terminated, the problem corrected, and the samples associated with that LCS redigested and reanalyzed.

2. The EPA provided solid LCS is prepared and analyzed using the same procedures as the samples, one solid LCS must be prepared and analyzed for every group of solid samples in a Sample Delivery Group, or for each batch of samples digested, whichever is more frequent. If the result for the solid LCS falls outside the control limits established by the EPA, the analyses must be terminated, the problem corrected and samples associated with that LCS redigested and reanalyzed.

K. ICP Serial Dilution

1. The ICP Serial Dilution analysis is performed on each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent.

2. Samples identified as field blanks cannot be used for serial dilution analysis.

3. If the analyte concentration is at least a factor of 50 above the instrument detection limit in the original sample, an analysis of a 5 fold dilution must agree within 10% of the original determination.

L. Instrument Detection Limits

1. Detection limits for the ICP are determined quarterly (every 3 months). The detection limits are determined on three nonconsecutive days using the following protocol:

   a. A low level standard at three to five times the estimated IDL is measured seven times and the standard deviation is multiplied by three.

   b. The average detection limit for the three days is the IDL.

M. Interelement Corrections

1. Interelement corrections are determined quarterly by analyzing 1000 ppm standards of the interferants and determining the effect on the analytes.

N. Linear Ranger

1. A linear range check standard is analyzed quarterly for each element analyzed by ICP. The analytically determined concentration must be within ± 5% of the true value. This concentration is the upper limit of the ICP linear range beyond which results cannot be reported without dilution of the analytical sample.

SECTION 2.0 MATRIX SPIKE SOLUTIONS

I. SUMMARY

A. At least one predigested spike sample analysis must be performed on each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent. The following is the procedures for preparing the spiking solutions used.

II. ICP/AA SOLUTION #1

A. Using Class A volumetric pipettes, add IV-30, IV-40, 1000 ppm antimony and cadmium at the following volumes to a 100 mL volumetric flask. Add 2 mL of conc. HNO_3 and dilute to 100 mL with ASTM Type II water.

ELEMENT	Conc. of Stock Sol.	mL of stock Sol./100 mL	Final Conc. spiking sol.(ppm)	Conc. in matrix spike (ug/L)
Aluminum	20000	1.0	200	2000
Antimony	1000	5.0	50	500
Barium	20000	1.0	200	2000
Beryllium	50	10.0	5	50
Cadmium	1000	0.5	5	50
Chromium	200	1.0	20	200
Cobalt	500	10.0	50	500
Copper	250	10.0	25	250
Iron	1000	10.0	100	1000
Manganese	500	10.0	50	500
Nickel	500	10.0	50	500
Vanadium	500	10.0	50	500
Zinc	500	10.0	50	500

B. For aqueous samples add 1.0 mL of spiking solution. Final volume of digestate = 100 mL.

C. For soil samples add 2.0 mL of spiking solution. Final volume of digestate = 200 mL.

III. ICP/AA SOLUTION #2

A. Using a Class A volumetric pipette add the 1000 ppm stock standard at the following volume to a 100 mL volumetric flask. Add 2.0 mL of conc. HNO_3 and dilute to 100 mL with ASTM Type II water. This solution should be made fresh weekly.

ELEMENT	mL of 1000 PPM Std/100 mL	Conc. of Spiking Solution (PPM)	Final Conc. in Matrix Spike (ug/L)
Silver	0.5	5	50

B. For aqueous samples add 1.0 mL of spiking solution. Final volume of digestate = 100 mL.

C. For soil samples add 2.0 mL of spiking solution. Final volume of digestate = 200 mL.

IV. ICP/AA SOLUTION #3

A. Using Class A volumetric pipettes add the 100 ppm stock standards at the following volumes to a 100 mL volumetric flask. Add 2 mL of conc. HCl and dilute to 100 mL with ASTM Type II water.

ELEMENT	mL of 1000 PPM Std/100 mL	Conc. of Spiking Solution (PPM)	Final Conc. in Matrix Spike (ug/L)
Arsenic	20.0	200	2000
Lead	5.0	50	500
Selenium	20.0	200	2000
Thallium	20.0	200	2000

B. For aqueous samples add 1.0 mL of spiking solution. Final volume of digestate = 100mL.

C. For soil samples add 2.0 mL of spiking solution. Final volume of digestate = 200 mL.

V. FURNACE SOLUTION #4

A. Using Class A volumetric pipettes make a 100 ppm intermediate stock solution for the elements listed below. This is done by adding 10 mL of the 1000 ppm stock solution to a separate 100 mL volumetric flask. Add 2 mL of conc. HNO_3 and dilute to 100 mL. For the matrix spike solution add the appropriate amounts of the 100 ppm intermediate stock solution to a 100 mL volumetric flask. Add 2 mL of conc. HNO_3 and dilute to 100 mL with ASTM Type II water.

ELEMENT	mL of 1000 PPM Std/100 mL	Conc. of Spiking Solution (PPM)	Final Conc. in Matrix Spike (ug/L)
Arsenic	4.0	4.0	40
Cadmium	0.5	0.5	5
Lead	2.0	2.0	20
Selenium	1.0	1.0	10
Thallium	5.0	5.0	50

B. For aqueous samples add 1.0 mL of spiking solution. Final volume of digestate = 100 mL.

C. For soil samples add 2.0 mL of spiking solution. Final volume of digestate = 200 mL.

VI. MERCURY SOLUTION #5

A. Using Class A volumetric pipettes make a 10 ppm intermediate stock solution by adding 1.0 mL of the 1000 ppm stock solution to a 100 mL volumetric flask. Add 2 mL of conc. HNO_3 and dilute to 100 mL. For the matrix spike solution add the appropriate amount of the 10 ppm intermediate stock solution to a 100 mL volumetric flask. Add 2.0 mL conc. HNO_3 and dilute to 100 mL with ASTM Type II water.

ELEMENT	mL of 1000 PPM Std/100 mL	Conc. of Spiking Solution (PPM)	Final Conc. in Matrix Spike (ug/L)
Mercury	1.0	100	1.0

B. For both aqueous and soil samples add 1.0 mL of spiking solution. Final volume of digestate = 100 mL.

C. The matrix spike solution should be made fresh each day of use.

VII. CYANIDE SOLUTION #6

A. Using a Class A volumetric pipette add the 1000 ppm stock standard at the following volume to a 100 mL volumetric flask. Add 1.0 gram of NaOH and dilute to 100 mL with ASTM Type II water. This solution should be made fresh daily.

ELEMENT	mL of 1000 PPM Std/100 mL	Conc. of Spiking Solution (PPM)	Final Conc. in Matrix Spike (ug/L)
Cyanide	5.0	50	100

A. For both aqueous and soil samples add 1.0 mL of spiking solution. Final volume of digestate = 250 mL.

SECTION 3.0 Summary of Furnace Analysis

I. SAMPLES ARE RECEIVED FROM CLIENTS

II. SAMPLE LOG IN TO LIMS SYSTEM

A. Sample Custodians will assign the proper test codes to each sample according to the customers traffic log.

III. SAMPLE PREPARATION FOR FURNACE AND MERCURY METALS

A. By looking at LIMS the Inorganic or Metals Program Manager will assign digestions that are required.

B. The Sample Prep Technician will then digest or prep samples according to the procedure of the methods used.

C. After being prepped, he/she will place the digestion in the designated cabinet.

IV. WORKSHEETS AND PRIORITY LIST

A. The Furnace Supervisor or the Senior Furnace Operator will make up the worksheets for the furnace metals.

B. Then they will place the digestion on the priority list.

V. ANALYSIS FOR REQUIRED METALS

A. The first thing the analyst will decide is which digestion he/she will do. This will be dictated by the priority list.

B. Before starting the actual analysis, the analyst will decide what protocol they will have to use (either Private or CLP), then run samples according to that protocol.

C. Once an analyst finishes what he/she is working on, they will look the priority list and the folder with the rest of the worksheets, and start working on the next group of digested samples that is due.

VI. WRITE-UPS FOR EACH RUN TO BE DONE

A. When the run is done, the analyst will fill out the worksheet and do the write-up according to protocol.

VII. DATA REVIEW

A. Once the write-up is done it will be required to be given to the Furnace Supervisor or the Senior Furnace Operator for data review.

VIII. DATA GIVEN TO DATA CLERKS

A. After the data has been reviewed, all CLP protocol data will go to the Inorganic Data Clerks, and the Private protocol will go into the instrument box for storage.

IX. DATA TAKEN OFF LIMS AND WORKBOOK

A. After the data has been reviewed and the digestion is completely analyzed, the Furnace Supervisor will designate a person to enter the results in LIMS and put it in the book if necessary.

X. STORAGE AND DISPOSAL OF SAMPLES

A. After each digestion has been analyzed for all elements required, they will be stored for a predetermined length of time.

B. After the predetermined length of time is up, the samples will be disposed of according to protocol.

SECTION 4.0 Graphite Furnace Atomic Absorption Spectrometry

I. INSTRUMENTATION

A. 1 — Perkin Elmer 5000 spectrophotometer HGA-500 Furnace Zeeman background correction

AS-40 auto sampler

As, Se EDL lamps

B. 1 — Thermo Jarrell Ash Video 22E AA spectrophotometer

CTF 188 Atomizer

Smith-Hieftye background correction

ISC 75 microprocessor controlled auto sampler

Pb, Tl HCL lamps

*The TJA22 is also supplied with air which powers the door mechanism on the auto sampler.

C. 2 — Perkin Elmer 5100 spectrophotometer

HGA-600 Furnace

Zeeman background correction

AS-60/70 auto sampler

As, Pb, Se, Tl EDL lamps

Pb, Tl HCL lamps

*All instruments are supplied with zero grade Argon and cooled with water coolers filled with distilled water.

II. DAILY OPERATION

A. If the analyst has any problem with the daily operation of the instruments, they are instructed to look at the accompanying manuals

III. THEORY OF GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROPHOTOMETRY

A. Every analyst should thoroughly understand the principles and practices of atomic absorption. Should you need references upon this subject, consult the following text:

1. Graphite Furnace AAS, a Source Book, Slavin, W.

2. Concepts, Instrumentation, and Techniques in Atomic Absorption Spectrophotometry, Beaty, R.D.

IV. SAFETY INFORMATION

A. Never look directly at the furnace during the atomization state without the proper eye protection.

B. Never touch the atomizer cell until it has returned to ambient temperature.

C. Follow standard safety procedures for the handling of hazardous materials.

V. PARAMETERS

A. Parameters for each instrument and element are placed in a logbook (which is explained in the last section of this SOP). It should be noted that the temperatures are employed as guidelines. Since temperature sensing mechanisms and temperature controllers can vary with time, the validity of the furnace parameters must be periodically confirmed by systemically altering the furnace parameters while analyzing a standard. In this manner, losses of analyte due to higher than necessary temperature settings or losses in sensitivity due to less than optimum settings can be minimized.

VI. ROUTINE MAINTENANCE

A. Everyday before replacing the graphite tube, wipe off the excess carbon residue on the contact rings.

B. As the contact rings are being wiped off, check for wear and if worn, replace them.

C. Clean the quartz windows daily with methanol and dry with a soft, lint-free cloth.

D. Clean the workhead surface daily.

E. Make sure the water reservoir is full and empty the waste bottle daily.

F. For other required maintenance, check with the accompanying instrument manual.

* Directions for changing contact rings and replacing graphite tubes are in the respective instrument manuals.

VII. TROUBLE SHOOTING

A. Each instrument manual has a section on trouble shooting common problems within each system. It is therefore advised that each analyst consult these manuals first.

B. If the instrument manual fails to show any light on the problem, it is advised to ask one of the managers or the Lead Furnace Operator.

C. If none of these are around, you are advised to call one of the following:

SAMPLE DIGESTION RECORD

INORGANICS DEPARTMENT

Digestion Date: _____ Digestion Batch #: _____ Analyst: _____

Matrix: _____ Type of Analysis: _____ Client: _____ Page _____ of Book _____

Sample ID	Client ID	Beaker #	Initial Wt/Vol g/mL	Final Vol (mL)	Description, Water-Color, Clarity, Soil-Color, Texture Artifacts	pH <2>	Comments (Spiking Sol)	Soil Preparation			
								Pan wt(g)	Wet wt(g)	Dry wt (g)	Solid %

SOUTHWEST LABORATORY OF OKLAHOMA, INC.
1700 WEST ALBANY • BROKEN ARROW, OK 74012-1421 • (918) 251-2858 • FAX (918) 251-2599

[IN029-1193-01]

1. Electronics Plus (Alan Brasil or Rollie Scot)
   Telephone Number (918) 250-1505

   Electronics Plus has our maintenance contracts for the TJA22 and the PE5000. They will be helpful for most problems with these instruments.

2. Perkin-Elmer (Ernie Riggs or Art Ingraham)
   Telephone Number (918) 743-5302 or 743-5303

   Ernie and Art are our Field Service Engineers for both of the PE5100s. Call either one of them if we have any mechanical problems with the instrument. They will also be able to answer a limited amount of technical questions.

3. Perkin-Elmer (Martha Cole)
   Telephone Number (713) 530-5554

   Martha is an applications specialist and should be able to answer all technical questions.

4. Thermo-Jarrel Ash (ask for AA specialist)
   Telephone Number (508) 520-1880

   At this phone number you should be able to get any answers you have that Electronics Plus could not answer.

SECTION 5.0 Elemental Analysis — As, Pb, Se, Tl

I. APPLICATION

A. Tested Concentration Range:

1. Arsenic: 10.0 - 100.0 ug/l
2. Lead: 3.0 - 100.0 ug/l (Perkin-Elmer 5100s)
   3.0 - 50.0 ug/l (TJA22)
3. Selenium: 5.0 - 50.0 ug/l
4. Thallium: 10.0 - 50.0 ug/l

B. Instrument Detection Limits

1. We will determine these every three months as required by the EPA. They are determined by running 7 consecutive measurements of a 3x - 5x standard solution on three nonconsecutive days. Then taking the standard deviations of each day and adding them together, we will receive the IDL for that instrument.

C. Interferences

1. Molecular absorption bands - the use of background correction should eliminate this interference.
2. Memory effects - clean tube by operating at atomization temperature.
3. Carbide formation - the use of a pyrolytically coated graphite tube reduces this interference.
4. Anion interference - the use of nickel nitrate matrix modifier reduces this effect.

D. Safety Information

1. Never look directly at the furnace during the atomization state without the proper eye protection.
2. Never touch the atomizer cell until it has returned to ambient temperatures.
3. Follow standard safety procedures for the handling of hazardous materials.

II. PREPARATION OF STANDARDS

A. Source of all the standards we use are from separate Plasma-Chem standards containing 1000.0 mg/l of each of the elements. The exception is the standard for the ICV and LCSW, which we receive from the EPA.

B. Two intermediate standards are made every 8 weeks, while two more intermediate standards are made every week.

C. All calibration standards are made up every day.

D. All calibration standards are made up with ASTM Type II water and made as 1% HNO . Specific directions of how to make them up and when, are at the beginning of the calibration and standards notebook.

III. INSTRUMENT CALIBRATION

A. Calibration

1. Set up spectrophotometer, furnace and autosampler according to manufacturers recommendations.

2. Analyze the calibration blank to establish the baseline.

3. Optimize the instrument by adjusting operating parameters to achieve maximum response.

4. Beginning with the blank and working toward the highest standard, inject the solutions and record the readings.

B. Analysis of Calibration Data

1. Tabulate the calibration standard concentration versus peak area response for each calibration standard.

2. Analyze the data by linear regression on calculator. Correction coefficients must be greater than 0.995 before proceeding with analysis.

IV. INSTRUMENTAL ANALYSIS

A. Set up instrument parameters according to current optimized parameters, as discussed in Section V of the Graphite Furnace AA Spectrometry.

B. Calibrate instrument following procedure in Section III.

C. Analyze samples using the appropriate Protocol as explained in the next section.

SECTION 6.0 Protocol — CLP & Private

I. CALIBRATION CHECKS

A. Initial Calibration Verification

1. After the system has been calibrated, the accuracy of the initial calibration shall be verified and documented by the analysis of an EPA supplied standard at a concentration other than that used for calibration, but within the calibration range.

2. The measurement must be within + or - 10% of the trace value or the analysis must be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

B. Calibration Blank

1. A calibration blank is analyzed immediately after the calibration verifications.

2. Blanks are to be reported down to the instrument detection limit.

3. If the absolute value of the blank is greater than 3.0 ppb, terminate analysis, correct the problem and recalibrate.

C. Continuing Calibration Verification

1. To assure calibration accuracy during each analysis run, an independently prepared standard solution, will be analyzed at the frequency of 10% or 20 injections after the last analytical sample.

2. If the deviation of continuing calibration verification is greater than + or - 10% of the true value, the instrument will be recalibrated and the proceeding 10 samples reanalyzed.

D. Sample Analysis

1. Analyze each sample, except during Full Method of Standard Addition (MSA) with duplicated injections. If the value is within the calibration range, record the concentration values for both injections, the average value and the coefficient of variation (CV). For concentrations greater than the CRDL, the CV between duplicate injections must agree within 20%, or the sample must be rerun once.

2. All analytical samples, except the predigested spike sample, requires an analytical spike to determine if the MSA will be required for quantitation. For lead the spike concentration will be 20.0 ppb., all others will be 2 x CRDL. The analytical spike of a sample will be run immediately after that sample. The percent recovery (%R) of the spike will then determine how the sample will be quantitated as follows:

   a. If the spike recovery is less than 40%, the sample will be diluted by a factor of 5 and rerun with another spike. If after dilution the spike recovery is still <40%, the data will be reported and flagged with an "E" to indicate interference problems.

   b. If the spike recovery is greater than 40% and the sample concentration is <50% of the spike, the sample result will be reported to the IDL. If the spike recovery is less than 85% or greater than 115%, the data will be flagged with a "W".

c. If the sample concentration is >50% of the spike and the spike recovery is between 85%-115%, the sample will be quantitated directly from the calibration curve and reported to the IDL.

d. If the sample concentration is ≥ 50% of the spike and the spike recovery is <85% or >115%, the sample must be quantitated by MSA.

3. The following will be used for MSA analysis:

a. Data from MSA calculations will be within the linear range as determined by the calibration curve generated at the beginning of the analytical run.

b. The sample and three spikes will be analyzed consecutively for MSA quantitation, only single injections will be used.

c. Spikes will be prepared such that:

Spike 1: is approximately 50% of the sample absorbance.

Spike 2: is approximately 100% of the sample absorbance.

Spike 3: is approximately 150% of the sample absorbance.

d. The data for each MSA analysis will be identified in the raw data documentation along with the slope, intercept, and correlation coefficient (r) for the least squares fit of the data. Reported values obtained by MSA will be flagged on the data sheet with the letter "S" if the correlation coefficient is greater than or equal to 0.995.

e. If the correlation coefficient (r) is less than 0.995, the MSA analysis will be repeated once. If the correlation coefficient is still less than 0.995, the result with the best correlation coefficient will be reported and flagged with a "+".

E. The above procedure is the procedure for CLP protocol. It is also further explained in Section E of your SOW 7/88 & 7/89. For Private Client protocol, ask your supervisor.

SECTION 7.0 Raw Data Requirements

I. SAMPLE LABELING

A. All CLP Protocol must be labeled with EPA Sample Number and AATS I.D. Number.

B. All Non-CLP Protocol must be labeled with AATS I.D. and client name.

II. CODES FOR LABELING DATA

A. Table 1 located on page B-11 of SOW 7/88 is used to identify the following on all raw data:

1. Calibration standards, including source and preparation date.
2. Initial and Continuing Calibration Blanks and Preparation Blanks.
3. Initial and Continuing Calibration Verification standards, CRA standards.
4. Diluted and undiluted samples and all dilutions and volumes used to obtain the reported values.
5. Duplicates.
6. Spikes (indicating standard solutions used, final spike concentrations, and volumes used).
7. Instrument used, any instrument adjustments, data corrections or other apparent ab normalities in the measurement record, including all data voided or data not used to obtain reported values and a brief written explanation in the case narrative.
8. All information for each furnace analysis clearly and sequentially identified on the raw data:

   a. EPA Sample Number

   b. Sample and analytical spike data

   c. Percent recovery

   d. Coefficient of variation

   e. Full MSA data:

      - MSA correlation coefficient
      - Slope
      - Intercepts of linear fit
      - Final sample concentration (standard addition concentration)
      - Type of background correction used:

        BZ for Zeeman

        BS for Smith-Heiftje

**NOTE: For any samples on which MSA's are required, the samples will be labeled "0", "1", "2", or "3" at the end of the Sample I.D., with the value of the spike added by "1", "2", or "3".*

9. Time and date of each analysis. Instrument run logs can be submitted if they contain this information.

   a. If the instrument does not automatically provide times of analysis, these must be manually entered on all raw data for Initial and Continuing Calibration Verifications and Blanks, as well as Calibration standards and CRDL standards.

10. Integration times for AA analysis.

SECTION 8.0 Logbook Write-up (Manually)

I. HEADER INFORMATION

A. Analyst: Fill in the analyst's initials, then your initials (JDR/JDR).

B. Date: Write in the day or days it was done on in the following format; mm/dd/yy.

C. Instrument: Fill in the instrument that the data was run on.

D. Bkgrd: Fill in the background correction used upon the analysis.

E. Element: Write in the element being analyzed.

F. Wavelength: Fill in the element's wavelength.

G. Calibration Source: Write in "Plasma-Chem STD 1A."

H. Calibration Prep Date: Fill in the first day of analysis.

II. CALIBRATION FOR ANALYSIS

A. Underneath the concentration column write in S###, with the ### standing for the concentration value for that standard.

B. Under the ABS column fill in the average absorbance for each standard (excluding S0 in which you would write in AZ).

1. If the analyst does happen to run more than 5 standards, then continue down into the samples box.

C. Under the r column (after you cross the "r" out and write in "Time") fill in the time for each analysis.

III. SAMPLES BOX

A. In the Client I.D. column should go the following:

1. EPA numbers
2. Private Client Numbers (if they are CLP Protocol)
3. Client Names (if Private Protocol)

**Note: The Private and EPA CLP protocol numbers at times will have/might have one of the following at the end of the number: D, S, 0, 1, 2, 3, or A.*

B. In the AATS I.D. column should go the following:

1. QA/QC (ICV, ICB, CRA, CCV, CCB, PBS, PBW, LCSS, LCSW, BLK, BLK SPK);
2. AATS I.D.'s (which include all in the following format: ####.##)

**Note: If there is an MSA on the run, write in the AATS number for the first one, then write in on the spiked samples the value it was spiked at.*

C. The first Burn ABS/Conc. column should be used for the times of each analysis. Cross out the heading and write "Time" above the box. For PE5100 runs, the times should be on the raw data and for the TJA22 and PE5000, the times should be written in manually.

D. The second Burn ABS/Conc. column is used only for the absorbance of MSA's. Write in the absorbance only. The concentrations are not needed for MSA's. Circle the "ABS" in the heading when using this column.

E. In the Average ABS/Conc. column should be written all of the average concentrations exactly how they are shown on the raw data.

F. The Dilution Factor column is used for designating dilutions. For example, a sample that was diluted 1:4 will have a final concentration X 5. Write the dilution factor in for both the straight sample and the analytical sample.

G. The Final Concentration column should be used for all the final calculated data. For diluted samples, be sure to multiply by the correct factor. For CLP Protocol samples under the IDL, write in the IDL in this column. For Non-CLP Protocol samples under the CRDL, write in the CRDL. For example: a CLP Protocol sample has a value of 0.80. The IDL is 2.0, therefore, the value written in is 2.0U. The same applies for Non-CLP Protocol. When rounding up numbers, use the following rule: less than 10 = 2 significant figures; greater than 10 = 3 significant figures.

H. The Comments column is used for writing the following:

1. True Value/Percent Recovery: for ICV, CCV, matrix and analytical spikes.
2. MSA: If the sample requires one.
3. HRSD(S) or (A): with the % RSD between injections written above. (S) stands for the sample and (A) stands for the analytical sample.
4. L%R: If the percent recovery of the analytical spike is <40%.
5. Overcal: This is for samples higher than our largest standard.
6. Dil X:X: to call for a dilution next time we run that sample.
7. Any explanation about the performance of the instrument or the order of samples.

IV. MULTI-PAGE WRITE-UPS

A. When going onto the next page with the same calibration, the calibration box does not have to be written up again. Only fill out the header information as detailed in Section I, A-H. This applies to all pages under the same calibration.

SECTION 8.0 Automatic Data Write-Ups

I. PERKIN-ELMER 5100S

A. Before starting the analysis, make sure you have put in your data file of XYYYYZZ;

1. X is either A or B depending on which instrument is used.
2. Y is the month and day.
3. Z is the hour the run is started.

B. The next step is to reformat the files.

1. Enter "Reformat Files" in windows selection.
2. Select the file desired to be reformatted from the selection on the screen and press "Enter".
3. From the list of selections, select Smartlog.
4. After you have typed out the appropriate date, file select "Execute Reformat".

C. Now to copy the file to the diskette:

1. Exit to DOS
2. Go into the \AA_USER\AA_FILES data directory.
3. Type "COPY XYYYYZZ.PRN A:"

D. The next step is to transfer it to the Telecations software. After you reach the Smartlog Program on another computer:

1. Load the Furnace file
   a. Go to the "Load File" option and hit "Enter".
   b. Choose "F5" for an archive file.
   c. Type "FURNACE". You are now in the \ARCHIVES\FURNACE directory.
2. Load the data file
   a. Cursor to "Automatic" and hit "Enter".
   b. Choose "F5" for ASCII file.
   c. Type "A:XYYYYZZ.PRN", and press "Enter".
   d. Type "8;1;16;57;40;17;41;0" to choose the fields, press "Enter", and press "F10" to load.

E. Choose "Data Review" from the main menu, and press "F2" to review all data. You will need to make sure everything is entered correctly and in accordance with the manual write-up requirements.

F. To type out the run, after updating the data, you will need to isolate the run;

1. Choose "Data Review"

   a. Isolate the data by "Report Name"

   b. Type in the given report name

   c. When the isolated data comes up on the screen, press "F8" for "Print Report"

   d. You would then press "F6" for "Custom"

   e. Then type in the correct report name and press "Enter.

G. As for now the TJA22 and PE5000 do not have the capabilities for automatic write-ups, but are expected soon.

- Procedures may change due to the process of an upcoming network.

- This is a short summery covering the automatic data entry. If any further information is needed, refer to "Logbook Write-Up - Manually".

SECTION 9.0 Worksheet Requirements

I. WORKSHEETS

A. Worksheets should be finished by the instruments that started them under the same linear range.

B. When starting a new worksheet, always look on the prepped furnace case sheet on the clipboard to find the case which is due first. Always start the case which is due the soonest, unless told otherwise.

1. When a sample is finished:

a. Write your initials and the date in the Date/Analyst column. If the entire case worked, with no reruns, put an arrow all the way down the column. If there are any reruns, adjust arrows accordingly.

b. The Result column is the actual concentration, rounded to necessary significant figures. The IDL or CRDL is also written in this column. When a figure is written in this column, this signifies that the sample has been done.

c. The Comments column is used to write the instrument used, as well as rerun comments.

(1) The following initials are used for instruments:

PE5100A — A
PE5100B — B
PE5000 — P
TJA22 — T

(2) The following comments are to be written in case of reruns:

- HRSD(S) — write %RSD above when RSD of sample is >20%
- HRSD(A) — write %RSD above when RSD of analytical sample is >20%
- L %R — when analytical recovery is <40%
- MSA — write concentration of sample above
- H dil (X:X) — be sure to write in dilution needed when concentration is above calibration curve.

B. Attach worksheet to raw data and logbook write-up and place in appropriate box for data review.

SECTION 10.0 Keeping of Books

I. MAINTENANCE LOGBOOK

A. Maintenance Logbooks are kept to record any adjustments, instrument repair, part replacement, etc. The analyst should also note any problems or anything they might perceive to be a problem with the instrument in the future. After the entry, the analyst is required to initial and date it.

II. PARAMETERS LOGBOOK

A. This book is designed to keep track of the most current optimized conditions of the HGA programs. When a HGA program is changed, it is up to the analyst to place the new parameters into the parameters book under the correct instrument, and date the most current one.

III. CALIBRATION STANDARDS

A. The procedure of how and when each standard, ICV, modifier needs to be made is in the front of the Calibration and Stock Standards book.

B. The "Preparation Dates of Furnace Calibration Standards and Modifiers" sheet is pretty much self explanatory. At the top of the sheet is a place for all the Log numbers of the chemicals used. Each sheet is designed for a week of prep, the date of each day goes on top of the ======= entry. The initials of the analyst who did the prep goes on the line corresponding with the date and standard done.

IV. INVENTORY BOOK

A. The purpose of this book is to keep track of all the parts we use on our instruments to make sure we have the necessary backup supplies. The three sheets are the following:

1. Parts List: to be filled out for each instrument or instruments if similar. These should be updated every two weeks and then the sheet dated and signed.

2. Running Inventory: the sheet is kept to show when we replaced or used a part on one of the instruments.

3. Lamp Log: is kept for keeping track of each lamp as we receive them. This is done in case we can return it under warranty for replacement. So it is important for the analyst to record all information on the Lamp Log that there is room for.

SECTION 11.0 MERCURY ANALYSIS IN WATER BY COLD VAPOR

I. APPLICATION

A. Tested concentration range: 0.2 to 10.0 ug/l.

B. Approximate instrument detection limit: 0.15 ug/l.

C. Interferences:

1. Sulfide — eliminated by the addition of potassium permanganate.

II. APPARATUS

A. Instrumentation

1. Leeman Labs PS200 Automated Mercury Analyzer.
2. Instrumentation Laboratories Model 440 Atomic Vapor Accessory.
3. Zero-grade argon.

B. Reagents

1. Sulfuric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
2. Sulfuric acid, 0.5 N: Dilute 14.0 mL of conc. sulfuric acid to 1.0 liter.
3. Nitric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
4. Hydrochloric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
5. Stannous chloride: Add 25 grams stannous chloride to 500 mL 25% HCl. Filter solution through a #4 Whatman filter paper.
6. Sodium chloride - hydroxylamine hydrochloride solution: Dissolve 12 grams of NaCl and 12 grams hydroxylamine hydrochloride in Millipore water and dilute to 100 mL.
7. Potassium permanganate, 5% solution, w/v: Dissolve 5 grams of potassium permanganate in 100 mL of Millipore water.
8. Potassium persulfate, 5% solution, w/v: Dissolve 5 grams of potassium persulfate in 100 mL of Millipore water.

C. Parameters

1. Wavelength: 253.3 nm
2. Rinse Time: 50 seconds
3. Pump Speed: 5mL/min.

FURNACE RUNLOG

AATS / SWOK

WAVELENGTH:			INTEGRATION TIME:	INSTRUMENT:	ANALYST/DATE:
Arsenic	=	193.70	5.0 Sec.		
Lead	=	283.30			
Selenium	=	196.00	BKGRND CORRECTION:	DATA FILE:	ELEMENT RAN:
Thallium	=	276.00			AS PB SE TL

#	Lab ID #	Client ID #	Used	Used
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				

#	Lab ID #	Client ID #	Used	Used
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				
31.				
32.				
33.				
34.				
35.				
36.				
37.				
38.				
39.				
40.				

4. Readout mode Absorbance
5. Integration time: 10.0 seconds
6. Gas Flow: 0.3L/min.

III. PROCEDURE

A. Standard Preparation

1. Stock solutions for mercury are prepared solutions from PlasmaChem containing 1,000 mg mercury/l.
2. An intermediate stock solution of 10.0 mg/l mercury is prepared by diluting 1.0 mL of stock solution and 1.0 mL of conc. HNO_3 to 100 mL with ASTM Type II water. This standard is prepared weekly.
3. A second intermediate solution of 0.1 mg/l mercury is prepared each day of analysis by diluting 1.0 mL of the 10.0 mg/l intermediate stock solution and 1.0 mL of conc. HNO_3 to 100 mL with ASTM Type II water. Make fresh daily.
4. Calibration standards are prepared by diluting the 0.1 mg/l intermediate standard to 100 mL with ASTM Type II water according to the following schedule:

Standard Calibration ug/l	mL of 0.1 mg/l Intermediate Standard
0.0	0.0
0.2	0.2
1.0	1.0
5.0	5.0
10.0	10.0

5. Working calibration standards are prepared fresh each day of analysis and carried through the digestion procedure outlined in Section III.B.

B. Sample Preparation

1. Add the standards prepared above in Section III.A.4. to 250 mL glass bottle.
2. Transfer 100 mL of well mixed sample to a 250 mL glass bottle.
3. Add 5 mL of conc. sulfuric acid and 2.5 mL of conc. nitric acid to each bottle.
4. Add 5 mL of $KMnO_4$ solution to each bottle and allow to stand at least 15 minutes.
5. Add 8 mL of potassium persulfate to each bottle.
6. Heat for 2 hours in a water bath at 95°C.
7. Cool and add 5 mL of sodium chloride-hydroxylamine sulfate solution to reduce the excess permanganate.

C. Calibration

1. Instrument Calibration

   a. Set up instrument according to manufacturers recommendations.

   b. Attach the stannous chloride to the Pump Assembly.

   c. Fill water bath with 10% HCl.

   d. Rinse system or a minimum of 40 minutes before starting calibration.

   e. Check aperature reading. If > ± 100, adjust, wait 10 minutes, and recheck.

   f. Place fresh drying tube containing Magnesium Perchlorate into system.

   g. Place calibration standards into cups, then rack.

   h. Build autosampler table, then add sample to cups.

   i. Press F2 macro. Type STANDARD, then press enter key.

2. Analysis of Calibration Data

   a. Tabulate the calibration standard concentration versus absorbance response for each calibration standard.

   b. Analyze data by linear regression. The correlation coefficient must be greater than 0.995 before proceeding with analysis.

   c. If data is acceptable, press "A" to accept calibration curve.

3. Calibration Checks

   a. Initial Calibration Verification

      - After the system has been calibrated, the accuracy of the initial calibration shall be verified and documented by the analysis of an EPA supplied standard carried through the digestion procedure.

      - The measurement must be within ± 20% of the true value or the analysis must be terminated, the problem corrected, the instrument recalibrated and the calibration reverified.

   b. Calibration Blank

      (1) A calibration blank is analyzed at the beginning and end of the run and at a frequency of 10% during the run.

      (2) Blanks are to be reported down to the instrument detection limit.

      (3) If the blank result is greater than 0.2 ppb, terminate analysis, correct the problem and recalibrate.

   c. Continuing Calibration Verification

      (1) To assure calibration accuracy during each analysis run, an independently

prepared standard solution carried through the digestion procedure will be analyzed at a frequency of 10% and after the last analytical samples.

(2) The mercury concentrations will be at the mid-range level of the calibration curve.

(3) If the deviation of the continuing calibration verification is greater than 20%, the instrument will be recalibrated and the proceeding samples since the last calibration verification will be reanalyzed.

D. Instrument Analysis

1. Set up instrument parameters as discussed in Section II.C.
2. Calibrate instrument as discussed in Section III.C.1.
3. Add samples to the autosampler and press F8 sample to start analysis run.
4. Report mercury concentrations as follows:
   a. Below 0.2 ug/l = 0.2 u
   b. Between 0.2 and 10 ug/l = one decimal place
   c. Above 10 ug/l = three significant figures
5. After analysis remove drying tube, rinse with deionized water, then 1:1 HNO_3, then deionized water again. Place in drying oven overnight.
6. Soak water bath in 1:1 HCl overnight.

IV. QUALITY CONTROL

A. Initial calibration verification: Analyzed immediately after instrument calibration. Control limits are $\pm$ 20% of the true value. (Supplied by EPA).

B. Initial calibration blank: Analyzed immediately after initial calibration verification. Control limits are $\pm$ 0.2 ug/l.

C. Continuing calibration verification: Analyzed at a frequency of 10% or every two hours during an analysis run, whichever is more frequent. Control limits are 80% to 120% of the true value.

D. Continuing calibration blank: Analyzed at a frequency of 10% or every two hours during an analysis run, whichever is more frequent. Control limits are $\pm$ 0.2 ppb.

E. Preparation blank: At least one preparation blank must be prepared and analyzed with every Sample Delivery Group or with each batch of samples digested, whichever is more frequent.

F. Matrix spike sample: At least one spike analysis is performed on each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever

is more frequent. Samples identified as field blanks cannot be used for spiked sample analysis.

G. Post-digested spike: When the matrix spike sample recovery falls outside the control limits of 75% to 125% and the sample concentration does not exceed 4 times the spike added, a post-digested spike is performed. Spike the unspiked aliquot of the sample at 2 times the indigenous level or 2 times CRDL, whichever is greater.

H. Duplicate sample: One duplicate sample is analyzed from each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent. Samples identified as field blanks cannot be used for duplicate sample analysis. A control limit of 20% for relative percent difference (RPD) is used for original and duplicate sample values greater than or equal to 5 times CRDL. A control limit of ± CRDL is used for sample values less than 5 times CRDL.

I. Laboratory control sample: An aqueous LCS is not required for accuracy.

J. Holding times: The holding time for mercury is 21 days from verified time of sample receipt to sample digestion.

SECTION 12.0 MERCURY ANALYSIS IN SOIL BY COLD VAPOR

I. APPLICATION

A. Tested concentration range: 0.1 — 5.0 mg/kg.

B. Approximate detection limit: 0.08 mg/kg.

C. Interferences:

1. Sulfide — eliminated by the addition of potassium permanganate.

II. APPARATUS

A. Instrumentation

1. Leeman Labs PS200 Automated Mercury Analyzer.
2. Zero-grade argon.

B. Reagents

1. Sulfuric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
2. Sulfuric acid, 0.5 N: Dilute 14.0 mL of conc. sulfuric acid to 1.0 liter.
3. Nitric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
4. Hydrochloric acid, conc.: Baker Instra-Analyzed for trace metals analysis.
5. Stannous chloride: Add 25 grams stannous chloride to 500 mL 25% HCl. Filter solution through a #4 Whatman filter paper.
6. Sodium chloride - hydroxylamine hydrochloride solution: Dissolve 12 grams of NaCl and 12 grams hydroxylamine hydrochloride in Millipore water and dilute to 100 mL.
7. Potassium permanganate, 5% solution, w/v: Dissolve 5 grams of potassium permanganate in 100 mL of Millipore water.
8. Potassium persulfate, 5% solution, w/v: Dissolve 5 grams of potassium persulfate in 100 mL of Millipore water.

C. Parameters

1. Wavelength: 253.3 nm
2. Rinse Time: 50 seconds
3. Pump Speed: 5mL/min.
4. Readout mode: Absorbance
5. Integration time: 10.0 seconds
6. Gas Flow: 0.3 L/min.

III. PROCEDURE

A. Standard Preparation

1. Stock solutions for mercury are prepared solutions from PlasmaChem containing 1,000 mg mercury/l.

2. An intermediate stock solution of 10.0 mg/l mercury is prepared by diluting 1.0 mL of stock solution and 1.0 mL of conc. HNO_3 to 100 mL with ASTM Type II water. This standard is prepared weekly.

3. A second intermediate solution of 0.1 mg/l mercury is prepared each day of analysis by diluting 1.0 mL of the 10.0 mg/l intermediate stock solution and 1.0 mL of conc. HNO_3 to 100 mL with ASTM Type II water. Make fresh daily.

4. Calibration standards are prepared by diluting the 0.1 mg/l intermediate standard to 100 mL with ASTM Type II water according to the following schedule:

Standard Calibration ug/l	mL of 0.1 mg/l Intermediate Standard
0.0	0.0
0.2	0.2
1.0	1.0
5.0	5.0
10.0	10.0

5. Working calibration standards are prepared fresh each day of analysis and carried through the digestion procedure outlined in Section III.B.

B. Sample Preparation

1. Add the standards prepared above in Section III.A.4. to 250 mL glass bottle..

2. Weigh a representative 0.2 gram portion of wet sample and place in a 250 mL glass bottle.

3. Add 5.0 mL of conc. sulfuric acid and 2.5 mL of conc. nitric acid to each bottle.

4. Add 50 mL distilled water, 5 mL potassium permanganete and 8 mL of potassium persulfate solution.

5. Mix thoroughly and place in the water bath for 30 minutes at 95°C.

6. Cool and add 5 mL of sodium chloride-hydroxylalmine sulfate.

8. Add 55 mL of distilled water.

C. Calibration

1. Instrument Calibration

   a. Set up instrument according to manufacturers recommendations.

   b. Attach the stannous chloride to the pump assembly.

   c. Fill water bvath with 10% HCl.

d. Rinse system for a minimum of 40 minutes before starting calibration.

e. Check aperature reading. If >± 100, adjust, wait 10 minutes, and recheck.

f. Place fresh drying tube containing Magnesium Terchlorate into system.

g. Place calibration standards into cup, then autosampler.

h. Press F2 macro. Type STANDARD, then press enter key.

2. Analysis of Calibration Data

a. Tabulate the calibration standard concentration versus absorbance response for each calibration standard.

b. Analyze data by linear regression. The correlation coefficient must be greater than 0.995 before proceeding with analysis.

c. If data is acceptable, press "A" to accept calibration curve and then return to main menu.

3. Calibration Checks

a. Initial Calibration Verification

(1) After the system has been calibrated, the accuracy of the initial calibration shall be verified and documented by the analysis of an EPA supplied standard carried through the digestion procedure.

(2) The measurement must be within ± 20% of the true value or the analysis must be terminated, the problem corrected, the instrument recalibrated and the calibration reverified.

b. Calibration Blank

(1) A calibration blank is analyzed at the beginning and end of the run and at a frequency of 10% during the run.

(2) Blanks are to be reported down to the instrument detection limit.

(3) If the blank result is greater than 0.2 ppb, terminate analysis, correct the problem and recalibrate.

c. Continuing Calibration Verification

(1) To assure calibration accuracy during each analysis run, an independently prepared standard solution carried through the digestion procedure will be analyzed at a frequency of 10% and after the last analytical samples.

(2) The mercury concentrations will be at the mid-range level of the calibration curve.

(3) If the deviation of the continuing calibration verification is greater than 20%, the instrument will be recalibrated and the proceeding samples since the last calibration verification will be reanalyzed.

D. Instrument Analysis

1. Set up instrument parameters as discussed in Section II.C.

2. Calibrate instrument as discussed in Section III.C.1.

3. At main menu press A—Autosampler, S—Setup. Build autosampler table, add samples to autosampler, and press F8 Sample to start run.

4. Convert concentrations to dry weight by the following:

$$\text{Concentration, ug/g} = \frac{C \times V}{W}$$

Where: C = concentration , ug/l

V = final volume in liters after sample preparation

W = weight in grams of wet sample in preparation

IV. QUALITY CONTROL

A. Initial calibration verification: Analyzed immediately after instrument calibration. Control limits are ± 20% of the true value. (Supplied by EPA).

B. Initial calibration blank: Analyzed immediately after initial calibration verification. Control limits are ± 0.2 ug/l.

C. Continuing calibration verification: Analyzed at a frequency of 10% or every two hours during an analysis run, whichever is more frequent. Control limits are 80% to 120% of the true value.

D. Continuing calibration blank: Analyzed at a frequency of 10% or every two hours during an analysis run, whichever is more frequent. Control limits are ± 0.2 ppb.

E. Preparation blank: At least one preparation blank must be prepared and analyzed with every Sample Delivery Group or with each batch of samples digested, whichever is more frequent.

F. Matrix spike sample: At least one spike analysis is performed on each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent. Samples identified as field blanks cannot be used for spiked sample analysis.

G. Post-digested spike: When the matrix spike sample recovery falls outside the control limits of 75% to 125% and the sample concentration does not exceed 4 times the spike added, a post-digested spike is performed. Spike the unspiked aliquot of the sample at 2 times the indigenous level or 2 times CRDL, whichever is greater.

H. Duplicate sample: One duplicate sample is analyzed from each group of samples of a similar matrix type and concentration or for each Sample Delivery Group, whichever is more frequent. Samples identified as field blanks cannot be used for duplicate sample analysis. A control limit of 20% for relative percent difference (RPD) is used for original and duplicate sample values greater than or equal to 5 times CRDL. A control limit of ± CRDL is used for sample values less than 5 times CRDL.

I. Laboratory control sample: The EPA-provided solid LCS is prepared and analyzed using the sample procedures as the soil samples. If the result for the solid LCS falls outside the control limits established by EPA, the analyses must be terminated, the problem corrected and the samples associated with the LCS redigested and reanalyzed.

J. Holding times: The EPA-CLP holding time for mercury is 21 days from verified time of sample receipt to sample digestion.

MERCURY RUN LOG

Calibration			
Std.#	Conc.	Abs.	r
Std.0			
Std.1			
Std.2			
Std.3			
Std.4			

Analyst_____ Date_____

Instrument_____ Bkgrd_____

Element_____ Wavelength_____

Calibration Standard: Source_____ Prep Date_____

Client I.D.	SWLO I.D.	Time of Analysis	wt/vol	Percent ABS	Dilution Factor	Final Concentration ug/l mg/kg	Comments

SWLO FORM 1027W (12/89)

075

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF

CYANIDE

IN120
REV 4.1 — 1/25/95

Document Control #: SWL-IN120- 017

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APPROVALS BY:

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I. MIDI DISTILLATION PROCEDURE FOR TOTAL CYANIDES IN WATER

A. *Distillation Summary*

1. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution.

B. *Interferences*

1. The presence of surfactants may cause the sample to foam during refluxing. If this occurs, the addition of an agent such as Dow Corning 544 Antifoam Agent will prevent the foam from collecting in the condenser.

C. *Apparatus*

1. Midi-reflux distillation apparatus having a 100 mL boiling flask, gas-dispersion tube, allihn water-cooled condenser, air-inlet tube, vacuum source and screw clamp to adjust vacuum flow.

D. *Distillation Reagents*

1. Sodium hydroxide solution, 0.25 N: Dissolve 10 grams of NaOH in distilled water. Dilute to 1 liter with distilled water.
2. Sulfuric Acid; 50%: Carefully add 500 mL of concentrated H_2S0_4 to 400 mL of distilled water. After the solution cools, dilute to 1 liter.
3. Magnesium chloride solution: Weigh 510 grams of $MgCl_2 \cdot 6H_2O$ into a 1000 mL flask. Dissolve and dilute to 1 liter with distilled water.
4. Ascorbic Acid, Analytical Reagent Grade.
5. Bismuth Nitrate: Dissolve 30.0 grams of $Bi(NO_3)_3$ in 100 mL of deionized water. While stirring, add 250 mL of glacial acetic acid. Stir until dissolved. Dilute to 1 liter with deionized water.
6. Sulfamic Acid: Dissolve 40 g of sulfamic acid in deionized water. Dilute to 1 liter.

E. *Distillation Procedure*

1. Test a drop of sample for the presence of chlorine using potassium iodide starch paper. A blue color indicates the need for treatment. Add ascorbic acid a few crystals at a time until a drop of sample produces no color on the indicator. Then add an additional 0.6 g of ascorbic acid for each liter of water.
2. Place 50 mL of sample into the 100 mL boiling flask.
3. Add 30 mL of 0.25 N sodium hydroxide to the absorbing tube.
4. Connect the boiling flask, condenser/absorber and trap in the train.
5. Start a slow stream of air entering the boiling flask by adjusting the screw clamp on the vacuum line. Adjust the vacuum so that approximately three bubbles of air per second enters the boiling flask.

   NOTE: The bubble rate will not remain constant after the reagents have been added and while heat is being applied to the flask. It will be necessary to readjust the air rate occasionally to prevent the solution in the boiling flask from backing up into the air inlet tube.

6. Use lead acetate paper to check the sample for the presence of sulfide. A positive test is indicated by a black color on the paper. If positive, treat the sample by adding 5.0 mL of Bismuth Nitrate solution through the air inlet tube after the air rate is set.
7. Slowly add 5 mL 50% sulfuric acid through the air inlet tube. Rinse the tube with distilled water and allow the airflow to mix the flask contents for 5 minutes.
8. Pour 2 mL of magnesium chloride solution into the air inlet and wash down with a stream of water.
9. Add 5.0 mL of sulfamic acid solution into the air inlet tube.
10. Heat the solution to boiling and reflux for one hour.
11. Turn off the heat and continue the air flow for at least 15 minutes.
12. After cooling the boiling flask, disconnect the absorber and close off the vacuum source. Quantitatively transfer contents of the absorber tube to a plastic, 100 ml, snap-cap container.
13. Adjust the final volume to 50 ml with NaOH solution by weighing on a top-loading balance (50.00 g ± 0.25 g.)
14. Seal the receiving solutions and store at 4°C until analyzed.
15. Document all distillation details in the Sample Distillation Record Log (see figure 1). The analyst must then sign and date the log.

II. Midi-Distillation Procedure For Total Cyanides In Soil

A. Interferences

1. The presence of surfactants may cause the sample to foam during refluxing. If this occurs, the addition of an agent such as Dow Corning 544 Antifoam Agent will prevent the foam from collecting in the condenser.

B. Apparatus

1. Midi reflux distillation apparatus having a 100 mL boiling flask, gas-dispersion tube, allihn water-cooled condenser, air-inlet tube, vacuum source and screw clamp to adjust vacuum flow.

C. Distillation Reagents

1. Sodium hydroxide solution, 0.25 N: Dissolve 10 grams of NaOH in distilled water. Dilute to 1 liter with distilled water.
2. Sulfuric Acid; 50%: Carefully add 500 mL of concentrated H_2S0_4 to 400 mL of distilled water. After the solution cools, dilute to 1 liter.
3. Magnesium chloride solution: Weigh 510 grams of $MgCl_2 \cdot 6H_2O$ into a 1000 mL flask Dissolve and dilute to 1 liter with distilled water.
4. Sulfamic acid: Dissolve 40g of sulfamic acid in deionized water. Dilute to 1 liter.

D. Distillation Procedure

1. Place 1.0g ± 0.5 grams of sample into the 100 mL boiling flask.
2. Add 50 mL of distilled water. Shake the sample so that it is dispersed.
3. Add 30 mL of sodium hydroxide to the absorbing tube.
4. Connect the boiling flask, condenser/absorber and trap in the train.
5. Start a slow stream of air entering the boiling flask by adjusting the screw clamp on the vacuum line. Adjust the vacuum so that approximately three bubbles of air per second enters the boiling flask through the air inlet tube.

   NOTE: The bubble rate will not remain constant after the reagents have been added and while heat is being applied to the flask. It will be necessary to readjust the air rate occasionally to prevent the solution in the boiling flask from backing up into the air inlet tube.
6. Slowly add 5 mL 50% sulfuric acid through the air inlet tube. Rinse the tube with distilled water and allow the air flow to mix the flask contents for 3 minutes.
7. Pour 2 mL of magnesium chloride solution into the air inlet and wash down with a stream of water.
8. Add 5 mL of sulfamic acid solution into the air inlet tube.
9. Heat the solution to boiling and reflux for one hour.
10. Turn off the heat and continue the air flow for at least 15 minutes.
11. After cooling the boiling flask, disconnect the absorber and close off the vacuum source. Quantitatively transfer contents of the absorber tube to a plastic, 100 ml, snap-cap container.
12. Adjust the final volume to 50 ml with NaOH solution by weighing on a top-loading balance (50.00 g ± 0.25 g.)
13. Seal the receiving solutions and store at 4°C until analyzed.
14. Document all distillation details in the Sample Distillation Record Log (see fig. 1).

III. Total Cyanide Analysis In Water And Soil

A. Tested Concentration Range: 10 to 200 μg/l

B. Principle

1. Total cyanide from alkaline distillates is converted to cyanogen chloride, CNCl, by reaction with chloramine-T at pH lower than 8. The CNCl then forms a red-blue dye by reacting with pyridine-barbituric acid reagent. The color is read at 570 nm.

C. Interferences

1. See distillation procedure.

SWLO / AATS Sample Digestion Record

Date : 12/09/1994 Batch: Analyst: DSF
Type : IN120 TOTAL CYANIDE Client: Matrix: W

LAB ID	Client ID	TYP	Initial Wt/Vol	Final Wt/Vol	Color Before	Color After	Texture	pH	Comments
ICV	ICV1191	LB1	50.0 ML	50.0 ML					0.5ML ICV06
CRA		LB1	50.0 ML	50.0 ML					0.5ML 10UG/ML KCN
PBW941209B		LB1	50.0 ML	50.0 ML					
LCW941209B		BS1	50.0 ML	50.0 ML					0.5ML 10UG/ML KCN
LBW941209B		BS1	50.0 ML	50.0 ML					0.5ML 10UG/ML KCN
20770.09	CYANIDE	PE	50.0 ML	50.0 ML				>12	10.0ML TO 1L. D.I.
20776.01	11772.01		50.0 ML	50.0 ML				>12	
20776.02	11772.02		50.0 ML	50.0 ML				>12	
20780.01	D-8		50.0 ML	50.0 ML				7.0	
20790.01	PIT		50.0 ML	50.0 ML				>12	
20791.01	COOK ROOM		50.0 ML	50.0 ML				7.0	
4.01	D-1-A		50.0 ML	50.0 ML				7.0	
20804.02	D-2-A		50.0 ML	50.0 ML				>12	
20804.03	D-3-A		50.0 ML	50.0 ML				>12	
20804.04	C-1B		50.0 ML	50.0 ML				7.0	
20804.05	EQUIP BLANK #1		50.0 ML	50.0 ML				>12	

FIGURE 1 SAMPLE DISTILLATION RECORD EXAMPLE PRINTOUT

D. Instrumentation

1. Lachat QuikChem Automated Flow Injection Analyzer which includes:
   a. Automatic sampler
   b. Proportioning pump
   c. Injection valve module with a 150cm, 0.8mm i.d. sample loop
   d. Flow cell, 10mL
   e. Interference filter wavelength, 570 nm
   f. Heater module
   g. Reaction module 10-204-00-1-A

E. Reagents

1. *Sodium hydroxide solution, 1.25 N:* Dissolve 50 grams NaOH in distilled water and dilute to 1 liter.
2. *Sodium hydroxide solution, 0.25 N:* Dissolve 10 grams NaOH in distilled water and dilute to 1 liter.
3. *Phosphate Buffer, 0.71 M:* Dissolve 97 grams anhydrous potassium dihydrogen phosphate (potassium phosphate, monobasic, anhydrous, KH PO) in a one liter volumetric flask containing 800 mL of deionized water. Dilute to the mark and mix well. D. Chloramine-T solution: Dissolve 2.0 grams of chloramine-T hydrate in 500 mL of deionized water. Prepare fresh weekly.
4. *Pyridine-Barbituric Acid Reagent:* In the fume hood, place 15.0 grams barbituric acid in a 1 liter beaker and add 100 mL of water, rinsing down the sides of the beaker to wet the barbituric acid. Add 75 mL pyridine with stirring and mix until the barbituric acid dissolves. Add 15 mL concentrated hydrochloric acid and mix. Transfer to a 1 liter volumetric flask, dilute to the mark and mix.
5. *Sulfamic acid:* Dissolve 40g of sulfamic acid in deionized water and dilute to 1 liter.

F. Initial Calibration

1. *Preparation of standards*
   a. *Stock cyanide solution:* Dissolve 2.51 grams of KCN and 2 grams NaOH in one liter of deionized water. Standardize with 0.0192 N AgNO (1 mL = 1.0 mg).
   b. *Standard cyanide solution:* Dilute 1.0 mL of stock solution to 100 mL with distilled water (1 mL = 10 μg).
   c. *Standard silver nitrate solution, 0.0192 N:* Prepare by crushing approximately 5 grams of AgNO crystals and drying to constant weight at 40°C. Weigh out 3.2647 grams of dried AgNO . Dissolve in distilled water and dilute to 1000 mL (1 mL = 1 mg CN^-).

d. *Calibration standards:* Prepare by diluting the 10.0 mg/l standard solution to 250 mL with 0.25 N sodium hydroxide according to the following schedule:

mL of Standard Solution, (10 mg/l)	conc. μg CN^- per 500 mL
0.0	0.0
0.5	10.0
2.5	50.0
5.0	100.0
10.0	200.0

e. Prepare calibration standards daily.

f. Prepare Standard Preparation Log with lot number of KCN used and preparation date.

2. *Instrument Calibration and Analysis*

a. Turn on power to all modules. Allow heater to warm up to 60°C.

b. Place reagent transmission lines into proper containers. Raise tension levers on pump tube cassettes.

c. Pump system until a stable baseline is attained.

d. Set baseline. If necessary, manually inject a high standard to set gain on colorimeter.

e. Program autosampler system.

f. Place calibration standards and blank in sample tray in descending order of concentration followed by QA/QC and unknown samples.

g. Submit tray and start run.

h. At end of run, place all transmission lines in water and flush.

i. Remove lines from water and pump dry.

j. Turn off pump, all modules, and release pump tube cassettes.

3. *Calibration Checks*

a. *Initial Calibration Verification*

(1) After the system has been calibrated, the accuracy of the initial calibration shall be verified and documented by the analysis of an independent standard carried through the distillation procedure. The concentration of the standard will be different than that used for calibration, but within the calibration range.

(2) The measurement must be within $\pm$ 15 % of the true value or the analysis must be terminated, the problem corrected, the instrument recalibrated and the calibration reverified.

b. Calibration Blank

(1) A calibration blank, carried through the distillation procedure, is analyzed at the beginning and the end of the run, and at a frequency of 10% during the run.

(2) Blanks are to be reported down to the instrument detection limit.

(3) If the absolute value of the blank is greater than 10 ppb, terminate analysis correct the problem and recalibrate.

c. Continuing Calibration Verification

(1) To assure calibration accuracy during each analysis run, an independently prepared solution, carried through the distillation procedure, will be analyzed at a frequency of 10% and after the last analytical sample.

(2) The cyanide concentration will be at the mid-range level of the calibration curve.

(3) If the deviation of the continuing calibration verification is greater than 15%, the instrument will be recalibrated and the proceeding samples, since the last continuing calibration verification, will be reanalyzed.

G. Calculations

1. Calculate the cyanide, in mg/kg as follows:

$$\frac{A * 0.05}{B}$$

Where:

A = μg/l CN^- from analysis
B = wet weight of original sample in grams

2. Water samples are calculated by the instrument in μg/L.

IV. REFERENCES

A. U.S. EPA "Standard Methods for the Evaluation of Water and Wastewater," Method 4500, 18th edition.

B. U.S. EPA SW846, Method 9010.

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

CN^- ANALYSIS LOGSHEET

Analyst: _____ EPA Case No.: _____

Distillation Date: _____ SDG No.: _____

Lab Batch No.: _____

EPA Sample #	Lab Sample #	Absorbance	(mg)	Dilution Factor	Initial Weight (g) Volume (ml)	Final Concentration ug/l mg/kg

Distillate Transfer

Removed from Storage	Returned to Storage
Area #: _____	Area #: _____
By: _____	By: _____
On: _____	On: _____

Received by _____ Date _____

Logbook No.: _____

Page No.: _____

SWLO FORM - 1026W

FIGURE 2 CYANIDE ANALYSIS LOGSHEET

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RED STAMP INDICATES ORIGINAL

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF NITROAROMATICS & NITRAMINES BY HPLC

GC200
REV 2.2 — 2/3/95

DOCUMENT CONTROL #SWL-GC200- 013

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APPENDIX A ..... SALTING-OUT EXTRACTION METHOD

APPENDIX B ..... SALTING-OUT EXTRACTION METHOD(MEHOD 8330)

APPENDIX C ..... Chromatogram Examples

I. SCOPE AND APPLICATION

A. Method 8330 is intended for the analysis of explosives residues. This method is limited to use by analysts experienced in handling and analyzing explosive materials. This method is used to determine the concentration of the following compounds in a water, soil or sediment matrix:

Compound	Abbrev	CAS No[a]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	TNB	99-35-4
1,3-Dinitrobenzene	DNB	99-65-0
Methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-3
2,4,6-Trinitrotoluene	TNT	118-96-7
2,4-Dinitrotoluene	24DNT	121-14-2
2,6-Dinitrotoluene	26DNT	606-20-2
o-Nitrotoluene	2NT	88-72-2
m-Nitrotoluene	3NT	99-08-1
p-Nitrotoluene	4NT	99-99-0
2-amino-4,6,dinitrotoluene	2ADNT	355-72-78-2
4-amino-2,6-dinitrotoluene	4ADNT	1946-51-0

[a] Chemical Abstracts Service Registry number

B. All of these compounds are either used in the manufacture of explosives or are the degradation products of compounds used for that purpose. When making stock solutions for calibration, treat each compound as if it were extremely explosive.

C. The estimated quantitation limits (EQLS) of target analytes are presented in Table 7.

D. This method is restricted to use by or under the supervision of analysts experienced in the use of HPLC, skilled in the interpretation of chromatograms, and experienced in handling explosive materials. Each analyst must demonstrate the ability to generate acceptable results with this method.

II. SUMMARY OF METHOD

A. Aqueous samples are diluted 2X (v/v) with methanol, filtered, separated on a Spherisorb ODS-II reverse phase column (or equivalent), determined at 254 nm, and confirmed on a CN reverse phase column.

1. Aqueous samples may also be extracted using the Army Corps of Engineers procedure "Salting-Out Extraction method for low-level determination of Nitroaromatics in Groundwater" by T.F. Jenkins and P.H. Miyares, or 8330 nonpromulgated method (SW846 proposed Update II, November 1992.) (See Appendix A & B.) This procedure results in significantly reduced detection limits for explosives in water.

B. Soil and sediment samples are extracted using acetonitrile in an ultrasonic bath, filtered, and chromatographed as in Section 2.1.

III. INTERFERENCES

A. 2,4,6-TNT, Nitrobenzene, 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene elute as unresolved peaks on the primary quantitation column used in this procedure. The compounds must be confirmed on the LC-CN column if any are seen on the primary ODS column.

B. Tetryl decomposes rapidly in methanol/water solutions, as well as with heat. All aqueous samples expected to contain tetryl should be diluted with acetonitrile prior to filtration. All samples expected to contain tetryl should not be exposed to temperatures above room temperature.

C. Degradation products of tetryl appear as a shoulder on the TNT peak. Peak heights rather than peak areas should be used when tetryl is present in concentrations that are significant relative to the concentration of TNT.

IV. APPARATUS AND MATERIALS

A. Primary HPLC system

1. *Pump* — HP Model 1050 quaternary system (or equivalent.)
2. *Column* — Spherisorb ODS-II, 5 μm, 250 mm x 4.6 mm ID.
3. *Detector* — HP Model 1050 Variable UV (or equivalent.)
4. *Autosampler* — HP Model 1050 autosampler (or equivalent.)
5. *Data System* — VG Minichrom data system or equivalent.

B. Confirmation HPLC System

1. *Pump* — Waters model 510 high pressure pump capable of 6000 psi at 10 ml/min. or equivalent.
2. *Column* — Supelco LC-CN, 5 μm, 25cm x 4.6mm ID.
3. *Detector* — Waters model 486 variable wavelength Detector set at 254 nm or equivalent.
4. *Autosampler* — Waters model 715 WISP or equivalent.
5. *Data System* — VG Minichrom or equivalent.

C. Other Equipment

1. NEY-300 Ultrasonic Bath equipped with drainage, that can hold water at room temperature to 35°C (or equivalent). The sonicator is kept covered during sonication to keep the samples in the dark.
2. BLUE M Convection Heating Oven with the temperature range of 0-300°C or equivalent.
3. Balance ± 0.0001 g.

D. Materials

1. *Filters* — Gelman Accuspec CR 0.45 μm filters for filtering extracts, or equivalent
2. *Filters* — Supelco Nylon 66 0.45 μm x 47 mm membranes for filtering chromatographic solvents.
3. *Pipettes* — volumetric, Class A, glass, 50 mL, 10 mL, 5 mL, 4 mL, 2 mL, 1 mL
4. *Vials* — 20 mL, glass.
5. *Vials* — 15 mL, glass, Teflon lined screw cap or crimp top.
6. *Vials* — 40 mL VOA vials with Teflon lined screw caps.
7. *Syringes* — 3 mL and 10 mL
8. *Volumetric flasks* — Class A - 10 mL, 20 mL, 50 mL, 100 mL, 200 mL, 250 mL.
9. *Mortar and pestle.*
10. *SMI glass pipettor* — 50-250 μL and 10-60 μL.

V. REAGENTS

A. HPLC grade chemicals shall be used in all tests. It is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lowering the accuracy of the determination.

1. Acetonitrile, CH_3CN — HPLC grade.
2. Methanol, CH3OH — HPLC grade.
3. Water, H_2O — HPLC grade.

B. *Stock Standard Solutions*

1. *Analyte Standards obtained from AccuStandard at 1000 μg/mL.*
   a. HMX — Standard Analytical Reference Material.
   b. RDX — Standard Analytical Reference Material.
   c. DNB — Standard Analytical Reference Material.
   d. Tetryl — Standard Analytical Reference Material.
   e. TNT — Standard Analytical Reference Material.
   f. 2,4-DNT — Standard Analytical Reference Material.
   g. 2,6-DNT — Standard Analytical Reference Material.

h. 1,3,5-TNB — Standard Analytical Reference Material.

i. NB — Standard Analytical Reference Material.

j. 2-NT — Standard Analytical Reference Material.

k. 3-NT — Standard Analytical Reference Material.

l. 4-NT — Standard Analytical Reference Material.

m. 2ADNT — Standard Analytical Reference Material.

n. 4ADNT — Standard Analytical Reference Material.

D. Intermediate Stock Standards Solutions

1. Since 2ADNT and 4ADNT are incompletely resolved from TNT and NB, therefore prepare two separate intermediate stock standard solutions in methanol according to the examples in Tables 1 and 2.

TABLE 1.
Intermediate Standard Stock Solution A

Compound	AccuStandard #	Orig. Conc. (µg/mL)	Aliquot (mL)	Final Conc. (µg/mL)
HMX	M-8330-04	1000	0.600	60.00
RDX	M-8330-05	1000	0.250	25.00
TETRYL	M-8330-10	1000	0.220	22.00
TNT	M-8330-11	1000	0.160	16.00
2,4-DNT	M-8330-02	1000	0.140	14.00
2,6-DNT	M-8330-03	1000	0.230	23.00
1,3-DNB	M-8330-01	1000	0.96	9.60
1,3,5-TNB	M-8330-12	1000	0.179	17.90
NB	M-8330-06	1000	0.195	19.50
2NT	M-8330-07	1000	0.200	20.00
3NT	M-8330-08	1000	0.190	19.00
4NT	M-8330-09	1000	0.200	20.00
Total Volume is 10.0 mL				

TABLE 2.
Intermediate Standard Stock Solution B

Compound	AccuStandard #	Orig. Conc. (µg/mL)	Aliquot (mL)	Final Conc. (µg/mL)
2ADNT	M-8330-13	1000	0.500	50.00
4ADNT	M8330-14	1000	0.460	46.00
Total Volume is 10.0 mL				

These stock standard solutions may be kept at 4°C in the dark for up to one year.

2. Dilute the two concentrated intermediate stock solutions with the appropriate solvent and this solution should be refrigerated and kept in the dark upon preparation at 4°C.

E. Working standards

1. Prepare working standards by diluting intermediate stock standards with 50:50 v/v Acetonitrile/Water for soil or low concentration water analysis and 50:50 v/v Methanol/Water for high concentration water analysis.

2. When following nonpromulgated SW-846 method 8330, Nov. 1992, five-level intermediate standards have been prepared in the manner which less concentrated standard is at MDL level or above, and high level standard at detector linear range. Same range has been used when following the SW-846 method 8330, Rev. 0, November 1990, with three-level standards prepared from high concentration to low concentration with each level injected three times.

F. LCS (Laboratory Control Spike) and LCSD (Laboratory Control Spike Duplicate)

1. LCS and LCSD are prepared from stock standard solutions that differ from the intermediate stock standard solution which is used to prepare the standards (see examples in Table 3.) Spike the blanks with analytes of interest at midpoint level or higher.

TABLE 3.
Intermediate Stock Solution for Spike A

Compound	AccuStandard #	Orig. Conc. (µg/mL)	Aliquot (µL)	Final Conc. (µg/
HMX	M-8330-04	1000	1920	64.0
RDX	M-8330-05	1000	750	25.0
TETRYL	M-8330-10	1000	600	20.0
TNT	M-8330-11	1000	465	15.5
2,4-DNT	M-8330-02	1000	420	14.0
2,6-DNT	M-8330-03	1000	690	23.0
1,3-DNB	M-8330-01	1000	288	9.6
1,3,5-TNB	M-8330-12	1000	459	15.3
NB	M-8330-06	1000	585	19.5
2NT	M-8330-07	1000	870	29.0
3NT	M-8330-08	1000	570	19.0
4NT	M-8330-09	1000	600	20.0
Total Volume is 30.0 µL				

G. MS (Matrix Spike) and MSD (Matrix Spike Duplicate)

1. MS and MSD are prepared as V.F. Spike the sample at midpoint or higher calibration range. (See examples in Table 4.)

TABLE 4.
Intermediate Stock Solution for Spike B

Compound	AccuStandard #	Orig. Conc. (µg/mL)	Aliquot (µL)	Final Conc. (µg/mL)
2ADNT	M-8330-13	1000	0.688	68.8
4ADNT	M8330-14	1000	0.752	75.2
Total Volume is 10.0 µL				

H. Eluent

1. To prepare 1 liter of mobile phase, add 500 ml of methanol to 500 mL of organic-free water.
2. The eluent should be filtered through a 0.45 µm filter subsequent to use.
3. The eluent should have helium continuously bubbled through the solution in order to remove air.

VI. SAMPLE COLLECTION, PRESERVATION, AND HANDLING

A. Grab samples must be collected and stored in glass containers. Follow conventional sampling procedures.

B. Samples must be kept below 4°C from the time of collection through analysis.

C. Soil and sediment samples, after collection, should be air dried at room temperature or colder, or oven dried with the oven set at 24°- 28°C if the humidity is too high, to constant weight. While it is possible to analyze wet soil samples, it is much more difficult to obtain a homogeneous subsample on a wet sample. If wet soil samples are to be analyzed, a moisture determination must be made on a separate subsample.

VII. PROCEDURE

A. Sample Preparation

1. *Aqueous Samples*

   a. **Sample Filtration:** Place a 5 mL portion of each water sample in a scintillation vial, add 5 mL of methanol, shake thoroughly, and filter through a 0.5 Am filter. Discard the first 3 mL of filtrate, and retain the remainder for analysis.

   b. Alternatively aqueous samples may be prepared according to the salting out procedure which is attached to this SOP (see Appendix A & B).

2. *Soil and Sediment Samples*

   a. **Sample homogenization:** Dry soil samples in air at room temperature or colder, being careful not to expose the samples to direct sunlight. Grind sample thoroughly in an acetonitrile rinsed mortar.

b. **Sample extraction**: Place a 2.0 g subsample of each soil sample in a 15 mL glass vial. Add 10.0 mL of acetonitrile, cap with teflon lined cap, vortex swirl for one minute, and place in ultrasonic bath for 18 hours. Keep ultrasonic bath at room temperature or below.

c. After sonication, allow sample to settle for 30 minutes. Place supernatant in syringe and filter through a Gelman Accuspec CR 0.45 μm. Discard first 1 mL and retain remainder in 15 mL glass with teflon-lined screwcap. Keep the extracts in 4°C and in a dark place until analysis.

d. Prior to analysis, dilute each extract 2X with HPLC water.

B. Chromatographic Conditions

Mobile Phase: 50/50 (v/v) methanol/HPLC water

Flow rate: 1.0 mL/min

Injection volume: 200 ml

UV Detector: 254 nm

C. Calibration of HPLC

1. When following nonpromulgated SW-846 method 8330, November 1992, the initial calibration standard at the minimal 5 concentration levels is injected only one time. Following the SW-846 method 8330, Revision 0, November 1990, a minimal of 3 concentration levels with each level is injected 3 times. Average the areas of the three injections at each level and prepare a calibration curve. The %RSD of the calibration factors should be $\leq$ 20%. The curve should be linear and intercept zero. Use the mean calibration factors for all calculations as long as continuing calibrations described below meet specifications.

2. *Calibration Factor (CF): 5-Level*

$$CF = \frac{\text{Peak Area of Standard}}{\text{Mass Injected (ng)}}$$

$$\overline{CF} = \sum_{i=5}^{n} \frac{CF_1}{n}$$

$$\%RSD = \frac{STD \times 100}{\overline{CF}}$$

Where:

$\overline{CF}$ = Mean of the calibration factor
n = (5) Total number of values
STD = Standard deviation of the calibration factors
CF_1 = Calibration factors

3. *Calibration Factor (CF): 3-Level*

$$CF = \frac{\overline{A}}{\text{Mass Injected (ng)}}$$

$$\overline{CF} = \frac{CF_1 + CF_2 + CF_3}{3}$$

$$\%RSD = \frac{STD \times 100}{\overline{CF}}$$

Where:

$\overline{A}$ = Mean of the area
CF = Calibration Factor
$\overline{CF}$ = Mean of the calibration factor
CF_1, CF_2, CF_3 = Calibration factor of each standard concentration
STD = Standard deviation of the calibration factors

4. Continuing Calibration using the mid point standards should be injected at the beginning of an analysis day and about every ten injections and at the end of the run. These standards should agree within a percent deviation of no more than ± 15% with mean obtained from the initial calibration. If a continuing calibration fails, it may be reinjected and analyses restarted from that point if it meets specifications on reinjection. If it fails again, the initial calibration must be repeated.

5. *Percent Deviation (%D)*

$$\%D = \frac{R1 - R2}{R1} \times 100$$

Where:

R1 = Calibration factor from first analysis
R2 = Calibration factor from second analysis.

6. A three-level calibration is also run on the LC-CN confirmation column. However, each standard is only injected once. For the nitrotoluenes, each compound must be injected separately since they are inseparable. However, if they are not present in the primary run, it is not necessary to calibrate the system with them.

7. Retention windows should be established for each new calibration. Average the retention time for each injection of each component for all initial calibration runs and

continuing calibration runs. Determine the standard deviation. The window for any compound is ± 3 times the standard deviation. If chromatographic retention drift should occur, make sure the mobile phase is fresh and has not evaporated and that the pumps are functioning properly. If the column itself has deteriorated and caused loss of efficiency and retention, it may have to be replaced.

D. Sample Analysis

1. Analyze the samples using the chromatographic conditions given in VII.B. Confirm each measurement by injecting onto the CN column.
2. Table 8 presents the retention times for the analytes on both the ODS-II and CN columns. Appendix C presents typical chromatograms.
3. *Calculation for positive hits.*

$$\text{Concentration } (\mu g/L \text{ or } \mu g/kg) = \frac{(A)\ (VT)\ (DF)}{(CF)\ (VO)\ (VI)}$$

Where:

A	=	Area of the peak for the compound to be measured
CF	=	Calibration factor (ng)
VO	=	Volume of water (g) or amount of soil extracted (mL)
VI	=	Volume of extract injected (μL)
VT	=	Volume of the concentrated extracted (μL)
DF	=	Dilution factor

VIII. QUALITY CONTROL

A. Prior to preparation of stock solutions, acetonitrile, methanol, and water blanks should be run to determine possible interferences with analyte peaks. If the acetonitrile, methanol, or water blanks show contamination, a different batch should be used.

B. Method Blanks

1. Method blanks for the analysis of aqueous samples should be organic-free reagent water carried through all sample storage and handling procedures.
2. Method blanks for the analysis of soil samples should be uncontaminated soil carried through all sample storage, extraction, and handling procedures.

C. Laboratory Control Spikes

TABLE 5.
Laboratory Control Spike Recovery QC Limits

Compound	Water %Recovery QC Limits	Soil %Recovery QC Limits
HMX	46-151	57-137
RDX	72-129	77-113
TNB	74-118	64-125
TETRYL	58-120	23-124
DNB	79-132	82-118
TNT	61-145	75-118
NB	68-135	69-143
26DNT	77-125	78-117
24DNT	70-134	74-126
2NT	70-131	78-123
4NT	73-116	79-125
3NT	71-127	78-121
2ADNT	ND	ND
4ADNT	ND	ND

D. Matrix Spikes

TABLE 6.
Matrix Spike/Matrix Spike Duplicate Recovery QC Limits

Compound	Water %Recovery QC Limits	Water%RPD QC Limits	Soil %Recovery QC Limits	Soil %RPD QC Limits
HMX	44-145	30	54-128	30
RDX	66-139	30	66-109	30
TNB	56-129	30	57-130	30
TETRYL	76-120	45	32-119	45
DNB	76-122	30	74-122	30
TNT	76-137	35	44-124	35
NB	82-111	30	70-135	30
26DNT	80-118	35	58-125	35
24DNT	72-123	35	59-120	35
2NT	74-130	35	79-124	35
4NT	78-116	35	74-128	35
3NT	72-126	35	79-121	35
2ADNT	ND	ND	ND	ND
3ADNT	ND	ND	ND	ND

ND = not determined

IX. METHOD PERFORMANCE

A. Method 8330 was tested by six laboratories. The results of this testing indicate that the results presented in Tables 3 through 5 are to be expected.

B. See attached chromatograms of standards obtained with this procedure (Appendix C).

X. DATA VERIFICATION

A. If the compound is found above the PQL in the quantitation column and it is within the established retention time window, the confirmational analysis of the compound will be performed. If the compound is found within the retention time window of the confirmational analysis, the compound will be reported. If all the compounds in the QA/QC samples exceeded the established laboratory QC limits, the batch of samples will be reextracted and reanalyzed. If some of the compounds in the QA/QC samples are out of the established limits, the compounds will be flagged and the data will be reported as is.

XI. REFERENCES

A. Bauer, C.F., S.M. Koza, and T.F. Jenkins, "Collaborative Test Results for a Liquid Chromatographic Method for the Determination of Explosives Residues in Soil," manuscript submitted to the Journal of the AOAC, April 1989.

B. Department of the Army, "Reversed-Phase HPLC Method for the Determination of Explosive Residues in Soil," Appendix B, provided by Dennis J. Wynne, Chief, Technology Division, U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland 21010-5401.

C. Department of the Army, "An Improved RP-HPLC Method for the Determination of Nitroaromatics and Nitramines in Water" Appendix B, provided by Dennis J. Wynne, Chief, Technology Division, U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland 21010-5401.

XII. SAFETY

A. Standard precautionary measures used for handling other organic compounds should be sufficient for safe handling of the analytes targeted by Method 8330.

TABLE 7.
ESTIMATED QUANTITATION LIMITS

Compound	Low Level Water (µg/L)	High Level Water (µg/L)	Soil (µg/kg)
HMX	0.88	13.0	2200
RDX	0.73	14.0	1000
TNB	0.19	7.3	250
DNB	0.06	4.0	250
Tetryl	0.19	10.0	650
NB	0.25	7.0	260
TNT	0.12	6.4	250
24DNT	0.08	5.7	250
26DNT	0.20	9.4	260
2NT	0.78	12.0	250
3NT	0.65	7.9	250
4NT	0.65	8.0	250
2ADNT	0.01	ND	ND
4ADNT	0.02	ND	ND

ND = not determined

TABLE 8.
RETENTION TIMES FOR ANALYTES ON ODS-II AND CN COLUMNS

ODS-II		*CN*	
Analyte	Retention Time (min)	Analyte	Retention Time (min)
HMX	3.2	NB	5.5
RDX	4.3	2NT	6.1
TNB	5.4	3NT	6.1
Tetryl	6.0	4NT	6.1
DNB	6.8	DNB	6.2
TNT	7.4	TNB	6.3
NB	7.7	26TNT	6.8
26DNT	8.8	24DNT	7.2
24DNT	9.6	TNT	7.5
2NT	11.0	RDX	10.2
4NT	11.8	Tetryl	12.3
3NT	12.5	HMX	16.3
2A DNT	7.8	2ADNT	8.7
4A DNT	7.3	4ADNT	7.8

TABLE 9.
INTERLABORATORY PRECISION OF METHOD FOR SOIL SAMPLES

	Spiked soils			*Field-contaminated soils*		
	Mean Concentration (mg/g)	**SD**	**%RSD**	**Mean Concentration (mg/g)**	**SD**	**%RSD**
HMX	46.0	1.7	3.7	14.0 153.0	1.8 21.6	12.8 14.1
RDX	60.0	1.4	2.3	104.0 877.0	12.0 29.6	11.5 3.4
TNB	8.6 46.0	0.4 1.9	4.6 4.1	2.8 72.0	0.2 6.0	7.1 8.3
DNB	3.5	0.14	4.0	1.1	0.11	9.8
tetryl	17.0	3.1	17.9	2.3	0.41	18.0
TNT	40.0	1.4	3.5	7.0 669.0	0.61 55.0	9.0 8.2
24DNT	5.0	0.17	3.4	1.0	0.44	42.3

TABLE 10.
INTERLABORATORY ERROR OF METHOD FOR SOIL SAMPLES

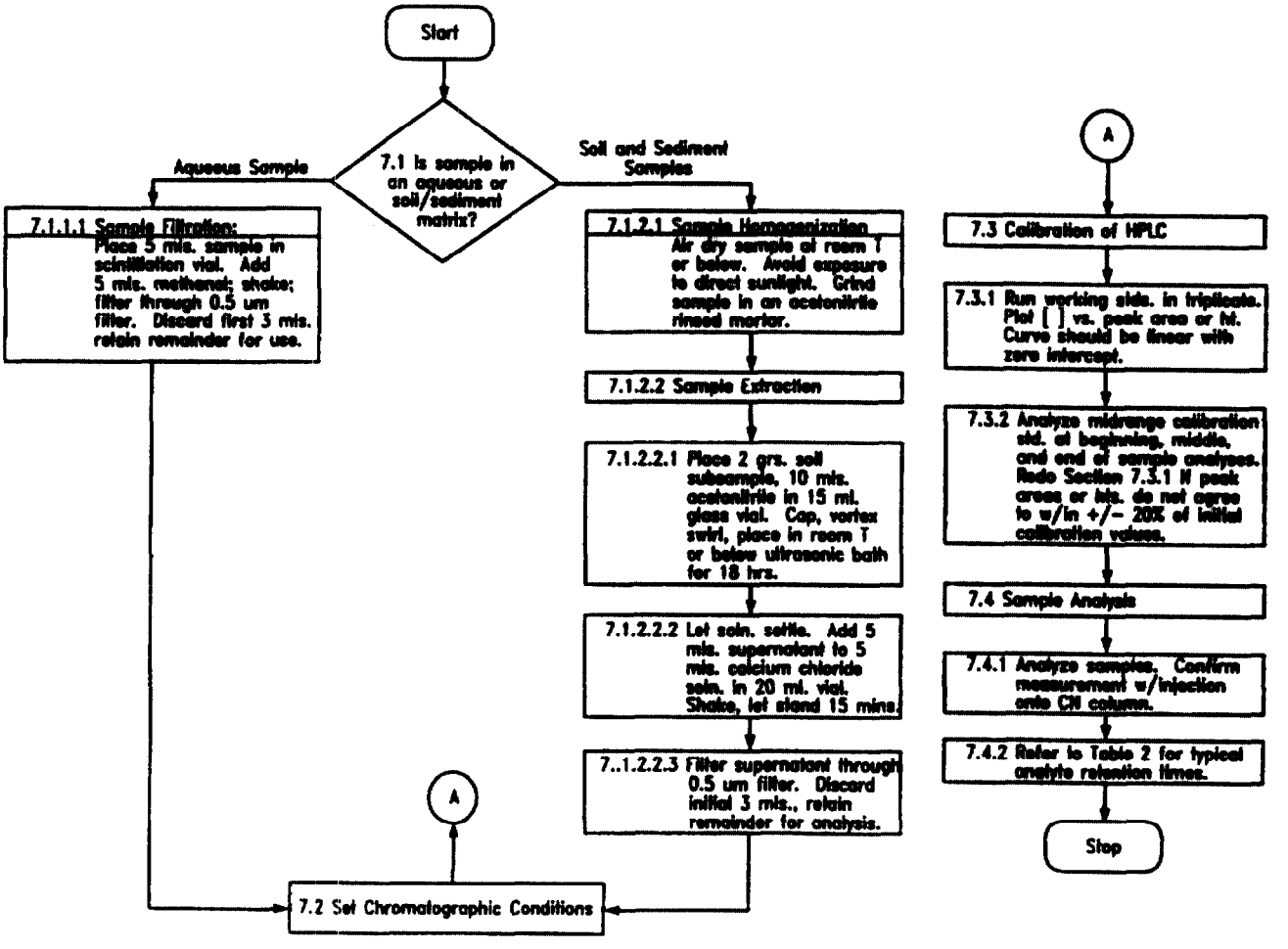
	Spiked soils			*Field-contaminated soils*		
	Mean Concentration (mg/g)	**SD**	**%RSD**	**Mean Concentration (mg/g)**	**SD**	**%RSD**
HMX	46.0	2.6	5.7	14 153	3.7 37.3	26.0 24.0
RDX	60.0	2.6	4.4	104 877	17.4 67.3	17.0 7.7
TNB	8.6 460	0.61 2.97	7.1 6.5	2.8 72.0	0.23 8.8	8.2 12.2
DNB	3.5	0.24	6.9	1.1	0.16	14.5
tetryl	17.0	5.22	30.7	2.3	0.49	21.3
TNT	40.0	1.88	4.7	7.0 669.0	1.27 63.4	18.0 9.5
24DNT	5.0	0.22	4.4	1.0	0.74	74.0

TABLE 11.
INTERLABORATORY ERROR OF METHOD FOR WATER SAMPLES[a]

	Sample 1		**Sample 2**	
	Mean conc. (mg/L)	**%RSD**	**Mean conc. (mg/L)**	**%RSD**
HMX	nd	-	184.0 [b]	8.4
RDX	431.0	22.9	2117.0	29.5
TNB	74.3	3.2	27.6[c]	4.2
TNT	10635.0	59.4	1746.0	26.8

a 10 replicate determinations, except where noted
b 6 replicate determinations
c 7 replicate determinations

Figure 1
METHOD 8330
NITROAROMATICS AND NITRAMINES BY HIGH PERFORMANCE CHROMATOGRAPHY (HPLC)



APPENDIX A

SALTING-OUT EXTRACTION METHOD FOR LOW-LEVEL DETERMINATION OF NITROAROMATICS AND NITRAMINES IN GROUNDWATER

By: T.F. Jenkins and P.H. Niyares

SUMMARY

A 400 mL aliquot of groundwater is placed in a 500 mL separatory funnel and 130 g of reagent grade NaCl added. The NaCl is dissolved completely by vigorous shaking. A 100 mL volume of acetonitrile (AcN) is then added using a glass volumetric pipette and the separatory funnel is shaken vigorously for 5 minutes. The funnel is allowed to stand undisturbed for 30 minutes and the two phases separated. The water layer is discarded and the AcN layer (approximately 23 mL) is placed in a clean Teflon-capped vial. The separatory funnel is rinsed with 5 mL of AcN and the rinsate added to the extract.

The AcN extract is concentrated to less than 1.0 mL using a Kuderna-Danish evaporator and brough to a 1.0 mL total volume using AcN. This concentrated extract is diluted with a 3.0 mL of reagent grade water and the solution saved in a Teflon-capped vial for RP-HPLC analysis.

Notes:

1. If possible use NaCl from glass bottles. High background levels have been observed from NaCl shipped in plastic containers.
2. Be sure to dissolve all salt before adding AcN, otherwise the dissolution process takes much longer.
3. Be sure to dilute the AcN extract 1:3 with water, otherwise the solvent strength of the injected sample will be too great and peak distortion will occur.
4. All glassware must be carefully cleaned before use to include a thorough final rinse with either AcN or acetone.
5. Be sure all water droplets are removed from the AcN layer before the extract is evaporated in the Kuderna-Danish unit.

APPENDIX B

SALTING-OUT EXTRACTION METHOD FOR LOW-LEVEL DETERMINATION OF NITROAROMATICS AND NITRAMINES IN GROUNDWATER BY NONPROMULGATED SW-846 METHOD 8330, PROPOSED UPDATE-II, NOVEMBER 1992.

METHOD

A. Low Level Method (Salting-out Extraction)

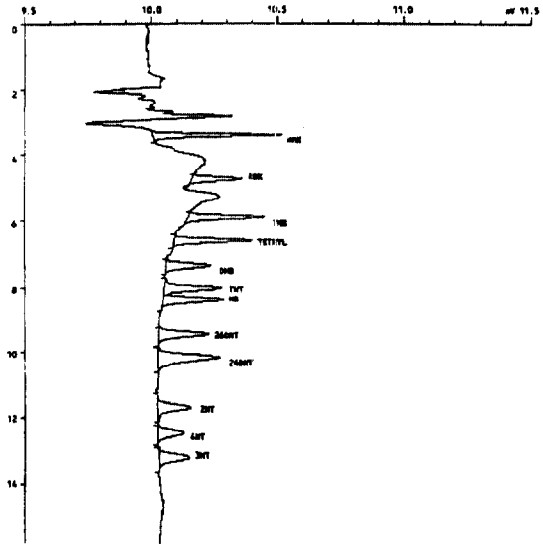
1. Add 251.3 grams of sodium chloride to a 1 liter volumetric flask (round.) Measure out 770 mL of a water sample (using a 1 liter graduated cylinder) and transfer it to the volumetric flask containing the salt. Add a stir bar and mix the contents at maximum speed on a magnetic stirrer until the salt is completely dissolved.
2. Add 164 mL of acetonitrile (measured with a 250 mL graduated cylinder) while the solution is being stirred and stir for an additional 15 minutes. Turn off the stirrer and allow the phases to separate for ten minutes.
3. Remove the acetonitrile (upper) layer (about 8 mL) with a Pasteur pipet and transfer it to a 100 mL volumetric flask (round.) Add 10 mL of fresh acetonitrile to the water sample in the 1 liter flask. Again stir the contents of the flask for 15 minutes followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract. The inclusion of a few drops of salt water at this point is unimportant.
4. Add 84 mL of salt water (325 grams NaCl) per 1000 mL of reagent water) to the acetonitrile extract in the 100 mL volumetric flask. Add a stir bar and stir the contents on a magnetic stirrer for 15 minutes followed by 10 minutes for phase separation. Carefully transfer the acetonitrile phase to a 10 mL graduated cylinder using a Pasteur pipet. At this stage the amount of water transferred with the acetonitrile must be minimized. The water contains a high concentration of NaCl that produces a large peak at the beginning of the chromatogram where it could interfere with the HMX determination.
5. Add an additional 1.0 mL of acetonitrile to the 100 mL volumetric flask. Again stir the contents of the flask for 15 minutes followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract in the 10 mL graduated cylinder (transfer to a 25 mL graduated cylinder if the volume exceeds 5 mL.) Record the total volume of acetonitrile extract [V(t)] in the calculation of concentration after converting to μL.) The resulting extract, about 5 - 6 mL is then diluted 1:1 with reagent water prior to analysis.
6. If the diluted extract is turbid, filter it through a 0.45 μ teflon filter using a disposable syringe. Discard the first 0.5 mL of filtrate, and retain the remainder in a Teflon-capped vial for RP-HPLC analysis.

APPENDIX C

INJECTION REPORT

Injection F: <NC3> 1 1EXO118,2,1

Acquired on 18-Jan-95 at 11:29:09
Modified on 20-Jan-95 at 10:20:32
Reported on 20-Jan-95 at 10:24:49
INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1



INJECTION REPORT

Injection F: <NC3> 1 1EXO118,2,1

Acquired on 18-Jan-95 at 11:29:09
Modified on 20-Jan-95 at 10:20:32
Reported on 20-Jan-95 at 10:23:20

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1
Number of samples.: 40
Calibration file..: 1EXO118 Last modified on 20-Jan-95 at 10:22:06
Method file.....: EXPLOS Last modified on 20-Jan-95 at 10:22:52
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L1 STANDARD
Sample ID.....: 10-293-5:IA1
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 1
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000
PH.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

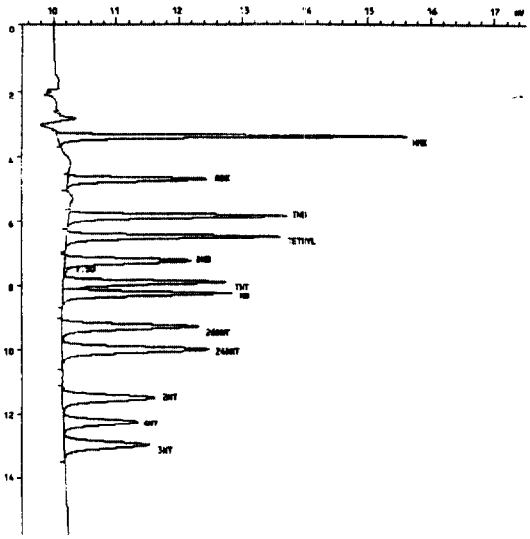
PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak Name
1	3.409	311	3282	0.061	HMX
2	4.760	201	1676	0.026	RDX
3	5.916	306	2500	0.017	TNB
4	6.618	312	2498	0.021	TETRYL
5	7.356	176	1801	9.023E-003	DNB
6	8.036	230	2298	0.016	TNT
7	8.391	242	2715	0.018	NB
8	9.444	200	2342	0.024	26DNT
9	10.160	247	3783	0.020	24DNT
10	11.693	131	1818	0.020	2NT
11	12.471	103	1455	0.019	4NT
12	13.213	123	1794	0.018	3NT
Total		2782	27882	0.270	
Residual		0	0	0.000	

INJECTION REPORT

Injection F: <NC3> 1 1EXO118,6,1

Acquired on 18-Jan-95 at 14:03:52
Modified on 20-Jan-95 at 10:21:48
Reported on 20-Jan-95 at 10:26:13
INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1



INJECTION REPORT

Injection F: <NC3> 1 1EXO118,6,1

Acquired on 18-Jan-95 at 14:03:52
Modified on 20-Jan-95 at 10:21:48
Reported on 20-Jan-95 at 10:23:24

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1
Number of samples.: 40
Calibration file..: 1EXO118 Last modified on 20-Jan-95 at 10:22:06
Method file.....: EXPLOS Last modified on 20-Jan-95 at 10:22:52
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L3 STANDARD
Sample ID.....: 10-293-5:IA3
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 2
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000
PH.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak Name
1	3.381	3147	35170	0.682	HMX
2	4.733	2200	18164	0.283	RDX
3	5.867	3477	29263	0.190	TNB
4	6.538	3407	28488	0.242	TETRYL
5	7.289	2010	20809	0.104	DNB
7	7.938	2575	25193	0.179	TNT
8	8.293	2607	31025	0.218	NB
9	9.316	2173	25243	0.256	26DNT
10	10.004	2341	30010	0.187	24DNT
11	11.503	1451	19871	0.219	2NT
12	12.276	1182	16421	0.218	4NT
13	12.996	1387	19922	0.205	3NT
Total		30486	299772	2.932	
Residual		86	473	2.362E-003	

APPENDIX C

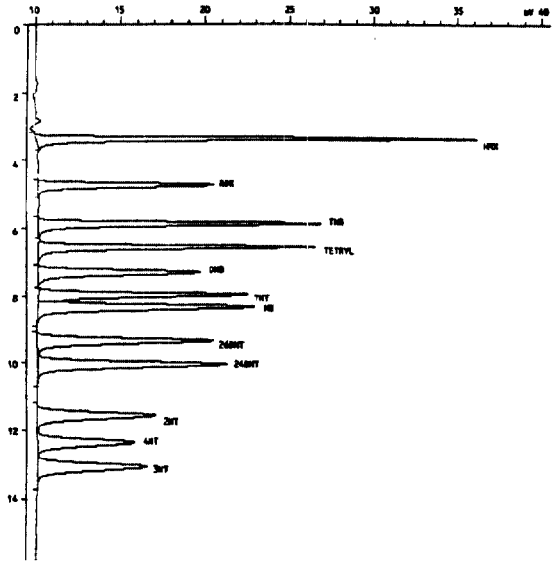
(continued)

Page 1

INJECTION REPORT

Injection F: <HC3> 1 1EX0118,8,1

Acquired on 18-Jan-95 at 15:21:16
Modified on 20-Jan-95 at 10:21:04
Reported on 20-Jan-95 at 10:27:17
INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1



INJECTION REPORT

Injection F: <HC3> 1 1EX0118,8,1

Acquired on 18-Jan-95 at 15:21:16
Modified on 20-Jan-95 at 10:21:04
Reported on 20-Jan-95 at 10:23:26

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN13, COL. TYPE: ODS-II, ID: ODS-02, INJ:200,COL#:1
Number of samples.: 60
Calibration file..: 1EX0118 Last modified on 20-Jan-95 at 10:22:05
Method file.....: EXPLOS Last modified on 20-Jan-95 at 10:22:52
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L3 STANDARD
Sample ID.....: 10-291-5:IA3
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 3
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000
PH.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

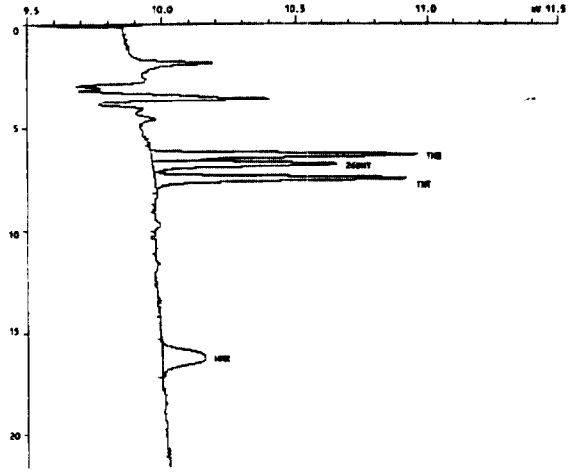
PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
1	3.387	26190	177597	3.299	HMX
2	4.738	10317	89019	1.378	RDX
3	5.880	16674	145768	0.986	TNB
4	6.860	16326	140768	1.213	TETRYL
5	7.311	9539	105861	0.538	DNB
6	7.973	12354	123734	0.879	TNT
7	8.329	12763	153044	1.072	NB
8	9.364	10388	124794	1.264	26DNT
9	10.053	11154	145471	0.760	24DNT
10	11.569	6981	97860	1.100	2NT
11	12.347	5740	83591	1.099	4NT
12	13.080	6510	99277	1.045	3NT
Total		144935	1486457	14.626	
Residual		0	0	0.000	

INJECTION REPORT

Injection F: <HC3> 2 2CH0124,5,1

Acquired on 24-Jan-95 at 14:34:38
Modified on 26-Jan-95 at 08:13:56
Reported on 26-Jan-95 at 08:41:40
INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <HC3> 2 2CH0124,5,1

Acquired on 24-Jan-95 at 14:34:38
Modified on 26-Jan-95 at 08:13:56
Reported on 26-Jan-95 at 08:41:04

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples.: 28
Calibration file..: 2CH0124 Last modified on 26-Jan-95 at 08:37:04
Method file.....: LCCN Last modified on 26-Jan-95 at 08:38:58
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L1A STANDARD
Sample ID.....: 10-302-5:IA1
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 1
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
1	6.333	1001	14416	0.046	TNB
2	6.769	692	12070	0.051	26DNT
3	7.502	946	14751	0.045	TNT
4	16.338	162	8115	0.072	HMX
Total		2802	49351	0.214	
Residual		0	0	0.000	

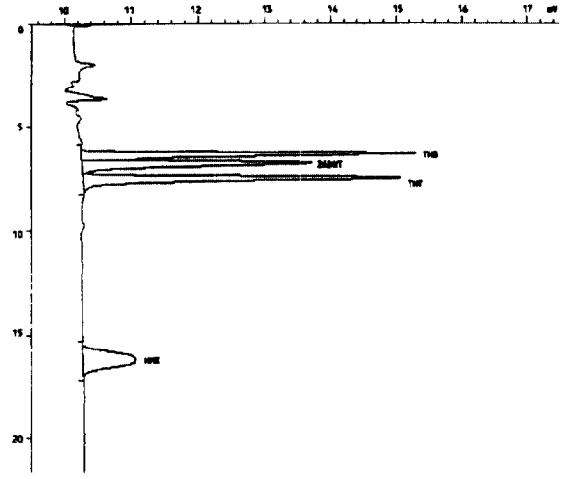
APPENDIX C

(continued)

INJECTION REPORT

Injection F: <HC3> 2 2CH0124.6.1

Acquired on 24-Jan-95 at 15:11:55
Modified on 26-Jan-95 at 08:14:06
Reported on 26-Jan-95 at 08:41:58
INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <HC3> 2 2CH0124,6,1

Acquired on 24-Jan-95 at 15:11:55
Modified on 26-Jan-95 at 08:14:06
Reported on 26-Jan-95 at 08:41:05

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples..: 28
Calibration file...: 2CH0124 Last modified on 26-Jan-95 at 08:37:06
Method file.....: LCCN Last modified on 26-Jan-95 at 08:39:50
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L2A STANDARD
Sample ID.....: 10-301-S:IA2
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 2
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

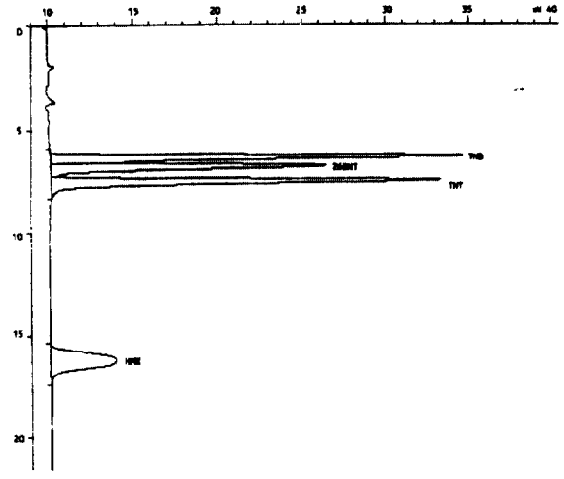
PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
1	6.342	5031	71975	0.229	TNB
2	6.791	3436	59350	0.281	26DNT
3	7.516	4770	75032	0.228	TNT
4	16.209	788	38992	0.347	HMX
Total		14025	245350	1.057	
Residual		0	0	0.000	

INJECTION REPORT

Injection F: <HC3> 2 2CH0124,7,1

Acquired on 24-Jan-95 at 15:49:11
Modified on 26-Jan-95 at 08:14:14
Reported on 26-Jan-95 at 08:42:34
INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <HC3> 2 2CH0124,7,1

Acquired on 24-Jan-95 at 15:49:11
Modified on 26-Jan-95 at 08:14:14
Reported on 26-Jan-95 at 08:41:07

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples..: 28
Calibration file...: 2CH0124 Last modified on 26-Jan-95 at 08:37:06
Method file.....: LCCN Last modified on 26-Jan-95 at 08:39:50
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L3A STANDARD
Sample ID.....: 10-300-S:IA3
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 3
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
1	6.342	24454	360994	1.150	TNB
2	6.800	16293	295223	1.250	26DNT
3	7.520	23052	377196	1.150	TNT
4	16.289	3898	196445	1.750	HMX
Total		67696	1229858	5.301	
Residual		0	0	0.000	

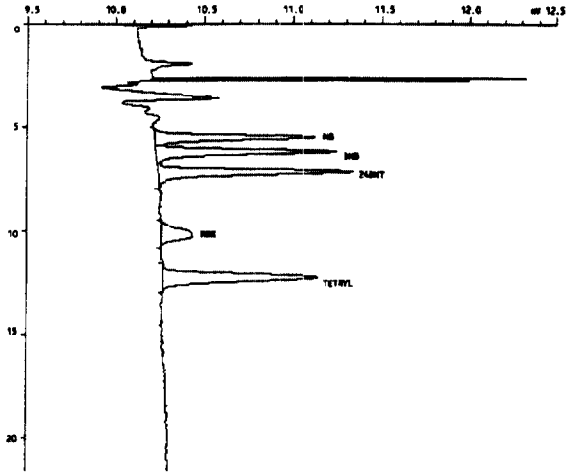
APPENDIX C

(continued)

INJECTION REPORT

Injection F: <HC3> 2 2CH0124,8,1

Acquired on 24-Jan-95 at 16:26:18
Modified on 26-Jan-95 at 08:14:24
Reported on 26-Jan-95 at 08:43:06
INST ID: IH12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <HC3> 2 2CH0124,8,1

Acquired on 24-Jan-95 at 16:26:18
Modified on 26-Jan-95 at 08:14:24
Reported on 26-Jan-95 at 08:41:08

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IH12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples.: 28
Calibration file..: 2CH0124 Last modified on 26-Jan-95 at 08:27:06
Method file.....: LCCN Last modified on 26-Jan-95 at 08:39:50
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L1B STANDARD
Sample ID.....: 10-306-5:IB1
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 1
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

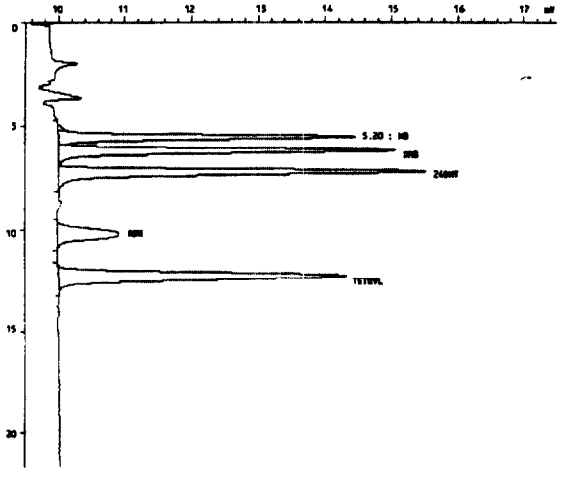
PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
1	5.511	901	15143	0.050	NB
2	6.196	1014	18244	0.039	DNB
3	7.209	1095	21299	0.049	24DNT
4	10.236	179	6640	0.046	RDX
5	12.236	873	21909	0.088	TETRYL
Total		4061	83236	0.273	
Residual		0	0	0.000	

INJECTION REPORT

Injection F: <HC3> 2 2CH0124,9,1

Acquired on 24-Jan-95 at 17:03:34
Modified on 26-Jan-95 at 08:37:04
Reported on 26-Jan-95 at 08:43:25
INST ID: IH12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <HC3> 2 2CH0124,9,1

Acquired on 24-Jan-95 at 17:03:34
Modified on 26-Jan-95 at 08:37:04
Reported on 26-Jan-95 at 08:41:10

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IH12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples.: 28
Calibration file..: 2CH0124 Last modified on 26-Jan-95 at 08:27:06
Method file.....: LCCN Last modified on 26-Jan-95 at 08:39:50
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L2B STANDARD
Sample ID.....: 10-306-5:IB2
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 2
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
2	5.520	4453	72173	0.236	NB
3	6.204	5059	87679	0.189	DNB
4	7.222	5511	102202	0.236	24DNT
5	10.182	935	33319	0.232	RDX
6	12.262	4319	107462	0.432	TETRYL
Total		20276	402835	1.328	
Residual		110	881	2.037E-003	

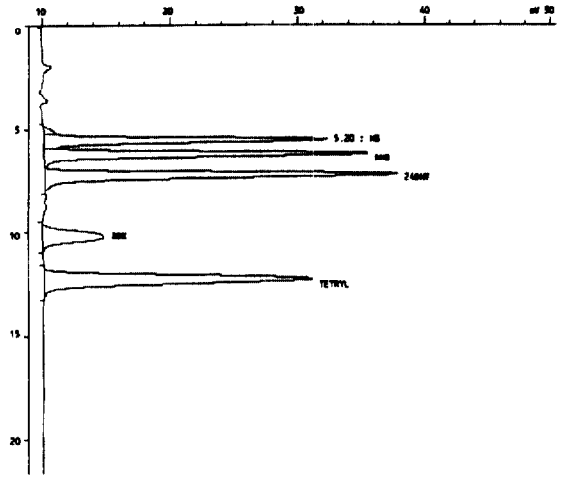
APPENDIX C

(continued)

INJECTION REPORT

Injection F: <MC3> 2 2CN0124,10,1

Acquired on 24-Jan-95 at 17:40:49
Modified on 26-Jan-95 at 08:14:52
Reported on 26-Jan-95 at 08:43:50
INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



INJECTION REPORT

Injection F: <MC3> 2 2CN0124,10,1

Acquired on 24-Jan-95 at 17:40:49
Modified on 26-Jan-95 at 08:14:52
Reported on 26-Jan-95 at 08:41:11

ANALYSIS INFORMATION

Analysis ID.....: EXP, GC 200
Analyst name.....: SS
Comment.....: INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV
Number of samples..: 28
Calibration file...: 2CN0124 Last modified on 26-Jan-95 at 08:17:04
Method file.....: LCCN Last modified on 26-Jan-95 at 08:20:10
Method title.....: SW846-8330

SAMPLE INFORMATION

Sample name.....: EXPLOSIVE L3B STANDARD
Sample ID.....: 10-304-S:IB3
Sample type.....: Standard
Sample amount.....: 1.0000
Number of injections.....: 1
Bottle Number.....: 1

Retention time update.....: No update
Calibration level identifier.....: 3
Response factor update.....: Initialize

Dilution factor amounts:
PERCENT MOISTURE.....: 0.000

User factors:
Volume (mL).....: 1.000
Dilution.....: 1.000
Amount (g or mL).....: 1.000

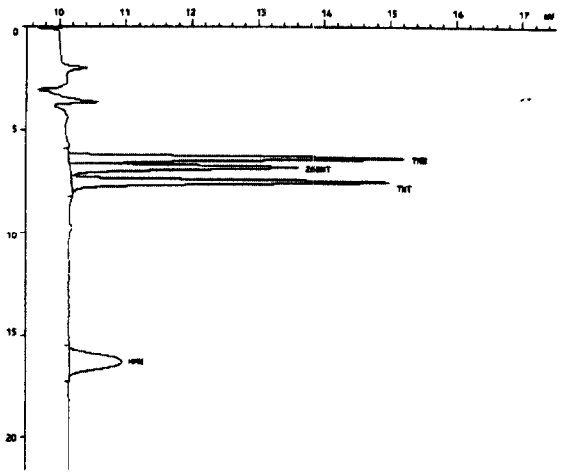
PEAK INFORMATION

Peak	RT mins	Hght uV	Area uVs	ug/mL	Peak name
2	5.502	22178	379886	1.252	HS
3	6.187	25331	463812	1.002	DNB
4	7.200	27555	541863	1.253	24DNT
5	10.222	4737	179929	1.254	RDX
6	12.271	21053	561113	2.254	TETRYL
Total		100854	2126403	7.015	
Residual		1027	12031	0.028	

INJECTION REPORT

Injection F: <MC3> 2 2CN0124,20,1

Acquired on 24-Jan-95 at 23:53:28
Modified on 26-Jan-95 at 09:04:58
Reported on 26-Jan-95 at 09:06:15
INST ID: IN12, COL. TYPE: LC-CN, ID: LC-CN-03, INJ:100, UV



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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF POLYCHLORINATED DIBENZO-P-DIOXINS AND DIBENZOFURANS BY HIGH RESOLUTION MASS SPECTROMETRY

METHOD SW8290 & TO-9

REV 1.3 — 5/19/95

Document Control # SWL-MS790-020

CONTROLLED DOCUMENT: DO NOT COPY!

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Signature: Chuck Hoover

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I. SCOPE AND APPLICATION

A. This method is appropriate for the detection and quantitative measurement of 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (2,3,7,8-TCDD) and total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in drinking water, soil, and chemical waste samples including still bottom, fuel oil, sludge, and fly ash matrices. The analytical method requires the use of high resolution gas chromatography and high resolution mass spectrometry (HRGC/HRMS) on sample extracts that have been subjected to specified cleanup procedures.

B. This method is designed for use only by analysts experienced with residue analysis and skilled in HRGC/HRMS.

C. Because of the extreme toxicity of these compounds, the analyst must take necessary precautions to prevent exposure of personnel to materials known or believed to contain PCDDs/PCDFs.

II. SUMMARY OF METHOD

A. This procedure is derived from the U.S. EPA "Test Methods For Evaluating Solid Waste," (SW-846), Revision 0, November, 1990.

B. This procedure uses a matrix-specific extraction, analyte-specific cleanup, and high-resolution capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS) techniques.

If interferants are encountered, the method provides selected cleanup procedures to aid the analyst in their elimination. The cleanup flow chart is shown in Figure 1.

C. *Holding Times:*

All samples must be extracted within 30 days of VTSR (Validated Sample Receipt) and the extracts must be analyzed within 45 days of extraction.

III. INTERFERENCES

A. Any compound that yields ions of PCDDs/PCDFs and also elutes within the retention time window of the corresponding homolog is a potential interference. PCDDs/PCDFs are often associated with other chlorinated compounds such as polychlorinated biphenyls (PCBs) and polychlorinated diphenyl ethers (PCDPE). These compounds may be found at concentrations several orders of magnitude higher than that of the analytes of interest, and may otherwise interfere with the analysis of PCDDs/PCDFs.

B. Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts and/or elevated baselines which may cause misinterpretation of chromatographic data. All of these materials shall be demonstrated to be free from interferants under the conditions of analysis by running laboratory method blanks. Analysts should avoid using PVC gloves.

C. The use of high purity reagents and solvents helps to minimize interference problems. Purification of solvents by distillation in all glass systems may be necessary.

D. High resolution capillary columns are used to resolve as many PCDD/PCDF isomers as possible; however, no single column is known to resolve all of the isomers.

IV. APPARATUS AND EQUIPMENT

A. *Gas Chromatograph/Mass Spectrometer/Data System* (GC/MS/DS)

B. *GC Column.* Fused silica capillary columns are required. The columns shall demonstrate the required separation of all 2,3,7,8-specific isomers whether a dual column or a single column analysis is chosen. Column operating conditions shall be evaluated at the beginning and end of each 12-hour period during which sample extracts or concentration calibration solutions are analyzed.

Isomer specificity for all 2,3,7,8-substituted TCDFs cannot be achieved on the 60-m DB-5 column. In order to determine the concentration of the individual 2,3,7,8-substituted isomers, the sample extract shall be reanalyzed on a 60m SP2331 or equivalent column that resolves the TCDF isomers.

Analysis on a single column is acceptable if the required separation of all the 2,3,7,8-specific isomers is demonstrated and the minimum acceptance criteria are met.

C. *Equipment and Glassware*

1. Nitrogen blowdown apparatus.
2. Analytical balance.
3. Water Bath.
4. Glove box.
5. Centrifuge.
6. Drying oven
7. Extraction jars.
8. Kuderna-Danish Apparatus (KD).
9. Disposable Pasteur pipets.
10. Disposable serological pipets.
11. Mini Vials.
12. Funnels.
13. Concentrator Tubes.
14. Separatory Funnels.
15. Continuous Liquid-Liquid Extractor.
16. Boiling Chips.
17. Buchner funnel.
18. Filtration flask.
19. Chromatography Columns: 300 mm x 10.5 mm glass chromatographic column fitted with Teflon stop cock.
20. Soxhlet apparatus, 500 ml flask, all glass: Complete with glass extraction thimbles, heating mantle, and variable transformer for heat control.

21. Dean Stark Water Separator Apparatus: With Teflon stopcock. Must fit between Soxhlet extractor body and condenser.
NOTE: Reuse of glassware should be minimized to avoid the risk of using contaminated glassware. All glassware that is reused shall be scrupulously cleaned, applying the following procedure, as soon as possible after use. Rinse glassware with the last solvent used in it. Wash with hot water containing detergent. Rinse with copious amounts of tap water and several portions of distilled water. Drain dry. Rinse with high-purity acetone and hexane. After glassware is dry, store inverted or capped with aluminum foil in a clean environment. Do not bake reusable glassware after cleaning, as repeated baking may cause active sites on the glass surface that will irreversibly adsorb PCDDs/PCDFs.

V. Reagents and Consumable Materials

A. Alumina, acidic AG4, Bio Rad Laboratories (catalogue #132-1240) or equivalent. Soxhlet extract with methylene chloride for 21 hours and activate by heating in a foil covered glass container for 24 hours at 190°C.

B. Charcoal Carbon. Active carbon AX-21 (Anderson Development Company, Adrian, MI, or equivalent), prewashed with methanol and dried in vacuo at 110°C.

C. Celite 545 (Supelco) or equivalent.

D. Potassium Hydroxide. ACS grade, prepare a 20 percent (w/v) solution in distilled water. Sulfuric Acid, Concentrated. ACS grade, specific gravity 1.84. Silica gel. High purity grade, type 60, 70-230 mesh; Soxhlet extract with methylene chloride for 21 hours and activate by heating in a foil covered glass container for 24 hours at 190°C.

E. Silica gel impregnated with sodium hydroxide. Add one part of 1 M NaOH solution to two parts silica gel (extracted and activated) in a screwcap bottle and mix with a glass rod until free of lumps.

F. Silica gel impregnated with 40% (by weight) sulfuric acid. Add two parts by weight concentrated sulfuric acid to three parts silica gel (extracted and activated), mix with a glass rod until free of lumps, and store in a screw-capped glass bottle.

G. Filter paper. Whatman No. 1 or equivalent.

H. Glass fiber filter. 15 cm, for use with Buchner funnel.

I. 0.45 micron, Millipore or equivalent. Rinse with toluene.

J. White quartz sand. 60/70 mesh, for use in the Soxhlet-Dean Stark extractor. Bake at 450°C for 4 hours minimum.

K. Glass Wool, Silanized. Extract with methylene chloride and hexane before use.

L. Sodium Sulfate. Granular, anhydrous. Before use, heat to 400°C in a shallow tray.

M. Solvents. High purity, distilled-in-glass: Hexane, methanol, methylene chloride, toluene, isooctane, cyclohexane, acetone, tridecane.

N. Calibration Solutions (Table 3).

O. Labeled PCDDs/PCDFs solution (Table 4)

P. Labeled Standard Solution. The nonane solution contains the internal standards, $^{13}C_{12}$-1,2,3,4-TCDD and $^{13}C_{12}$-1,2,3,7,8,9-HxCDD, at concentrations of 100 pg/μL.

Q. Window Defining Mix.

VI. CALIBRATION

A. Assemble the GC/MS and establish the operating conditions necessary to meet the relative retention time specifications in Table 1.

1. The following GC operating conditions are used and adjusted as needed to meet the relative retention time specification in Table 1.

Injector temp:	300°C
Interface temp:	300°C
Initial temp & time:	150°C, 5 min.
Temp Program:	150° - 215°C at 35°C/min.
	215°C for 5 min.
	215° - 230°C at 1.5°C/min.
	230°C for 6 min.
	230 - 315°C at 7°C/min.
	315°C for 6 min.

NOTE: All portions of the column which connect the GC to the ion source shall remain at the interface temperature specified above during analysis, to preclude condensation of less volatile compounds.

2. Mass Spectrometer (MS) resolution: Obtain a selected ion current profile (SICP) of each analyte in Table 3 at the two exact masses specified in Table 5 and at $\geq$10,000 resolving power by injecting an authentic standard of the PCDDs and PCDFs either singly or as part of a mixture in which there is no interference between closely eluted components.

A static resolving power of at least 10,000 must be demonstrated for masses 330.9792 and 430.9729. The check must be performed at the beginning and end of 12 hour shift.

a. The analysis time for PCDDs and PCDFs may exceed the long-term mass stability of the mass spectrometer. Because the instrument is operated in the high-resolution mode, mass drifts of a few ppm (e.g., 5 ppm in mass) can have serious adverse effects on the instrument performance. Therefore, a mass-drift correction is mandatory. A lock-mass ion from the reference compound (PFK) is used for tuning the mass spectrometer. The lock-mass ion is dependent on the masses of the ions monitored within each descriptor, as shown in Table 5. The level of the reference compound (PFK) metered into the ion chamber during HRGC/HRMS analyses should be adjusted so that the amplitude of the most intense selected lock-mass ion signal (regardless of the descriptor number) does not exceed 10 percent of the full-scale deflection for a given set of detector parameters. Under those conditions, sensitivity changes that might occur during the analysis can be more effectively monitored.

NOTE: Excessive PFK (or any other reference substance) may cause noise problems and contamination of the ion source resulting in an increase in time lost in cleaning the source.

B. Inject the HRCC1 calibration solution (Table 3) and check for ion abundance ratios, minimum levels, signal-to-noise ratios, and absolute retention times.

1. Measure the SICP areas for each analyte and compute the ion abundance ratios specified in Table 6. Compare the computed ratio to the theoretical ratio given in Table 6.

   a. The groups of m/z's to be monitored are shown in Table 5. Each group or descriptor shall be monitored in succession as a function of GC retention times to ensure that all PCDDs and PCDFs are detected. The theoretical abundance ratios for the m/z's are given in Table 6, along with the control limits of each ratio.

   b. The mass spectrometer shall be operated in a mass drift correction mode, using perfluorokerosene (PFK to provide lock masses. The lock mass for each group of m/z's is shown in Table 5. Each lock mass shall be monitored and shall not vary by more than ±10 percent throughout its respective retention time window. Variations of the lock mass by more than 10 percent indicate the presence of coeluting interferences that may significantly reduce the sensitivity of the mass spectrometer. Reinjection of another aliquot of the sample extract will not resolve the problem. Additional cleanup of the extract may be required to remove the interferences.

   c. Verify that the HRGC/HRMS instrument meets the minimum levels in Table 3. The peaks representing both unlabeled and labeled analytes in the calibration standards must have a signal-to-noise ration (S/N) greater than or equal to 10; otherwise, the mass spectrometer shall be adjusted and this test repeated until the minimum levels in Table 3 are met.

   d. The absolute retention time of $^{13}C_{12}$-1,2,3,4-TCDD shall exceed 25.0 minutes on the DB-5 column, and 15.0 minutes on the SP2331 column; otherwise, the GC temperature program shall be adjusted and this test repeated until the above stated minimum retention time criteria are met.

C. Compute the percent valley between the GC peaks that elute most closely to the 2,3,7,8-TCDD and TCDF isomers, on their respective columns, per Figure 4.

   a. Verify that the height of the valley between the most closely eluted isomers and the 2,3,7,8- isomers is less than 25 percent. If the valley exceeds 25 percent, adjust the analytical conditions and repeat the test or replace the GC column and recalibrate.

D. Calibration with isotope dilution: Isotope dilution is used for the fifteen 2,3,7,8-substituted

PCDDs and PCDFs with internal standards added to the samples prior to the extraction. The reference compound for each unlabeled compound is shown in Table 2.

E. Five Point Calibration: Analyze 5 calibration solutions (Table 3).

F. Calculate the relative response factors (RRFn) for the 17 unlabeled target analytes (2,3,7,8-specific PCDD/PCDFs, OCDD and OCDF) relative to their appropriate internal standards (RRFis), and the RRFis for the ten labeled standards according to the following formulas:

$$RRFn = \frac{An \times Qis}{Ais \times Qn} \qquad RRFis = \frac{Ais \times Qrs}{Ars \times Qis}$$

where:

An = Sum of integrated ion abundance of the quantitation ions for unlabeled PCDDs/PCDFs (Table 2.)

Ais = Sum of integrated ion abundance of the quantitation ions of the appropriate recovery standard (Table 2.)

Ars = Sum of integrated ion abundance of the quantitation ion of the appropriate internal standard.

Qn = Quantity of the unlabeled PCDD/PCDF analyte injected (pg).

Qis = Quantity of the appropriate internal standard injected (pg).

Qrs = Quantity of the appropriate recovery standard injected (pg).

The RRFn and RRFis are dimensionless quantities; therefore, the units used to express the Qn, Qis, and Qrs must be the same.

G. ***Relative Response Factor Criteria***

1. Calculate the mean RRF and percent relative standard deviation (%RSD) of the five RRFs (HRCC1 to HRCC5) for each unlabeled PCDD/PCDF and labeled PCDD/PCDF and internal standards present in all five concentration calibration solutions.

2. The RRFs calculated for the unlabeled PCDDs/PCDFs are relative to the appropriate labeled standard, and the RRFs for the labeled PCDD/PCDFs are relative to the internal standards.

$$\%RSD = \frac{\text{Standard Deviation}}{\text{Mean RRF}} \times 100$$

3. The %RSD is calculated for the unlabeled and labeled analytes only. The %RSD (HRCC1 - HRCC5) for the unlabeled PCDDs/PCDFs and the labeled PCDD/PCDFs must not exceed 20% & 30% respectively.

H. ***Continuing Calibration***

1. The continuing calibration consists of two parts: analysis of the homologue window defining mix containing isomer specific TCDDs to verify that the appropriate descriptor

switching times are used and % Valley criteria is met; and analysis of the HRCC3 solution to demonstrate DB-5 GC column resolution and for use as a quantitation standard. At the beginning of a 12-hour analytical period, window defining mix is analyzed and if all criteria are met, the HRCC3 solution is analyzed.

I. ***Continuing Calibration (Verification Standard) Procedure***

1. Inject a 1μL aliquot of the continuing calibration solution (HRCC3) into the GC/MS. The identical GC/MS conditions used for the analysis of the initial calibration solutions must be used for the continuing calibration solution.

2. Calculate the relative response factors (RRF) for the 17 unlabeled target analytes relative to their appropriate internal standards (RRFn) and the response factors for the nine internal PCDD/PCDFs relative to the appropriate recovery standard (RRFis), according to the following formulas:

$$RRFn = \frac{An \times Qis}{Ais \times Qn} \qquad RRFis = \frac{Ais \times Qrs}{Ars \times Qis}$$

An, Ais, Qis, Qn Ars, and Qrs are defined on page 6.

The RRFn and RRFis are dimensionless quantities; therefore, the units used to express the Qn, Qis, and Qrs must be the same.

3. The Verification Standard must meet the criteria specified in Table 7.

4. Analyze the Calibration Verification Solution at the end of the 12 hr sequence. It must meet the criteria specified in Table 7.

VII. SAMPLE PRESERVATION AND HANDLING

A. ***Water Samples***. Each water sample received will consist of at least two (2) 1-liter (or quart) amber glass bottles. Do not freeze. After a portion of the sample is removed for analysis, the unused portion of the sample is stored in a locked, limited access area for at least 60 days from the date of data submission.

B. ***Soil/Chemical Waste Samples***. When received, each sample will be contained in a 1-pint glass jar surrounded by vermiculite in a sealed metal paint can. Until a portion is removed for analysis, the sealed sample must be stored in a locked limited access area where ambient temperature is maintained above freezing. After a portion is removed for analysis, the unused portion of the sample is returned to its original container and stored at ambient temperature for at least 60 days from the date of data submission.

C. ***Air Samples.*** PUF cartridges will be received wrapped in Aluminum foil and enclosed in a glass jar. The filter papers which are part of PUF cartridge sampling will be received either separately wrapped in foil or folded inside the cartridge. The glass jars will be kept inside the refrigerator at 4°C ± 2°C until ready for extraction for Pesticide/PCBs, Semivolatile, or Dioxin analysis.

VIII. EXTRACTION PROCEDURES

A. *Soxhlet-Dean Stark (SDS) Apparatus*

1. The combination of a Soxhlet extractor and a Dean Stark Moisture trap is used for the removal of water and extraction of PCDDs/PCDFs from samples of oily sludge, wet fuel oil, fly ash, soil/sediment, and the particulate fraction of water samples. The combination consists of a Soxhlet extractor body with a Dean Stark moisture trap fitted between the extractor and the condenser.

2. The extraction of soil/sediment, fly ash, and particulates from water samples will require the use of a Soxhlet thimble by adding 5g of 70/230 mesh silica gel to the thimble to produce a thin layer in the bottom of the thimble. This layer will trap fine particles in the thimble. Add 100 g of quartz sand on top of the silica gel, and place the thimble in the extractor.

3. After preextraction for three hours, allow the apparatus to cool and remove the thimble. Mix the soil/sediment, fly ash, or particulates with the quartz sand, being careful <u>not</u> to disturb the layer of silica gel.

B. *Chemical Waste Sample Extraction*

1. *Oily Sludge/Wet Fuel Oil.* Weigh about 1 gram of sample to two decimal places into a tared 125-mL flask. Add 1 mL of the acetone-diluted labeled standard solution to the sample. Extract the sample by refluxing it with 50 mL of toluene in a Soxhlet-Dean Stark (sds) extractor.

   Continue refluxing the sample until all the water has been removed. Cool the sample, filter the toluene; extract through a rinsed glass fiber filter into a 100 mL round bottom flask. Rinse the filter with 10 mL of toluene; combine the extract and rinsate. Concentrate the combined solution to near dryness using a rotary evaporator at 50°C.

2. *Stillbottom/Oil.* Weigh about 1 gram of sample to two decimal places into a tared 50-mL flask. Add 1 mL of the acetone-diluted labeled standard solution to the sample. Mix the sample with 10 mL of toluene and filter the solution through a rinsed glass fiber filter into a 50 mL round-bottom flask. Rinse the flask and filter with 10 mL of toluene. Concentrate the combined toluene solutions to near dryness, or until all the solvent is removed, using K-D-apparatus.

3. *Fly ash.* Weigh about 10 grams of the fly ash to two decimal places, and transfer to an extraction jar. Add 1 mL of the acetone-diluted labeled standard solution to the sample.

   Add 150 mL of 1 N HCl to the fly ash in the jar. Seal the jar with the Teflon-lined screw cap and shake for 3 hours at room temperature. Rinse a Whatman #1 (or equivalent) filter paper with toluene, and then filter the sample through the filter paper in a Buchner funnel into a 1 L receiving flask. Wash the fly ash with approximately 500 mL distilled water. Transfer the fly ash sample and filter paper to an extraction thimble. Place the thimble in a Soxhlet-Dean Stark extractor, add 200 mL toluene, and extract for 16 hours.

   The solvent must cycle completely through the system 5-10 times per hour. Cool and filter the toluene extract through a rinsed glass fiber filter into a 500 mL round-bottom flask. Rinse the filter with 10 mL of toluene. Concentrate the combined toluene solutions to near dryness using a rotary evaporator at 50°C.

Note: A blank must be analyzed using a piece of filter paper handled in the same manner as the fly ash sample.

C. *Soil Sediment Sample Extraction*

1. *Soxhlet Method*

   a. Weigh about 10 g of the soil to two decimal places and transfer to a preextracted thimble. Mix the sample with approximately 20 g of quartz sand and add 1 mL of the labeled standard solution to the sample. Add small portions of the solution at several sites on the surface of the soil/sediment. Place the thimble in the Soxhlet-Dean Stark apparatus. Add 400-425 mL toluene to the SDS apparatus, and reflux for 16 hours. The solvent must cycle completely through the system 5-10 times per hour.

   b. Place a solvent rinsed piece of filter paper in a funnel and fill approximately half full with anhydrous sodium sulfate. Filter the extract through the funnel into a 500 mL KD concentrator fitted with a 10 mL concentrator tube. Add 50 mL of methylene chloride to the extraction flask and swirl gently. Filter this rinse through the funnel into the KD concentrator.

   c. Add a Teflon boiling chip to the KD flask and attach a three-ball Snyder column. Concentrate the extract in a hot water bath to an approximate volume of 10 mL. Remove the apparatus from the water bath and allow it to cool for 5 minutes. (Optional: The total volume of extract can be reduced on a hot plate in a 500 mL beaker.) Concentrate the volume to 1 mL.

   NOTE: Extremely wet samples may require centrifugation to remove standing water before extraction.

2. *Jar Method*

   a. Weigh about 10 g of the soil sample to two decimal places into a tared 1000 mL jar. Add sodium sulfate accordingly and rinse to a sandy consistency. Add 1 mL of the labeled standard solution to the sample. Mix the sample with 200 mL. Concentrate the extract to 1 mL.

3. *Sonication Method*

   a. Weigh approximately 10 g of soil sample to two decimal places into a tared beaker. Add sodium sulfate accordingly and mix to a sandy consistency. Add 1 mL of the labeled standard solution to the sample. Mix the sample with 100 mL of methylene chloride and sonicate for three minutes. Do this three times, each time filtering the extract into a prepared KD apparatus assembly by means of a prerinsed filter paper and funnel. Reduce the volume to 1 mL.

D. *PUF Sample Extraction*

1. Remove the PUF from the glass cartridge and place it in the Soxhlet extractor. Rinse the cartridge with methylene chloride and collect the washings into the Soxhlet. Place the filter paper or the wipe into the Soxhlet along with the PUF (the filter paper is used to collect the samples along with PUF.) Spike the PUF with the labeled compound. Wait for 30 minutes and start the Soxhlet extraction. Extract for 18 hours. Concentrate the volume to 1 ml and proceed to Step F.

2. The outside glass surface of PUF cartridges which are packed with XAD resin sandwiched between two PUFs will be rinsed carefully with solvent and then carefully placed in the Sohxlet extractor along with the filter paper. Spike the PUF with labeled compounds; wait for 30 minutes, and then start the Soxhlet extraction. Extract for 18 hours. Concentrate the volume to 1 mL and proceed to step F.

E. Water Sample Extraction

1. *Continuous Liquid/Liquid Extraction*

   a. Allow the sample to come to ambient temperature, then mark the water meniscus on the side of the 1 L sample bottle for determination of the exact sample volume. Cap the bottle, and mix the sample by gently shaking for 30 seconds.

   b. Add the aqueous sample to the continuous liquid-liquid extractor. Add 50 mL of methylene chloride to the sample bottle. Seal and shake for 30 seconds.

   c. Transfer the solvent to the extractor. Repeat the sample bottle rinse with an additional 50 to 100 mL portion of the methylene chloride and add the rinse to the extractor. Add 200-450 mL methylene chloride to the distilling flask and sufficient reagent water to ensure proper operation. Add 1 mL of the labeled standard to the water portion in the continuous liquid-liquid extractor.

   d. Extract for 16 hours. Allow to cool, then detach the flask and dry the sample by running it through a rinsed funnel and filter paper with approximately 100 g anhydrous sodium sulfate into a 500 mL KD flask.

   e. Add two cleaning boiling chips to the flask, and attach a three-ball Snyder column. Concentrate the extract on a water bath until the approximately volume of the liquid reaches 50 mL. Exchange the solvent by adding 50 mL Hexane at the top of the Snyder column and continue concentrating to approximately 10 mL. Further reduce the volume to 2 mL on a nitrogen blowdown apparatus. The sample is now ready for the column cleanup.

   f. Determine the original sample volume by refilling the sample bottle to the mark and transferring the liquid to a 1 L graduated cylinder. Record the sample volume to the nearest 5 mL.

   g. Samples containing greater than 1% solids must be filtered after the addition of labeled standard. The solid portion must be extracted separately. Combine the extract before column cleanup.

2. *Separatory Funnel Extraction*

   a. Allow the sample to come to ambient temperature, then mark the water meniscus on the side of the 1 L sample bottle for determination of the extract sample volume. Cap the bottle, and rinse the sample by gently shaking for 30 seconds.

   b. Add the aqueous sample to the separatory funnel. Add 50 mL of methylene chloride to the sample bottle, seal, and shake for 30 seconds.

c. Transfer the solvent to the separatory funnel. Repeat the sample bottle rinse with 50 mL solvent and add to the separatory funnel. Add 1 mL of the labeled standard solution into the water portion of the separatory funnel. Seal and shake the separatory funnel vigorously for 3 minutes with period venting to release excess pressure. Allow the sample to stand for approximately 10 minutes so that the organic layer can be separated from the water phase.

d. Repeat the extraction two more times using fresh portions of solvent (100 mL). Continue the three solvent extracts and filter into a KD assembly via a sodium sulfate packed funnel. Concentrate the extract to 1 mL.

e. Samples containing greater than 1% solids must be filtered after the addition of labeled standard. The solid portion must be extracted separately. Combine the extract before column cleanup.

F. Back Extraction with Base and Acid

1. Spike 1.0 mL of the cleanup standard into the separatory funnels containing the sample and QC extracts.

2. Partition the extract against 50 mL of potassium hydroxide solution. Shake for 2 minutes with periodic venting into a hood. Remove and discard the aqueous layer, to a maximum of four washings. Minimize contact time between the extract and the base to prevent degradation of the PCDDs and PCDFs. Stronger potassium hydroxide solutions may be employed for back extraction, provided that the laboratory meets the specifications for labeled compound recovery.

3. Partition the extract against 50 mL of sodium chloride solution in the same way as with base. Discard the aqueous layer.

4. Partition the extract against 50 mL of sulfuric acid in the same way as with base. Repeat the acid washing until no color is visible in the aqueous layer, to a maximum of four washings.

5. Repeat the partitioning against sodium chloride solution and discard the aqueous layer.

6. Pour each extract through a drying column containing 7 to 10 cm of anhydrous sodium sulfate. Rinse the separatory funnel with 30 - 50 mL of toluene and pour through the drying column. Collect each extract in a 500 mL round bottom flask. Concentrate and clean up the samples and QC aliquots to 1 mL.

IX. ANALYTICAL PROCEDURES

A. Column Chromatography

1. *Column 1.* Place 1 g silica gel into a 1 cm x 30 cm column fitted with a Teflon stopcock. With glass wool tap the column gently to settle the silica gel. Add 2 g sodium hydroxide-impregnated silica gel, 1 g silica gel, 4 g sulfuric acid-impregnated silica gel, and 2 g silica gel, 1 g Na2SO4. Tap the column gently after each addition. A small positive pressure (5 psi) of clean nitrogen may be used if needed.

2. *Column 2.* Pack a gravity column (glass 1 cm x 30 cm column) fitted with a Teflon

stopcock. Insert a glass-wool plug onto the bottom of the column. Place 6 g layer of the activated acid alumina. Add a 1 cm layer of purified sodium sulfate to cover the alumina. Tap the top of the column gently.

3. Add hexane to each column until the packing is free of air bubbles. A small positive pressure (5psi) of clean dry nitrogen may be used if needed. Check the columns for channeling. If channeling is present, discard the column.

   Caution: Do not tap a wetted column.

4. The 10 mL Hexane collection from phase I is loaded to the top of the silica gel column. Rinse the concentrator tube or KD flask with enough hexane (3-4 mL) to complete the quantitative transfer of the sample to the surface of the silica.

5. Using 60 mL of hexane, elute the extract from Column 1 directly onto Column 2, which contains the alumina and sodium sulfate.

   Caution: Do not allow the alumina column to run dry.

6. Add 20 mL of hexane to Column 2, and elute until the hexane level is just below the top of the sodium sulfate. Do not discard the eluted hexane, but collect in a separate flask, and store it for later use, as it may be useful in determining where the labelled analytes are being lost if recoveries are less than 80%.

7. Add 20 mL of 40% methylene chloride/60% hexane (volume/volume) to column 2 and collect the eluate.

8. Concentrate the extract to approximately 2 to 3 mL.

   Caution: Do not concentrate the eluate to dryness. The sample is now ready to be transferred to the Carbon column.

B. Carbon Column Chromatographic Procedure

1. Thoroughly mix 5.35 g active carbon AX-21 and 62.0 g Celite 545 to produce a 7.9% w/w mixture. Activate the mixture at 130°C for 6 hours, and store in a desiccator.

2. Check each new batch of the Carbon/Celite and maintain the results from the analyses for examination. To accomplish this, add 50 μL of the continuing calibration solution to 950 μL of hexane. Concentrate the continuing calibration solution to 50 μL. If the recovery of any of the analytes is less than 80%, this batch of Carbon/Celite mixture may not be used.

3. Prepare a 4-inch glass column by cutting off each end of a 10 mL disposable serological pipet. Fire polish both ends and flare if desired. Insert a glass wool plug at one end of the column, and pack it with 1 g of the Carbon/Celite mixture. Insert an additional glass wool plug in the other end.

4. Rinse the column with:

   a. 4 mL Toluene.

   b. 2 mL of Methylene Chloride/Methanol/Toluene (75:20:5 v/v).

   c. 4 mL of Cyclohexane/Methylene Chloride (50:50 v/v).

5. Discard all the column rinsates.

6. While the column is still wet, transfer the concentrated eluate to the prepared carbon column. Rinse the eluate container with two 0.5 mL portions of hexane and transfer the rinses to the AX-21 carbon column. Elute the column with the following sequence of solvents.

   a. 10 mL of Cyclohexane/Methylene Chloride (50:50 v/v).

   b. 5 mL of Methylene Chloride/Methanol/Toluene (75:20:5 v/v).

7. Once the solvents have eluted through the column, turn the column over, and elute the PCDD/PCDF fraction with 20 mL of toluene.

8. Evaporate the toluene fraction to near dryness in a rotary evaporator. Transfer the extract to a 2.0 mL reacti-vial using a toluene rinse. Exchange the solvent to methylene chloride.

9. Concentrate to near dryness.

C. GC/MS Analysis

1. Remove the extract of the sample or blank from storage. Gently swirl the solvent on the lower portion of the vial to ensure complete dissolution of the PCDDs/PCDFs. Add 10 μL of Labeled Standard Solution and 10 μL nonane solution to vial.

2. Analyze the extract by GC/MS, and monitor all of the ions listed in Table 5. The same MS parameters used to analyze the calibration solutions shall be used for the sample extracts.

D. Identification Criteria. For a gas chromatographic peak to be identified as a PCDD of PCDF, it must meet all of the following criteria.

1. ***Relative Retention Times:***

   a. In order to make a positive identification of the 2,3,7,8-substituted isomers for which an isotopically labeled or labeled standard is present in the sample extract, the absolute retention time at the maximum peak height of the analyte must be within -1 to 3 of the retention time of the corresponding labeled standard.

   b. In order to make a positive identification of the 2,3,7,8-substituted isomers for which a labeled standard is <u>not</u> available, the relative retention time (RRT) of the analyte must be within 0.005 RRT units of the RRT established by the continuing calibration. The RRT is calculated as follows:

$$RRT = \frac{\text{retention time of analyte}}{\text{retention time of corresponding labeled compound}}$$

   c. For non-2,3,7,8-substituted compounds (tetra through octa) the retention time must be within the retention time windows established by the window defining mix for the corresponding homologue.

   d. All of the specified ions listed in Table 5 for each PCDD/PCDF homologue and

labeled standards must be present in the SICP. The ion current response for the quantitation and confirmation ions for the analytes and labeled standards must maximize simultaneously (± 2 seconds).

e. *Signal-to-Noise Ratio:* The integrated ion current for each analyte ion listed in Table 5 must be at least 2.5 times background noise and must not have saturated the detector.

f. *Ion Abundance Ratios:* The relative ion abundance criteria listed in Table 6 for native analytes and labeled standards must be met using areas to calculate ratios.

E. Polychlorinated Diphenyl Ether (PCDPE) Interferences

1. The identification of a GC peak as a PCDF cannot be made if a signal having S/N > 2.5 is detected at the same retention time (+ or - 2 seconds) as in the corresponding PCDPE channel (see Table 5). If a PCDPE is detected, it shall be documented in the Case Narrative. Any other intereference will be documented in the case narrative.

F. Method Blanks

1. A minimum of one blank per matrix shall be analyzed with each sample batch (maximum of 20 samples). If samples of the same matrix are extracted in different episodes (i.e. different shifts or days), one blank per matrix must be prepared for each episode.

2. An additional blank shall be analyzed when new reagents are used and with each set of samples rerun. When water samples in a sample batch are extracted using both the separatory funnel and continuous liquid-liquid extraction procedures, at least one blank must be prepared by each procedure.

3. *Method Blank Criteria:* Acceptable laboratory method blanks must not contain any chemical interference or electronic noise at the m/z of the specified unlabeled PCDD/ PCDF ions which is greater than 5 percent of the signal of the appropriate labeled standard quantitation ion. A peak that meets identification criteria in the method blank must not exceed 2 percent of the concentration of the appropriate labeled standard. If the method blank that was extracted along with a batch of samples is contaminated, the associated samples with positive hits must be reextracted and reanalyzed.

X. CALCULATION

A. ***Concentration:***

For GC peaks that have met all the identification criteria calculate the concentration of the individual PCDD or PCDF isomers using the formulas:

1. ***ALL MATRICES OTHER THAN WATER***

$$Cn\ (ng/kg) = \frac{Qis \times An}{W \times Ais \times \overline{RRFn}}$$

2. ***WATER***

$$Cn\ (pg/L) = \frac{Qis \times An}{V \times Ais \times \overline{RRFn}}$$

Where:

An = Sum of integrated ion abundance of the quantitation ion for unlabeled PCDDs/PCDFs (Table 2.)

Ais = Sum of integrated ion abundance of the quantitation ion of the appropriate internal standard (Table 2.)

Cn = Concentration of native PCDD/PCDF found in the sample.

W = Weight (g) of sample extracted.

V = Volume (L) of sample extracted.

Qis = Quantity (pg) of the appropriate labeled standard added to the sample prior to extraction.

$\overline{RRFn}$= Average response factor from initial calibration.

3. The concentrations of the specific isomers are calculated as follows:

   a. For homologs that contain only one isomer (OCDD and OCDF) or only one 2,3,7,8-substituted isomer (TCDD, PeCDD, HpCDD, and TCDF), the $\overline{RRF}$ of the 2,3,7,8-substituted isomer from the initial calibration will be used to quantitate both the 2,3,7,8-substituted isomers and the non-2,3,7,8 isomers.

   b. For homologs that contain more than one 2,3,7,8-substituted isomer, the $\overline{RRF}$ used to calculate the concentration of each 2,3,7,8-substituted isomer will be the $\overline{RRF}$ determined for that isomer during the initial calibration.

   c. For homologs that contain one or more non-2,3,7,8 isomers, the $\overline{RRF}$ used to calculate the concentration of these isomers will be the average of the $\overline{RRF}$s determined during the initial calibration for the 2,3,7,8-substituted isomers in that homolog.

   d. In addition to the concentrations of specific isomers, the total homolog concentrations are reported on Form I. Calculate the total concentration of each homolog of PCDDs/PCDFs as follows:

      (1) Total concentration = sum of the concentrations of every positively identified 2,3,7,8-isomer and the non-2,3,7,8 isomers which meet ion identification criteria.

   e. If the original sample, prior to any dilutions, has a percent recovery of the labeled standard of less than 40%, reextraction and reanalysis is required.

   f. If the concentration of any PCDD/PCDF in the sample has exceeded the calibration range, or the detector has been saturated, a dilution shall be performed.

g. "Estimated Maximum Possible Concentration" (EMPC) calculated according to the same expression, except that An shoud represent the sum of the area under the smaller peak and of the other peak area calculated using the theoretical chloride isotope ratio.

B. Calculate the percent recovery for each labeled standard in the sample extract, Ris, using the equation:

$$Ris = \frac{Ais \times Qrs}{Ars \times \overline{RRF}is \times Qis} \times 100\%$$

The $^{13}C_{12}$-1,2,3,4-TCDD is used to quantitate the tetra and penta labeled standards, and $^{13}C_{12}$-1,2,3,7,8,9-HxCDD is used to quantitate the HxCDD, HpCDF and OCDD internal standards (see Table 2.)

C. ***Sample Data***

1. A sample data summary top sheet (Figure 5 & 6) summarizes the analyte concentrations, detection limit, EMPC values, ion abundance ratios, and relative retention time. Figure 6 shows the carbon-labeled standard percent recovery.

2. A set of "raw data" (Figure 7 to 8) reports the corresponding area measurement, ion ratio, and retention times for all GC/MS peaks. The peak list includes all homologue isomer peaks which meet the identification criteria.

XI. QUALITY CONTROL

A. *Method Blank:* Before processing any samples, the analyst must demonstrate through the analysis of a method blank that all glassware and reagents are interferant-free at the method detection limit of the matrix of interest. Each time a set of samples is extracted, or there is a change in reagents, a method blank must be processed as a safeguard against laboratory contamination.

A laboratory "method blank" must be run along with each analytical batch (20 or fewer samples). A method blank is performed by executing all of the specified extraction and cleanup steps, except for the introduction of a sample. The method blank is also spiked with the labeled standards. For water samples, one liter of deionized and/or distilled water should be used as the method blank. Processed sand is used for soil blank.

B. *Performance Samples:* The laboratory is expected to analyze performance evaluation samples as provided by the EPA on a periodic basis throughout the course of a given project. Additional sample analyses will not be permitted if the performance criteria are not achieved. Corrective action must be taken and acceptable performance must be demonstrated before sample analyses can resume.

C. *Field Duplicates* (individual samples taken from the same location at the same time) should be analyzed per 20 samples to determine the total precision (field and lab).

D. *Field Blanks:* Where appropriate, "field blanks" will be provided to monitor for possible cross-contamination of samples in the field. The typical "field blank: will consist of uncontaminated soil (background soil taken off-site).

E. *Performance Check Solution:* GC column performance must be demonstrated initially and verified prior to analyzing any sample in a 12-hr period. The GC column performance check solution must be analyzed under the same chromatographic and mass spectrometric conditions used for other samples and standards.

G. *Calibration Standards:* Before using any cleanup procedure, the analyst must process a series of calibration standards through the procedure to validate elution patterns and the absence of interferants from reagents. Both alumina column and carbon column performance must be checked. Routinely check the 8 percent CH2Cl2/hexane eluate of environmental extracts from the alumina column for presence of target analytes.

H. *Documentation*: Initial demonstration of the ability to generate acceptable accuracy and precision must be documented.

I. *Aliquots:* Four 1 liter aliquots of reagent water spiked with precision and accuracy standard along with labeled standard. The aliquot must go through the extraction and cleanup procedure. The standard deviation and average concentration must meet the criteria in Table 7.

J. *LCS:* An ongoing precision and accuracy standard (Laboratory Control Spike) must be extracted and analyzed with each batch containing more than 10 samples. It should match the criteria specified in Table 7.

XII. DATA DELIVERABLES

A. For CLP requirements, the data will be delivered in the following format.

1. PCDD/PCDF couplet SDG File Inventory Sheet.
2. SDG Narrative.
3. PCDD/PCDF Analysis Data Sheet (Form 1)
4. PCDD/PCDF Confirmation Analysis Data Sheet (Form 1)
5. PCDD/PCDF Labeled Compound & Cleanup Standard Recovery (Form 2)
6. MS/MSD or LCS/LCSD Spike Sample Summary.
7. PCDD/PCDF Method Blank Summary (Form 4DF)
8. PCDD/PCDF Analytical Sequence Summary (Form 5DFC)
9. PCDD/PCDF RT Window and Isomer Specificity Standards.
10. Peak Locate (Mass Resolution) Display
11. PCDD/PCDF Initial Calibration (Form 3A, 3B, 3C, 3D)
12. PCDD/PCDF Calibration Verification (Form 4A)

13. PCDD/PCDF Analysis Data Sheet for blank.
14. PCDD/PCDF Analysis Data Sheet for MS/MSD or LCS/LCSD.
15. Run Logs.
16. Extraction Logs.
17. Chain-of-Custody

Table 1
Analyte Relative Retention Time Reference Attributions

Analyte	Analyte RRT Reference
2,3,7,8-TCDD	^{13}C-2,3,7,8-TCDD
2,3,7,8-TCDF	^{13}C-2,3,7,8-TCDF
1,2,3,7,8-PeCDD	^{13}C-1,2,3,7,8-PeCDD
1,2,3,7,8-PeCDF	^{13}C-1,2,3,7,8-PeCDF
2,3,4,7,8-PeCDF	^{13}C-1,2,3,7,8-PeCDF
1,2,3,4,7,8-HxCDD	^{13}C-1,2,3,6,7,8-HxCDD
1,2,3,4,7,8-HxCDD	^{13}C-1,2,3,6,7,8-HxCDD
1,2,3,7,8,9-HxCDD	^{13}C-1,2,3,6,7,8-HxCDD
1,2,3,4,7,8-HxCDF	^{13}C-1,2,3,4,7,8-HxCDF
1,2,3,6,7,8-HxCDF	^{13}C-1,2,3,4,7,8-HxCDF
1,2,3,7,8,9-HxCDF	^{13}C-1,2,3,4,7,8-HxCDF
2,3,4,6,7,8-HxCDF	^{13}C-1,2,3,4,7,8-HxCDF
1,2,3,4,6,7,8-HpCDD	^{13}C-1,2,3,4,6,7,8-HpCDD
1,2,3,4,6,7,8-HpCDF	^{13}C-1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF	^{13}C-1,2,3,4,6,7,8-HpCDF
OCDD	^{13}C-OCDD
OCDF	^{13}C-OCDD

Table 2
Reference Compounds for Quantitation of Native and Labeled PCDDs and PCDFs

Compound Number	Type	Name	Reference Compound
1	NAT	2,3,7,8-TCDD	18
2	NAT	1,2,3,7,8-PeCDD	19
3	NAT	1,2,3,4,7,8-HxCDD	20
4	NAT	1,2,3,6,7,8-HxCDD	20
5	NAT	1,2,3,7,8,9-HxCDD	20
6	NAT	1,2,3,4,6,7,8-HpCDD	21
7	NAT	OCDD	22
8	NAT	2,3,7,8-TCDF	23
9	NAT	1,2,3,7,8-PeCDF	24
10	NAT	2,3,4,7,8-PeCDF	24
11	NAT	1,2,3,4,7,8-HxCDF	25
12	NAT	1,2,3,6,7,8-HxCDF	25
13	NAT	1,2,3,7,8,9-HxCDF	25
14	NAT	2,3,4,6,7,8-HxCDF	25
15	NAT	1,2,3,4,6,7,8-HpCDF	26
16	NAT	1,2,3,4,7,8,9-HpCDF	26
17	NAT	OCDF	22
18	IS	^{13}C-2,3,7,8-TCDD	27
19	IS	^{13}C-1,2,3,7,8-PeCDD	27
20	IS	^{13}C-1,2,3,6,7,8-HxCDD	28
21	IS	^{13}C-1,2,3,6,7,8-HpCDD	28
22	IS	^{13}C-OCDD	28
23	IS	^{13}C-2,3,7,8-TCDF	27
24	IS	^{13}C-1,2,3,7,8-PeCDF	27
25	IS	^{13}C-1,2,3,4,7,8-HxCDF	28
26	IS	^{13}C-1,2,3,4,6,7,8-HpCDF	28
27	RS	^{13}C-1,2,3,4-TCDD	
28	RS	^{13}C-1,2,3,7,8,9-HxCDD	
29	C/UP	^{37}Cl-1,2,3,7,8-TCDD	27

NAT = Native Compounds
IS = Internal Standard (Labeled Compounds)
RS = Recovery Standard
C/UP = Cleanup Standard

Table 3
Concentrations of Solutions Containing Labeled and Unlabeled PCDDs and PCDFs Calibration and Verification Solutions

Compound	HRCC1 (ng/mL)	HRCC2 (ng/mL)	VER[a] HRCC3 (ng/mL)	HRCC4 (ng/mL)	HRCC5 (ng/mL)
Native CDDs and CDFs [b]					
2,3,7,8-TCDD	0.5	2	10	40	200
2,3,7,8-TCDF	0.5	2	10	40	200
1,2,3,7,8-PeCDD	2.5	10	50	200	1000
1,2,3,7,8-PeCDF	2.5	10	50	200	1000
2,3,4,7,8-PeCDF	2.5	10	50	200	1000
1,2,3,4,7,8-HxCDD	2.5	10	50	200	1000
1,2,3,6,7,8-HxCDD	2.5	10	50	200	1000
1,2,3,7,8,9-HxCDD	2.5	10	50	200	1000
1,2,3,4,7,8-HxCDF	2.5	10	50	200	1000
1,2,3,6,7,8-HxCDF	2.5	10	50	200	1000
1,2,3,7,8,9-HxCDF	2.5	10	50	200	1000
2,3,4,6,7,8-HxCDF	2.5	10	50	200	1000
1,2,3,4,6,7,8-HpCDD	2.5	10	50	200	1000
1,2,3,4,6,7,8-HpCDF	2.5	10	50	200	1000
1,2,3,4,7,8,9-HpCDF	2.5	10	50	200	1000
OCDD	5.0	20	100	400	2000
OCDF	5.0	20	100	400	2000
Internal Standards					
$^{13}C_{12}$-2,3,7,8-TCDD	100	100	100	100	100
$^{13}C_{12}$-2,3,7,8-TCDF	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8-PeCDF	100	100	100	100	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	100	100	100	100	100
$^{13}C_{12}$-OCDD	200	200	200	200	200
Cleanup Standard					
$^{37}Cl_4$-2,3,7,8-TCDD	0.5	2.0	10	40	200
Recovery Standards					
$^{13}C_{12}$-1,2,3,4-TCDD	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	100	100	100	100	100

(a) *Calibration verification (VER) solution.*

(b) *The calibration range is based on Method 1613, which the lowest point is twice lower than Method 8290, HRCC1 required. The highest point is twice higher than Method 8290, HRCC5, except the tetra compounds.*

Table 4
Concentrations of Solutions Containing Labeled and Unlabeled PCDDs and PCDFs Stock and Spiking Solutions

	Labeled Compound Stock Solution(1) (ng/mL0	Labeled Compound Spiking Solution(2) (ng/mL)	PAR Stock Solution (3) (ng/mL)	Cleanup Standard Spiking Solution (4) (ng/mL)	Internal Standard Spiking Solution(5) (ng/mL)
Native CDDs and CDFs					
2,3,7,8-TCDD	—	—	40	—	—
2,3,7,8-TCDF	—	—	40	—	—
1,2,3,7,8-PeCDD	—	—	200	—	—
1,2,3,7,8-PeCDF	—	—	200	—	—
1,2,3,4,7,8-HxCDD	—	—	200	—	—
1,2,3,6,7,8-HxCDD	—	—	200	—	—
1,2,3,7,8,9-HxCDD	—	—	200	—	—
1,2,3,4,7,8-HxCDF	—	—	200	—	—
1,2,3,6,7,8-HxCDF	—	—	200	—	—
1,2,3,7,8,9-HxCDF	—	—	200	—	—
2,3,4,6,7,8-HxCDF	—	—	200	—	—
1,2,3,4,6,7,8-HpCDD	—	—	200	—	—
1,2,3,4,6,7,.8-HpCDF	—	—	200	—	—
1,2,3,4,7,8,9-HpCDF	—	—	200	—	—
OCDD	—	—	400	—	—
OCDF	—	—	400	—	—
Internal Standards					
$^{13}C_{12}$-2,3,7,8-TCDD	100	2	—	—	—
$^{13}C_{12}$-2,3,7,8-TCDF	100	2	—	—	—
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100	2	—	—	—
$^{13}C_{12}$-1,2,3,7,8-PeCDF	100	2	—	—	—
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100	2	—	—	—
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	100	2	—	—	—
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100	2	—	—	—
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	100	2	—	—	—
$^{13}C_{12}$--OCDD	200	4	—	—	—
Cleanup Standard					
$^{37}Cl_4$-2,3,7,8-TCDD	—	—	—	0.8	—
Recovery Standards					
$^{13}C_{12}$-1,2,3,4-TCDD	—	—	—	—	200
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	—	—	—	—	200

(1) Prepared in nonane and diluted to prepare spiking solution.
(2) Prepared from stock solution daily.
(3) Precision and Recovery (PAR) standard. Prepared in nonane and diluted to prepare spiking solution.
(4) Prepared in nonane.
(5) Prepared in nonane.

Table 5
Descriptors, m/z Types, and Elemental Compositions of the CDDs and CDFs[1]

Descriptor Number	Accurate m/z[2]	m/z Type	Elemental Composition	Compound[3]	Primary m/z?
1	292.9825	LOCK	$C_7 F_{11}$	PFK	
	303.9016	M	$C_{12} H_4 {}^{35}Cl_4 O$	TCDF	YES
	305.8987	M+2	$C_{12} H_4 {}^{35}Cl_3$	TCDF	
	315.9419	M	${}^{13}C_{12} H_4 {}^{35}Cl_4 O$	TCDF[4]	YES
	317.9389	M+2	${}^{13}C_{12} H_4 {}^{35}Cl_3$	TCDF[4]	
	319.8965	M	$C_{12} H_4 {}^{35}Cl_4 O_2$	TCDD	YES
	321.8936	M+2	$C_{12} H_4 {}^{35}Cl {}^{37}Cl O_2$	TCDD	
	327.8847	M	$C_{12} H_4 {}^{37}Cl_4 O_2$	TCDD[5]	
	330.9792	QC	$C_7 F_{13}$	PFK	
	331.9368	M	${}^{13}C_{12} H_4 {}^{35}Cl_4 O_2$	TCDD[4]	YES
	333.9339	M+2	${}^{13}C_{12} H_4 {}^{35}Cl O_2$	TCDD[4]	
	375.8364	M+2	$C_{12} H_4 {}^{35}Cl_5 {}^{37}Cl O$	HxCDPE	
2	339.8597	M+2	$C_{12} H_3 {}^{35}Cl_4 {}^{37}Cl O$	PeCDF	YES
	341.8567	M+4	$C_{12} H_3 {}^{35}Cl_3 {}^{37}Cl_2 O$	PeCDF	
	351.9000	M+2	${}^{13}C_{12} H_3 {}^{35}Cl_4 {}^{37}Cl O$	PeCDF[4]	YES
	353.8970	M+4	${}^{13}C_{12} H_3 {}^{35}Cl_3 {}^{37}Cl_2 O$	PeCDF[4]	
	354.9792	LOCK	$C_9 F_{13}$	PFK	
	355.8546	M+2	$C_{12} H_3 {}^{35}Cl_4 {}^{37}Cl O_2$	PeCDD	YES
	357.8516	M+4	$C_{12} H_3 {}^{35}Cl_3 {}^{37}Cl_2 O_2$	PeCDD	
	367.8949	M+2	${}^{13}C_{12} H_3 {}^{35}Cl_4 {}^{37}Cl O_2$	PeCDD[4]	YES
	369.8919	M+4	${}^{13}C_{12} H_3 {}^{35}Cl_3 {}^{37}Cl_2 O_2$	PeCDD[4]	
	409.7974	M+2	$C_{12} H_3 {}^{35}Cl_6 {}^{37}Cl O$	HpCDPE	
3	373.8208	M+2	$C_{12} H_2 {}^{35}Cl_5 {}^{37}Cl O$	HxCDF	YES
	375.8178	M+4	$C_{12} H_2 {}^{35}Cl_4 {}^{37}Cl2 O$	HxCDF	
	383.8639	M	${}^{13}C_{12} H_2 {}^{35}Cl_6 O$	HxCDF[4]	YES
	385.8610	M+2	${}^{13}C_{12} H_2 {}^{35}Cl_5 {}^{37}Cl O$	HxCDF[4]	
	389.8157	M+2	$C_{12} H_2 {}^{35}Cl_5 {}^{37}Cl O_2$	HxCDD	YES
	391.8127	M+4	$C_{12} H_2 {}^{35}Cl_4 {}^{37}Cl_2 O_2$	HxCDD	
	392.9760	LOCK	$C_9 F_{15}$	PFK	
	401.8559	M+2	${}^{13}C_{12} H_2 {}^{35}Cl_5 {}^{37}Cl O_2$	HxCDD[4]	YES
	403.8529	M+4	${}^{13}C_{12} H_2 {}^{35}Cl_4 {}^{37}Cl_2 O_2$	HxCDD[4]	YES
	430.9729	QC	$C_9 F_{13}$	PFK	
	445.7555	M+4	$C_{12} H_2 {}^{35}Cl_6 {}^{37}Cl_2 O$	OCDPE	
4	407.7818	M+2	$C_{12} H {}^{35}Cl_6 {}^{37}Cl O$	HpCDF	YES
	409.7789	M+4	$C_{12} H {}^{35}Cl_7 O$	HpCDF	
	417.8253	M	${}^{13}C_{12} H {}^{35}Cl_7 O$	HpCDF[4]	YES
	419.8220	M+2	${}^{13}C_{12} H {}^{35}Cl_6 {}^{37}Cl O$	HpCDF[4]	
	423.7766	M+2	$C_{12} H {}^{35}Cl_6 {}^{37}Cl O_2$	HpCDD	YES
	425.7737	M+4	$C_{12} H {}^{35}Cl_5 {}^{37}Cl_2 O_2$	HpCDD	
	430.9729	LOCK	$C_9 F_{17}$	PFK	
	435.8169	M+2	${}^{13}C_{12} H {}^{35}Cl_6 {}^{37}Cl O_2$	HpCDD[4]	YES
	437.8140	M+4	${}^{13}C_{12} H {}^{35}Cl_5 {}^{37}Cl_2 O_2$	HpCDD[4]	
	479.7165	M+4	$C_{12} H {}^{35}C_{17} {}^{37}C_{12} O$	NCDPE	

Table 5 (continued)
Descriptors, m/z Types, and Elemental Compositions of the CDDs and CDFs[1]

Descriptor Number	Accurate m/z[2]	m/z Type	Elemental Composition	Compound[3]	Primary m/z?
5	441.7428	M+2	$C_{12}\ ^{35}Cl_7\ ^{37}Cl\ O$	OCDF	YES
	442.9728	LOCK	$C_{10}\ F_{17}$	PFK	
	443.7399	M+4	$C_{12}\ ^{35}C_{16}\ ^{37}Cl_2\ O$	OCDF	
	457.7377	M+2	$C_{12}\ ^{35}C_{17}\ ^{37}Cl\ O_2$	OCDD	YES
	459.7348	M+4	$C_{12}\ ^{35}C_{16}\ ^{37}Cl_2\ O_2$	OCDD	
	469.7779	M+2	$^{13}C_{12}\ ^{35}C_{17}\ ^{37}Cl\ O_2$	OCDD[4]	YES
	471.7750	M+4	$^{13}C_{12}\ ^{35}C_{16}\ ^{37}Cl_2\ O_2$	OCDD[4]	
	513.6775	M+4	$C_{12}\ ^{35}C_{18}\ ^{37}Cl_2\ O$	DCDPE	

(1) From Reference 5

(2) Nuclidic masses used:

H = 1.007825 C = 12.00000 ^{13}C = 13.003355 F = 18.9984
O = 15.994915 ^{35}Cl = 34.968853 ^{37}Cl = 36.965903

(3) Compound abbreviations:

Chlorinated dibenzo-p-dioxins:
TCDD = Tetrachlorodibenzo-p-dioxin
PeCDD = Pentachlorodibenzo-p-dioxin
HxCDD = Hexachlorodibenzo-p-dioxin
HpCDD = Heptachlorodibenzo-p-dioxin
OCDD = Octachlorodibenzo-p-dioxin

Chlorinated dibenzofurans
TCDF = Tetrachlorodibenzofuran
PeCDF = Pentachlorodibenzofuran
HxCDF = Hexachlorodibenzofuran
HpCDF = Heptachlorodibenzofuran

Chlorinated diphenyl ethers
HxCDPE = Hexachlorodiphenyl ether
HpCDPE = Heptachlorodiphenyl ether
OCDPE = Octachlorodiphenyl ether
NCDPE = Nonachlorodiphenyl ether
DCDPE = Dechachlorodiphenyl ether

Lock mass and QC compound
PFK = Perfluorokerosene

(4) Labeled compound

(5) There is only one m/z for $^{37}Cl_4$-2,3,7,8-TCDD (cleanup standard).

Table 6
Theoretical Ion Abundance Ratios and Control Limits

No. of Chlorine Atoms	m/z's Forming Ratio	Theoretical Ratio	Control Limits (1)	
			Lower	Upper
4(2)	M/M+2	0.77	0.65	0.89
5	M+2/M+4	1.55	1.32	1.78
6	M+2/M+4	1.24	1.05	1.43
6(3)	M/M+2	0.51	0.43	0.59
7	M+2/M+4	1.05	0.88	1.20
7(4)	M/M+2	0.44	0.37	0.51
8	M+2/M+4	0.89	0.76	1.02

(1) Represent ±15% windows around the theoretical ion abundance ratios.

(2) Does not apply to $^{37}Cl_4$-2,3,7,8-TCDD (cleanup standard).

(3) Used for ^{13}C-HxCDF only.

(4) Used for ^{13}C-HpCDF only.

Table 7
Acceptance Criteria for Performance Tests

Compound	I-Cal %RSD	Con-Cal %Delta	Dup %RPD	MS-MSD %RPD
2,3,7,8-TCDD	20	20	25	20
2,3,7,8-TCDF	20	20	25	20
1,2,3,7,8-PeCDD	20	20	25	20
1,2,3,7,8-PeCDF	20	20	25	20
2,3,4,7,8-PeCDF	20	20	25	20
1,2,3,4,7,8-HxCDD	20	20	25	20
1,2,3,4,7,8-HxCDD	20	20	25	20
1,2,3,7,8,9-HxCDD	20	20	25	20
1,2,3,4,7,8-HxCDF	20	20	25	20
1,2,3,6,7,8-HxCDF	20	20	25	20
1,2,3,7,8,9-HxCDF	20	20	25	20
2,3,4,6,7,8-HxCDF	20	20	25	20
1,2,3,4,6,7,8-HpCDD	20	20	25	20
1,2,3,4,6,7,8-HpCDF	20	20	25	20
1,2,3,4,7,8,9-HpCDF	20	20	25	20
OCDD	20	20	25	20
OCDF	20	20	25	20
^{13}C-2,3,7,8-TCDD	30	30	25	20
^{13}C-2,3,7,8-TCDF	30	30	25	20
^{13}C-1,2,3,7,8-PeCDD	30	30	25	20
^{13}C-1,2,3,7,8-PeCDF	30	30	25	20
^{13}C-1,2,3,6,7,8-HxCDD	30	30	25	20
^{13}C-1,2,3,4,7,8-HxCDF	30	30	25	20
^{13}C-1,2,3,4,6,7,8-HpCDD	30	30	25	20
^{13}C-1,2,3,4,6,7,8-HpCDF	30	30	25	20
^{13}C-OCDD	30	30	25	20
^{37}Cl-2,3,7,8-TCDD	30	30	25	20

Table 8.
PCDD/PCDF Isomers Used for Defining the Homologue GC Retention Time Windows on a 60m DB-5 Column

No. of Chlorine Atoms	PCDD Positional First Eluter	Isomer Last Eluter	PCDF Positional First Eluter	Isomer Last Eluter
*4	1368	1289	1368	1289
5	12468/12479	12389	13468	12389
6	124679/124689	123467	123468	123489
7	1234679	1234678	1234678	1234789
8	12346789	---	12346789	---

** The following Tetra CDD isomers are added to Window Defining Mix to determine isomer specificity: 1,2,3,4-TCDD, 1,2,3,7-/1,2,3,8-TCDD, 2,3,7,8-TCDD, and 1,2,3,9-TCDD.*

Table 9.
Isomers of Chlorinated Dioxins and Furans as a Function of the Number of Chlorine Atoms

No. of Chlorine Atoms	No. of Dioxin Isomers	No. of 2,3,7,8 Isomers	No. of Furan Isomers	No. of 2,3,7,8 Isomers
1	2	---	4	---
2	10	---	16	---
3	14	---	28	---
4	22	1	38	1
5	14	1	28	2
6	10	3	16	4
7	2	1	4	2
8	1	1	1	---
Total	**75**	**7**	**135**	**10**

Table 10.
GC Retention Time Window Defining Mixtures and Isomer Specificity Test Mixtures

Congener	First Eluted	Last Eluted
DB-5 Column GC Retention Time Window Defining Standard		
TCDF	1,3,6,8-	1,2,8,9-
TCDD	1,3,6,8-	1,2,8,9-
PeCDF	1,3,4,6,8-	1,2,3,8,9-
PeCDD	1,2,4,7,9-	1,2,3,8,9-
HxXCDF	1,2,3,4,6,8-	1,2,3,4,8,9-
HxCDD	1,2,4,6,7,9-	1,2,3,4,6,7-
HpCDF	1,2,3,4,6,7,8-	1,2,3,4,7,8,9-
HpCDD	1,2,3,4,6,7,9-	1,2,3,4,6,7,8-
DB-5 TCDD Isomer Specificity Test Standard		
	1,2,3,4-TCDD	1,2,3,7-TCDD
	1,2,7,8-TCDD	1,2,3,8-TCDD
	1,4,7,8-TCDD	2,3,7,8-TCDD
DB-225 Column TCDF Isomer Specificity Test Standard		
	2,3,4,7-TCDF	
	2,3,7,8-TCDF	
	1,2,3,9-TCDF	

FIGURE 1.
Flow Chart for Sample Extraction and Cleanup as Used for the Analysis of PCDDs and PCDFs in Complex Waste Samples

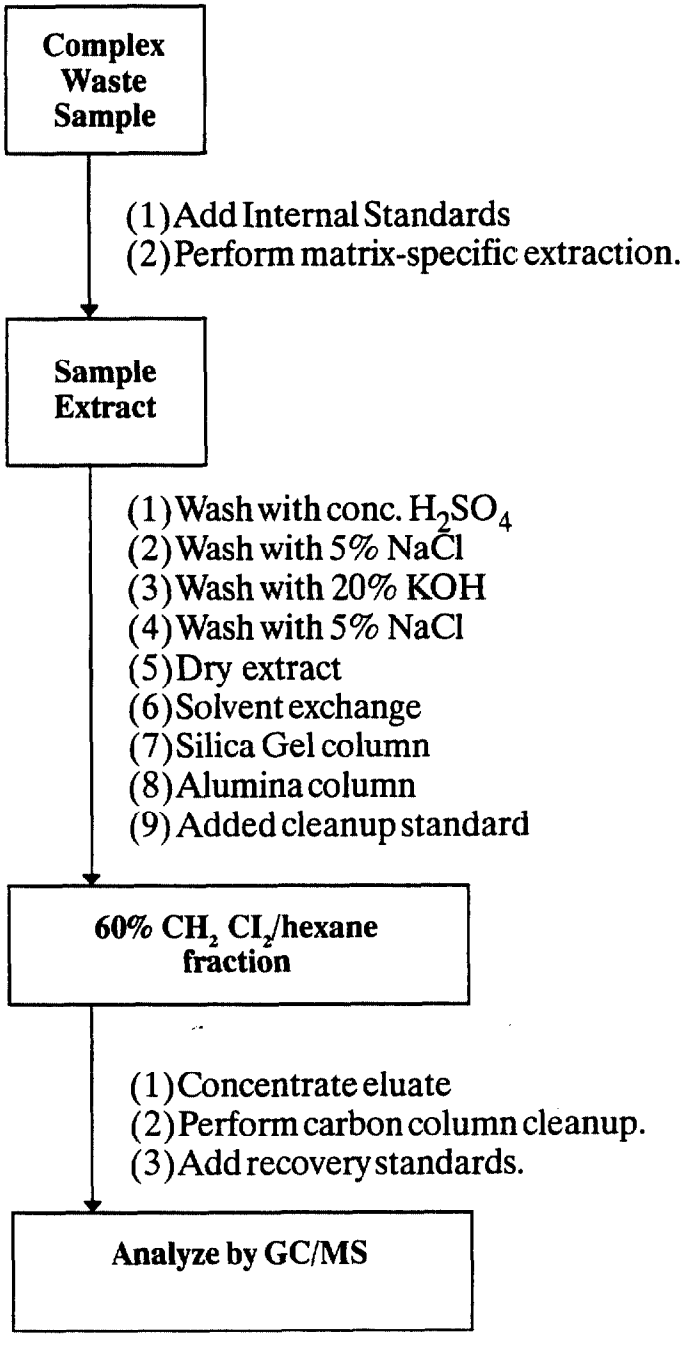
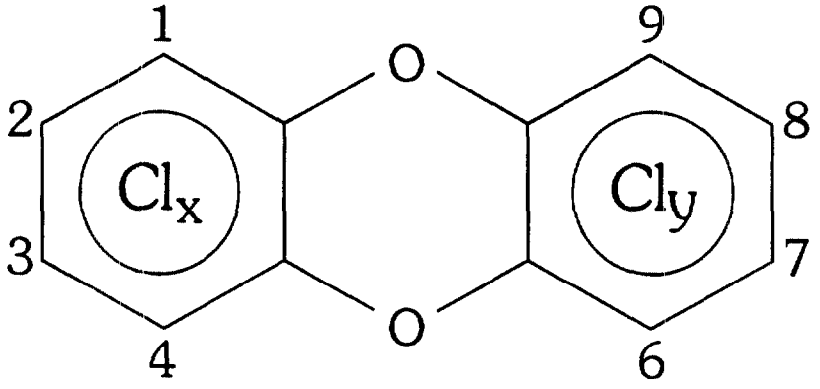
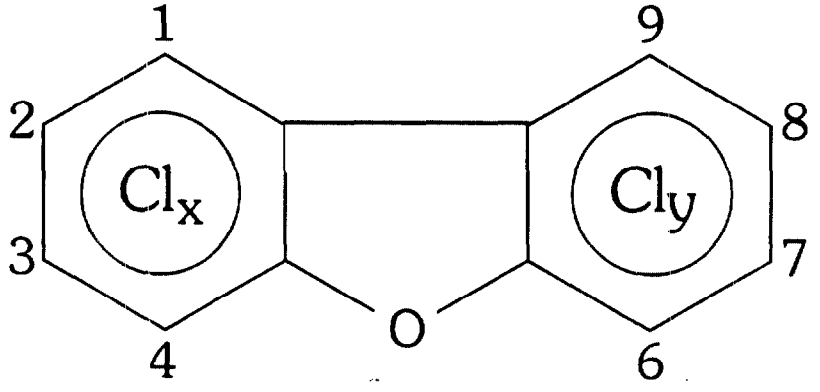


Figure 2.
General Structures of PCDD and PCDF



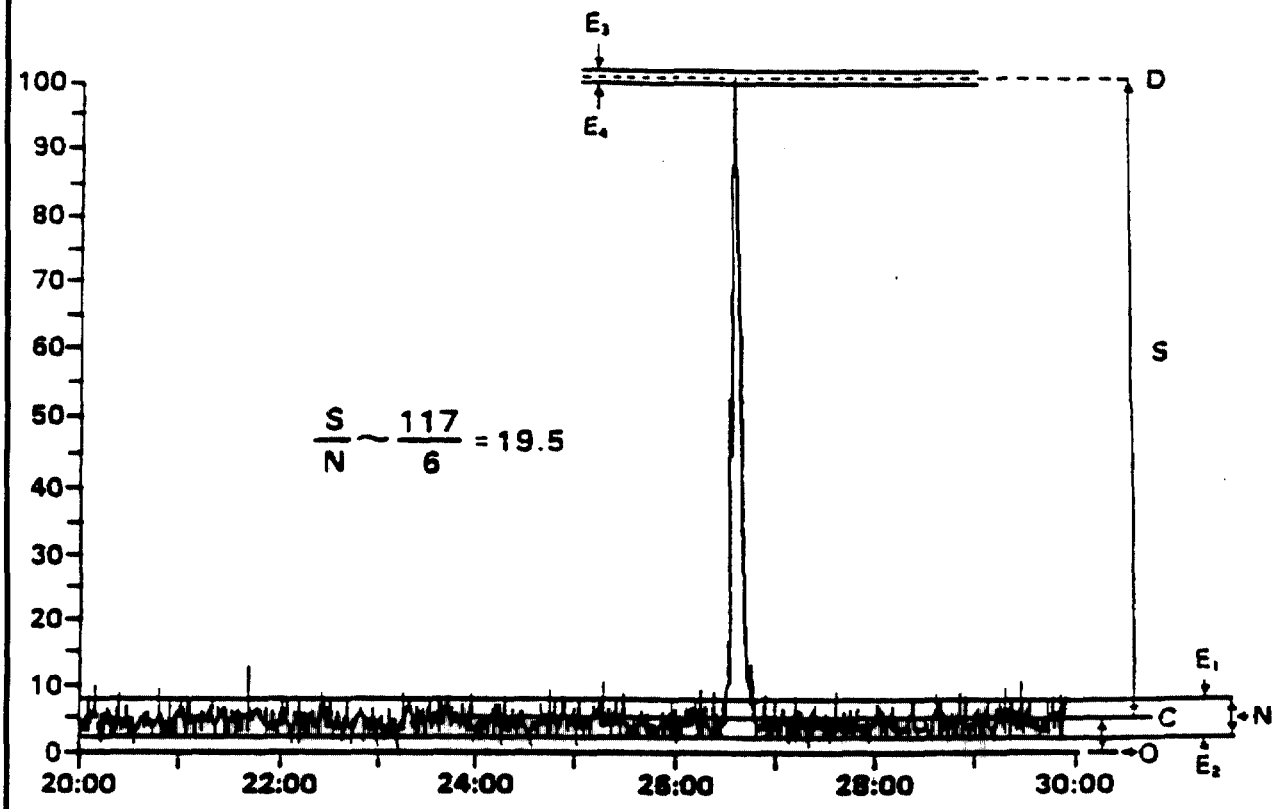
Polychlorinated dibenzo-p-dioxin (PCDD)

where $x + y \leq 8$



Polychlorinated dibenzofuran (PCDF)

Figure 3. Manual Determination of S/N

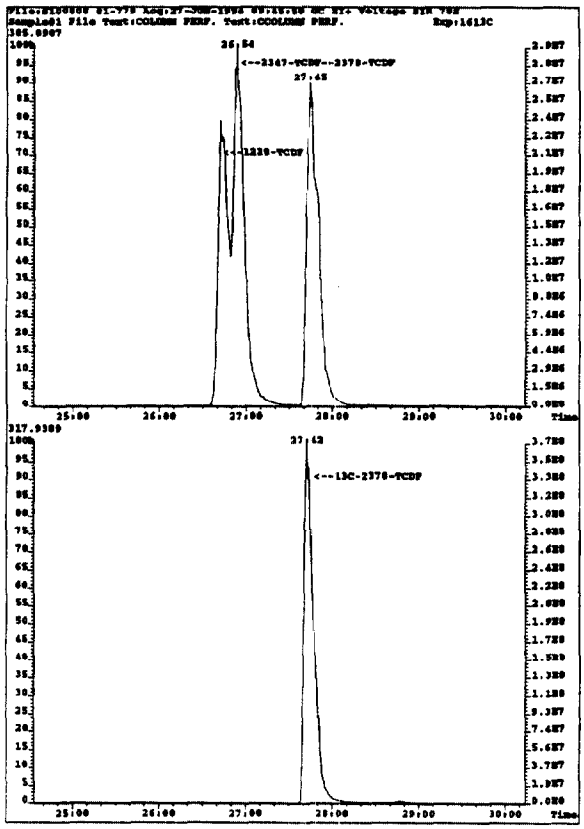


The peak height (S) is measured between the mean noise (lines C and D0. These mean signal values are obtained by tracing the line betwen the baseline average moise extremes, E1 and E2, and between the apex average noise extremes, E3 and E4, at the apex of the signal.

NOTE: It is imperative that the instrument interface amplifier electronic zero offset be set high enough so that negative going baseline noise is recorded.

Figure 4. Window Define and Column Performance Resolution Check

SP-2331 Column:
2,3,7,8-TCDF and
other closely eluting isomers.



DB-5:
2,3,7,8-TCDD and
other closely eluting isomers.

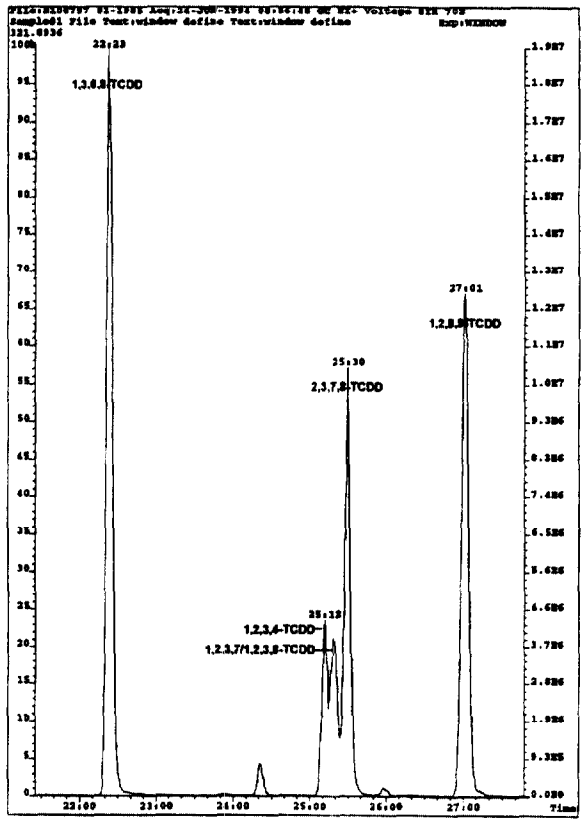


Figure 5. Sample Data Summary Top Sheet (Analyte Concentration)

AATS/SWL OK 10-NOV-1994 Page 1

USEPA - ITD Page 6 of 7

Form 1A
PCDD/PCDF ANALYSIS DATA SHEET
Use for Sample and Blank Results

CLIENT ID.
94HPSD02SD

Lab Name: Southwest Lab. of Oklahoma Episode No.: 20483

Client Name: SWL Lab Sample ID: 20483.04

Matrix (aqueous/solid/leachate): solid Sample Wt/Vol: 10 g or mL: g

Sample Receipt Date: 11-02-94 Initial Calibration Date: 09-15-94

Ext. Date: 11-03-94 Instrument ID: AutoSpec

Analysis Date: 8-NOV-94 Time: 16:12:32 GC Column ID: DB-5

Extract Volume (uL): 20 Sample Data Filename: A100546#1

Injection Volume (uL): 1.00 Blank Data Filename: A100544#1

Dilution Factor: 1 Cal. Ver. Data Filename: A100543#1

Concentration Units (pg/L or ng/Kg dry weight): ng/Kg % Solids: 62.88

ANALYTE	CONCENTRATION FOUND	DETECTION LIMIT	EMPC	ION ABUND. RATIO (1)	RRT (1)
2,3,7,8-TCDD	*	2.018	*	*	*
1,2,3,7,8-PeCDD	*	1.496	*	*	*
1,2,3,4,7,8-HxCDD	*	0.706	*	*	*
1,2,3,6,7,8-HxCDD	*	0.440	*	*	*
1,2,3,7,8,9-HxCDD	*	0.443	*	*	*
1,2,3,4,6,7,8-HpCDD	-	0.666	1.181	0.55	1.000
OCDD	8.065	0.410	-	0.88	1.000
2,3,7,8-TCDF	*	1.023	*	*	*
1,2,3,7,8-PeCDF	*	0.435	*	*	*
2,3,4,7,8-PeCDF	*	0.412	*	*	*
1,2,3,4,7,8-HxCDF	*	0.396	*	*	*
1,2,3,6,7,8-HxCDF	-	0.251	0.423	1.03	1.004
1,2,3,7,8,9-HxCDF	-	0.340	0.612	2.35	1.047
2,3,4,6,7,8-HxCDF	*	0.336	*	*	*
1,2,3,4,6,7,8-HpCDF	0.875	0.306	-	1.13	1.000
1,2,3,4,7,8,9-HpCDF	*	0.367	*	*	*
OCDF	-	0.609	1.038	1.37	1.002
Total Tetra-Dioxins	*	2.018			
Total Penta-Dioxins	*	1.496			
Total Hexa-Dioxins	*	0.505			
Total Hepta-Dioxins	*	0.666			
Total Tetra-Furans	*	1.023			
Total Penta-Furans	*	0.424			
Total Hexa-Furans	*	0.322			
Total Hepta-Furans	10.258	0.334			

(1) Reference Attributions for RRTs and ion abundance ratios are specified in Tables 11 and 8, respectively, Method 8290 8290F1

Figure 6. Sample Data Summary Top Sheet (QA/QC Summary)

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FORM 2
PCDD/PCDF LABELED COMPOUND AND
CLEANUP STANDARD RECOVERIES

CLIENT ID.
94HPSD02SD

Lab Name: Southwest Lab. of Oklahoma Episode No.: 20483

Client Name: SWL Lab Sample ID: 20483.04

Matrix (aqueous/solid/leachate): solid Sample Wt/Vol: 10 g or mL: g

Sample Receipt Date: 11-02-94 Initial Calibration Date: 09-15-94

Ext. Date: 11-03-94 Instrument ID: AutoSpec

Analysis Date: 8-NOV-94 Time: 16:12:32 GC Column ID: DB-5

Extract Volume (uL): 20 Sample Data Filename: A100546#1

Injection Volume (uL): 1.00 Blank Data Filename: A100544#1

Dilution Factor: 1 Cal. Ver. Data Filename: A100543#1

Concentration Units (pg/L or ng/Kg dry weight): ng/Kg % Solids: 62.88

	SPIKE CONC.	CONCENT. FOUND	RECOV. %	ION ABUND. RATIO (2)	RRT (2)
LABELED COMPOUNDS					
13C-2,3,7,8-TCDD	2000	842.17	42.11	0.76	1.041
13C-1,2,3,7,8-PeCDD	2000	892.10	44.60	1.59	1.349
13C-1,2,3,6,7,8-HxCDD	2000	1247.65	62.38	1.23	0.991
13C-1,2,3,4,6,7,8-HpCDD	2000	1401.30	70.06	1.06	1.082
13C-OCDD	4000	2498.03	62.45	0.88	1.159
13C-2,3,7,8-TCDF	2000	922.87	46.14	0.82	*
13C-1,2,3,7,8-PeCDF	2000	941.94	47.10	1.56	1.272
13C-1,2,3,4,7,8-HxCDF	2000	1407.29	70.36	0.52	0.961
13C-1,2,3,4,6,7,8-HpCDF	2000	1136.54	56.83	0.42	1.054
CLEANUP STANDARD					
37Cl-2,3,7,8-TCDD	800	742.98	92.87		1.042

(1) Contract-required limits for percent recovery are 40%-135% (section 8.4, Method 8290).

(2) Contract-required Reference Attributions for RRTs and ion abundance ratios are specified in Tables 11 and 8, respectively, Method 8290.

NOTE: There is no ion abundance ratio for 37Cl4-2378-TCDD (cleanup standard).

8290F2

Figure 7. Response "Raw Data"

AATS/SWL OK 10-NOV-1994 Page 1

Southwest Laboratory of Oklahoma, Inc. Page 6 of 7
Sample Response Summary
EPA SAMPLE NO.
94HPSD02SD

Run #11 Filename A100546#1 Samp: 1 Inj: 1 Acquired: 8-NOV-94 16:12:32
Processed: 8-Nov-94 17:57:52 Comments: 20483.04

	Typ	Name RT	Resp 1	Resp 2	Ratio	Meet
1	Unk	2,3,7,8-TCDF|NotFnd	*	*	*	no
2	Unk	1,2,3,7,8-PeCDF|NotFnd	*	*	*	no
3	Unk	2,3,4,7,8-PeCDF|NotFnd	*	*	*	no
4	Unk	1,2,3,4,7,8-HxCDF|NotFnd	*	*	*	no
5	Unk	1,2,3,6,7,8-HxCDF|36:37	2.703e+04	2.636e+04	1.03	no
6	Unk	2,3,4,6,7,8-HxCDF|NotFnd	*	*	*	no
7	Unk	1,2,3,7,8,9-HxCDF|38:10	4.004e+04	1.704e+04	2.35	no
8	Unk	1,2,3,4,6,7,8-HpCDF|39:59	3.940e+04	3.495e+04	1.13	yes
9	Unk	1,2,3,4,7,8,9-HpCDF|NotFnd	*	*	*	no
10	Unk	OCDF|44:04	4.946e+04	3.603e+04	1.37	no
11	Unk	2,3,7,8-TCDD|NotFnd	*	*	*	no
12	Unk	1,2,3,7,8-PeCDD|NotFnd	*	*	*	no
13	Unk	1,2,3,4,7,8-HxCDD|NotFnd	*	*	*	no
14	Unk	1,2,3,6,7,8-HxCDD|NotFnd	*	*	*	no
15	Unk	1,2,3,7,8,9-HxCDD|NotFnd	*	*	*	no
16	Unk	1,2,3,4,6,7,8-HpCDD|41:03	2.656e+04	4.841e+04	0.55	no
17	Unk	OCDD|43:58	2.408e+05	2.749e+05	0.88	yes
18	IS	13C-2,3,7,8-TCDF|24:25	1.270e+07	1.540e+07	0.82	yes
19	IS	13C-1,2,3,7,8-PeCDF|31:04	1.602e+07	1.024e+07	1.56	yes
20	IS	13C-1,2,3,4,7,8-HxCDF|36:27	7.167e+06	1.390e+07	0.52	yes
21	IS	13C-1,2,3,4,6,7,8-HpCDF|39:59	5.752e+06	1.354e+07	0.42	yes
22	IS	13C-2,3,7,8-TCDD|25:24	6.513e+06	8.579e+06	0.76	yes
23	IS	13C-1,2,3,7,8-PeCDD|32:56	8.938e+06	5.617e+06	1.59	yes
24	IS	13C-1,2,3,6,7,8-HxCDD|37:34	1.349e+07	1.092e+07	1.23	yes
25	IS	13C-1,2,3,4,6,7,8-HpCDD|41:02	1.070e+07	1.009e+07	1.06	yes
26	IS	13C-OCDD|43:58	1.603e+07	1.812e+07	0.88	yes
27	RS	13C-1,2,3,4-TCDD|25:08	1.659e+07	2.102e+07	0.79	yes
28	RS	13C-1,2,3,7,8,9-HxCDD|37:55	2.133e+07	1.693e+07	1.26	yes
29	C/Up	37Cl-2,3,7,8-TCDD|25:26	1.384e+07			
				SUM AREA		
30	Tot	Total Tetra-Furans|NotFnd		*	*	no
31	Tot	Total Tetra-Dioxins|NotFnd		*	*	no
32	Tot	Total Penta-Furans|NotFnd		*	*	no
33	Tot	Total Penta-Dioxins|NotFnd		*	*	no
34	Tot	Total Hexa-Furans|NotFnd		*	*	no
35	Tot	Total Hexa-Dioxins|NotFnd		*	*	no
36	Tot	Total Hepta-Furans|39:59		8.053e+05	1.13	yes
37	Tot	Total Hepta-Dioxins|NotFnd		*	*	no

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Broken Arrow, OK 74012
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Figure 8. Response "Raw Data"

AATS/SWL OK 10-NOV-1994 Page 1

Page 7 of 16

Southwest laboratory of Oklahoma, Inc.
Peak List Summary

CLIENT ID.
94HPSD02SD

Entry: 36 Totals Name: Total Hepta-Furans

Run: 11 File: A100546#1 Sample:1 Injection:1 Function:4

Acquired: 8-NOV-94 16:12:32 Processed: 8-Nov-94 17:57:52

Mass:407.782 409.779 Response:

#	RT	Resp	Resp Ratio	Meet	Tot Resp	Conc.	Name
1	39:59	3.94e+04	3.49e+04 1.13	yes	7.43e+04	0.875	1,2,3,4,6,7,8-HpCDF
2	40:25	3.88e+05	3.43e+05 1.13	yes	7.31e+05	9.384	

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OFFICIAL COPY RED STAMP INDICATES ORIGINAL

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF CHEMICAL OXYGEN DEMAND

(COLORIMETRIC WITH HACH TUBES, MID-HIGH LEVEL 0-1500 PPM, DETECTION LIMIT 10 PPM)

IN090

REV 1.1 — 3/3/93

SWL-IN090C-002

CONTROLLED DOCUMENT: DO NOT COPY!

APPROVALS BY:

Name: Steve L. Markham **Title:** Inorganic Manager

Signature: Steve L. Markham

Name: Chuck Hoover **Title:** QC Officer

Signature: Chuck Hoover

I. SCOPE AND APPLICATION

1.1 This method covers the determination of COD in surface waters, domestic and industrial wastes.

1.2 The applicable range of this method is 10—1500 ppm, samples above 1500 ppm may be diluted, then run using same standard curve.

II. SUMMARY OF METHOD

2.1 Sample, blanks and standards in sealed Hach tubes are heated in a block digestor at 150°C for a minimum of two hours. After heating period, the tubes are removed from the digestor, cooled and measured spectrophotometrically at 600nm.

III. SAMPLE HANDLING AND PRESERVATION

3.1 Collect the samples in glass bottles if possible. Use of plastic containers is permissible if it is known that no organic contaminants are present in the containers.

3.2 Samples should be preserved with sulfuric acid to a pH <2 and maintained at 4°C until analysis.

3.3 Holding Time: 28 days from collection, if preserved. Non-preserved samples should be run as soon as possible from collection date.

IV. INTERFERENCES

4.1 Chlorides are quantitatively oxidized by dichromate and represent a positive interference. Mercuric sulfate has been added to the Hach tubes to complex the chlorides.

V. APPARATUS

5.1 Block digestor, 150°C.

5.2 Hach COD tubes 0—1500 ppm.

5.3 5.0ml x 1/10 Disposable Serological pipets.

5.4 Spectrophotometer.

VI. REAGENTS

6.1 Hach COD tubes 0—1500 ppm.

6.2 Each tube (0—1500 ppm) contains:

- H_2SO_4 98% concentration
- Mercuric sulfate
- Chromic acid
- Ag_2SO_4
- DI water

VII. STANDARDS

7.1 Stock potassium acid phthalate (KHP): Dissolve 1.700g of dried (2 hours at 120°C) KHP in 800 mls of distilled water and dilute to 1 liter. 1ml = 2mg of COD; 2000mg/l COD.

7.1.1 Prepare six standard solutions, i.e., 10,50,100,500,1000,1500 mg/l, by diluting appropriate volumes of stock standard.
7.1.2 Analyze DI water as a reagent blank with standard curve.

VIII. PROCEDURE

8.1 Turn on both block digestor and spectrophotometer, set wavelength to 600nm.
8.2 Mix both unknowns and standards by inversion.
8.3 Add with 5.0 ml disposable serological pipet 2.0 mls of sample to each tube. Use same volume for both standards and unknowns.
8.4 Use 100 ppm standard as a blank spike (ICV) with each run of unknowns.
8.5 Use DI water for a reagent blank with each run of unknowns to set zero absorbance on spectrophotometer.
8.6 Cap tightly and mix tubes by inversion to blend both phases.
8.7 Place tubes in block digestor at 150°C ± 5°C for two hours.
8.8 Remove tubes from digestor, place in Nalgene rack, and allow to cool for 10 minutes. Mix each tube by inversion twice and allow any precipitate to settle and for tubes to reach room temperature, about 20 minutes.
8.9 Measure intensity in spectrophotometer at 600nm, making sure that the Hach label on the tubes faces to the right in the spectrophotometer.

IX. CALCULATION

9.1 Prepare a standard curve by plotting absorbance against known concentrations of standards.
9.2 Compute concentration of unknowns by comparing sample response to standard curve.

X. QUALITY CONTROL (ICV'S)

10.1 Your ICV should be ± 10%. If outside your control limits, report ICV and unknowns using fresh standards.
10.2 Standard KHP kept in the refrigerator should be good for 4 months or until discoloration appears.
10.3 Every new lot number of tubes must have a new standard curve.

XI. PRECISION AND ACCURACY

11.1 Duplicates should be run every 10 samples and data recorded in QA/QC book.
11.2 Matrix spikes should be done with stock KHP every 10 samples and data recorded in QA/QC book.
11.3 If duplicates or matrix spikes are outside control limits see your supervisor.

BIBLIOGRAPHY

1. US EPA: Methods for Chemical Analysis of Waters and Wastes.
2. Standard Methods for the Examination of Water and Wastewater, 16th Addition
3. Hach: Water Analysis Handbook

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF

TOTAL DISSOLVED SOLIDS

IN270

REV 1.0 — 5/20/92

Document Control # SWL-IN270- 012

CONTROLLED DOCUMENT: DO NOT COPY!

APPROVALS BY:

Name: Chuck Hoover Title: QC Officer

Signature: Chuck Hoover

Name: Jason D. Ruckman Title: Inorganic Program Manager

Signature:

I. Scope and Application

1. This method is applicable to drinking, surface and saline waters, domestic and industrial wastes.
2. The practical range of determination is 1 mg/l to 20,000 mg/l.

II. Summary of Method

1. A well-mixed sample is filtered through a standard glass fiber filter. The filtrate is evaporated and dried to constant weight at 180°.
2. If total suspended solids is being determined, the filtrate from that method may be used for total dissolved solids.

III. Sample Handling and Preservation

1. Preservation of the sample is not practical; analysis should begin as soon as possible. Refrigeration at 4° helps minimize microbiological decomposition of solids.
2. Holding time is 7 days from sample collection.

IV. Interferences

1. Highly mineralized waters containing significant concentrations of calcium, magnesium, chloride and/or sulfate may be hygroscopic and will require prolonged drying, desiccation and rapid weighing.
2. Samples containing high concentrations of bicarbonate will require careful and possibly prolonged drying at 180° to insure that all the bicarbonate is converted to carbonate.
3. Too much residue in the evaporating dish will crust over and entrap water that will not be driven off during drying. Total residue should be limited to about 200 mg.

V. Apparatus

1. Glass fiber filter discs, 2.1 cm
2. Gooch crucible adapter
3. Vacuum flask, 500ml
4. Gooch crucibles, 25 ml
5. Evaporating dishes, porcelain, 100 ml volume
6. Hot plate
7. Drying oven, 1800° ± 2°C
8. Desiccator
9. Analytical balance, Metler, model # H8

VI. Procedure

1. *Preparation of glass fiber filter disc:* Place the disc, on the bottom of a Gooch crucible. While vacuum is applied, wash the disc with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum. Discard washings.
2. *Preparation of evaporating dishes:* Heat the clean dish to 180° + 2° for one hour. Cool in desiccator and store until needed. Weigh immediately before use.

3. Assemble the filtering apparatus and begin suction. Shake the sample vigorously and rapidly transfer 100ml to the funnel by means of a 100 ml graduated cylinders.
4. Filter the sample through the glass fiber filter. Rinse the cylinder and Gooch crucible with three 10 ml portions of distilled water and continue to apply vacuum for about 3 minutes after filtration is complete to remove as much water as possible.
5. Transfer the filtrate to a weighed evaporating dish and evaporate to dryness on a hot plate.
6. Transfer the evaporating dish to the drying oven and heat for at least one hour at 180° ± 2°. cool in a desiccator and weigh. Repeat the drying cycle until a constant weight is obtained or until weight loss is less than 0.5 mg.

VII. Calculation

1. Calculate filterable residue as follows:

$$\text{TDS, mg/L} = \frac{(A-B) \times 1000}{C}$$

Where: A = weight of dried residue + dish in mg.
B = weight of dish in mg
C = volume of sample used in ml

OFFICIAL COPY RED STAMP INDICATES ORIGINAL

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF INORGANIC ANIONS IN WATER BY ION CHROMATOGRAPHY

IN030, IN055, IN135, IN185, IN195, IN255, IN295
REV 1.0 — 1/11/93

Document Control# SWL-IN030A- 007

CONTROLLED DOCUMENT: DO NOT COPY!

APPROVALS BY:

Name: Chuck Hoover **Title:** QC Officer

Signature: Chuck Hoover

Name: Jason D. Ruckman **Title:** Inorganic Program Manager

Signature: for DR

I. SUMMARY

A. **Analytes:** Bromide, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, Sulfate.

B. **Matrix:** This method is applicable to the determination of the above anions in drinking water, surface water, mixed domestic and industrial waste waters, groundwater, and reagent water.

C. **General Method:** A 1 to 2 ml volume of sample is introduced into the ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor device, and conductivity detector.

II. APPLICATION

A. **Calibration Range:**

Bromide .....0 - 500 ug/l
Chloride .....0 - 500 ug/l
Fluoride .....0 - 200 ug/l
Nitrate .....0 - 100 ug/l
Nitrite.....0 - 100 ug/l
Orthophosphate .....0 - 200 ug/l
Sulfate.....0 - 500 ug/l

B. **Tested Concentration Range:**

Bromide .....25 - 500 ug/l in water
Chloride .....25 - 500 ug/l in water
Fluoride .....10 - 200 ug/l in water
Nitrate .....5 - 100 ug/l in water
Nitrite.....5 - 100 ug/l in water
Orthophosphate ....10 - 200 ug/l in water
Sulfate.....25 - 500 ug/l in water

C. **Sensitivity**

Bromide ..... A 50 ug/l standard gives an approximate peak height of 17895.
Chloride ..... A 50 ug/l standard gives an approximate peak height of 67000.
Fluoride ..... A 20 ug/l standard gives an approximate peak height of 37500.
Nitrate ..... A 10 ug/l standard gives an approximate peak height of 5262.
Nitrite..... A 10 ug/l standard gives an approximate peak height of 7210.
Orthophosphate ..... A 20 ug/l standard gives an approximate peak height of 2452.
Sulfate..... A 50 ug/l standard gives an approximate peak height of 12948.

D. **Interferences**

1. Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or spiking can be used to solve most interference problems.

2. Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that leads to discrete artifacts or elevated baselines.

3. Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow systems.

E. **Safety Information**

1. Normal, accepted laboratory safety procedures should be followed during reagent preparation and instrument operation. No known carcinogenic materials are used in this method.

III. APPARATUS AND CHEMICALS

A. **Instrumentation**

1. Dionex-100X ion chromatograph with required accessories including autosampler, analytical columns, compressed gases, and detectors.

2. Anion guard column: Dionex Ion Pac AG4A-SC

3. Anion separator column: Dionex Ion Pac AS4A-SC

4. Anion suppressor device: Dionex Anion Micro-Membrane Suppressor

5. Detector: Dionex Conductivity Cell

6. Dionex ACI interface

7. Dionex AI-450 software

B. **Analytes**

Bromide: ..... Ion of Bromine, CAS No. 7726-95-6
Chloride: ..... Ion of Chlorine, CAS No. 7782-50-5
Fluoride: ..... Ion of Fluorine, CAS No. 7782-41-4
Nitrate: ..... An intermediate oxidation state of nitrogen.
Nitrite: ..... An intermediate oxidation state of nitrogen.
Orthophosphate: . Inorganic form of phosphorus.
Sulfate: ..... Naturally occurring ion widely distributed in water.

C. Reagents and SARMS

1. *Reagent Water:* Deionized water, free of the anions of interest. The water must be filtered through a 0.2 micron filter.

2. *Eluent Solution:* Sodium bicarbonate 1.7 mm, sodium carbonate 1.8 mm. Dissolve 0.2856 g sodium bicarbonate ($NaHCO_3$) and 0.3816 g of sodium carbonate (Na_2CO_3) in reagent water and dilute to 2 liters.

3. *Regeneration solution:* Sulfuric acid, 0.025 N. Dilute 2.8 ml conc. H_2SO_4 to 4 liters with reagent water.

4. *Stock standard solutions, 1000 mg/l:* Stock standard solutions are purchased form Spex Industries. Please see attached certificate of analysis.

IV. PRECERTIFICATION CALIBRATION

A. Preparation of Standards

1. Intermediate Stock Standard (10 mg/l): For all anions add 1.0 ml of stock standard to a 100 ml volumetric flask. Dilute to 100 ml with reagent water. Make fresh weekly.

2. Table I lists the preparation of the high calibration standard (10x TRL), which is prepared from the dilution of the intermediate stock standards. All remaining standards are made from dilutions of the high calibration standard. All standards are made using volumetric pipettes and volumetric flasks. All standards are brought to final volume using reagent water and are made fresh daily. Tables II through V list the preparation of the remaining calibration standards.

TABLE I.
PREPARATION OF HIGH CALIBRATION STANDARD (10X TRL)

Anion	mls of 10 mg/l Int. Stock /100ml	Final Conc. (ug/l)
Bromide	5.0	500
Chloride	5.0	500
Fluoride	2.0	200
Nitrate	1.0	100
Nitrite	1.0	100
Orthophosphate	2.0	200
Sulfate	5.0	500

TABLE II.
PREPARATION OF 5X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/l)
Bromide	50	250
Chloride	50	250
Fluoride	50	100
Nitrate	50	50
Nitrite	50	50
Orthophosphate	50	100
Sulfate	50	250

TABLE III.
PREPARATION OF 2X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/l)
Bromide	20	100
Chloride	20	100
Fluoride	20	40
Nitrate	20	20
Nitrite	20	20
Orthophosphate	20	40
Sulfate	20	100

TABLE IV.

PREPARATION OF 1X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/l)
Bromide	1.0	50
Chloride	1.0	50
Fluoride	1.0	20
Nitrate	1.0	10
Nitrite	1.0	10
Orthophosphate	1.0	20
Sulfate	1.0	50

TABLE V.

PREPARATION OF 0.5X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/l)
Bromide	0.5	25
Chloride	0.5	25
Fluoride	0.5	10
Nitrate	0.5	5
Nitrite	0.5	5
Orthophosphate	0.5	10
Sulfate	0.5	25

B. Instrument Calibration

1. Start the pump by pressing the pump start button. Gradually increase flow to 2.0 ml/min. by increments of 0.5 until ready light comes on.
2. Start regeneration flow.
3. Turn on the conductivity cell and set attenuator range to 1K us.
4. Wait for system to stabilize, generally 15 - 30 minutes.
5. After stabilization, set baseline, then inject 1.0 ml of mid-range standard.
6. Using the retention times from this standard, build your calibration table entering the concentrations for each standard.
7. Using injections of 1.0 ml of each calibration standard, tabulate peak height against the concentration.

C. Analysis of Calibration Data

1. The resulting curve must have a linear regression correlation coefficient greater than 0.995.
2. Analyze an EPA certified check standard to verify your curve. The result must be within the check standard control limits.
3. When analyzing samples, the certified check standard must be run twice, once at the beginning and once at the end of the day. If results are found to exceed acceptability limits, immediate reanalysis of the check standard is required. If results from the reanalysis still exceed acceptability limits, the system must be recalibrated.

V. PROCEDURE

A. Sample Preparation

1. No sample preparation is necessary if autosampler vials with filters are used. If manual injection is used, the sample must first be filtered through a 0.2 micron filter.

2. Three spiked standard matrix QC samples shall be included in each lot. Two spiked standard matrix QC samples shall contain all control analytes at a concentration near the upper end of the certified range. The third spiked sample shall be at approximately 2x CRL.

B. Chemical Reactions:

None Known

C. Instrument Analysis

1. Set-up and calibrate instrument as specified in section IV.B.

2. Load the autosampler and inject 1.0 ml of sample. Use the same size loop and conditions for standards and samples.

3. The width of the retention time window used to make identifications should be based upon measurements of actual retention time variations of standards.

4. If the response for the peak exceeds the working range of the highest standard, dilute the sample with an appropriate amount of reagent water and reanalyze.

5. In addition to the certified check standards, a standard at the highest concentration must be analyzed after sample analyses are completed. For the first seven calibrations, the response must agree within 10% of the mean response for the same concentration, as determined from precertification, and the certification Initial Calibration. After seven calibrations, responses must agree within two standard deviations. If the response fails the test, the daily standard should be reanalyzed. If the response from the second analysis fails the test, the system is considered to have failed calibration and all samples must be reanalyzed after repeating Initial Calibration.

VI. CALCULATIONS

A. All results will be taken directly from the ion chromatograph in ug/l.

B. If results for a analyte are obtained without dilution, the anion concentration in the sample will be reported to the significant figures. If dilution was required, the result will be reported to only two significant figures.

C. The method blank value, if above the CRL, will be subtracted from field sample values for the same lot.

VII. REFERENCES

A. Rocky Mountain Arsenal, Chemical Quality Assurance Plan, Version 1.0, July 1989.

B. US EPA, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Method 300.0.

VIII. DATA

A. Response versus concentration data: see attached.

B. Response versus concentration graphs: see attached.

C. LOF tests: see attached.

D. ZI tests: see attached.

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SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE ANALYSIS OF ANIONS IN SOIL BY ION CHROMATOGRAPHY

IN030, IN055, IN185, IN195, IN255, IN295

REV 1.0 — 1/11/93

Document Control # SWL-IN030- 006

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APPROVALS BY:

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Signature: Chuck Hoover

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Signature: for DR

I. SUMMARY

A. **Analytes:** Bromide, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, Sulfate.

B. **Matrix:** This method is applicable to the determination of the above anions in soil, sludges, and sediments.

C. **General Method:** A 1 to 2 ml volume of extracted sample is introduced into the ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor device, and conductivity detector.

II. APPLICATION

A. **Calibration Range:**

Bromide .....0 - 5 ug/g
Chloride .....0 - 5 ug/g
Fluoride .....0 - 2 ug/g
Nitrate .....0 - 1 ug/g
Nitrite.....0 - 1 ug/g
Orthophosphate .....0 - 2 ug/g
Sulfate.....0 - 5 ug/g

B. **Tested Concentration Range:**

Bromide .....0.25 - 5 ug/g in soil
Chloride .....0.25 - 5 ug/g in soil
Fluoride .....0.10 - 2 ug/g in soil
Nitrate .....0.5 - 1 ug/g in soil
Nitrite.....0.5 - 1 ug/g in soil
Orthophosphate .....0.10 - 2 ug/g in soil
Sulfate.....0.25 - 5 ug/g in soil

C. **Sensitivity**

Bromide ..... A 0.5 ug/g standard gives an approximate peak height of 17895.
Chloride ..... A 0.5 ug/g standard gives an approximate peak height of 67000.
Fluoride ..... A 0.2 ug/g standard gives an approximate peak height of 37500.
Nitrate ..... A 0.1 ug/g standard gives an approximate peak height of 5262.
Nitrite..... A 0.1 ug/g standard gives an approximate peak height of 7210.
Orthophosphate ..... A 0.2 ug/g standard gives an approximate peak height of 2452.
Sulfate..... A 0.5 ug/g standard gives an approximate peak height of 12948.

D. **Interferences**

1. Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or spiking can be used to solve most interference problems.

2. Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that leads to discrete artifacts or elevated baselines.

3. Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow systems.

E. **Safety Information**

1. Normal, accepted laboratory safety procedures should be followed during reagent preparation and instrument operation. No known carcinogenic materials are used in this method.

III. APPARATUS AND CHEMICALS

A. **Instrumentation**

1. Dionex-100X ion chromatograph with required accessories including autosampler, analytical columns, compressed gases, and detectors.

2. Anion guard column: Dionex Ion Pac AG4A-SC

3. Anion separator column: Dionex Ion Pac AS4A-SC

4. Anion suppressor device: Dionex Anion Micro-Membrane Suppressor

5. Detector: Dionex Conductivity Cell

6. Dionex ACI interface

7. Dionex AI-450 software

8. Mechanical Shaker

B. **Analytes**

Bromide: ..... Ion of Bromine, CAS No. 7726-95-6
Chloride: ..... Ion of Chlorine, CAS No. 7782-50-5
Fluoride: ..... Ion of Fluorine, CAS No. 7782-41-4
Nitrate: ..... An intermediate oxidation state of nitrogen.
Nitrite: ..... An intermediate oxidation state of nitrogen.
Orthophosphate: . Inorganic form of phosphorus.
Sulfate: ..... Naturally occurring ion widely distributed in water.

C. Reagents and SARMS

1. *Reagent Water:* Deionized water, free of the anions of interest. The water must be filtered through a 0.2 micron filter.

2. *Eluent Solution:* Sodium bicarbonate 1.7 mm, sodium carbonate 1.8 mm. Dissolve 0.2856 g sodium bicarbonate ($NaHCO_3$) and 0.3816 g of sodium carbonate (Na_2CO_3) in reagent water and dilute to 2 liters.

3. *Regeneration solution:* Sulfuric acid, 0.025 N. Dilute 2.8 ml conc. H_2SO_4 to 4 liters with reagent water.

4. *Stock standard solutions, 1000 mg/l:* Stock standard solutions are purchased form Spex Industries. Please see attached certificate of analysis.

IV. PRECERTIFICATION CALIBRATION

A. Preparation of Standards

1. Intermediate Stock Standard (10 mg/l): For all anions add 1.0 ml of stock standard to a 100 ml volumetric flask. Dilute to 100 ml with reagent water. Make fresh weekly.

2. Table I lists the preparation of the high calibration standard (10x TRL), which is prepared from the dilution of the intermediate stock standards. All remaining standards are made from dilutions of the high calibration standard. All standards are made using volumetric pipettes and volumetric flasks. All standards are brought to final volume using reagent water and are made fresh daily. Tables II through V list the preparation of the remaining calibration standards.

TABLE I.

PREPARATION OF HIGH CALIBRATION STANDARD (10X TRL)

Anion	mls of 10 mg/l Int. Stock /100ml	Final Conc. (ug/g)
Bromide	5.0	5
Chloride	5.0	5
Fluoride	2.0	2
Nitrate	1.0	1
Nitrite	1.0	1
Orthophosphate	2.0	2
Sulfate	5.0	5

TABLE II.

PREPARATION OF 5X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/g)
Bromide	50	2.5
Chloride	50	2.5
Fluoride	50	1.0
Nitrate	50	0.5
Nitrite	50	0.5
Orthophosphate	50	1.0
Sulfate	50	2.5

TABLE III.

PREPARATION OF 2X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/g)
Bromide	20	1.0
Chloride	20	1.0
Fluoride	20	0.4
Nitrate	20	0.2
Nitrite	20	0.2
Orthophosphate	20	0.4
Sulfate	20	1.0

TABLE IV.

PREPARATION OF 1X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/g)
Bromide	1.0	0.5
Chloride	1.0	0.5
Fluoride	1.0	0.2
Nitrate	1.0	0.1
Nitrite	1.0	0.1
Orthophosphate	1.0	0.2
Sulfate	1.0	0.5

TABLE V.

PREPARATION OF 0.5X TRL CALIBRATION STANDARD

Anion	mls of 10x TRL per 100ml	Final Conc. (ug/g)
Bromide	0.5	0.25
Chloride	0.5	0.25
Fluoride	0.5	0.10
Nitrate	0.5	0.05
Nitrite	0.5	0.05
Orthophosphate	0.5	0.10
Sulfate	0.5	0.25

B. Instrument Calibration

1. Start the pump by pressing the pump start button. Gradually increase flow to 2.0 ml/min. by increments of 0.5 until ready light comes on.
2. Start regeneration flow.
3. Turn on the conductivity cell and set attenuator range to 1K us.
4. Wait for system to stabilize, generally 15 - 30 minutes.
5. After stabilization, set baseline, then inject 1.0 ml of mid-range standard.
6. Using the retention times from this standard, build your calibration table entering the concentrations for each standard.
7. Using injections of 1.0 ml of each calibration standard, tabulate peak height against the concentration.

C. Analysis of Calibration Data

1. The resulting curve must have a linear regression correlation coefficient greater than 0.995.
2. Analyze an EPA certified check standard to verify your curve. The result must be within the check standard control limits.
3. When analyzing samples, the certified check standard must be run twice, once at the beginning and once at the end of the day. If results are found to exceed acceptability limits, immediate reanalysis of the check standard is required. If results from the reanalysis still exceed acceptability limits, the system must be recalibrated.

V. PROCEDURE

A. Sample Preparation

1. The following extraction should be used for solid materials. Add an amount of reagent water equal to ten times the weight of dry solid material taken as a sample. The slurry is mixed together for 30 minutes on a mechanical shaker. Filter the sample with 0.45 micron filter. Care should be taken to show that good recovery and identification of peaks is obtained with the matrix through the use of spikes.

2. A method blank will be processed with each analytical lot.

3. Three spiked standard matrix QC samples shall be included in each lot. Two spiked standard matrix QC samples shall contain all control analytes at a concentration near the upper end of the certified range. The third spiked sample shall be at approximately 2x CRL.

B. Chemical Reactions:

None Known

C. Instrument Analysis

1. Set-up and calibrate instrument as specified in section IV.B.

2. Load the autosampler and inject 1.0 ml of sample. Use the same size loop and conditions for standards and samples.

3. The width of the retention time window used to make identifications should be based upon measurements of actual retention time variations of standards.

4. If the response for the peak exceeds the working range of the highest standard, dilute the sample with an appropriate amount of reagent water and reanalyze.

5. In addition to the certified check standards, a standard at the highest concentration must be analyzed after sample analyses are completed. For the first seven calibrations, the response must agree within 10% of the mean response for the same concentration, as determined from precertification, and the certification Initial Calibration. After seven calibrations, responses must agree within two standard deviations. If the response fails the test, the daily standard should be reanalyzed. If the response from the second analysis fails the test, the system is considered to have failed calibration and all samples must be reanalyzed after repeating Initial Calibration.

VI. CALCULATIONS

A. All results will be reported as ug/g. To convert ug/l (instrument reading) to ug/g, calculate as follows:

$$ug/g = \frac{C \times V}{W}$$

where:
C = Concentration (ug/l).
V = Final Volume in liters after sample preparation.
W = Weight in grams of sample used in preparation.

B. If results for a analyte are obtained without dilution, the anion concentration in the sample will be reported to the significant figures. If dilution was required, the result will be reported to only two significant figures.

C. The method blank value, if above the CRL, will be subtracted from field sample values for the same lot.

VII. REFERENCES

A. Rocky Mountain Arsenal, Chemical Quality Assurance Plan, Version 1.0, July 1989.

B. US EPA, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Method 300.0.

VIII. DATA

A. Response versus concentration data: see attached.

B. Response versus concentration graphs: see attached.

C. LOF tests: see attached.

D. ZI tests: see attached.

Preliminary

DRAFT

DATE: 1-27-95

SOUTHWEST LABORATORY OF OKLAHOMA, INC.

STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF TOTAL ALKALINITY CARBONATE AND BICARBONATE IN WATER

IN010, IN023, IN024
REV 1.0 — 1/27/95

Document Control # SWL-IN010- ØØA

APPROVALS BY:

Name: _____ **Title:** _____

Signature: _____

Name: _____ **Title:** _____

Signature: _____

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I. SCOPE AND APPLICATION

A. This method covers the determination of total alkalinity, carbonate, and bicarbonate in drinking, surface, and waste waters.

B. This method is applicable to concentrations of 20 mg/L. A special procedure is included for determination of alkalinity below 20 mg/L (see Sec. VII.C).

II. SUMMARY OF METHOD

A. This method is based upon titration of the sample with sulfuric acid down to a pH of 4.5 for measurement of total alkalinity. For determination of carbonate and bicarbonate contribution to total alkalinity, a two-step titration is used; the first endpoint at pH = 8.3, the second at pH = 4.5.

III. SAMPLE HANDLING AND PRESERVATION

A. Samples must not be preserved and stored at 4°C. Hold time is 14 days from date of sampling.

IV. INTERFERENCE

A. Oily or soapy samples can coat the pH electrode membrane, thereby retarding measurement, or possibly even damaging the probe. Care should be taken to clean the electrode thoroughly between each sample. A solution of 90% methanol can be used to clean organic compounds from the probe.

V. APPARATUS

A. pH meter capable of at least two-point pH calibration, such as an Orion model 720 electrometer

B. Standard double-junction combination pH/reference electrode.

C. Automatic Temperature Compensation (ATC) probe.

D. Thermally insulated magnetic stirrer with Teflon-coated stir bar.

E. 50 ml buret with 0.1 ml graduation.

VI. REAGENTS

A. *Sodium Carbonate solution, 0.05 N:* Dry 3-5g Na_2CO_3 at 250°C for 4h and cool in a desiccator. Weigh 2.500g, transfer to a 1L volumetric flask, and dilute to the mark with deionized water to dissolve reagent. Do not store for more than one week.

B. *Standard Sulfuric Acid, 0.02 N:* Weigh 1.02g concentrated sulfuric acid into a 1L volumetric flask and dilute to the mark with deionized water. Standardize against 40.00 ml 0.05 N Na_2CO_3 with 60.00 ml water in a beaker by titrating potentiometrically to pH = 5. Rinse electrodes into beaker, and then boil on a hot plate for 3-5 min. Remove from heat, cover with a watchglass, and cool to room temperature. Rinse watchglass into beaker, and continue titration to pH = 4.5. Determine normality as follows:

$$\text{Normality} = \frac{A \times B}{53 \times C}$$

where:

A= g Na_2CO_3 weighed into 1L flask

B= ml Na_2CO_3 solution taken for titration.

C= ml acid used

Record the normality and date standardized on the acid's storage receptacle.

C. *Na_2CO_3 spiking solution, 2500 ppm:* Weigh 2.500 g sodium carbonate, transfer to a 1L volumetric flask, and dilute to the mark with water.

VII. PROCEDURE

A. For total alkalinity, pour 50 ml of sample into a beaker. Insert pH electrode and wait until a stable reading is obtained. Record the pH. Titrate the sample with 0.02 N sulfuric acid down to pH = 4.5. Record the amount of acid used in milliliters.

B. To determine alkalinity due to carbonate and/or bicarbonate, pour 50 ml of sample into a beaker. Insert pH electrode and wait until a stable reading is obtained. Record the pH. Titrate the sample with 0.02 N sulfuric acid down to pH = 8.3, and record the amount of acid used. Continue the titration to pH = 4.5, and again record milliliters of acid used.

C. When it is necessary to determine alkalinity values below 20 mg/L, use 100 ml of sample, and follow the procedure described in Sec. 7.1, using a 10 ml microburet. Stop the titration in the pH range of 4.3-4.7 and record the amount of acid used and the exact pH. Add enough titrant to lower the pH exactly 0.30 units and again record the amount used.

VIII. CALCULATIONS

A. For total alkalinity:

$$\text{Alkalinity, mg/L} = \frac{A \times N \times 50{,}000}{\text{ml sample}}$$

where:

A = ml of standard acid used

N = normality of standard acid

B. For bicarbonate and carbonate determination, the calculation described in Sec. VIII.A must be done twice: once for the amount of acid used to reach pH 8.3 (the P value), and again for the total amount of acid used to reach pH 4.5 (the T value). In addition, the following relationships apply:

1. Carbonate alkalinity is present when the P value is not zero, but is less than the total alkalinity (the T value).
2. Bicarbonate alkalinity is present if the P value is less than half the T value. Furthermore, if the initial pH of the sample is less than 8.3, the total alkalinity of the sample equals the bicarbonate concentration i.e. the alkalinity of the sample is due entirely to bicarbonate.

   The following table summarizes these relationships:

Table I.

Result of Titration	Carbonate Alkalinity	Bicarbonate Alkalinity
P=0	0	T
P<1/2T	2P	T-2P
P=1/2T	2P	0
P>1/2T	2(T-P)	0

3. In order to determine the amount of carbonate or bicarbonate present, find the scenario under Result of Titration that applies, and then use the values for P and T in the corresponding equations from Table I for carbonate and bicarbonate alkalinity. Also note that, if total alkalinity (IN010) is requested in addition to testing for carbonate and bicarbonate, then all three quantities can be determined from the same titration. In this case, total alkalinity is simply the T value.

C. For low level total alkalinity, use the following equation:

$$\text{Alkalinity, mg/L} = \frac{(2B - C) \times N \times 50{,}000}{\text{ml sample}}$$

where:

B= ml titrant to first recorded pH

C= total ml titrant to reach pH 0.3 units lower

N= normality of standard acid.

Note that this low level test is only valid for total alkalinity; values below 20 mg/L for carbonate and bicarbonate must be reported as "nondetect."

IX. QUALITY CONTROL

A. The pH meter must have a two-point calibration run each day the meter is used.

B. Employ at least one blank per sample batch to detect contamination or slope drift.

C. An outside check standard (ICV), such as SPEX Minerals Standard, must be run with every sample batch.

D. If requested by the client, a matrix spike can be performed. Use 2 ml of the spiking standard (see Sec. VI.C) per 50 ml of sample for a spike value of 100 ppm.

X. SAFETY

A. Gloves should be worn when dealing with particularly corrosive samples.

B. Safety glasses must be worn at all times.

C. A lab coat should be worn during analysis.

XI REFERENCES

A. Standard Methods for the Examination of Water and Wastewater, 16th Edition, APHA-AWWA-WPCF, Method 403, pp. 269-273