540R93301

Sampling For Hazardous Materials
(165 9)
3 Days

FOREWORD

This manual is for reference use of students enrolled in scheduled training courses of the U.S. Environmental Protection Agency (EPA). While it will be useful to anyone who needs information on the subjects covered, it will have its greatest value as an adjunct to classroom presentations involving discussions among the students and the instructional staff.

This manual has been developed with a goal of providing the best available current information; however, individual instructors may provide additional material to cover special aspects of their presentations.

Because of the limited availability of the manual, it should not be cited in bibliographies or other publications.

References to products and manufacturers are for illustration only; they do not imply endorsement by EPA.

Constructive suggestions for improvement of the content and format of the manual are welcome.

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SAMPLING FOR HAZARDOUS MATERIALS

(165.9)

3 Days

This course provides individuals who have little or no sampling experience with practical information for effectively sampling hazardous materials at Superfund sites. The course focuses on sampling plan development, types of equipment suitable for hazardous materials sampling, and procedures for safely collecting samples. It is intended for personnel responsible for inspections, investigations, and remedial actions at Superfund sites. Air sampling is specifically addressed in *Air Monitoring for Hazardous Materials (165.4)* and is not discussed in this course.

The objectives of the course are:

- Instruct participants on the basic concepts of an effective sampling strategy.
- Present available equipment used to obtain representative samples from solid and liquid wastestreams.
- Compare applications and limitations of various sampling devices.
- Develop safe and effective sampling plans for environmental sampling events.

After completing the course, participants will be more familiar with fundamental concepts of sampling, sample plan development, and sampling equipment.

Acronyms and Abbreviations (continued)

QAO	quality assurance officer
QAP	quality assurance plan
QAPjP	quality assurance project plan
QA/QC	quality assurance/quality control
RA	remedial action
RAS	routine analytical services
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDCO	regional document control officer
REAC	Response Engineering and Analytical Contract
RI	remedial investigation
ROD	record of decision
RPM	remedial project manager
RSCC	Regional Sample Control Center
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SAS	special analytical services
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SIC	standard industrial classification
SM	site manager
SMO	Sample Management Office
SOP	standard operating procedure
SOW	statement of work
SW-846	*Test Methods for Evaluating Solid Waste (SW-846)* (EPA document)
TAL	Target Analyte List
TCDD	tetrochlorodibenzo-*p*-dioxin
TCL	Target Compound List
TDS	total dissolved solids
TIC	tentatively identified compounds
TOC	total organic carbon
TOX	total organic halogens
TR	traffic report
TSCA	Toxic Substances Control Act
USGS	U.S. Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound

ACRONYMS AND ABBREVIATIONS

AMD	Advanced Monitoring Systems Division
AMS	air monitoring system
API	American Petroleum Institute
ARAR	applicable or relevant and appropriate requirements
ASCS	Agricultural Stabilization and Conservation Service
ASTM	American Society for Testing and Materials
BNA	base/neutral and acid extractables
BTEX	benzene, toluene, ethylbenzene, and xylenes
CBI	confidential business information
CDP	common depth point
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CGI	combustible gas indicator
CLP	Contract Laboratory Program
COC	chain of custody
COE	U.S. Army Corps of Engineers
COLIWASA	composite liquid waste sampler
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
CWA	Clean Water Act
DCO	document control officer
DL	detection limit
DOT	U.S. Department of Transportation
DQO	data quality objectives
EAU	evidence audit unit
Eh	oxidation-reduction potential (redox potential)
EM	electromagnetic
EMSL-LV	Environmental Monitoring and Support Laboratory-Las Vegas
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ESD	Environmental Services Division (EPA)
FID	flame ionization detector
FIPS	federal information processing standards
FIT	field investigation team
FS	feasibility study
FSP	field sampling plan
FTS	federal telephone system

Acronyms and Abbreviations (continued)

GC	gas chromatograph or gas chromatography
GC/MS	gas chromatography/mass spectroscopy
GIS	geographic information system
GPR	ground-penetrating radar
HAZCAT	hazard categorization
HRS	hazard ranking system
HSL	hazardous substance list
IATA	International Air Transport Association
IDL	instrument detection limit
LEL	lower explosive limit
MDL	method detection limit
NAPL	nonaqueous phase liquid
NAPP	National Aerial Photography Program
ND	nondetect
NEIC	National Enforcement Investigation Center
NHAP	national high altitude photography
NMO	normal movement
n.o.s.	not otherwise specified
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTIS	National Technical Information Service
OD	outside diameter
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PE	performance evaluation
PID	photoionization detector
POTW	publicly owned treatment works
PPM	parts per million
PPB	parts per billion
PRP	potentially responsible party
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride

DATA QUALITY OBJECTIVES

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Identify the three stages of the data quality objective (DQO) process
- Identify the various data uses within the DQO framework
- Explain the five levels of sample analysis (analytic levels) available
- Relate the DQO process to a conceptual model

NOTES

DATA QUALITY OBJECTIVES

DATA QUALITY OBJECTIVES (DQOs)

A process that yields quality and cost-effective:

- Sampling
- Analysis
- Data

DQO DEVELOPMENT PROCESS

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses and needs
- Stage 3 - Design data collection program

NOTES

STAGE 1 - IDENTIFY DECISION TYPES

- Identify and involve data users
- Evaluate available data
- Develop a conceptual model
- Specify objectives and decisions

IDENTIFY AND INVOLVE DATA USERS

- Primary users: Those involved in ongoing remedial investigation and feasibility study (RI/FS) activities
- Secondary users: Those who rely on RI/FS outputs to support their activities

EVALUATE AVAILABLE DATA

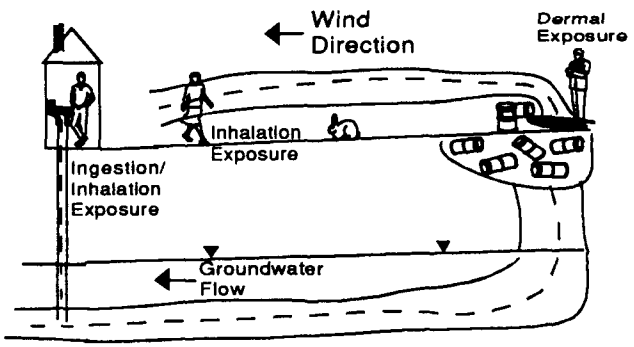
- Information from the EPA, the United States Geological Survey (USGS), and state and local regulatory agency files
- Other sources: Town hall, library, and site maps

NOTES

DEVELOP A CONCEPTUAL MODEL

Source → Pathway → Receptors

EXAMPLE OF A CONCEPTUAL MODEL



SPECIFY OBJECTIVES AND DECISIONS

- Identify problems to be solved
- Determine:
  - Presence or absence of contaminants
  - Types of contaminants
  - Concentrations of contaminants
  - Contaminant pathways
  - Public and environmental health effects

NOTES

STAGE 2 - IDENTIFY DATA USES AND NEEDS

- Identify data uses
- Identify data types
- Identify data quality needs
- Identify data quantity needs
- Evaluate sampling and analysis options
- Review PARCC parameters

IDENTIFY DATA USES

- Site characterization
- Health and safety
- Risk assessment
- Alternatives evaluation
- Monitoring
- Potentially responsible party (PRP) determination

IDENTIFY DATA TYPES

- Analytical requirements
  - Chemical analytical parameters
  - Physical parameters

NOTES

STAGE 2 - IDENTIFY DATA USES/NEEDS

- Identify data quality needs

  Analytical levels:
  - LEVEL I Field screening
  - LEVEL II Field analysis
  - LEVEL III Laboratory analysis
  - LEVEL IV Laboratory analysis CLP RAS
  - LEVEL V Laboratory analysis SAS

IDENTIFY DATA QUALITY NEEDS

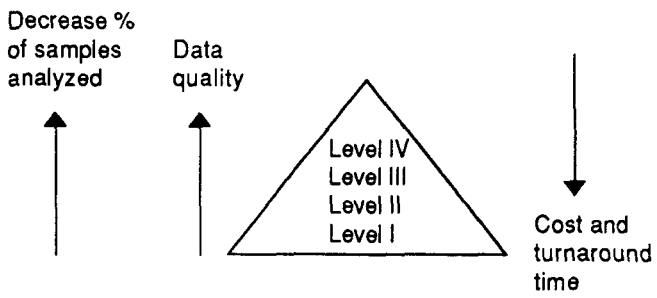
- Contaminants of concern
- Levels of concern
- Detection limit requirements
- Critical samples

IDENTIFY DATA QUANTITY NEEDS

- Data unavailable: Develop a phased sampling approach
- Data available: Use statistical techniques

NOTES

EVALUATE SAMPLING AND ANALYSIS OPTIONS



REVIEW PARCC PARAMETERS

- P recision
- A ccuracy
- R epresentativeness
- C ompleteness
- C omparability

PARCC

- Precise - Consistent, reliable sampling and analysis results
- Accurate - Free from error
- Representative - Thoroughness in selecting sampling locations and sufficient numbers of samples
- Complete - Sufficient amount of valid data
- Comparable - Consistency among data

NOTES

STAGE 3 - DESIGN DATA COLLECTION PROGRAM

- Assemble data collection components
- Develop data collection documentation

ASSEMBLE DATA COLLECTION COMPONENTS

- Develop a comprehensive data collection program

DEVELOP DATA COLLECTION DOCUMENTATION

- Sampling and analysis plan
- Work plans
- Enforcement concerns

SAMPLE PLAN DEVELOPMENT

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Discuss the necessary elements of a sampling plan
- Describe various sampling designs relative to sample location
- Discuss the differences between composite and grab samples
- Describe procedures for field decontamination of sampling equipment

NOTES

SAMPLE PLAN DEVELOPMENT

SAMPLE PLAN DEVELOPMENT REQUIRES COORDINATION

SAMPLING OBJECTIVES

- Establish threat to public health or welfare or to the environment
- Locate and identify potential sources of contamination
- Define the extent of contamination
- Determine treatment and disposal options
- Document the attainment of cleanup goals

NOTES

SAMPLE PLAN DEVELOPMENT

- Review existing historical site information
- Perform site reconnaissance
- Evaluate potential migration pathways and receptors
- Determine sampling objectives
- Establish data quality objectives

SAMPLE PLAN DEVELOPMENT

- Use field screening techniques
- Select analytical parameters
- Select sampling approach
- Determine sampling locations

ELEMENTS OF A SAMPLING PLAN

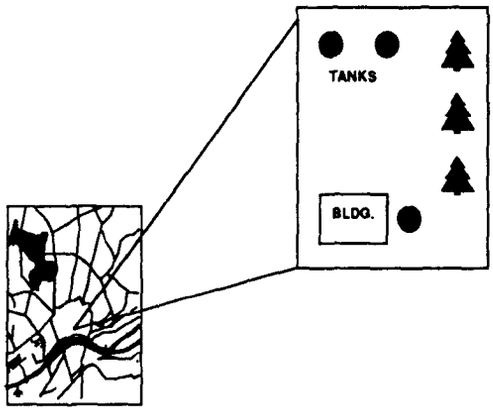
- Location and description of site
- Media to be sampled
- Analytical parameters
- Container requirements
- Field measurements
- Well purging procedures

NOTES

ELEMENTS OF A SAMPLING PLAN

- Preservation and filtration
- QA/QC samples
- Sample collection techniques
- Documentation and transportation
- Special equipment
- Decontamination

LOCATION AND DESCRIPTION OF SITE

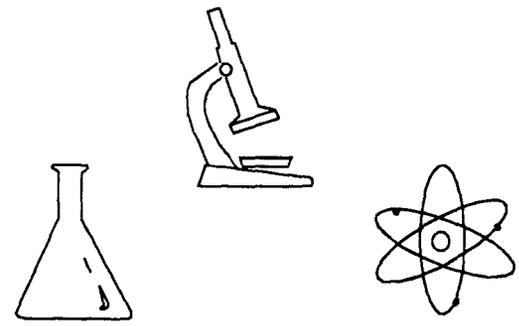


MEDIA TO BE SAMPLED

- Air
- Water
- Soil and sediments
- Bulk and containerized materials

NOTES

ANALYTICAL PARAMETERS



- Container requirements
- Field measurements
- Well purging procedures

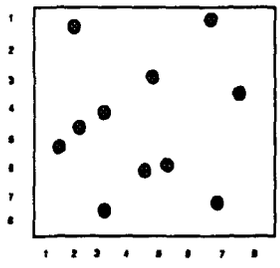
- Preservation and filtration
- QA/QC samples
- Sample collection techniques

NOTES

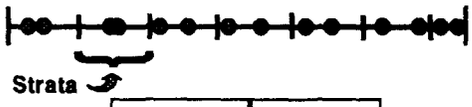
SAMPLING DESIGN

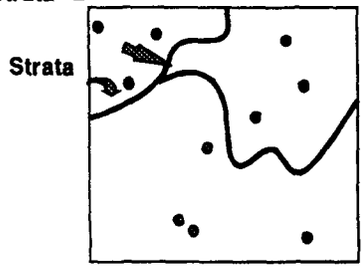
- Simple random sampling
- Stratified random sampling
- Systematic sampling
- Cluster sampling

SIMPLE RANDOM SAMPLING



STRATIFIED RANDOM SAMPLING

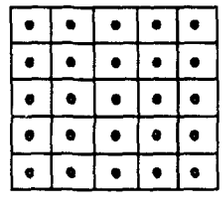




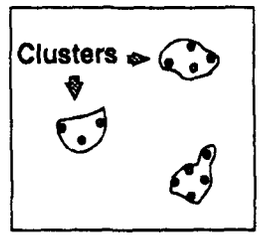
NOTES

SYSTEMATIC SAMPLING

Systematic Grid Sampling



CLUSTER SAMPLING

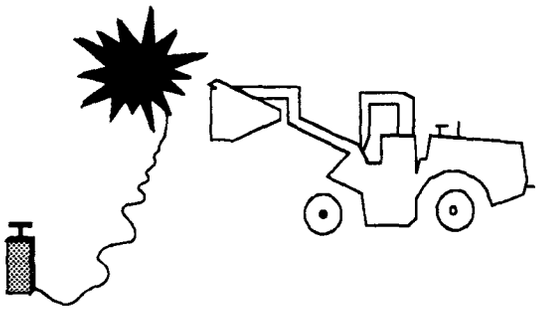


- Documentation
- Transportation

NOTES

- Special equipment
- Decontamination

SPECIAL EQUIPMENT



SAMPLING EQUIPMENT ATTRIBUTES

- Disposable or easily decontaminated
- Inexpensive, especially disposable items
- Easy to operate
- Nonreactive

NOTES

DECONTAMINATION

- The goal of most sampling efforts is to acquire representative samples
- Even trace amounts of contaminants from prior sampling may invalidate the entire project

DECONTAMINATION GOALS

- No nationwide standards; some states and regions have their own standards
- The goal of decontamination is to remove or reduce contaminants below detection limits in order to avoid cross-contamination

FIELD DECONTAMINATION PROCEDURES

- Wash with nonphosphate detergent
- Rinse with tap water
- Second rinse with distilled/deionized water
- Appropriate solvent rinse
- Final rinse with distilled/deionized water

NOTES

FIELD DECONTAMINATION PROCEDURES

- Air dry equipment
- Wrap in aluminum foil
- Collect equipment blanks daily

REDUCE EQUIPMENT DECONTAMINATION PROBLEMS

- Use disposable equipment
- Use nonpermeable equipment
- Bag equipment
- Follow safe work practices

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

January 1992

QualityAssurance Sampling Plan for Emergency Response

Office of Emergency and Remedial Response
Emergency Response Division
Environmental Response Branch, MS-101

Quality Assurance Technical Information Bulletin

What is QASPER?

QASPER is a PC-based software package which compiles generic text and user-provided site-specific information into a draft Quality Assurance / Quality Control (QA/QC) Sampling Plan for the Removal Program. QASPER addresses the nine sections of a QA/QC Sampling Plan, as specified in OSWER Directive 9360.4-01, QA/QC Guidance for Removal Activities, Sampling QA/QC Plan, and Data Validation Procedures (April 1990, EPA/540/G-90/004).

Who is the Anticipated QASPER User?

The On-Scene Coordinators (OSCs) or the Technical Assistance Team (TAT) contractors are the primary users of QASPER. These individuals will have access to the site-specific information and the sampling objectives that characterize the site. They are also the ones responsible for assembling that information into an acceptable game plan for implementation.

Why was QASPER Designed?

QASPER was created to facilitate the timely assembly of a comprehensive sampling plan for emergency response actions. By thorough consideration and attention to the necessary requirements of QA/QC sample planning through an automated process, it is anticipated that reliable, accurate, and quality data will be generated to meet the intended use.

Requirements

QASPER runs on an IBM PC or 100% compatible, with a hard drive, 640K RAM, and a printer (for hardcopy output).

Features of QASPER

- Requires no other software for support. A word processing package is included with the QASPER program.
- Generates ASCII output in both file and hardcopy formats. Files may be uploaded to other word processing packages (i.e., WordPerfect) for further manipulation.
- Creates a hard copy QA/QC Sampling Plan ready for approval signatures and implementation
- Retains database files on all previous sampling plans created. This allows for future manipulation of an existing plan without having to recreate the document or search for a similar sampling plan by location, facility type, or contaminant.
- Improves the consistency and comprehensiveness of sampling plan creation efforts throughout the office, region, or zone by prompting the user to consider the same set of questions for each site to be addressed.
- Improves efficiency for creating and reviewing QA/QC Sampling Plan documents by allowing easy modification of the document text either through the editor or through the word processing package.
- Picks up information that has repetitive use in the plan and imports the information to all sections after the first entry, thus avoiding redundant data entry.
- Provides the user with access to standardized generic text in various sections of the plan. Based on the user's needs, this text may be imported directly or may be edited to fit site-specific conditions.

- Has flexible data entry throughout plan generating activities and informs the user as to which sections are complete and which sections require additional information.

Contents of QASPER

QASPER addresses the nine sections of a QA/QC Sampling Plan, as specified in OSWER Directive 9360.4-01, QA/QC Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures:

0.0 Title Page Information
Section 0.0 identifies information required to complete the title page of a sampling plan. This information includes site name, relevant work order numbers, primary site personnel and titles, and the date. Some of this information is utilized elsewhere throughout the plan and will automatically appear in the proper places.

1.0 Background Information
Section 1.0 solicits background information about the site. This includes the location and type of facility, type and volume of material handled by the facility, current facility status and proximity and type of sensitive environments.

2.0 Data Use Objectives
Section 2.0 requests information regarding the data use objectives and about decisions the data will support. The purpose(s) of the sampling event is specified and this information is forwarded to other sections of the plan. The data quality objective (DQO) logic pathway begins in this section and is carried forward to Sections 3.0, 4.0, 6.0 and 8.0.

3.0 Quality Assurance Objectives
Section 3.0 facilitates the linkage of the DQO logic with the matrix and parameters being investigated. The user must also specify the purpose and QA objective (QA-1, QA-2, or QA-3) related to the selection. The same sequence will be repeated for all parameters of concern at the site.

4.0 Approach and Sampling Methodologies
Section 4.0 addresses the approach and sampling methodologies that will be employed. Included are sections on sampling equipment, sampling design, standard operating procedures, schedule of activities and tables.

In the case of equipment, there are pull down menus for type of equipment and materials of construction. Where dedicated sampling equipment is not utilized, QASPER assists in the development of a decontamination sequence. The sampling design section requires the user to input information related to the proposed design or grid to achieve the sample event objectives. In conjunction with the sampling design, the user must specify the standard operating procedures (SOPs) that will be employed. QASPER contains generic text for approximately 20 SOPs that can be imported as is or modified to fit a specific scenario. A schedule of activities detailing site activities and tentative start and completion dates is in the next section. The last components of this section are the sample summary tables and QC sample tables.

5.0 Project Organization and Responsibilities
Section 5.0 helps the user organize information about what personnel are assigned which responsibilities and which labs will be analyzing which samples.

6.0 QA Requirements
Section 6.0 is automatically completed based on the QA selections made in Section 3.0. Capabilities exist to edit the generic text as needed.

7.0 Deliverables
Section 7.0 allows the user to import generic text for standard deliverables that will be prepared for the site or input specific requirements.

8.0 Data Validation
Section 8.0 contains the requirements for validating the data generated under this plan as per OSWER Directive 9360.4-01, Part II, Data Validation Procedures (April, 1990). The criteria used ensure that analytical results received from the laboratory are valid and accurate for the objective chosen. The section is automatically completed based on the QA selections made in Section 3.0. Capabilities exist to edit the generic text as needed.

Once all the sections are completed, the user can compile the plan, make any necessary modifications, and print a hard copy of the site-specific QA/QC Sampling Plan.

For copies of the software, contact:

Mr. William Coakley
U.S. EPA, ERT
Phone: (908) 906-6921

Ms. Christine Andreas
Roy F. Weston, Inc./REAC
Phone: (908) 632-9200

Sampling QA/QC Work Plan

Example Sample Plan

Prepared by
Amazing Consultants

EPA Project No.: **.***
Contractor Work Order No.: NA
EPA Contract No.: NA

Approvals

Amazing Consultants		EPA	
_____	_____	_____	_____
Task Leader	Date	O.S. Cee On-Scene Coordinator	Date
_____	_____		
Fred Amazing Project Manager	Date		

1.0 BACKGROUND

The [suspected] contamination is a result of:

- Leaking drums

The following information is known about the site:

The site is located in the city of Swartz Creek in the county of Genesse in the state of Michigan. The nearest residents are located within 500 feet of the site, in a south direction. Other residents or significant environments in proximity to this site are located 1000 feet due north of the site.

It is a landfill site on an unknown number of acres which had been operating for an unknown period of time and is now abandoned since 1980.

The types of material(s) handled at this site were:

- Inorganics
- Petroleum products
- Unknown

The volume(s) of contaminated materials to be addressed are:

- Unknown

The contaminants of concern are:

- Unknown

The basis of this information may be found from:

- Citizens
- Records

2.0 DATA USE OBJECTIVES

The objective of this project/sampling event is to determine:

- The presence of contamination
- The extent of contamination
- The magnitude of contamination

For the purpose of:

- Site characterization
- Risk assessment

- Field personnel health and safety
- Enforcement plan

The data will be evaluated against:

- Federal/state action levels
- Michigan and federal ARARs

3.0 QUALITY ASSURANCE OBJECTIVES

As identified in Sections 1.0 and 2.0, the objective of this project/event applies to the following parameters:

Parameters	Matrix	Intended Data Use	QA Objective
BNA (semivolatiles)	drum liquid	site characterization	QA1
Metals	groundwater	risk assessment	QA3
Metals	potable water	risk assessment	QA3
PAHs	soil	site characterization	QA2
PAHs	waste material	site characterization	QA2

4.0 APPROACH AND SAMPLING METHODOLOGIES

4.1 Sampling Equipment

The following equipment will be used to obtain environmental samples from the respective media/matrix:

Parameter/Matrix	Sampling Equipment	Fabrication	Dedicated	Decontamination Steps
BNA (semivolatiles)	COLIWASA	glass	No	Physical removal Nonphosphate detergent wash Potable water rinse 10% nitric acid rinse Organic-free water rinse Air dry
Metals in groundwater	bladder pump	stainless steel	Yes	
Metals in potable water	sample bottle	glass	Yes	
PAHs in soil	trowel	stainless steel	No	Physical removal Nonphosphate detergent wash Pesticide-grade acetone rinse Distilled/deionized water rinse Organic-free water rinse Air dry
PAHs in waste material	bucket auger	stainless steel	No	Physical removal Nonphosphate detergent wash Potable water rinse 10% nitric acid rinse Distilled/deionized water rinse Organic-free water rinse Air dry

4.2 Sampling Design

The sampling design is depicted on the attached Sample Location Map (Figure 4-1) and is based on the following rationale:

4.3 Standard Operating Procedures

4.3.1 Sample Documentation

All sample documents will be completed legibly, in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialling the error.

Field Logbook

The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. All entries will be dated and signed by the individuals making the entries, and should include (at a minimum) the following:

1. Site name and project number.
2. Name(s) of personnel on-site.
3. Dates and times of all entries (military time preferred).
4. Descriptions of all site activities, including site entry and exit times.
5. Noteworthy events and discussions.
6. Weather conditions.
7. Site observations.
8. Identification and description of samples and locations.
9. Subcontractor information and names of onsite personnel.
10. Date and time of sample collections, along with chain-of-custody information.
11. Record of photographs.
12. Site sketches.

Sample Labels

Sample labels will clearly identify the particular sample and should include the following:

1. Site name and number.
2. Time and date sample was taken.
3. Sample preservation.
4. Analysis requested.

Optional, but pertinent, information is the sample location.

Sample labels will be securely affixed to the sample container. Tie-on labels can be used if properly secured.

Chain-of-Custody Record

A chain-of-custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples (or groups of samples) are not under direct

control of the individual responsible for them, they must be stored in a locked container sealed with a custody seal.

The chain-of-custody record should include (at minimum) the following:

1. Sample identification number.
2. Sample information.
3. Sample location.
4. Sample date.
5. Name(s) and signature(s) of sampler(s).
6. Signature(s) of any individual(s) with control over samples.

Custody Seals

Custody seals demonstrate that a sample container has not been tampered with or opened.

The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the sample packaging, will be noted in the field logbook.

4.3.2 Sampling SOPs

Drum Sampling

Prior to sampling, drums must be inventoried, staged, and opened. Inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation of drums which have similar wastes or characteristics. Opening of closed drums can be performed manually or remotely.
Remote drum opening is recommended for worker safety.

The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination. The thief is inserted into the drum until a solid layer or bottom of the drum is encountered. The waste is allowed to equilibrate in the sample tube, which is then capped and removed for discharge by gravity into the sample container.

Another drum sampling device is the Composite Liquid Waste Sampler (COLIWASA). Collection with a COLIWASA allows a sample to be collected from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. The COLIWASA is designed to permit representative sampling of multiphased wastes from containerized wastes. However, unlike the glass thief, a COLIWASA is extremely difficult to field decontaminate and relatively expensive, thereby making it impractical to throw away.

Groundwater Well Sampling

Prior to sampling well, the well will be purged. For this project, this will be accomplished with a [(bailer), (submersible pump), (non-gas contact bladder pump) or (suction pumps)].

Brush off well cap prior to opening, unlock and open well cap. A photoionization detector (HNU) or flame ionization detector (OVA) will be used on the escaping gases to determine the need for respiratory protection. Using a decontaminated water level indicator, the water level will be measured to the nearest 0.01 foot. Total depth of the well will be obtained with a depth sounder and the volume of water in the well will be calculated using the following procedure:

Well Volume = nr2h (7.48 gal/ft^3)

where:

n = pi
r = radius of well casing in feet.
h = height of water column of well from water level.
7.48 = conversion from ft^3 to number of gallons.

Three well volumes at a minimum should be purged if possible. Equipment must be decontaminated prior to use and between wells.

Approximately 10 feet of plastic sheeting will be placed around the well upon which the assembly of the decontaminated purging equipment will be placed. The assembly will be lowered into the well to a point just below the surface of the water.

When pumping the well, lower the pump slowly to a point 3 feet above the bottom of the well. Record the flow rate and calculate the length of pumping time required to purge the requisite three casing volumes. [Discharged to ground surface adjacent to the well or containerized if necessary.] Should the well yield be insufficient to produce the requisite three volumes, purging will continue to the point of well evacuation, then terminated and the well will be sampled upon recharge.

Once purging is completed and the correct sample jars and/or vials have been prepared, sampling will proceed. The sampling device (which may or may not be the same as the purging device) has been selected so as to not affect the integrity of the sample. Sampling equipment will be decontaminated as outlined elsewhere in Section 4.0. Sampling will occur in a progression from the least to most contaminated well, if known.

The water sample will be collected using a Teflon® or stainless steel bailer. The bailer will be attached to a clean, dedicated, nylon rope and introduced into the well. The bailer will be lowered to the approximate mid-point of the screened interval. Once the sample is collected, care will be taken not to unduly agitate or aerate the water while pouring into the appropriate sample containers.

Measure the conductivity, temperature, and pH of the groundwater in a separate container. Record all field measurements on the field data sheets and in the field logbook.

Potable Water Sampling

Potable water samples will be collected from the discharge spigot nearest the pump. Water will be purged from the system for approximately 15 minutes to remove all standing water in the holding tank. Any aerators or filtering systems will be bypassed if possible. Samples will be collected directly into sample bottles from the spigot. Samples will be iced and packaged in coolers as per the applicable shipping and handling SOPs.

Soil Sampling

(This text requires modification for site-specific application)

Collection of samples from near-surface soil will be accomplished with tools such as spades, shovels, and scoops. Surface debris will be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample. This method can be used in most soil types but is limited to sampling near surface areas. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications.

Sampling a depth will be accomplished with augers and thin-walled tube samplers. This system consists of an auger, a series of extensions, a "T" handle, and a thin-walled tube sampler. The auger is used to bore a hole to desired sampling depth, and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the bore hole,and driven into the soil at the completion depth. The core is then withdrawn and the sample collected.
Several augers are available. These include bucket type, continuous flight (screw), and post hole augers. Bucket types are better for direct sample recovery because they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly off the flights, which are usually at 5-foot intervals. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Post hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil.)

Depth samples will be collected via split spoon samplers. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

Subsurface soil sample collection will involve test pit/trench excavation activities. Test pits/trenches are used for detailed examination of soil characteristics. Samples are collected from the pit using a trowel scoop or coring device.

All sampling devices should be laboratory cleaned, preferably by the laboratory performing the analysis, using pesticide grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in cleaned and autoclaved aluminum foil, and custody sealed for identification. The sampling device should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of soil samples required. In this case, samplers should be cleaned in the field using the decontamination procedure described elsewhere in Section 4.0.

4.3.3 Sample Handling and Shipment

Each of the sample bottles will be sealed and labeled according to the following protocol. Caps will be secured with custody seals. Bottle labels will contain all required information including site name and sample number, time and date of collection, analysis requested, and preservative used. Sealed bottles will be placed in large metal or plastic coolers, and padded with an absorbent material such as vermiculite.

All sample documents will be affixed to the underside of each cooler lid. The lid will be sealed and affixed on at least two sides with custody seals so that any sign of tampering is easily visible.

4.4 Schedule of Activities

Table 1: Proposed Schedule of Work

Activity	Start Date	End Date
Soil sampling	07/28/93	08/10/93
Potable water sampling	07/28/93	08/10/93
Groundwater sampling	08/10/93	09/10/93
Drum sampling	08/10/93	11/22/93

5.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The EPA On-Scene Coordinator, O.S. Cee, will provide overall direction to Amazing Consultants staff concerning project sampling needs, objectives and schedule.

The Amazing Consultants Task Leader, _____ , is the primary point of contact with the EPA On-Scene Coordinator. The Task Leader is responsible for the development and completion of the Sampling QA/QC Plan, project team organization, and supervision of all project tasks, including reporting and deliverables.

The Amazing Consultants Site QC Coordinator, _____ , is responsible for ensuring field adherence to the Sampling QA/QC Plan and recording any deviations. The Site QC Coordinator is also the primary project team contact with the lab.

The following sampling personnel will work on this project:

Personnel	Responsibility
_____	_____

The following laboratories will be providing the following analyses:

Lab Name/Location	Lab Type	Parameters
Amazing Analytical Lab 123 Reading Rd Pittsburgh, KN	Non-CLP	All

6.0 QUALITY ASSURANCE REQUIREMENTS

The following requirements apply to the respective QA Objectives and parameters identified in Section 3.0:

The following QA Protocols for QA2 data are applicable to all sample matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field data sheets and chain-of-custody records. Chain-of-custody records are optional for field screening locations.

2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.

3. The detection limit will be determined and recorded, along with the data, where appropriate.

4. Document sample holding times; this includes documentation of sample collection and analysis dates.

5. Provide initial and continuing instrument calibration data.

6a. For soil, sediment and water samples, include rinsate blanks, field blanks and trip blanks, as specified in the attached table.

6b. For air samples, include lot blanks, field blanks, collocated samples, trip blanks, breakthrough, and QC positive samples, as specified in the attached table.

7. Performance Evaluation samples are optional, if available.

8. Choose any one or combination of the following three options:

   1. Definitive identification - confirm the identification of analytes on 10% of the screened (field or lab) or 100% of the unscreened samples via an EPA-approved method; provide documentation such as gas chromatograms, mass spectra, etc.

2. Quantitation - provide documentation for quantitative results from screening and the EPA-approved verification method (for screened samples) or just the quantitative results (in the case of unscreened samples).

3. Analytical error determination - determine the analytical error by calculating the precision, accuracy, and coefficient of variation on a subset of the screened or all of the unscreened samples using an EPA-approved method.

The following QA Protocols for QA3 data are applicable for all matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field data sheets and chain-of-custody records. Chain-of-custody records are optional for field screening locations.

2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.

3. The detection limit will be determined and recorded, along with the data, where appropriate.

4. Document sample holding times; this includes documentation of sample collection and analysis dates.

5. Provide initial and continuing instrument calibration data.

6a. For soil, sediment and water samples, include rinsate blanks, field blanks and trip blanks, as specified in the attached table.

6b. For air samples, include lot blanks, field blanks, collocated samples, trip blanks, breakthrough, and QC positive samples, as specified in the attached table.

7. Performance Evaluation samples are required.

8. Definitive identification on 100% of the "critical" samples by an EPA-approved method.

9. Quantitation - provide documentation for quantitative results from screening and EPA-approved verification methods (for screened samples) or just quantitative results (in the case of unscreened samples).

10. Analytical error determination on 100% of the "critical" samples by an EPA-approved method. Determine precision, accuracy and coefficient of variation. Determine false-positive and false-negative values.

7.0 DELIVERABLES

The Amazing Consultants Task Leader, _____ , will maintain contact with the EPA On-Scene Coordinator, O.S. Cee, to keep him/her informed about the technical and financial

progress of this project. This communication will commence with the issuance of the work assignment and project scoping meeting. Activities under this project will be reported in status and trip reports and other deliverables (e.g., analytical reports, final reports) described herein. Activities will also be summarized in appropriate format for inclusion in monthly and annual reports.

The following deliverables will be provided under this project:

Final Report

A (draft) final report will be prepared to correlate available background information with data generated under this sampling event and identify supportable conclusions and recommendations which satisfy the objectives of this sampling QA/QC plan.

8.0 DATA VALIDATION

QA2

Data generated under this QA/QC Sampling Plan will be evaluated accordingly with appropriate criteria contained in the Removal Program Data Validation Procedures which accompany OSWER Directive #9360.4-1.

The results of 10% of the samples in the analytical data packages should be evaluated for all of the elements listed in Section 6.0 of the QA/QC Sampling Plan. The holding times, blank contamination, and detection capability will be reviewed for all remaining samples.

QA3

Data generated under this QA/QC Sampling Plan will be evaluated accordingly with appropriate criteria contained in Removal Program Data Validation Procedures which accompany OSWER Directive #9360.4-1.

This objective, the most stringent of all objectives, requires that at least 10% of the samples in the lab data package be evaluated for all of the elements listed in Section 6.0 of this QA/QC Sampling Plan. Of the remaining samples, holding times, blank contamination, precision, accuracy, error determination, detection limits, and confirmed identification will be reviewed. This objective also requires review of all elements for all samples in each analyte category (i.e., VOAs and PCBs) in every tenth data package received from an individual lab.

Example Sample Plan
Figure 1-1 Site Location Map

Example Sample Plan
Figure 4-1 Sample Location Map

TABLE 2. FIELD SAMPLING SUMMARY

Analytical Parameter	Level of Sensitivity	Matrix	Container: Type and Volume	Container: Quantity	Preservative	Holding Time	Subtotal Samples	Rinsate Blanks	Trip Blanks	Performance Evaluation (PE) Samples	Matrix Spikes	Total Field Samples
BNA[a] (semivolatiles)	5 ppm	drum liquid	1 L amber glass	2	4°C	7/40 days	100	NA[b]	NA	NA	NA	100
Metals	0.05 ppm	groundwater	1 L polyethylene	1	HNO_3 to pH <2; 4°C	6 months	20	2	NA	1	8	23
Metals	1 ppm	potable water	1 L polyethylene	1	HNO_3 to pH <2; 4°C	6 months	20	2	NA	1	8	23
PAHs[c]	0.01 mg/kg	soil	8 oz. glass	1	4°C	7/40 days	35	3	NA	0	2	38
PAHs	5 ppm	waste material	8 oz. glass	1	4°C	NA[d]	100	NA	NA	NA	NA	101
PAHs	1 ppm	waste material	8 oz. glass	1	4°C	7/40 days	10[e]	1	NA	0	1	<11>[e]

[a] BNA - base, neutral, acid.
[b] NA - not applicable.
[c] PAH - polycyclic aromatic hydrocarbon.
[d] Field test (immunoassay).
[e] Confirmation samples sent to laboratory.

TABLE 3. QA/QC ANALYSIS AND OBJECTIVES SUMMARY

			Matrix Spike		QA/QC	
Analytical Parameter	Matrix	Analytical Method Reference	Laboratory	Additional	Detection Limits	QA Objective
BNA[a] (semivolatiles)	drum liquid	8270	NA[b]	NA	see attachments	QA1
Metals	groundwater	SW-846[c]	8	NA	see attachments	QA3
Metals	potable water	SW-846	8	NA	see attachments	QA3
PAHs[d]	soil	8100	2	NA	analyte specific	QA2
PAHs	waste material	immunoassay[e]	NA	NA	analyte specific	QA2
		SW-846	1	NA	analyte specific	QA2

[a] BNA - base, neutral, acid.
[b] NA - not applicable.
[c] SW-846 - U.S. EPA. 1986. *Test methods for evaluating solid waste: physical/chemical methods (SW-846).* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.
[d] PAH - polycyclic aromatic hydrocarbon.
[e] Used for field screening.

TARGET COMPOUND LIST (TCL) AND
QUANTITATION LIMITS (QL) (1)

Volatiles		CAS Number	Quantitation Limits (2) Water Low µg/L	Quantitation Limits (2) Soil/Sediment (3) 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	75-27-4	10	10
17.	1,2-Dichloropropane	78-87-5	10	10
18.	cis-1,3-Dichloropropene	10061-01-5	10	10
19.	Trichloroethene	79-01-6	10	10
20.	Dibromochloromethane	124-48-1	10	10
21.	1,1,2-Trichloroethane	79-00-5	10	10
22.	Benzene	71-43-2	10	10
23.	trans-1,3-Dichloropropene	10061-02-6	10	10
24.	Bromoform	75-25-2	10	10
25.	4-Methyl-2-pentanone	108-10-1	10	10
26.	2-Hexanone	591-78-6	10	10
27.	Tetrachloroethene	127-18-4	10	10
28.	Toluene	108-88-3	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

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

(3) Medium Soil/Sediment Quantitation Limits (QL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment QL.

Based on the Contract Laboratory Program Statement of Work, OLMO1.6 (6/91).

TARGET COMPOUND LIST (TCL) AND
QUANTITATION LIMITS (QL) (1)

Semivolatiles		CAS Number	Quantitation Limits (2) Water Low µg/L	Soil/Sediment (3) µg/kg
34.	Phenol	108-95-2	10	330
35.	bis(2-Chloroethyl)ether	111-44-4	10	330
36.	2-Chlorophenol	95-57-8	10	330
37.	1,3-Dichlorobenzene	541-73-1	10	330
38.	1,4-Dichlorobenzene	106-46-7	10	330
39.	1,2-Dichlorobenzene	95-50-1	10	330
40.	2-Methylphenol	95-48-7	10	330
41.	2,2-oxybis(1-chloropropane)	108-60-1	10	330
42.	4-Methylphenol	106-44-5	10	330
43.	N-Nitroso-di-n-propylamine	621-64-7	10	330
44.	Hexachloroethane	67-72-1	10	330
45.	Nitrobenzene	98-95-3	10	330
46.	Isophorone	78-59-1	10	330
47.	2-Nitrophenol	88-75-5	10	330
48.	2,4-Dimethylphenol	105-67-9	10	330
49.	bis(2-Chloroethoxy)methane	111-91-1	10	330
50.	2,4-Dichlorophenol	120-83-2	10	330
51.	1,2,4-Trichlorobenzene	120-82-1	10	330
52.	Naphthalene	91-20-3	10	330
53.	4-Chloroaniline	106-47-8	10	330
54.	Hexachlorobutadiene	87-68-3	10	330
55.	4-Chloro-3-methylphenol	59-50-7	10	330
56.	2-Methylnaphthalene	91-57-6	10	330
57.	Hexachlorocyclopentadiene	77-47-4	10	330
58.	2,4,6-Trichlorophenol	88-06-2	10	330
59.	2,4,5-Trichlorophenol	95-95-4	25	800
60.	2-Chloronaphthalene	91-58-7	10	330
61.	2-Nitroaniline	88-74-4	25	800
62.	Dimethylphthalate	131-11-3	10	330
63.	Acenaphthylene	208-96-8	10	330
64.	2,6-Dinitrotoluene	606-20-2	10	330
65.	3-Nitroaniline	99-09-2	25	800
66.	Acenaphthene	83-32-9	10	330
67.	2,4-Dinitrophenol	51-28-5	25	800
68.	4-Nitrophenol	100-02-7	25	800
69.	Dibenzofuran	132-64-9	10	330

70.	2,4-Dinitrotoluene	121-14-2	10	330
71.	Diethylphthalate	84-66-2	10	330
72.	4-Chlorophenyl-phenylether	7005-72-3	10	330
73.	Fluorene	86-73-7	10	330
74.	4-Nitroaniline	100-01-6	25	800
75.	4,6-Dinitro-2-methylphenol	534-52-1	25	800
76.	N-nitrosodiphenylamine	86-30-6	10	330
77.	4-Bromophenyl-phenyl ether	101-55-3	10	330
78.	Hexachlorobenzene	118-74-1	10	330
79.	Pentachlorophenol	87-86-5	25	800
80.	Phenanthrene	85-01-8	10	330
81.	Anthracene	120-12-7	10	330
82.	Carbazole	86-74-8	10	330
83.	Di-n-butylphthalate	84-74-2	10	330
84.	Fluoranthene	206-44-0	10	330
85.	Pyrene	129-00-0	10	330
86.	Butylbenzylphthalate	85-68-7	10	330
87.	3,3-Dichlorobenzidine	91-94-1	20	660
88.	Benz(a)anthracene	56-55-3	10	330
89.	Chrysene	218-01-9	10	330
90.	bis(2-Ethylhexyl)phthalate	117-81-7	10	330
91.	Di-n-octylphthalate	117-84-0	10	330
92.	Benzo(b)fluoranthene	205-99-2	10	330
93.	Benzo(k)fluoranthene	207-08-9	10	330
94.	Benzo(a)pyrene	50-32-8	10	330
95.	Indeno(1,2,3-cd)pyrene	193-39-5	10	330
96.	Dibenz(a,h)anthracene	53-70-3	10	330
97.	Benzo(g,h,i)perylene	191-24-2	10	330

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

(3) Medium Soil/Sediment Quantitation Limits (QL) for Semivolatile TCL Compounds are 60 times the individual Low Soil/Sediment QL.

Based on Contract Laboratory Program Statement of Work, OLMO1.6 (6/91).

TARGET COMPOUND LIST (TCL) AND
QUANTITATION LIMITS (QL) (1)

Pesticides/PCBs		CAS Number	Quantitation Limits (2) Water µg/L	Low Soil/Sediment (3) µg/kg
98.	alpha-BHC	319-84-6	0.05	1.7
99.	beta-BHC	319-85-7	0.05	1.7
100.	delta-BHC	319-86-8	0.05	1.7
101.	gamma-BHC (Lindane)	58-89-9	0.05	1.7
102.	Heptaclor	76-44-8	0.05	1.7
103.	Aldrin	309-00-2	0.05	1.7
104.	Heptachlor epoxide	1024-57-3	0.05	1.7
105.	Endosulfan I	959-98-8	0.05	1.7
106.	Dieldrin	60-57-1	0.10	3.3
107.	4,4'-DDE	72-55-9	0.10	3.3
108.	Endrin	72-20-8	0.10	3.3
109.	Endosulfan II	33213-65-9	0.10	3.3
110.	4,4'-DDD	72-54-8	0.10	3.3
111.	Endosulfan sulfate	1031-07-8	0.10	3.3
113.	4,4'-DDT	50-29-3	0.10	3.3
114.	Methoxychlor	72-43-5	0.50	17.0
115.	Endrin ketone	53494-70-5	0.10	3.3
116.	Endrin aldehyde	7421-36-3	0.10	3.3
117.	alpha-Chlordane	5103-71-9	0.5	1.7
118.	gamma-Chlordane	5103-74-2	0.5	1.7
119.	Toxaphene	8001-35-2	1.0	170.0
120.	Aroclor-1016	12674-11-2	0.5	33.0
121.	Aroclor-1221	11104-28-2	0.5	33.0
122.	Aroclor-1232	11141-16-5	0.5	67.0
123.	Aroclor-1242	53469-21-9	0.5	33.0
124.	Aroclor-1248	12672-29-6	0.5	33.0
125.	Aroclor-1254	11097-69-1	1.0	33.0
126.	Aroclor-1260	11096-82-5	1.0	33.0

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

(3) Medium Soil/Sediment Quantitation Limits (QL) for Pesticides/PCB TCL compounds are 15 times the individual Low Soil/Sediment QL.

Based on the Contract Laboratory Program Statement of Work, OLMO1.6 (6/91).

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Detection Limit (μg/L - water [1])
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	3
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

(1) Sediment detection limit 100× water (μg/kg - soil/sediment).

Based on the Contract Laboratory Program Statement of Work, ILMO2.1 (9/91).

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Appendix II

of the

"Guidance for Data Useability in Risk Assessment (Part A)"

Final

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, D.C. 20460

APPENDIX II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES

Appendix II identifies seven industries that generate waste which contains pollutants that are known to pose human and environmental hazards. This appendix is intended to aid the reader in three ways:

- To assist in the identification of target compounds and potential exposure pathways.
- To predict associated contaminants that potentially yield interferences.
- To assist in early identification of sites that contain high levels of compounds that may not be included as target analytes for routinely available methods.

The data for these tables were obtained by searching the USEPA Toxic Release Inventory System using the Standard Industrial Classification (SIC) codes listed below:

Industry		SIC Code
1	Battery Recycling	3691, 3692
2	Munitions/Explosives	2892
3	Pesticides Manufacturing	2842, 2879
4	Electroplating	3471
5	Wood Preservatives	2491
6	Leather Tanning	3111
7	Petroleum Refining	2911

The appendix consists of seven tables and depicts the pollutants associated with each of the seven industries, the CAS number of each pollutant, and the matrices where each pollutant has been found. The list is not inclusive of all pollutants or industrial sources. The seven industries were selected based on the recommendation of the Risk Assessment Subgroup of the Data Useability Workgroup because of the frequency of occurrence of the pollutants produced by those industries in Superfund sites.

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 1: BATTERY RECYCLING

Rank	Compound	CAS Number	Air	Water	Soil	Other[b]
1	LEAD	7439921	Y	Y	Y	Y
2	SODIUM SULFATE (SOLUTION)	7757826		Y		
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y		Y
4	SULFURIC ACID	7664939	Y	Y		Y
5	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
6	MANGANESE	7439965	Y	Y	Y	Y
7	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
8	METHANOL	67561	Y	Y		Y
9	FREON 113	76131	Y			Y
10	TRICHLOROETHYLENE	79016	Y	Y		Y
11	TOLUENE	108883	Y			Y
12	ZINC	7440666		Y	Y	Y
13	AMMONIA	7664417	Y	Y		Y
14	CADMIUM	7440439	Y	Y	Y	Y
15	ANTIMONY	7440360	Y	Y		Y
16	BARIUM	7440393	Y	Y		Y
17	NICKEL	7440020	Y	Y	Y	Y
18	FORMALDEHYDE	50000	Y			Y
19	ACETONE	67641	Y			
20	XYLENE (MIXED ISOMERS)	1330207	Y			
21	TETRACHLOROETHYLENE	127184	Y			Y
22	DICHLOROMETHANE	75092	Y			Y
23	PHENOL	108952	Y			Y
24	MERCURY	7439976	Y	Y		Y
25	N-BUTYL ALCOHOL	71363	Y			
26	METHYL ETHYL KETONE	78933	Y			Y
27	METHYL ISOBUTYL KETONE	108101	Y			
28	HYDROCHLORIC ACID	7647010	Y	Y		
29	NITRIC ACID	7697372	Y			Y
30	1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)	71556	Y			
31	COBALT	7440484	Y		Y	Y
32	ARSENIC	7440382	Y			Y
33	COPPER	7440508		Y		Y
34	SILVER	7440224	Y	Y		Y
35	ACETONITRILE	75058	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 2: MUNITIONS/EXPLOSIVES

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	ACETONE	67641	Y	Y	Y	Y
2	NITRIC ACID	7697372	Y	Y	Y	Y
3	AMMONIUM NITRATE (SOLUTION)	6484522	Y	Y	Y	Y
4	PENTACHLOROPHENOL	87865			Y	
5	SODIUM SULFATE (SOLUTION)	7757826		Y		
6	AMMONIA	7664417	Y	Y	Y	
7	SULFURIC ACID	7664939	Y	Y	Y	Y
8	METHYL ETHYL KETONE	78933	Y			Y
9	CYCLOHEXANE	110827	Y			Y
10	CHLORINE	7782505	Y	Y		
11	NITROGLYCERIN	55630	Y	Y	Y	Y
12	DICHLOROMETHANE	75092	Y			Y
13	CALCIUM CYANAMIDE	156627	Y		Y	
14	LEAD	7439921	Y	Y	Y	Y
15	ETHYLENE GLYCOL	107211	Y	Y	Y	
16	N-BUTYL ALCOHOL	71363	Y			
17	TERT-BUTYL ALCOHOL	75650	Y			Y
18	M-XYLENE	108383	Y			
19	METHANOL	67561	Y	Y		Y
20	ASBESTOS (FRIABLE)	1332214				Y
21	1,1,1-TRICHLOROETHANE	71556	Y			Y
22	POLYCHLORINATED BIPHENYLS	1336363				Y
23	COPPER	7440508	Y	Y	Y	Y
24	ALUMINUM	7429905	Y	Y	Y	Y
25	2,4-DINITROTOLUENE	121142	Y	Y		
26	GLYCOL ETHERS	79141	Y			
27	BENZENE	71432	Y	Y	Y	Y
28	BIS(2-ETHYLHEXYL) ADIPATE	103231		Y		
29	ZINC	7440666	Y			
30	DIBUTYL PHTHALATE	84742	Y	Y	Y	
31	SODIUM HYDROXIDE (SOLUTION)	1310732	Y		Y	
32	DIETHYL PHTHALATE	84662		Y		

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SODIUM SULFATE (SOLUTION)	7757826		Y	Y	Y
2	AMMONIA	7664417	Y	Y	Y	Y
3	TOLUENE	108883	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	TITANIUM TETRACHLORIDE	7550450				Y
6	METHANOL	67561	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y	Y	Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
9	CHLOROBENZENE	108907	Y	Y		Y
10	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
11	CHLOROPHENOLS	106489	Y	Y	Y	Y
12	STYRENE	100425	Y	Y		Y
13	ACRYLONITRILE	107131	Y	Y		Y
14	FORMALDEHYDE	50000	Y	Y	Y	Y
15	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
16	CHLOROTHALONIL	1897456	Y	Y		Y
17	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
18	ACETONE	67641	Y	Y	Y	Y
19	HEXACHLOROBENZENE	118741	Y	Y		Y
20	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
21	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
22	GLYCOL ETHERS	79141	Y	Y	Y	Y
23	1,3-BUTADIENE	106990	Y	Y		Y
24	CHLOROMETHANE	74873	Y			Y
25	CAPTAN	133062	Y		Y	Y
26	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
27	CHLORINE	7782505	Y	Y	Y	Y
28	CARBARYL	63252	Y	Y		Y
29	COPPER	7440508	Y	Y	Y	Y
30	PARATHION	56382	Y			Y
31	ZINEB	12122677				Y
32	PYRIDINE	110861	Y	Y		
33	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
34	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
35	CARBON DISULFIDE	75150	Y		Y	
36	1,2,4-TRICHLOROBENZENE	120821	Y		Y	Y
37	SULFURIC ACID	7664939	Y	Y	Y	Y
38	MALEIC ANHYDRIDE	108316	Y		Y	Y
39	ETHYLBENZENE	100414	Y	Y		Y
40	2,4-D	94757	Y	Y	Y	Y
41	BROMOMETHANE	74839	Y			
42	SEC-BUTYL ALCOHOL	78922	Y	Y		

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
43	LEAD	7439921				Y
44	CUMENE	98828	Y	Y		Y
45	M-XYLENE	108383	Y			Y
46	ASBESTOS (FRIABLE)	1332214			Y	Y
47	FREON 113	76131	Y			Y
48	DICHLOROBENZENE (MIXED ISOMERS)	25321226	Y		Y	Y
49	CYCLOHEXANE	110827	Y		Y	Y
50	2,4-DICHLOROPHENOL	120832			Y	Y
51	1,4-DICHLOROBENZENE	106467	Y			
52	DICHLOROBROMOMETHANE	75274	Y			Y
53	TRIFLURALIN	1582098	Y	Y	Y	Y
54	1,2,4-TRIMETHYLBENZENE	95636	Y	Y		Y
55	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
56	1,4-DIOXANE	123911	Y			Y
57	NITRIC ACID	7697372	Y	Y		Y
58	N-BUTYL ALCOHOL	71363	Y	Y		Y
59	FLUOMETURON	2164172	Y	Y		Y
60	2-METHOXYETHANOL	109864				Y
61	BIS(2-ETHYLHEXYL) ADIPATE	103231	Y			Y
62	PHENOL	108952	Y	Y		Y
63	ACRYLIC ACID	79107	Y		Y	Y
64	QUINTOZENE	82688	Y			Y
65	ALUMINUM	1344281	Y	Y	Y	Y
66	BENZOYL PEROXIDE	94360			Y	Y
67	O-XYLENE	95476	Y			
68	CHROMIUM	7440473	Y	Y		Y
69	2-PHENYLPHENOL	90437	Y	Y		
70	HYDROGEN CYANIDE	74908	Y	Y		Y
71	ZINC	7440666	Y	Y	Y	Y
72	HEXACHLOROCYCLOPENTADIENE	77474				Y
73	DICOFOL	115322	Y			Y
74	BIPHENYL	92524	Y	Y		Y
75	4-NITROPHENOL	100027	Y		Y	Y
76	METHYL ETHYL KETONE	78933	Y			Y
77	TRICHLOROETHYLENE	79016	Y		Y	
78	M-CRESOL	108394	Y			Y
79	TETRACHLORVINPHOS	961115				Y
80	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817		Y		Y
81	TEREPHTHALIC ACID	100210	Y			Y
82	DICHLORVOS	62737	Y			Y
83	MANEB	12427382	Y			Y
84	P-XYLENE	106423	Y			Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
85	METHYLENE BROMIDE	74953	Y			
86	CHLORAMBEN	133904	Y			Y
87	BENZENE	71432	Y			Y
88	HYDROGEN FLUORIDE	7664393	Y	Y		
89	ETHYLENE	74851	Y			
90	C.I. ACID BLUE 9, DISODIUM SALT	3844459		Y		Y
91	DIMETHYL SULFATE	77781	Y			
92	ISOPROPYL ALCOHOL	67630	Y			
93	HYDRAZINE	302012	Y	Y		
94	VINYL CHLORIDE	75014	Y			
95	METHYLENEBIS(PHENYLISOCYANATE)	101688	Y			Y
96	EPICHLOROHYDRIN	106898	Y			
97	PROPYLENE	115071	Y			
98	NITRILOTRIACETIC ACID	139139		Y		
99	ARSENIC	7440382	Y			Y
100	NAPHTHALENE	91203	Y	Y		
101	VINYLIDENE CHLORIDE	75354	Y			
102	TRICHLORFON	52686	Y			Y
103	DIBUTYL PHTHALATE	84742		Y		
104	ANILINE	62533	Y	Y		
105	METHOXYCHLOR	72435	Y	Y		Y
106	DIETHANOLAMINE	111422	Y	Y	Y	Y
107	NITROBENZENE	98953	Y	Y		
108	CYANIDE COMPOUNDS	57125	Y	Y		
109	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
110	LINDANE	58899	Y			Y
111	POLYCHLORINATED BIPHENYLS	1336363	Y			Y
112	PROPYLENE OXIDE	75569	Y			
113	2,4-DINITROPHENOL	51285	Y	Y		Y
114	PHOSGENE	75445	Y			
115	HEXACHLOROETHANE	67721	Y			
116	CADMIUM	7440439				Y
117	ETHYLENE OXIDE	75218	Y			
118	BENZYL CHLORIDE	100447	Y	Y		
119	4,6-DINITRO-O-CRESOL	534521	Y			
120	CHLOROBENZILATE	510156	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4: ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SULFURIC ACID	7664939	Y	Y	Y	Y
2	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
4	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y
5	SODIUM SULFATE (SOLUTION)	7757826	Y	Y		Y
6	NITRIC ACID	7697372	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y		Y
8	NICKEL	7440020	Y	Y	Y	Y
9	TRICHLOROETHYLENE	79016	Y	Y		Y
10	CHROMIUM	7440473	Y	Y	Y	Y
11	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
12	METHYL ETHYL KETONE	78933	Y	Y		Y
13	ZINC	7440666	Y	Y	Y	Y
14	FREON 113	76131	Y		Y	Y
15	ALUMINUM	7429905	Y	Y	Y	Y
16	COPPER	7440508	Y	Y	Y	Y
17	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
18	TOLUENE	108883	Y	Y	Y	Y
19	LEAD	7439921	Y	Y	Y	Y
20	XYLENE (MIXED ISOMERS)	1330207	Y			Y
21	ACETONE	67641	Y	Y		Y
22	CADMIUM	7440439		Y	Y	Y
23	ETHYLBENZENE	100414	Y			Y
24	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
25	CYANIDE COMPOUNDS	57125	Y	Y	Y	Y
26	AMMONIA	7664417	Y	Y		Y
27	FORMALDEHYDE	50000	Y	Y		Y
28	GLYCOL ETHERS	79141	Y	Y		Y
29	CHLORINE	7782505	Y	Y		Y
30	METHANOL	67561	Y	Y		Y
31	ETHYLENE OXIDE	75218	Y			
32	METHYL ISOBUTYL KETONE	108101	Y			Y
33	2-METHOXYETHANOL	109864	Y			Y
34	HYDROGEN FLUORIDE	7664393	Y	Y		Y
35	PHENOL	108952	Y			Y
36	1,2-DICHLOROBENZENE	95501	Y			Y
37	N-BUTYL ALCOHOL	71363	Y			Y
38	TERT-BUTYL ALCOHOL	75650	Y			
39	BARIUM	7440393				Y
40	VINYLIDENE CHLORIDE	75354	Y			
41	2-ETHOXYETHANOL	110805	Y			Y
42	ISOPROPYL ALCOHOL	67630	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4: ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
43	MANGANESE	7439965	Y			Y
44	HYDROGEN CYANIDE	74908				Y
45	STYRENE	100425	Y			
46	TETRACHLORVINPHOS	961115	Y			
47	MELAMINE	108781				Y
48	N-DIOCTYL PHTHALATE	117840				Y
49	1,4-DIOXANE	123911	Y			
50	COBALT	7440484		Y		
51	NAPHTHALENE	91203				Y
52	AMMONIUM SULFATE (SOLUTION)	7783202				Y
53	SILVER	7440224		Y		Y
54	PROPYLENE	115071	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 5: WOOD PRESERVATION

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	CHROMIUM	7440473	Y	Y	Y	Y
2	NAPHTHALENE	91203	Y	Y	Y	Y
3	AMMONIA	7664417	Y		Y	Y
4	PENTACHLOROPHENOL	87865	Y	Y	Y	Y
5	DIBENZOFURAN	132649	Y	Y	Y	Y
6	ANTHRACENE	120127	Y	Y	Y	Y
7	COPPER	7440508	Y	Y	Y	Y
8	ARSENIC	7440382	Y	Y	Y	Y
9	FORMALDEHYDE	50000	Y			
10	BIPHENYL	92524	Y	Y	Y	Y
11	BENZENE	71432	Y	Y		
12	DICHLOROMETHANE	75092	Y			
13	1,1,1-TRICHLOROETHANE	71556	Y			Y
14	AMMONIUM SULFATE (SOLUTION)	7783202		Y	Y	
15	QUINOLINE	91225	Y	Y	Y	Y
16	PHENOL	108952	Y	Y		
17	ZINC	7440666	Y	Y		Y
18	PHOSPHORIC ACID	7664382	Y			
19	O-CRESOL	95487	Y	Y		
20	HYDROCHLORIC ACID	7647010	Y			
21	M-CRESOL	108394	Y	Y		

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 6: LEATHER TANNING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	AMMONIUM SULFATE (SOLUTION)	7783202	Y	Y	Y	Y
2	SULFURIC ACID	7664939	Y	Y		Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732		Y		Y
4	AMMONIA	7664417	Y	Y	Y	Y
5	TOLUENE	108883	Y			Y
6	SODIUM SULFATE (SOLUTION)	7757826		Y		
7	METHYL ETHYL KETONE	78933	Y			Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y		Y
9	CHROMIUM	7440473	Y	Y	Y	Y
10	GLYCOL ETHERS	79141	Y	Y		Y
11	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
12	2-METHOXYETHANOL	109864	Y	Y		Y
13	ACETONE	67641	Y	Y		Y
14	2-ETHOXYETHANOL	110805	Y	Y		Y
15	N-BUTYL ALCOHOL	71363	Y	Y		Y
16	TETRACHLOROETHYLENE	127184	Y	Y		
17	CYCLOHEXANE	110827	Y			Y
18	AMMONIUM NITRATE (SOLUTION)	6484522			Y	
19	MANGANESE	7439965		Y	Y	Y
20	1,1,1-TRICHLOROETHANE	71556	Y			
21	DICHLOROMETHANE	75092	Y			
22	DIETHANOLAMINE	111422	Y			Y
23	METHANOL	67561	Y	Y		
24	ISOPROPYL ALCOHOL	67630	Y			Y
25	PHOSPHORIC ACID	7664382		Y		
26	ETHYLENE GLYCOL	107211	Y			
27	FREON 113	76131	Y			
28	PHENOL	108952		Y		
29	ETHYL ACRYLATE	140885	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SODIUM SULFATE (SOLUTION)	7757826	Y	Y	Y	Y
2	ALUMINUM	7429905	Y	Y	Y	Y
3	AMMONIA	7664417	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	SULFURIC ACID	7664939	Y	Y	Y	Y
6	TOLUENE	108883	Y	Y	Y	Y
7	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
8	BENZENE	71432	Y	Y	Y	Y
9	METHYL ETHYL KETONE	78933	Y	Y	Y	Y
10	PROPYLENE	115071	Y	Y		Y
11	PHENOL	108952	Y	Y	Y	Y
12	DIETHANOLAMINE	111422	Y	Y	Y	Y
13	ETHYLENE	74851	Y	Y		Y
14	METHANOL	67561	Y	Y	Y	Y
15	CYCLOHEXANE	110827	Y	Y	Y	Y
16	1,2,4-TRIMETHYLBENZENE	95636	Y	Y	Y	Y
17	ETHYLBENZENE	100414	Y	Y	Y	Y
18	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
19	CHROMIUM	7440473	Y	Y	Y	Y
20	METHYL TERT-BUTYL ETHER	1634044	Y	Y	Y	Y
21	ASBESTOS (FRIABLE)	1332214			Y	Y
22	P-XYLENE	106423	Y	Y	Y	Y
23	AMMONIUM SULFATE (SOLUTION)	7783202		Y		Y
24	M-XYLENE	108383	Y	Y	Y	Y
25	CUMENE	98828	Y	Y	Y	Y
26	ACETONE	67641	Y	Y	Y	
27	CRESOL (MIXED ISOMERS)	1319773	Y	Y	Y	Y
28	HYDROGEN FLUORIDE	7664393	Y	Y	Y	Y
29	O-XYLENE	95476	Y	Y	Y	Y
30	NAPHTHALENE	91203	Y	Y	Y	Y
31	NICKEL	7440020	Y	Y	Y	Y
32	CHLORINE	7782505	Y	Y		Y
33	LEAD	7439921	Y	Y	Y	Y
34	METHYL ISOBUTYL KETONE	108101	Y	Y		
35	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
36	MOLYBDENUM TRIOXIDE	1313275	Y	Y	Y	Y
37	ZINC	7440666	Y	Y	Y	Y
38	HYDROCHLORIC ACID	7647010	Y	Y		Y
39	GLYCOL ETHERS	79141	Y	Y	Y	Y
40	BARIUM	7440393	Y	Y	Y	Y
41	COPPER	7440508	Y	Y	Y	Y
42	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank	Compound	CAS Number	Air	Water	Soil	Other[b]
43	ANTIMONY	7440360	Y	Y	Y	Y
44	1,3-BUTADIENE	106990	Y	Y		Y
45	N-BUTYL ALCOHOL	71363	Y			
46	FORMALDEHYDE	50000	Y	Y	Y	Y
47	EPICHLOROHYDRIN	106898	Y		Y	
48	COBALT	7440484	Y	Y	Y	Y
49	VANADIUM (FUME OR DUST)	7440622	Y		Y	Y
50	CUMENE HYDROPEROXIDE	80159	Y			
51	TERT-BUTYL ALCOHOL	75650	Y		Y	
52	4,4'-ISOPROPYLIDENEDIPHENOL	80057	Y		Y	
53	BUTYRALDEHYDE	123728	Y			
54	BIPHENYL	92524	Y	Y	Y	Y
55	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
56	STYRENE	100425	Y	Y	Y	Y
57	TRICHLOROETHYLENE	79016	Y	Y		
58	MANGANESE	7439965	Y	Y		Y
59	ETHYLENE OXIDE	75218	Y			
60	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
61	CARBON DISULFIDE	75150	Y	Y		
62	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
63	POLYCHLORINATED BIPHENYLS	1336363				Y
64	PHOSPHORUS (YELLOW OR WHITE)	7723140				Y
65	QUINOLINE	91225	Y			
66	2-METHOXYETHANOL	109864	Y		Y	Y
67	1,2-DIBROMOETHANE	106934	Y	Y	Y	Y
68	TETRACHLOROETHYLENE	127184	Y	Y	Y	
69	ANTHRACENE	120127	Y	Y	Y	
70	2,4-DIMETHYLPHENOL	105679		Y	Y	
71	HYDROGEN CYANIDE	74908	Y	Y		
72	CHLOROMETHANE	74873	Y			
73	NITROBENZENE	98953		Y		
74	1,2-DICHLOROPROPANE	78875	Y	Y	Y	
75	CARBONYL SULFIDE	463581	Y	Y		
76	ACETONITRILE	75058	Y			
77	SILVER	7440224	Y	Y		Y
78	2-ETHOXYETHANOL	110805	Y			
79	THALLIUM	7440280		Y		Y
80	FREON 113	76131	Y			
81	SELENIUM	7782492	Y	Y	Y	Y
82	DICHLOROMETHANE	75092	Y			
83	MERCURY	7439976		Y	Y	Y
84	CADMIUM	7440439		Y	Y	Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
85	1,1,2-TRICHLOROETHANE	79005	Y	Y		
86	ARSENIC	7440382	Y	Y	Y	Y
87	CYANIDE COMPOUNDS	57125				Y
88	CHLORINE DIOXIDE	10049044	Y			
89	ACRYLIC ACID	79107	Y			
90	1,3-DICHLOROPROPYLENE	542756	Y			
91	1,2-BUTYLENE OXIDE	106887	Y			
92	CHLOROBENZENE	108907				Y
93	1,4-DIOXANE	123911	Y			
94	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817			Y	
95	BERYLLIUM	7440417	Y			
96	CHLOROFORM	67663				Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

FIELD SCREENING

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Describe the use of aerial photography and Sanborn Fire Insurance maps in site screening
- Determine the advantages and limitations of soil gas and x-ray fluorescence techniques
- Describe the advantages and limitations of the following geophysical techniques in locating drums and trenches:
  - Magnetics
  - Electromagnetics
  - Ground-penetrating radar

NOTES

FIELD SCREENING

VISUAL RECONNAISSANCE

- Aerial photographs
- Sanborn Fire Insurance maps
- Topographic and land use maps
- Site walkover

AERIAL PHOTOGRAPHY

- Historical photography (1920 - present)
- Contract photography (current site)

NOTES

EPIC

Environmental Photographic
Interpretation Center

Western Region - EMSL/Las Vegas, Nevada

Eastern Region - EPA-EPIC/Warrenton, Virginia

USDA ASCS

Agricultural Stabilization and Conservation Service

Aerial Photography Field Office
Salt Lake City, Utah
(801) 525-5856

1945 - present
black & white
color infrared

SANBORN FIRE INSURANCE MAPS

- 1869 to 1950s
- Communities with populations >2000
- Updated periodically
- Locations of industries, pipelines, storage vats, old dumps, and wetlands

NOTES

OTHER MAPS

USGS, ASCS, and states

- Topographic
- Land use
- Geologic
- Hydrologic

FIELD SCREENING

- X-ray fluorescence
- Soil gas
- Geophysics

X-RAY FLUORESCENCE

- Field portable instrument
- Metals identification
- Real-time quantitative analysis

NOTES

SOIL GAS

- Field portable or truck-mounted instrument
- Primarily volatile organics identification
- Real-time semiquantitative analysis

SOIL GAS USES

- Delineate groundwater plumes
- Locate source of soil contamination
- Locate groundwater monitoring wells

GEOPHYSICS

- Magnetics
- Electromagnetics (EM)
- Ground-penetrating radar (GPR)

NOTES

MAGNETICS

- Earth's magnetic field intensity measured
- Total field or vertical component
- Ferromagnetic material detected
- Passive method

ELECTROMAGNETICS

- Electric field induces secondary fields
- Electrical conductivity of ground measured
- Conductive material detected
- Active method

GROUND-PENETRATING RADAR

- Electromagnetic energy transmitted/ received
- Reflections at material horizons
- Metal or changes in geology detected
- Active method

NOTES

GPR PENETRATION

- Shallow for clay
- Deeper for dry sands

ENVIRONMENTAL PHOTOGRAPHIC INTERPRETATION CENTER

Advanced Monitoring Systems Division

Environmental Monitoring Systems Lab - Las Vegas

Products and Services

EPA

THE ENVIRONMENTAL PHOTOGRAPHIC INTERPRETATION CENTER (EPIC)

Advanced Monitoring Systems Division
Environmental Monitoring Systems Laboratory - Las Vegas

Products and Services

EPA's Environmental Photographic Interpretation Center (EPIC) provides a wide range of remote sensing and aerial photographic analyses, mainly in support of investigations under Superfund, RCRA, the Clean Water Act and the National Contingency Plan. The comprehensive aerial photographic analyses are supported by a wide array of services including aerial photo overflight planning, collateral data acquisition, aerial film processing, historical aerial photo search and acquisition, and GIS data base development. EPIC produces fully annotated maps and photos accompanied by descriptive text to document historical or current analyses of hazardous waste disposal and handling, emergency response efforts, inventories of potential hazardous waste sites, and specialized analyses including wetlands classification and delineation, photogeology and fracture trace analysis and photogrammetric mapping. EPIC maintains a multidisciplinary staff with backgrounds in geography, geology, biology, remote sensing, forestry and natural resources management.

The following sections present summary descriptions of EPIC's products and services.

Hazardous Waste Site Analyses

Analysis of hazardous waste sites using historical and current aerial photography comprises a major part of EPIC's workload. Utilizing the vast archives of aerial photography of the country maintained by government and private sources, dating back to the 1930's, EPIC's analysts can reconstruct the waste handling and disposal history of a site in order to support site cleanup and regulatory or enforcement efforts. Aerial photography can be a powerful tool in court in the form of evidence and expert witness testimony.

Interpretation of aerial photography can yield information on site size, drainage patterns, type of fill materials, leachate, burial sites, lagoons, impoundments and their contents, and general condition of the site. Locations and descriptions of tanks, drums, open storage areas, evidence of vegetation stress, on-site obstacles, structures, equipment and access routes can also be provided. Historical analysis provides the information necessary to obtain a chronological understanding of a site's development and activities, and can lead to the identification of a specific problem. The information interpreted from the

photography is provided to the requester on photo enlargements, with overlays annotated with descriptive findings. Accompanying text provides a full site description.

Inventories of Potential Hazardous Waste Sites

Inventories of potential hazardous waste sites covering large areas and decades in time are a very cost effective way to discover sites for future investigation. The aerial photography is systematically searched for specific features or types of sites specified by the requester. These can include landfills, open dumps, scrap salvage yards, chemical handling and storage facilities, impoundments, or abandoned industrial sites. Identified sites are located on overlays to topographic maps accompanied by data sheets describing site conditions. The site conditions are presented chronologically with the period of site activity shown on the map overlay. This approach is helpful in determining the origin of a progressive problem and in identifying a hazardous site that is currently hidden by new development.

Emergency Response

EPIC has the quick response capabilities to react to emergency situations such as hazardous material releases and natural disasters like hurricanes (Hugo) and earthquakes (San Francisco/Oakland, Ca.). Aerial photography is flown, processed and analyzed to provide immediate information to on-site personnel regarding circumstances not easily or safely observed from the ground. Typical products for an emergency response project include an immediate telephone report to on-site personnel followed by photographs or positive film transparencies with interpretation results annotated on overlays, annotated topographic maps, and a short letter report describing analysis results.

Wetlands

Wetland analyses are performed in support of various sections of the Clean Water Act concerning enforcement, permitting and advance identification. Analysis of historical aerial photography is often the only means of establishing the prior existence of wetlands on lands that have been dredged or filled, and calculating wetland loss acreages necessary for mitigation settlements. Aerial photographs can also provide information concerning vegetative type, periodicity of flooding, tidal influences, and affected drainage patterns.

A hierarchical wetlands and deepwater habitats classification system developed by Cowardin et al. for the U.S. Fish and Wildlife Service is used in the analyses. Jurisdictional delineation procedures are followed in the field according to the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. Field checking is performed in

enforcement cases to verify accuracy of interpretation and classification by visiting representative areas. The field reconnaissance checks representative wetlands in proximity to, and matching the aerial photographic signatures of, those at the site being investigated prior to its alteration.

Simplified studies are also performed on Superfund sites or on studies where a wetland/upland boundary satisfies the needs of the requestor. These studies entail the placement of wetland symbols or the delineation of wetland boundaries on overlays to photographic prints. The aerial photographic analysis is supported by collateral information regarding the soils, hydrology and local vegetation.

Photogeology

Photogeology involves the interpretation of the geology of an area from an analysis of landforms, drainage, tones, and vegetation distribution on aerial photographs. EPIC produces two types of photogeologic products: fracture trace analyses and lithologic mapping.

Fracture trace analysis involves the use of aerial photography and other types of imagery to identify linear features on the earth's surface that are naturally occurring and are surface manifestations of subsurface fracture zones in the bedrock. When viewed in cross-section, fracture traces are seen to be vertical or near vertical breaks in the bedrock. Fractures are of particular environmental concern because contaminants are likely to move more easily through zones of fractured bedrock than through the surrounding more consolidated bedrock material. Thus, fracture traces can be used to identify possible migration routes of pollutants and are often used in the placement of monitoring/remedial wells around hazardous waste sites.

Lithologic mapping (mapping of distinct rock types or units) from aerial photographs involves the interpretation of surface features in order to produce a more accurate geologic map in areas where geologic mapping is incomplete due to limited field work, small map scale, etc.

Photogrammetric Mapping

EPIC produces highly accurate topographic and planimetric maps, generally at a large scale, which conform with National Map Accuracy Standards and EPA Photogrammetric Mapping Specifications. Map scales, contour intervals, and planimetric details can be varied to suit specific requirements.

Photogrammetric techniques can be used to measure the area and volume of hazardous wastes; determine the height and placement of containment berms, dikes, and impoundments; and determine the depth of waste pits. Changes in size, shape, and other physical characteristics of a waste site can be documented

through sequential photogrammetric mapping.

Photogrammetric techniques can also be used in establishing precise location and orientation data to support geophysical monitoring or monitoring well placement.

Geographic Information Systems (GIS)

In cooperation with its sister branch, the Remote and Air Monitoring Branch (AMS), which houses one of EPA's GIS Centers of Excellence, EPIC has completed several GIS projects. One project supported a National Priorities List (NPL) hazardous waste site investigation using information from diverse sources (including numerous years of historical aerial photography, geological data, digital line graph data, soil data, property ownership, monitoring well data, etc.). This data was combined to produce topical maps and analyses for use in the Remedial Investigation/Feasibility Study decision-making process under Superfund. Another project involved the ecological characterization of a pilot site using photo-derived information on land use, vegetation, wetlands and landforms to produce maps and overlays for landscape characterization and trend analysis. Additionally, the GIS has been used to obtain wetland gain and loss measurements for enforcement actions against violations of the Clean Water Act.

Miscellaneous Analyses

Additional analyses include interpretation of thermal infrared imagery for detection of illegal river discharges and landfill and mine fires; detection of abandoned oil, gas and water wells; mapping of submerged aquatic vegetation; and land use and drainage mapping.

Data Acquisition

EPIC acquires historical photography, dating to the late 1930's, from a wide range of Federal, state and local government agencies and private aerial survey companies. Current overflights, customized to the requestor's needs as to scale, imagery type, time of year, etc, are obtained through a network of private aerial companies across the country. These aerial companies are also available on short notice for emergency response efforts. Additional sources of information acquired include U.S. Geological Survey maps, Sanborn Fire Insurance Maps and U.S. Department of Agriculture Soil Surveys.

Photo Lab

The technical services of EPIC's photographic laboratory include:

- Complete photographic processing and printing of

black-and-white, color, color infrared, and black-and-white thermal infrared film;

- Custom processing and printing, to include reproducing old maps, line work, and historical imagery

- Responding to emergencies, such as oil spills, train derailments, and chemical fires

Graphics Support

EPIC offers graphics, cartography, drafting and ancillary support for the preparation of finished documents. Our present capabilities include:

- Preparing camera-ready artwork for publications, reports, briefings, and presentations

- Preparing inked overlays keyed to aerial photography and maps, and preparation of transparencies for use as overlays or in briefings

- Assembling completed reports including layout, mounting of photographs and text, covers, and binding

- Mounting and labeling of photographs for litigation or public hearings

ENVIRONMENTAL PHOTOGRAPHIC INTERPRETATION CENTER (EPIC)

AERIAL SERVICES REQUEST FORM

Request Date: _____

I. SITE DATA

Site Name: _____ Region: _____

Program: (circle) Superfund RCRA RCRA Enf. Other _____

If Superfund: Site/Spill ID# _____

Purpose (circle): Remedial Removal Enf. Other_____

Geographic Coordinates: _____ Long. _____ Lat.

State: _____ County: _____ Municipality: _____

USGS Quad Name (IMPORTANT: ATTACH PHOTOCOPY OF MAP SHOWING SITE BOUNDARIES AND/OR STUDY AREA): _____

Regional Project Manager: _____ Phone# FTS_____ COMM_____

Brief discussion of site history, specific problems at site, what you hope to accomplish through this request. Elaborate on known or suspected aspects of site operation (e.g. barrels believed dumped between 1967 and 1972 adjacent to north lagoon). Please attach background information about the site such as site descriptions, action memos, etc.

II. STANDARD REQUEST OPTIONS - Check and complete the appropriate section for the type of service you are requesting.

_____ 1. CURRENT PHOTOGRAPHY ONLY (new overflight)

a. Scale: _____ (e.g., 1:24,000)

Average turnaround = 6 wks.

b. Special conditions (e.g., do not fly if snow cover, leaves time on, etc.) _____

c. Photo size: 9"x9" ____ 20"x20"____ Other_____

d. Are stereo pairs needed? ____Y ____N

e. Number of copies: _____

f. Desired delivery date: _____

_____ 2. HISTORICAL PHOTOGRAPHY ONLY

Average turnaround time = 6-10 wks.

a. Study period (e.g., 1936-1955): _____

b. Specific years desired: _____

c. Photo size: 9"x9" ____ 20"x20" ____ Other_____

d. Number of copies: _____

e. Desired delivery date: _____

_____ 3. ANALYSIS OF CURRENT (single coverage) PHOTOGRAPHY

Average turnaround time = 8 wks.

a. Scale: _____(e.g., 1:24,000)

b. Special conditions (e.g., do not fly if snow cover, leaves on, etc.) _____

c. Photo size: 9"x9" ____ 20"x20"____ Other_____

d. Number of copies: _____

e. Desired delivery date: _____

____ 4. ANALYSIS OF HISTORICAL PHOTOGRAPHY (standard site analysis package - see attachment)

***Average turnaround time = 12-24 wks.

a. Study period (e.g., 1936-1955): _____

b. Specific years of interest: _____

c. Are copies of historical photos (before analysis) needed?
____Y ____N
If yes, photo size: 9"x9"____ 20"X20"____ Other_____

d. Is an interim report (unbound format, handwritten photo overlays with typed body of report) needed? ____Y ____N

e. Number of copies of final bound report: _____

f. Desired delivery date: _____

____ 5. SURVEYING AND MAPPING - Complete and attach request form

III. SPECIAL REQUEST OPTIONS - The following remote sensing services are also available for sites with conditions that warrant their use. Check off items of interest and contact your remote sensing coordinator for more information.

_____ a. Land use analysis (within specified distance from site)

_____ b. Fracture trace analysis

_____ c. Wetland mapping/assessment

_____ d. Multi-spectral scanner overflights

_____ e. Thermal infrared scanner overflights

_____ f. Mensuration (measurements) of features (e.g., barrel/drum count, terrain transects, building dimensions, lagoon dimensions, etc.)

Sanborn Maps

The Sanborn maps are fire insurance maps created by the Sanborn Map Company of Pelham, New York. The maps, produced as early as 1867, were made to provide insurance companies with pertinent information to make risk assessments on commercial buildings, factories, and dwellings. Information provided on each of these structures typically includes a structure's size and shape, locations of windows and doors, presence of firewalls, sprinkler systems, types of roofs, distance to fire hydrants and the location of water mains.

The maps give an accurate delineation of the boundaries of industrial or commercial activities, the current state of activity (i.e., under construction in 1903), the number and location of storage tanks (and frequently their contents), the type of processing taking place in specific areas, and such features as the presence of earthen fire walls around storage tanks or processing areas which may serve as secondary structures to restrict the spread of any accidental spills or leaks.

COMPREHENSIVE LISTING OF AERIAL PHOTOGRAPHY

libraried at the

U.S. DEPT OF AGRICULTURE, ASCS
AERIAL PHOTOGRAPHY FIELD OFFICE
2222 WEST 2300 SOUTH
P.O. BOX 30010
SALT LAKE CITY, UTAH 84130-0010

The comprehensive listing shows the various photographic coverages used by the U.S. Department of Agriculture archived at the Aerial Photography Field Office. This library includes photography used by the Agriculture Stabilization and Conservation Service (ASCS) and it predecessor agencies, the U.S. Forest Service (FS) and the Soil Conservation Service (SCS).

Coverage of the Agricultural Stabilization and Conservation Service and the Soil Conservation Service is listed alphabetically by states and counties. A Federal Information Processing Standards (FIPS) numerical code is assigned to each county flown by ASCS and SCS after July 1, 1971.

Coverage of Forest Service photography is listed alphabetically for each forest within a region. Numerical codes used to identify FS projects are assigned by the Forest Service.

NAPP - National Aerial Photography Program and
NHAP - National High Altitude Photography - are flown in color infrared positive film. Coverage is listed alphabetically by state and county. Due to the constant state of change in the acquisition of new coverage available from NAPP/NHAP, this part of the listing is designed to allow for timely and periodic updates. New listings by state are available upon written request.

Photo indexes or spot indexes and microfilm duplicates are available for most projects. The number of index sheets required to cover a project is shown.

Rectified enlargements are available from photography used for ASCS programs. This means that scale, tip, and tilt data, computed through an analytical aerotriangulation system, is available to produce true-to-scale enlargements for indicated projects. An increasing amount of rectification data is also available from some of the Soil Conservation Service and Forest Service projects.

See reverse side for a glossary of terms, however, if you have any questions please contact the Aerial Photography Field Office at (801) 524-5856.

GLOSSARY OF TERMS

YEAR - Year the original contract was let.

CONTRACT YEAR(S) - Year the original contract was let. Not the year the photography was flown. (1 - Cycle 1 NHAP i.e. 1HAP80
2 - Cycle 2 NHAP i.e. 2HAP85
3 - Cycle 3 NAPP i.e. 3HAP87)

MAJ YR
FLOWN - (NAPP/NHAP Listing only) Year the majority of the county was flown.

(P) - Partial coverage. For ASCS projects, partial coverage generally occured in counties containing large areas of non-agricultural land.

SCALE - Fractional scale [i.e. (40) = 1:40,000]

INTERNEG - Black & white internegative from NAPP/NHAP photography is on file.

FILM - Film Type
B/W - Black and White Negative
CIRP - Color Infrared Positive
CIRN - Color Infrared Negative
CN - Color Negative

PI - Photo Index. A rough mosaic assembly of the prints covering each project or county area. The assembly of prints is copied to a scale of 1" = 1 mile. The number listed indicates the number of index sheets needed to cover a county or project area.

SI - Spot or Line Index. A detailed map with the center of each photograph plotted by flight line and exposure number.

RECT - Rectification data available. Enlargements can be photographically rectified to produce scale accurate reproductions of cropland or cultural areas.

REMARKS -

* - Scheduled for rectification.

BLK - One or more county or project areas grouped to form a larger block.

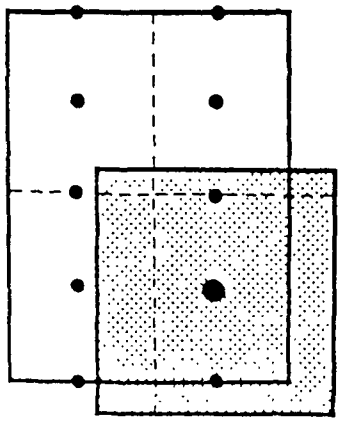
ASCS/
SCS - First agency to require rectification accuracy.

United States Department of Agriculture
Agricultural Stabilization and Conservation Service
Aerial Photography Field Office
P.O. Box 30010
Salt Lake City, Utah 84130

NAPP PHOTOGRAPHY (1987 - Present)

- NAPP - NATIONAL AERIAL PHOTOGRAPHY PROGRAM.
- COLOR INFRARED POSITIVE PHOTOGRAPHY/ ORIGINAL FILM HELD BY APFO. (B&W products are available.)
- 1:40,000 SCALE.
- CONTRACTED BY STATE/PARTIAL STATE.
- LEAF-ON AND LEAF-OFF PHOTOGRAPHY DEPENDING ON CONTRACTING SEASON.
- FLOWN IN N/S DIRECTION.
- 6" FOCAL LENGTH.
- AVERAGE ENDLAP 62%.
- AVERAGE SIDELAP 40%. (Ranges from 30% to 50% depending on latitude.)
- ONE FULL FRAME COVERS APPROXIMATELY 32 SQUARE MILES OF TERRAIN.
- 10 STEREOSCOPIC PHOTOGRAPHS PER USGS STANDARD 7 1/2' TOPOGRAPHIC MAP. (*Quarter-quad centered photography.)

*2 FLIGHT LINES PER 7 1/2' QUAD

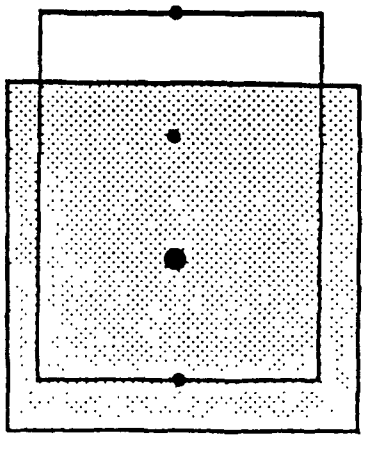


AREA COVERED BY ONE FRAME

NHAP PHOTOGRAPHY (1980 - 1987)

- NHAP - NATIONAL HIGH ALTITUDE PROGRAM.
- COLOR INFRARED POSITIVE PHOTOGRAPHY/ ORIGINAL FILM HELD BY APFO. (B&W products are available.)
- 1:60,000 SCALE.
- CONTRACTED GEOGRAPHICALLY 1°x1°.
- CYCLE 1 (1980-1985) - LEAF-OFF PHOTOGRAPH
  CYCLE 2 (1985-1987) - LEAF-ON PHOTOGRAPHY
- FLOWN IN N/S DIRECTION.
- 8 1/4" FOCAL LENGTH.
- AVERAGE ENDLAP 65%.
- AVERAGE SIDELAP 12%.
- ONE FULL FRAME COVERS APPROXIMATELY 72 SQUARE MILES OF TERRAIN.
- 4 STEREOSCOPIC PHOTOGRAPHS PER USGS STANDARD 7 1/2' TOPOGRAPHIC MAP. (*Quad centered photography.)

*1 FLIGHT LINE PER 7 1/2' QUAD



AREA COVERED BY ONE FRAME

SAMPLE ANALYSIS

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Define the target compound list
- Determine the type of analysis necessary to identify specific analytes
- Define quality control and how it affects the sampling process
- Determine appropriate sampling containers and preservatives based on the sample media
- Define holding time and its importance to sample analysis

NOTES

SAMPLE ANALYSIS

SAMPLE ANALYSIS

- Target compound list
- Quality control
- Quality control samples
- Sample containers

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Superfund
(CLP)
↓
Target compound list

NOTES

TARGET COMPOUND LIST

- Organics
  - Volatile compounds
  - Semivolatile compounds
  - Pesticides and PCBs
- Inorganics
  - Metals
  - Cyanide

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) GOAL

- Identify and implement correct sampling and analysis methods
- Limit the error introduced into the sampling and analysis procedures

QA/QC SAMPLES

- Analyze in addition to field samples
- Provide information on variability and usability of data

NOTES

BACKGROUND SAMPLES

- Collect sample upgradient of contaminated area (onsite or offsite)
- Select area with little or no contaminant migration

BACKGROUND SAMPLES

- Determine the natural composition of the soil
- Determine the constituents of water
- Provide a basis for comparison for samples collected at the site

COLLOCATED SAMPLES

- Collect adjacent to the routine field sample
- Collect 0.5 - 3 feet away from the selected field sample

NOTES

COLLOCATED SAMPLES

- Determine local variability of contamination at the site
- Can be used to assess site variation in immediate sampling area
- Cannot be used to assess variability across the site

FIELD REPLICATE SAMPLES

- Obtain samples from one location
- Homogenize the samples
- Divide homogenized sample into separate containers
- Treat as separate samples in subsequent sample handling and analysis processes

FIELD REPLICATE SAMPLES

Assess error associated with:

- Sample heterogeneity
- Sample methods
- Analytical procedures

NOTES

RINSATE BLANKS (Equipment Blanks)

- Obtain by running analyte-free deionized water over decontaminated sampling equipment
- Test for residual contamination

TRIP BLANKS

- Prepare prior to fieldwork
- Use certified clean sand or soil or analyte-free deionized water
- Use with volatile organic samples

TRIP BLANKS

Assess error associated with:

- Sampling
- Sample handling and shipping
- Laboratory handling and analysis

NOTES

FIELD BLANKS

- Prepare in the field
- Use certified clean sand or soil or analyte-free deionized water

FIELD BLANKS

Evaluate contamination errors associated with:

- Sampling methods
- Laboratory procedures

MATRIX SPIKE SAMPLES

- Field sampling
  - Collect triple the volume for organic water samples
  - Collect double the volume for inorganic water samples
- Laboratory analysis
  - Use selected or requested field samples
  - Spike samples in the laboratory with known concentrations of target analytes

NOTES

MATRIX SPIKE SAMPLES

- Verify percent recoveries
- Check sample matrix interferences
- Monitor laboratory and method performance

PERFORMANCE EVALUATION (PE) SAMPLES

- Third party prepares sample
- Analytes in PE samples are the same as analytes of concern
- Analyte concentration(s) known to preparer
- Analyte concentration(s) unknown to laboratory

PERFORMANCE EVALUATION (PE) SAMPLES

- Evaluate the overall bias of the analytical laboratory
- Detect error in the analytical method used

NOTES

QA/QC SAMPLES

Sample type	Quantity
Background	At least 1[a] Minimum of 8 samples[b,c] Individual agency's regulations may vary
Collocated	Varies by site

[a]Source: US EPA, 1991. *Removal Program: Representative Sampling Guidance*
[b]Source: US EPA, 1990. *QA/QC Control Guidance for Removal Activities*
[c]For statistical analysis to be valid

QA/QC SAMPLES

Sample type	Quantity
Field replicates	Minimum of 8 samples[a,b,c] or 1 sample per 10 samples, whichever is greater
Rinsate blanks (Equipment blanks)	One per day per type of sampling device[a]

[a]Source: US EPA, 1991. *Removal Program: Representative Sampling Guidance*
[b]Source: US EPA, 1990. *QA/QC Control Guidance for Removal Activities*
[c]For statistical analysis to be valid

QA/QC SAMPLES

Sample type	Quantity
Trip blanks	1 per day for VOA samples[a,b]
Field blanks	1 per day for each group of samples of a similar matrix[a]

[a]Source: US EPA, 1990. *Samplers Guide to the Contract Laboratory Program*
[b]One per cooler

NOTES

QA/QC SAMPLES

Sample type		Quantity
Matrix spike-liquids	Organics:	Triple volume for 1 sample per 20 samples[a]
	Inorganics:	Double volume for 1 sample per 20 samples[a]
Matrix spike-solids	Organics and Inorganics:	1 sample per 20 samples

[a]Source US EPA, 1990. *Samplers Guide to the Contract Laboratory Program*

SAMPLE CONTAINERS

- Volatiles
- Semivolatiles
- Pesticides and PCBs
- Metals
- Cyanide

HOLDING TIME

- The maximum amount of time that samples may be held before analysis and still be considered valid
- Starts when the sample is collected in the field

SAMPLE ANALYSIS

To understand the Superfund program and its role in cleaning up abandoned waste sites, some of the major environmental laws and regulations affecting these cleanups must be understood. These pieces of legislation introduce several compound lists that dictate a variety of sampling and analytical requirements, such as levels of analysis, media to be sampled, and type of sample container. It is important to recognize what compound list is associated with each of the laws or regulations to properly collect samples at a cleanup site.

Priority Pollutant List

The federal Water Pollution Control Act of 1972 was designed to keep intact the integrity of the nation's surface waters, either by maintaining their physical, chemical, and biological parameters or by restoring them and providing proper maintenance. In 1977, the act was amended by and became known as the Clean Water Act (CWA). The CWA is regulated by 40 CFR (Code of Federal Regulations) Part 122. This part of the CFR is the National Pollutant Discharge Elimination System (NPDES). NPDES states that a permit must be obtained prior to discharge of any "pollutants" from any "point source" into "waters of the United States" (40 CFR Part 122.1b). Before an NPDES permit will be issued, several analyses of the wastestream are required. These analyses are listed in the **Priority Pollutant List**. This list, which was derived from an initial list of 65 compounds, includes those constituents that were believed to be the most toxic and the most frequently discharged to wastestreams by industries.

Appendix IX of 40 CFR Part 264

Another important piece of legislation that affects sampling requirements is the Resource Conservation and Recovery Act of 1976 (RCRA). The intent of RCRA is to minimize hazardous waste (as defined in 40 CFR Part 261.3) to protect the public and the environment. There are many amendments associated with RCRA, but the regulations found in 40 CFR Parts 264 and 270 are most relevant to sampling. Appendix IX of 40 CFR Part 264 (also known as the **Groundwater Monitoring List**) contains 230 constituents that must be monitored as part of a groundwater compliance program before a RCRA permit will be issued (40 CFR Part 270—Hazardous Waste Permit Programs).

Target Compound List

A third relevant piece of legislation is the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), which has been most recently amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). These acts cover the cleanup of abandoned hazardous waste sites for which the U.S. Environmental Protection Agency's Contract Laboratory Program (CLP) offers analytical services of known quality to provide legally defensible results for use in enforcement actions. CLP laboratories follow the Target Compound List (TCL), which contains 147 constituents, when performing analyses for cleanups at hazardous waste sites. The TCL is provided on the following pages. Following the TCL is **Table 1**, which presents a comparison of the constituents found on the TCL with those found on the Priority Pollutant List.

TARGET COMPOUND LIST

Volatile Compounds

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
2-Butanone
Carbon disulfide
Carbon Tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Dibromochloromethane
1,1-Dichloroethane
1,2-Dichloroethene(Total)
1,1-Dichloroethene
1,2-Dichloroethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Ethylbenzene
2-Hexanone
Methylene Chloride
4-Methyl-2-pentanone
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Vinyl acetate
Vinyl chloride
Xylene (Total)

BTEX
Benzene
Toluene
Ethylbenzene
Xylene (Total)

TARGET COMPOUND LIST CONTINUED

Semi-Volatile Compounds

Base/Neutral Extractables

Bis(2-chloroethyl)ether
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
Bis(2-chloroisopropyl)ether
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
Bis(2-chloroethoxy)methane
1,2,4-Trichlorobenzene
Naphthalene
Hexachlorobutadiene
2-Chloronaphthalene
Dimethylphthalate
Acenaphthylene
2,6-Dinitrotoluene
Acenaphthene
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Bromophenyl-phenylether
Hexachlorobenzene
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
3-3'-Dichlorobenzidine
Benzo(a)anthracene
Chrysene
Bis(2-Ethylhexyl)phthalate
Di-n-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
Hexachlorocyclopentadiene
N-Nitrosodiphenylamine
Butylbenzylphthalate
4-Chloroaniline
2-Methylnaphthalene
2-Nitroaniline
3-Nitroaniline
Dibenzofuran
4-Nitroaniline

Acid Extractables

Phenol
2-Chlorophenol
2-Nitrophenol
2,4-Dimethylphenol
2,4-Dichlorophenol
4-Chloro-3-methylphenol
2,4,6-Trichlorophenol
2,4-Dinitrophenol
4-Nitrophenol
4,6-Dinitro-2-methylphenol
Pentachlorophenol
Benzyl alcohol
2-Methylphenol
4-Methylphenol
Benzoic Acid
2,4,5-Trichlorophenol

TARGET COMPOUND LIST CONTINUED

Pesticides and PCBs

Aldrin
alpha-BHC
beta-BHC
gamma-BHC (Lindane)
delta-BHC
alpha-Chlordane
gamma-Chlordane
4,4-DDT
4,4-DDE
4,4-DDD
Dieldrin
Endosulfan
Endosulfan II
Endosulfan sulfate
Endrin
Endrin ketone
Heptachlor
Heptachlor epoxide
Methoxychlor
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
Toxaphene

Inorganic Target Analyte List (TAL)
Metals

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

Reference: "USEPA Contract Laboratory Program Statement of Work for Organic and Inorganic Analysis" (refer to the most current publication).

TABLE 1: Priority Pollutant and Superfund Comparison Lists		
Chemical Name	**Priority Pollutant**	**Target Compound List**
ORGANICS:		
Acenaphthene	X	X
Acenaphthylene	X	X
Acetone		X
Acrolein	X	
Acrylonitrile	X	
Aldrin	X	X
Anthracene	X	X
Aroclor 1016	X	X
Aroclor 1221	X	X
Aroclor 1232	X	X
Aroclor 1242	X	X
Aroclor 1248	X	X
Aroclor 1254	X	X
Aroclor 1260	X	X
Benzene	X	X
Benzidine	X	
Benz(a)anthracene	X	X
Benzo(b)fluoranthene	X	X
Benzo(k)fluoranthene	X	X
Benzoic acid		X
Benzo(ghi)perylene	X	X
Benzo(a)pyrene	X	X
Benzyl alcohol		X

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
alpha-BHC	X	X
beta-BHC	X	X
delta-BHC	X	X
gamma-BHC	X	X
Bis(2-chloroethoxy)methane	X	X
Bis(2-chloroethyl)ether	X	X
Bis(2-chloroisopropyl)ether	X	X
Bis(2-ethylhexyl)phthalate	X	X
Bromodichloromethane	X	X
Bromomethane	X	X
4-Bromophenyl-phenylether	X	X
Butylbenzylphthalate	X	X
Carbon disulfide		X
Carbon tetrachloride	X	X
*Chlordane	X	X
4-Chloroaniline		X
Chlorobenzene	X	X
p-Chloro-m-cresol	X	X
Chlorodibromomethane	X	X
Chloroethane	X	X
2-Chloroethyl-vinylether	X	
Chloroform	X	X
Chloromethane	X	X
2-Chloronaphthalene	X	X

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
2-Chlorophenol	X	X
4-Chlorophenyl-phenylether	X	X
Chrysene	X	X
2-Methylphenol		X
4-Methylphenol		X
4,4'-DDD	X	X
4,4'-DDE	X	X
4,4'-DDT	X	X
Dibenzo(a,h)anthracene	X	X
Dibenzofuran		X
Di-n-butylphthalate	X	X
1,3-Dichlorobenzene	X	X
1,2-Dichlorobenzene	X	X
1,4-Dichlorobenzene	X	X
3,3'-Dichlorobenzidine	X	X
1,1-Dichloroethane	X	X
1,2-Dichloroethane	X	X
1,1-Dichloroethene	X	X
1,2-Dichloroethene(Total)	X	X
Dichloromethane	X	X
2,4-Dichlorophenol	X	X
1,2-Dichloropropane	X	X
cis-1,3-Dichloropropene	X	X
trans-1,3-Dichloropropene		X

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
Dieldrin	X	X
Diethylphthalate	X	X
2,4-Dimethylphenol	X	X
Dimethlyphthalate	X	X
4,6-Dinitro-o-cresol	X	X
2,4-Dinitrophenol	X	X
2,4-Dinitrotoluene	X	X
2,6-Dinitrotoluene	X	X
Di-n-octylphthalate	X	X
1,2-Diphenylhydrazine	X	
Di-n-propylnitrosamine	X	X
Endosulfan sulfate	X	X
Endosulfan I (alpha)	X	X
Endosulfan II (beta)	X	X
Endrin	X	X
Endrin aldehyde	X	
Endrin ketone		X
Ethyl benzene	X	X
Fluoranthene	X	X
Fluorene	X	X
Heptachlor	X	X
Heptachlor epoxide	X	X
Hexachlorobenzene	X	X
Hexachlorobutadiene	X	X

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
Hexachlorocyclopentadiene	X	X
Hexachloroethane	X	X
2-Hexanone		X
Indeno(1,2,3-cd)pyrene	X	X
Isophorone	X	X
Methoxychlor		X
2-Butanone (MEK)		X
2-Methylnaphthalene		X
4-Methyl-2-pentanone		X
Naphthalene	X	X
3-Nitroaniline		X
2-Nitroaniline		X
4-Nitroaniline		X
Nitrobenzene	X	X
2-Nitrophenol	X	X
4-Nitrophenol	X	X
N-nitrosodimethylamine	X	
N-nitrosodiphenylamine	X	X
Pentachlorophenol	X	X
Phenanthrene	X	X
Phenol	X	X
Pyrene	X	X
Styrene		X
2,3,7,8-Tetrachlorodibenzo-p-dioxin	X	

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
1,1,2,2,-Tetrachloroethane	X	X
Tetrachloroethene	X	X
Toluene	X	X
Toxaphene	X	X
Bromoform	X	X
1,2,4-Trichlorobenzene	X	X
1,1,1-Trichloroethane	X	X
1,1,2-Trichloroethane	X	X
Trichloroethene	X	X
2,4,5-Trichlorophenol		X
2,4,6-Trichlorophenol	X	X
Vinyl acetate		X
Vinyl chloride	X	X
Xylenes (Total)		X
METALS:		
Aluminum		X
Antimony	X	X
Arsenic	X	X
Barium		X
Beryllium	X	X
Cadmium	X	X
Calcium		X
Chromium	X	X
Cobalt		X

TABLE 1: Comparison Lists (Cont'd)		
Chemical Name	**Priority Pollutant**	**Target Compound List**
Copper	X	X
Iron		X
Lead	X	X
Magnesium		X
Manganese		X
Mercury	X	X
Nickel	X	X
Potassium		X
Selenium	X	X
Silver	X	X
Sodium		X
Thallium	X	X
Vanadium		X
Zinc	X	X
Cyanide	X	X

*Priority Pollutant List = Technical chlordane
Target Compound List = alpha and gamma chlordane

Source: Priority Pollutant List = 40 CFR Part 122, App. D
Target Compound List = "US EPA Contract Laboratory Program Statement of Work for Organic and Inorganic Analysis" (refer to the most current publication).

SAMPLE COLLECTION REQUIREMENTS

Sample collection methods are dictated by the analysis required for each sample. Therefore, it is important to consider the analytical test or tests that a sample will undergo before actual sample collection begins. To maintain the integrity of the sample, the sample type, type of container, preservation method, and holding time must be considered before sampling begins.

Table 2 can be used as a guide for sample collection for compounds and/or analytes found on the TCL. For example, to collect a liquid sample for a metals analysis, a 1-L polyethylene container with a polyethylene-lined cap is the recommended container. Nitric acid should be added to the sample until it has reached a pH <2. The preservative helps to keep the analytes that may be in the sample in solution. As shown in **Table 2**, the holding time for the metals sample is 6 months. The holding time is a specific time frame that is set from the time of sample collection to the time of completion of the laboratory analysis. If the holding time is exceeded, the sample analysis is not valid. If a particular sample will be analyzed for more than one test, it must be collected in the appropriate container, preserved properly, and analyzed within its holding time to be considered complete.

Table 3 lists the sample types, types of containers, preservatives, and holding times for a variety of tests other than those recommended on the TCL.

TABLE 2: REQUIRED CONTAINERS, PRESERVATION TECHNIQUES AND HOLDING TIMES			
NAME	**CONTAINER***	**PRESERVATION**	**HOLDING TIME**
ORGANIC TESTS:			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% sodium thiosulfate	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% sodium thiosulfate, HCl to pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4° C, 0.008% sodium thiosulfate, adjust pH to 4-5	14 days
Phenols	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate	7 days until extraction 40 days after extraction
Benzidines	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate	7 days until extraction 40 days after extraction
Phthalate esters	G, Teflon-lined cap	Cool, 4°C	7 days until extraction 40 days after extraction
Nitrosamines	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% sodium thiosulfate	7 days until extraction 40 days after extraction
PCB's, acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7days until extraction 40 days after extraction
Nitroaromatics and isophorone	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate, store in dark	7 days until extraction 40 days after extraction
Polynuclear aromatic hydrocarbons	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate, store in dark	7 days until extraction 40 days after extraction
Haloethers	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate	7 days until extraction 40 days after extraction
Chlorinated hydrocarbons	G, Teflon-lined cap	Cool, 4°C	7 days until extraction 40 days after extraction
TCDD	G, Teflon-lined cap	Cool, 4°C, 0.008% sodium thiosulfate	7 days until extraction 40 days after extraction
Total organic halogens	G, Teflon-lined cap	Cool, 4°C, sulfuric acid to pH <2	7 days
PESTICIDES TESTS:			
Pesticides	G, Teflon-lined cap	Cool, 4°C, pH 5-9	7 days until extraction 40 days after extraction
RADIOLOGICAL TESTS:			
Alpha, beta and radium	P, G	Nitric acid to pH <2	6 months

TABLE 2: REQUIRED CONTAINERS, PRESERVATION TECHNIQUES AND HOLDING TIMES (Cont'd)			
NAME	**CONTAINER***	**PRESERVATION**	**HOLDING TIME**
BACTERIAL TESTS:			
Coliform, fecal and total Fecal streptococci	P, G	Cool, 4°C, 0.008% sodium thiosulfate	6 hours
INORGANIC TESTS:			
Chloride	P, G	None required	28 days
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, sodium hydroxide to pH >12, 0.6g ascorbic acid	14 days
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Acidity and alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, sulfuric acid to pH <2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C. sulfuric acid to pH <2	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Fluoride	P	None required	28 days
Hardness	P, G	Nitric acid to pH <2, sulfuric acid to pH <2	6 months
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, sulfuric acid to pH < 2	28 days
METALS:			
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Chromium VI	P, G	Cool, 4°C	24 hours
Mercury	P, G	Nitric acid to pH <2	28 days
Metals, except chromium VI and mercury	P, G	Nitric acid to pH <2	6 months
Nitrate	P, G	Cool, 4°C	48 hours
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH >9	7 days
Nitrate-nitrite	P, G	Cool, 4°C, sulfuric acid to pH <2	28 days

TABLE 2: REQUIRED CONTAINERS, PRESERVATION TECHNIQUES TIMES AND HOLDING TIMES (Cont'd)			
NAME	**CONTAINER***	**PRESERVATION**	**HOLDING TIME**
METALS(cont'd):			
Nitrate	P, G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C, sulfuric acid to pH <2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or sulfuric acid to pH <2	28 days
Orthophosphate	P, G	Filter immediately, cool, 4°C	48 hours
Winkler	do	Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, sulfuric acid to pH <2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, sulfuric acid to pH <2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, Filterable	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
***G-Glass or P-Polyethylene**			

Reference: US EPA, November 1986, SW-846, Third Edition, Volume 1A

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CONTAINERIZED MATERIAL SAMPLING

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Describe the characteristics of samples from containers
- List the different types of containers likely to be encountered
- Describe the various techniques for accessing containers
- Describe appropriate techniques and devices for sampling containerized materials

NOTES

CONTAINERIZED MATERIAL SAMPLING

OSHA REGULATIONS

29 CFR Part 1910.120 (j) and Part 1926

General requirements and standards for storing, containing, and handling chemicals and containers

CHARACTERISTICS

- High concentrations and hazards
- Large quantities
- Multiphase layers/sludge
- Containers under pressure

NOTES

CONTAINER TYPES

TRUCKS

- Pressurized or nonpressurized
- Multicompartmented
- Placards/symbols for identification

TANKS

- Horizontal or vertical
- Underground vs. aboveground
- Safety
  - Structural integrity
  - Slip, trip, and fall

NOTES

DRUMS

- Labels
- Drum construction
- Exotic materials
  - Aluminum
  - Nickel
  - Stainless steel

POLY DRUMS AND CARBOYS

- Contents - strong acids or bases
- Hazards
- Configuration of drumhead
- Signs of deterioration (e.g., leaks)

ACCESSING CONTAINERS

NOTES

GAINING ACCESS PRIOR TO SAMPLING CONTAINERS

- Special equipment may be needed
  - Cherry picker
  - Safety lines
  - Bolt cutters
  - Air monitoring devices

ACCESS MAY NOT BE THROUGH NORMAL OPENINGS

- Existing holes in containers
- Plasma arc

PREPARATION NEEDED BEFORE SAMPLING

- Number containers
- Obtain information from labels
- Secure containers on flat surface before attempting to gain access

NOTES

OPENING CONTAINERS

MANUAL DRUM OPENING

- Bung wrench
- Drum deheader
- Manual spiking
- Bolt cutters

DRUM SAMPLING

Under OSHA 1910.120, manual drum opening cannot be used if contents are:

- Unknown
- Flammable
- Reactive or explosive
- Shock sensitive

NOTES

BUNG WRENCH

- Nonsparking alloy
  - Bronze
  - Beryllium
  - Aluminum
- Safety techniques

DRUM DEHEADER

- Not intrinsically safe
- Forged steel with an alloy steel blade
- Scissor-like cutting action
- Closed head drums only
- Industrial settings

MANUAL SPIKING

- Hand pick, pickax, and hand spike
- Nonsparking material
- Sharpened point that can penetrate drum lid

NOTES

SAFETY

- A remote opening device should be used on drums that are bulging or swelling
- DO NOT use a manual method!

REMOTE DRUM OPENING

- Pneumatic bung remover
- Pneumatic drill
- Hydraulic drum piercer
- Backhoe spike
- Robot units

PNEUMATIC BUNG REMOVER/DRILL

- Adequate distance
- Nonsparking equipment
- Do not use on sample containers or lab packs
- Decontaminate after each use
- Different types of fittings

NOTES

HYDRAULIC DRUM PIERCER

- Nonsparking tip
- Side or top mount
- Consider secondary containment with side mount

BACKHOE (with spike attachment)

- Advantages
  - Distance
  - Minimal personnel contact
- Disadvantages
  - Cross contamination
  - Access
  - Toxic vapor cloud

GAINING ACCESS PRIOR TO SAMPLING DRUMS

- Use caution when working below grade or high above ground
- Use drum grapplers to stage drums in rows for easy access

NOTES

GUIDELINES FOR STAGING AREAS

- Allow 2 feet between rows
- Place two drums per row
- Establish separate areas for drum opening and sampling
- Stage by compatibility groups

BULKING

Containers with small quantities of compatible materials are mixed together before sampling

HAZARD CATEGORIZATION (HAZCAT)

- Screening tool
- Cost-effective
- User friendly
- Can be used to identify hazard class for shipping

NOTES

PRIOR TO SAMPLING

- Inventory
- Stage
- Check container integrity (use secondary containment if necessary)
- Open using proper techniques

SAMPLE COLLECTION

DRUM SAMPLING

- Look for signs that drum is under pressure or is shock sensitive
- Monitor headspace gases
  - Combustible gas indicators (CGIs)
  - Radiation detection instruments
  - Organic vapor analyzers (OVAs)

NOTES

DRUM SAMPLING EQUIPMENT

GLASS THIEF SAMPLER

- 6 mm to 16 mm in diameter
- 48 inches long
- Do not break and leave in drum

COLIWASA
(COmposite LIquid WAste SAmpler)

- 4 cm in diameter
- 152 cm long
- Insert tube with neoprene stopper, Teflon® flange, or glass ball at end-sealing mechanism

NOTES

PUSH TUBES

- Use for sludge-like materials
- Remove plug easily with stainless steel spoon

SUMMARY

- Use proper drum opening techniques and equipment
- Use proper levels of protection
- Use caution

TANK SAMPLING

- Conduct air monitoring of headspace with CGI
  - If LEL >25%, discontinue sampling
- Can use a bailer, glass thief, sludge judge, bacon bomb, COLIWASA, or subsurface grab sampler

NOTES

TANK SAMPLING EQUIPMENT

SLUDGE JUDGE

- 3/4-inch plastic pipe in 5-foot sections marked in 1-foot increments
- Check valve on bottom

BACON BOMB

Cylindrical body made of brass, bronze, and stainless steel with an internal tapered plunger that acts as a valve to admit the sample

NOTES

PROBLEMS

SAFETY

- Slip, trip, and fall
- Buddy system
- Safety lines
- Shoring of excavation areas

SAFETY

- Stacked containers
- Overhead hazards
- Product-escaping containers
- Chip, wipe, and sweep sampling procedures may be used in these situations

NOTES

LAB PACKS

- Do not sample individual containers
- Use remote crushing technique

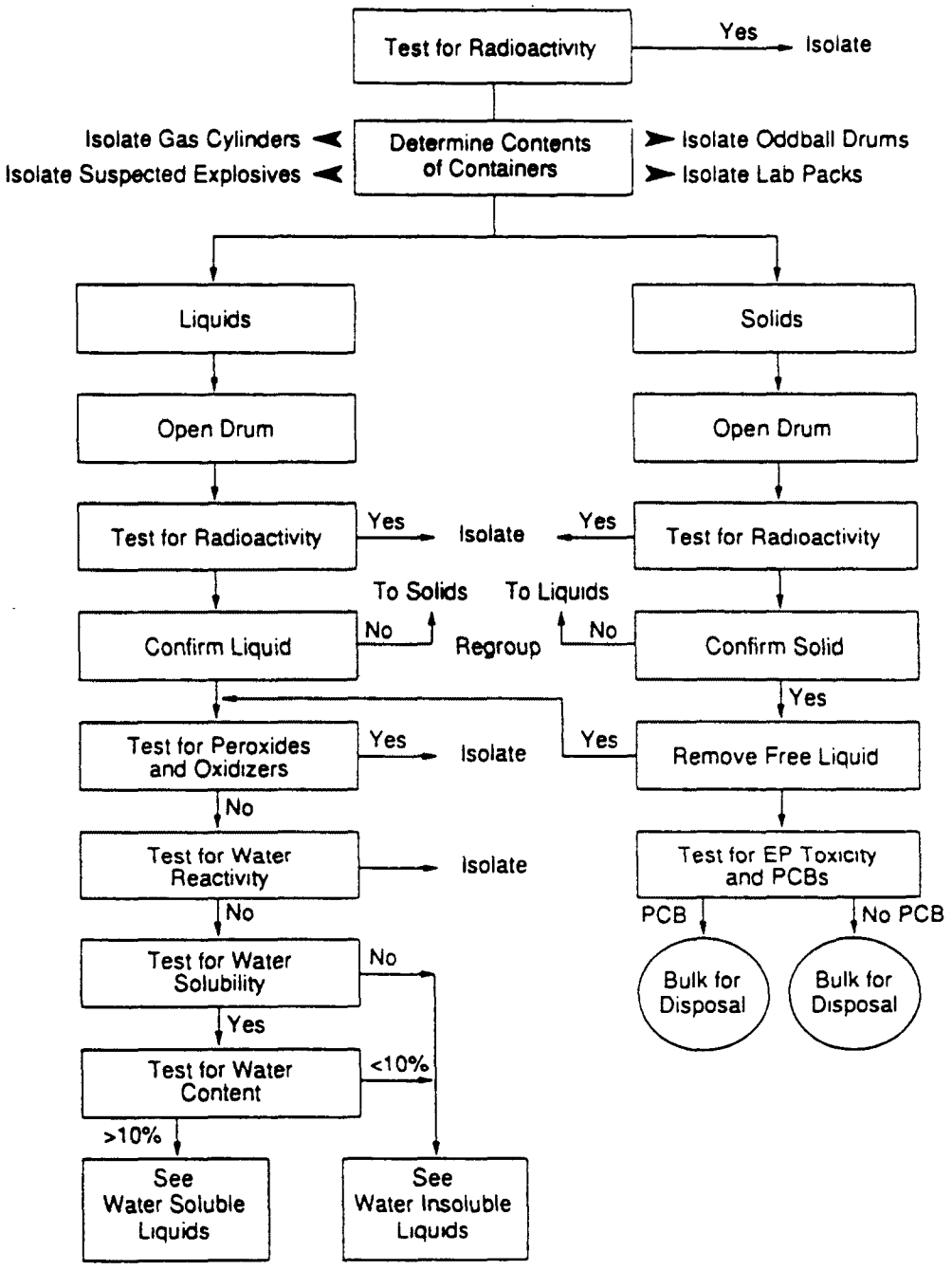
REMINDERS

- After sampling is complete, seal or close container to preserve integrity of the contents
- Follow proper sampling procedures and techniques to ensure quality results

HAZARD CATEGORIZATION (HAZCAT)

Stockpiled drums at a hazardous waste site pose problems in cleanup and disposal. Laboratory analysis of each individual drum can be costly and time consuming. Combining wastes from drums, tanks, ponds, and lab packs is more economical and efficient. However, wastes must first be sampled and tested for compatibility. Compatibility testing is a set of simple chemical tests such as pH, solubility, and flammability. Test results from field categorization can also be used to help satisfy RCRA hazardous waste characteristic definitions and will provide some data for use in defining DOT hazard classes for shipping. Hazard field categorization is not as extensive as laboratory analysis and not as costly; it is used only as a screening mechanism. There are limitations to each one of the different screening tests. Field HAZCAT procedures should not be substituted for standard laboratory analysis (see the **Compatibility Testing** flow diagrams of the HAZCAT procedures on the following pages). When using the diagrams, follow the steps sequentially. EPA-ERT has standard operating procedures for using the HAZCAT procedures during field investigations.

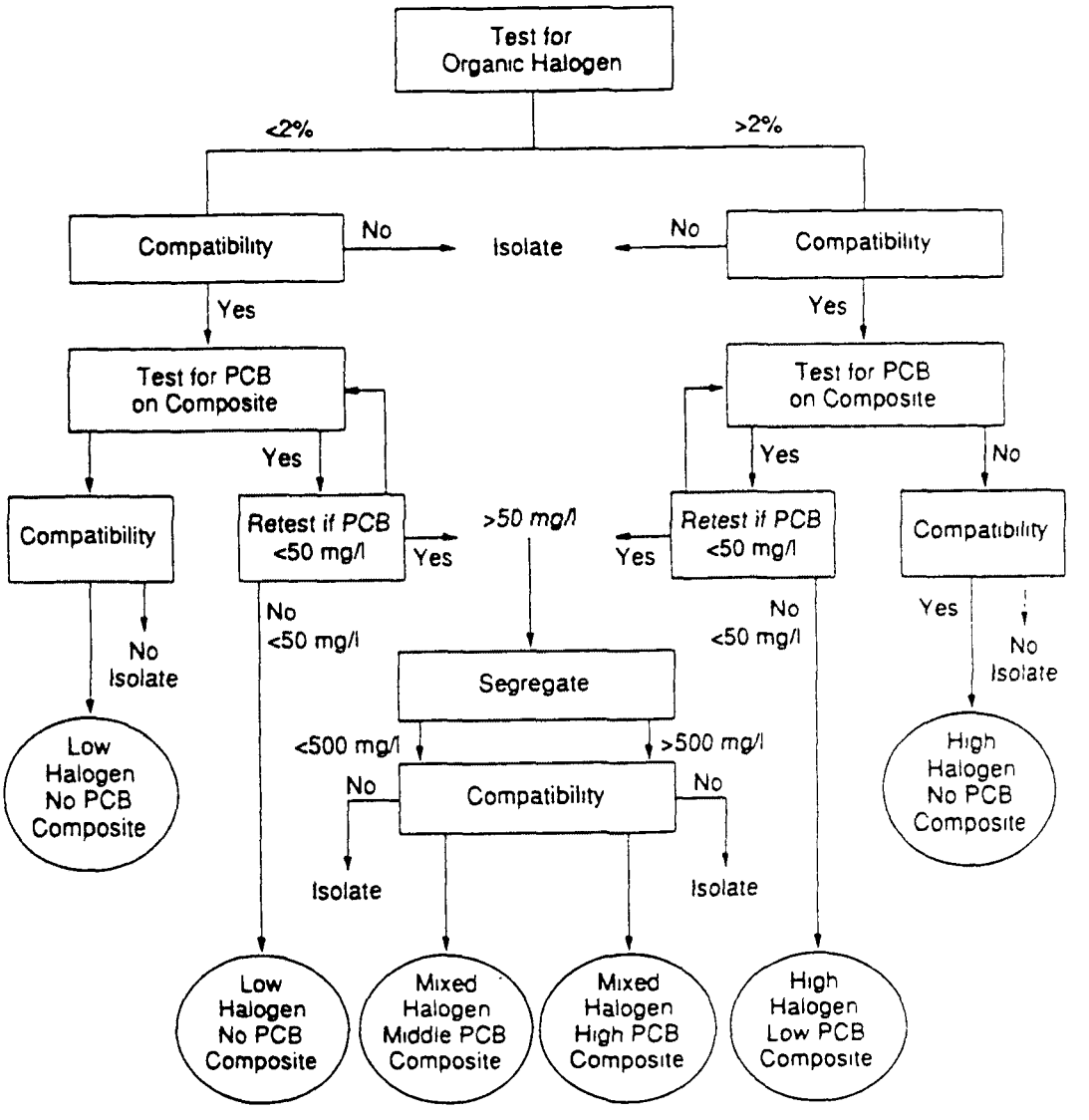
Flow Diagram 1: CMA COMPATIBILITY TESTING PROTOCOL



Source: *Drum Handling Practices at Hazardous Waste Sites.* (EPA/600/2-86/013).

Flow Diagram 2: CMA COMPATIBILITY TESTING PROTOCOL

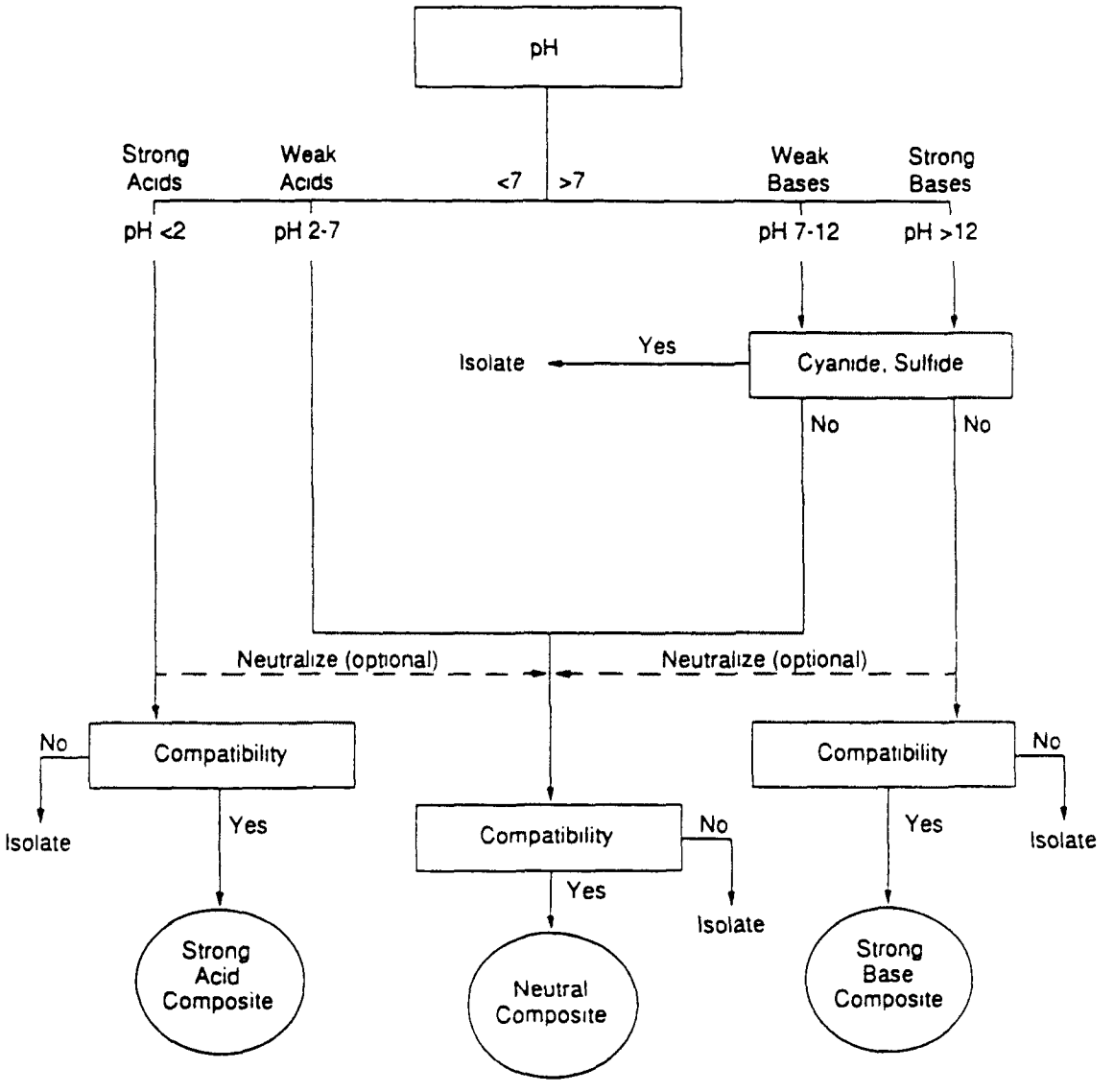
Water Insoluble Liquids Testing



Source: *Drum Handling Practices at Hazardous Waste Sites.* (EPA/600/2-86/013).

Flow Diagram 3: CMA COMPATIBILITY TESTING PROTOCOL

Water Soluble Scan



Source: *Drum Handling Practices at Hazardous Waste Sites.* (EPA/600/2-86/013).

SOIL SAMPLING

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Describe the objectives of a soil sampling event
- Describe the basic methods of soil sampling
- List examples of various soil sampling equipment
- Describe the use of the lysimeter
- List several methods of data presentation

NOTES

SOIL SAMPLING

WHY SAMPLE THE SOIL?

- Chemical characterization
- Migration pathways
- Soil/geologic characteristics

CHEMICAL CHARACTERIZATION

- Contaminant identification
- Spatial distribution
- Levels of contamination

NOTES

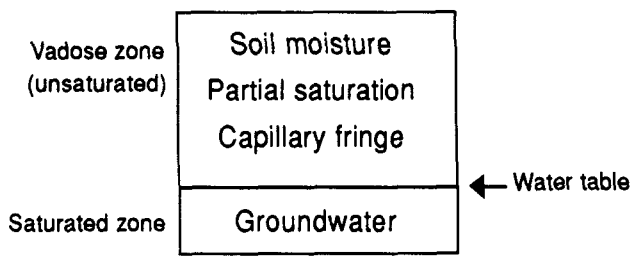
MIGRATION PATHWAYS AND TRANSPORT MECHANISMS

- Man-made pathways
- Surface drainage
- Vadose zone transport
- Wind dispersion
- Human and animal activity

SOIL/GEOLOGIC CHARACTERISTICS

- Soil classification
- Organic content
- Adsorptive characteristics
- Transport characteristics

RELATIONSHIP OF VADOSE AND SATURATED ZONES



NOTES

SURFACE SAMPLING

- Depth
- Tools

SUBSURFACE SAMPLING

- Power auger
- Hollow-stem auger
- Rotosonic drill

SAMPLING DEVICES

- Split spoon
- Shelby tube
- Core barrel

NOTES

ALTERNATIVE SAMPLING TECHNIQUES

- Backhoe/trenching
- Geoprobe®
- Cone penetrometer

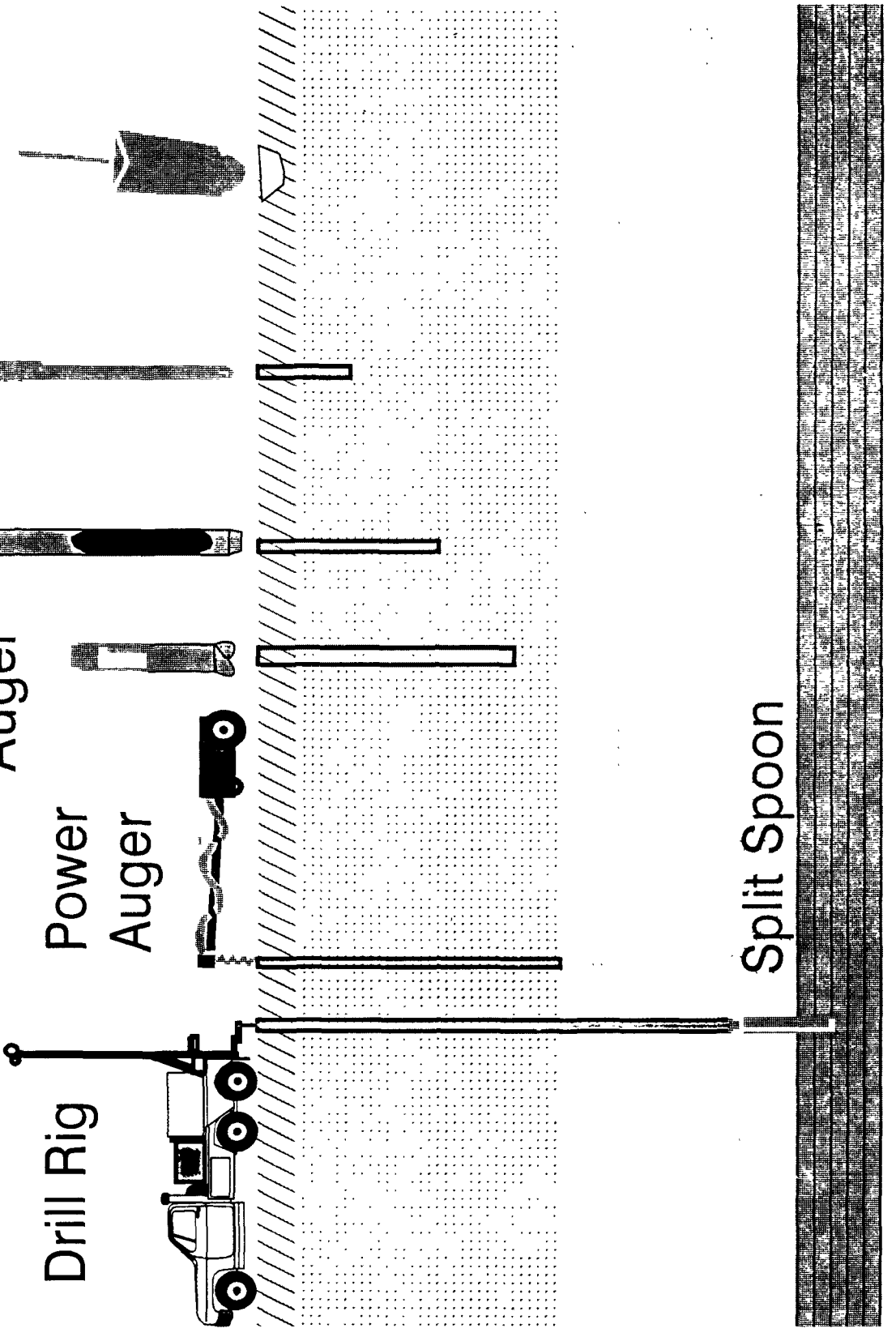
LYSIMETER

A device for sampling interstitial moisture in the unsaturated zone

DATA PRESENTATION

- Geologic graphics
- Data posting
- Contour plotting

Soil Sampling Equipment



SURFACE WATER AND SEDIMENT SAMPLING

PERFORMANCE OBJECTIVES

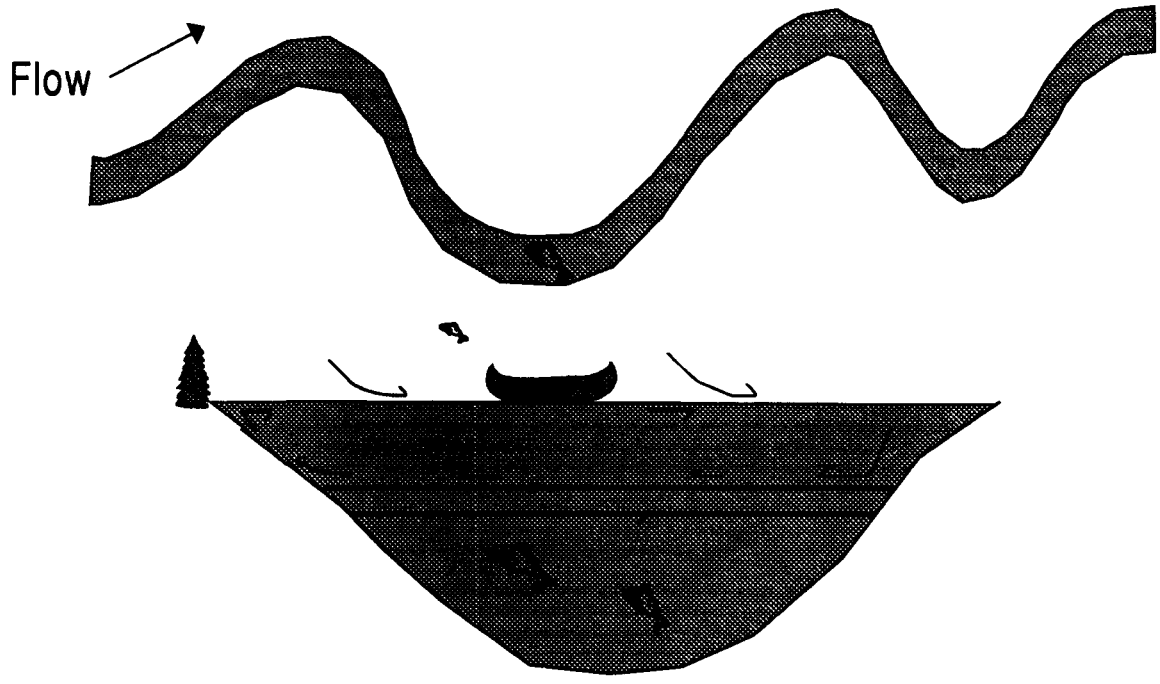
At the end of this lesson, participants will be able to:

- Describe basic stream morphology as it affects the location of sampling points
- Describe lake morphology as it affects the location of sampling points
- Describe and select equipment for obtaining representative samples from surface water and sediment
- Define the basic factors governing the fate of hazardous materials in the water column and sediment

SURFACE WATER AND SEDIMENT SAMPLING

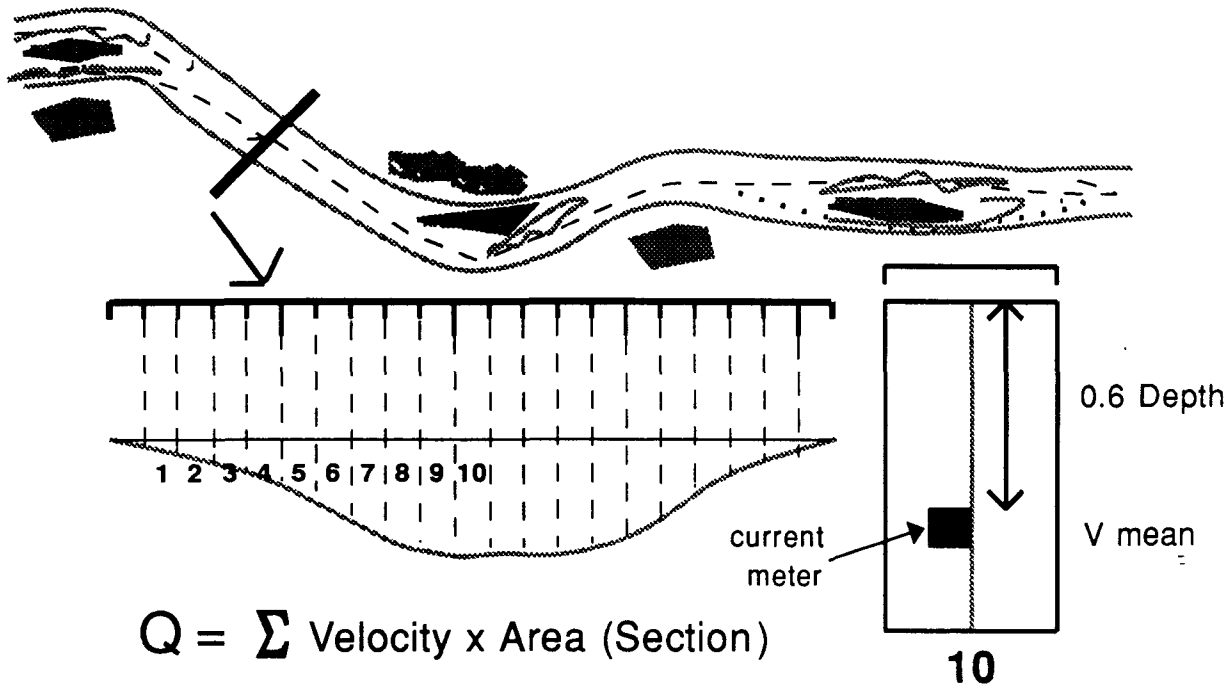
NOTES

SURFACE WATER MORPHOLOGY
Lakes and Streams



NOTES

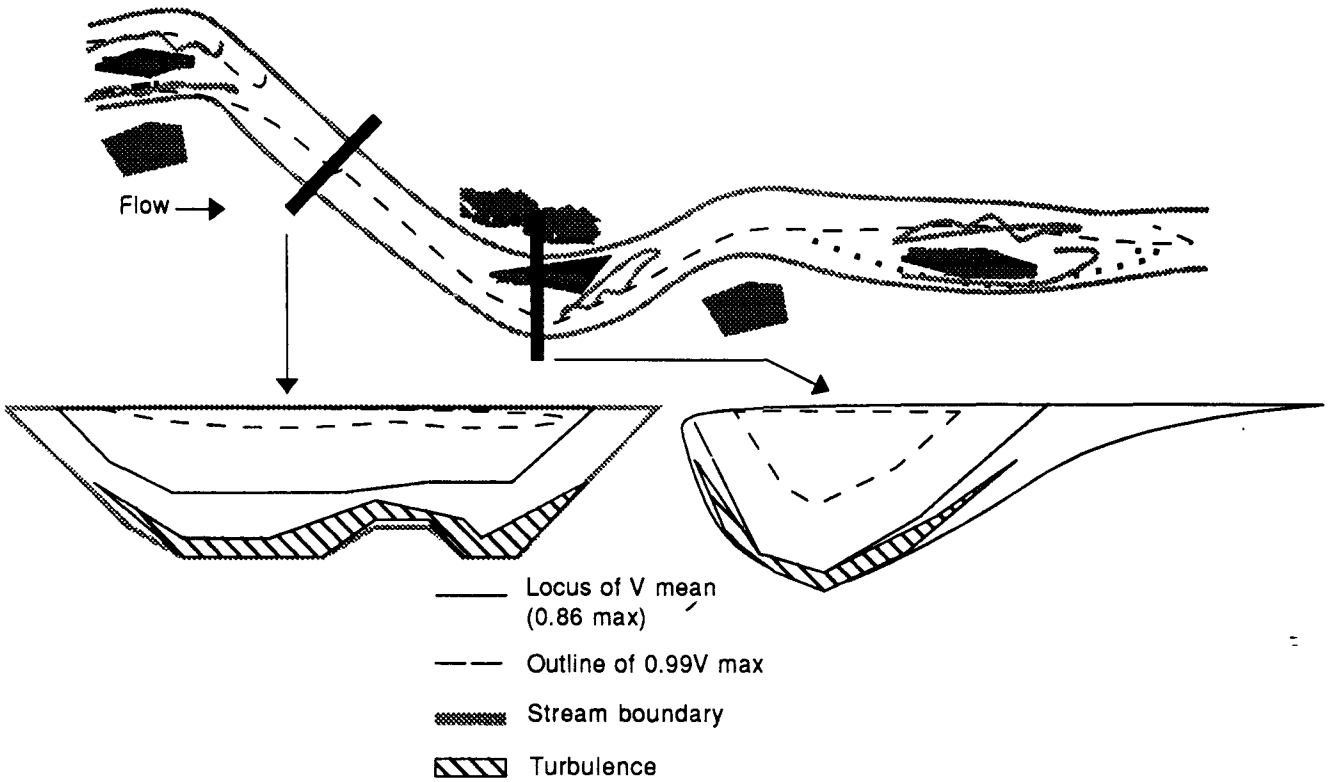
FLOW DETERMINATION
Stream Channel



$Q = \Sigma$ Velocity x Area (Section)

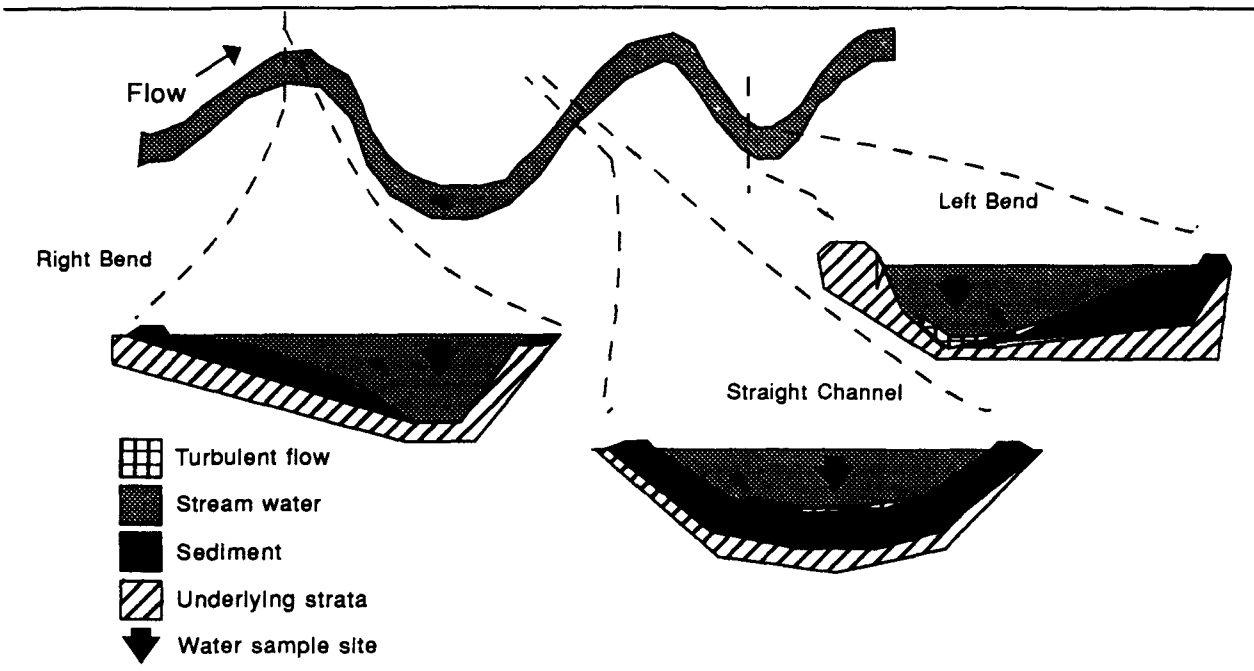
NOTES

STREAM CHANNEL FLOW



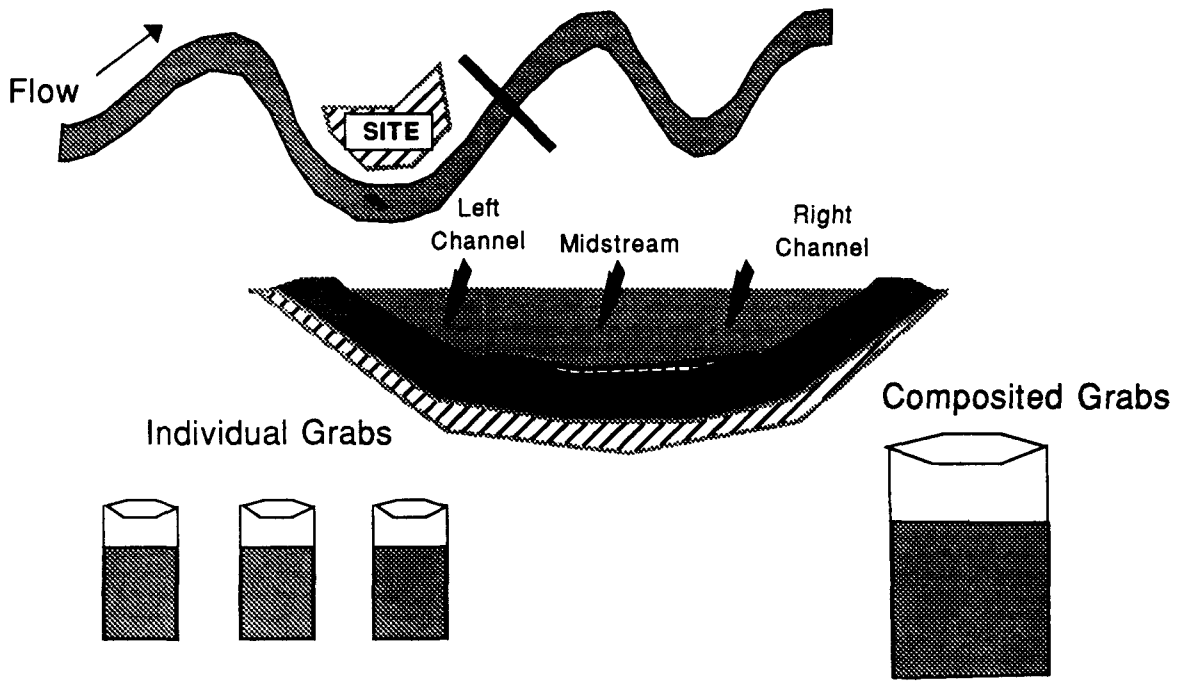
NOTES

IN-STREAM FLOW
Channel Flow Characteristics



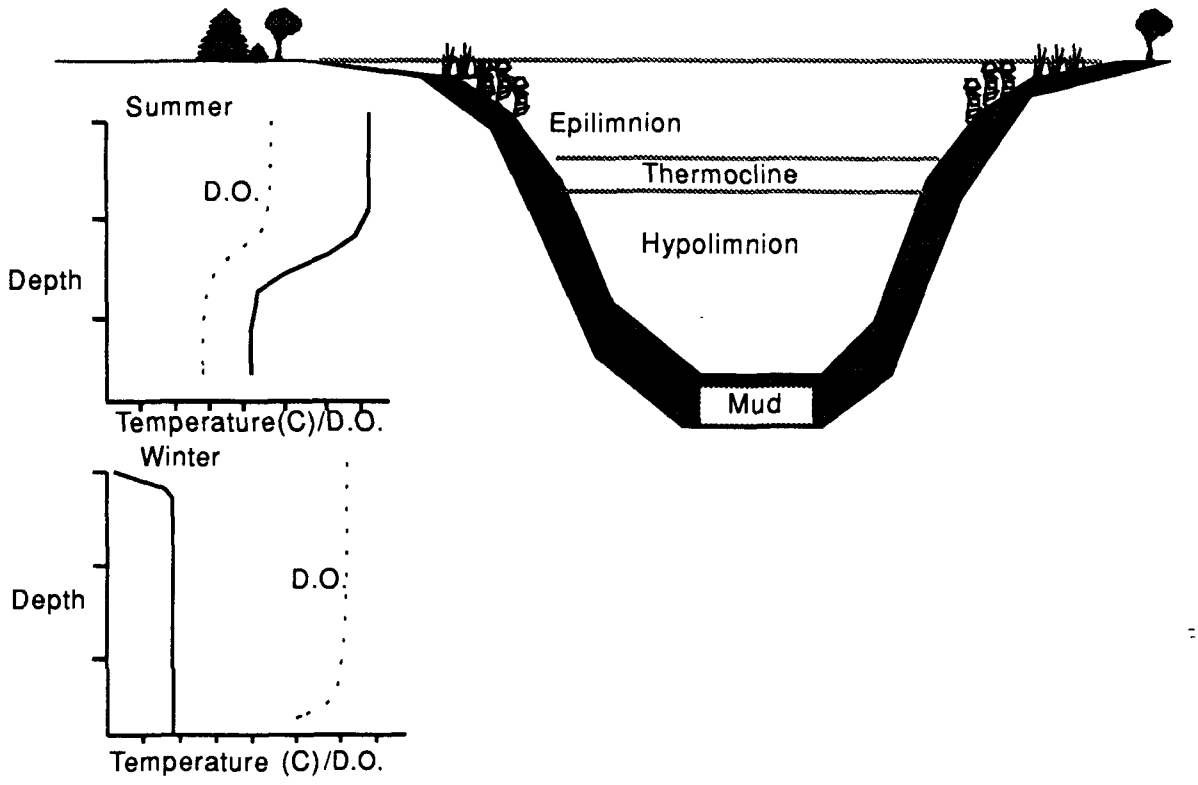
NOTES

GRAB VS. COMPOSITE SAMPLING



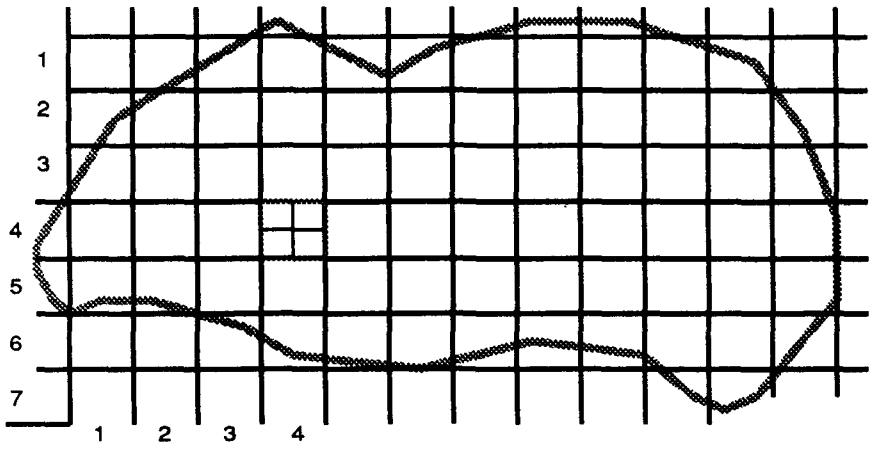
NOTES

LAKE STRATIFICATION



NOTES

RANDOM SAMPLING
Standing Water



Square
4-4

1	2
3	4

NOTES

SURFACE WATER SAMPLING EQUIPMENT

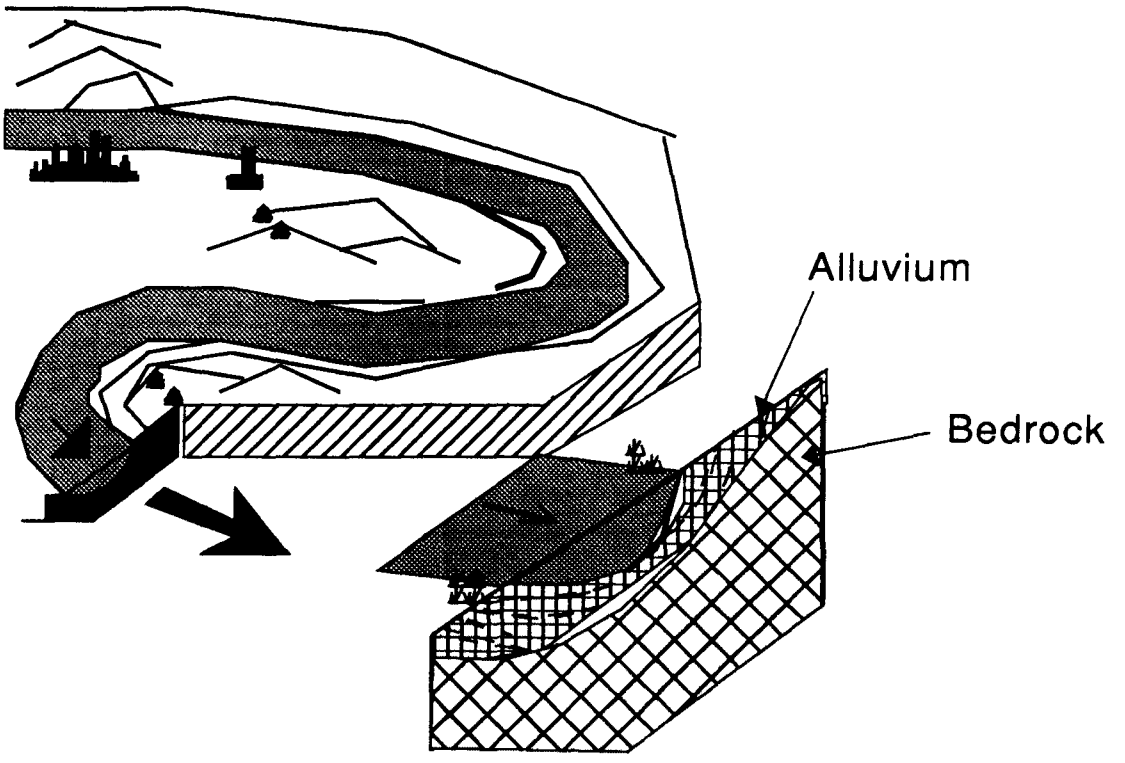
NOTES

WATER QUALITY PARAMETERS
Surface Water

- Temperature
- pH
- Dissolved oxygen
- Oxidation/reduction potential
- Conductivity

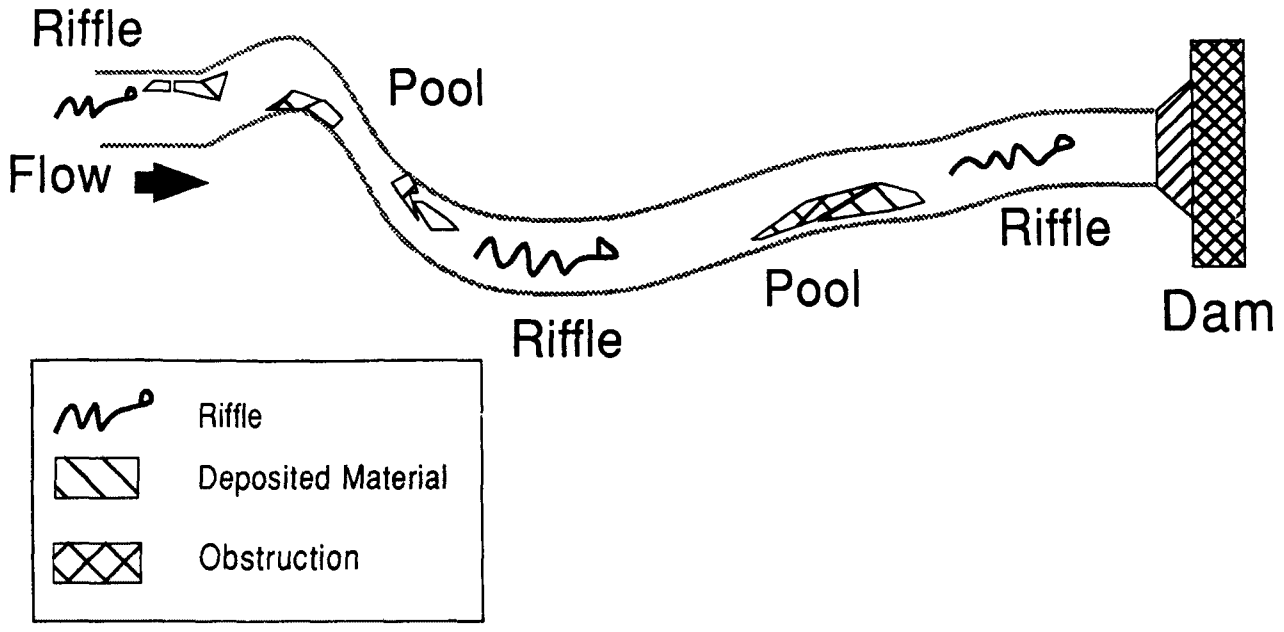
NOTES

STREAM CHANNEL MIGRATION



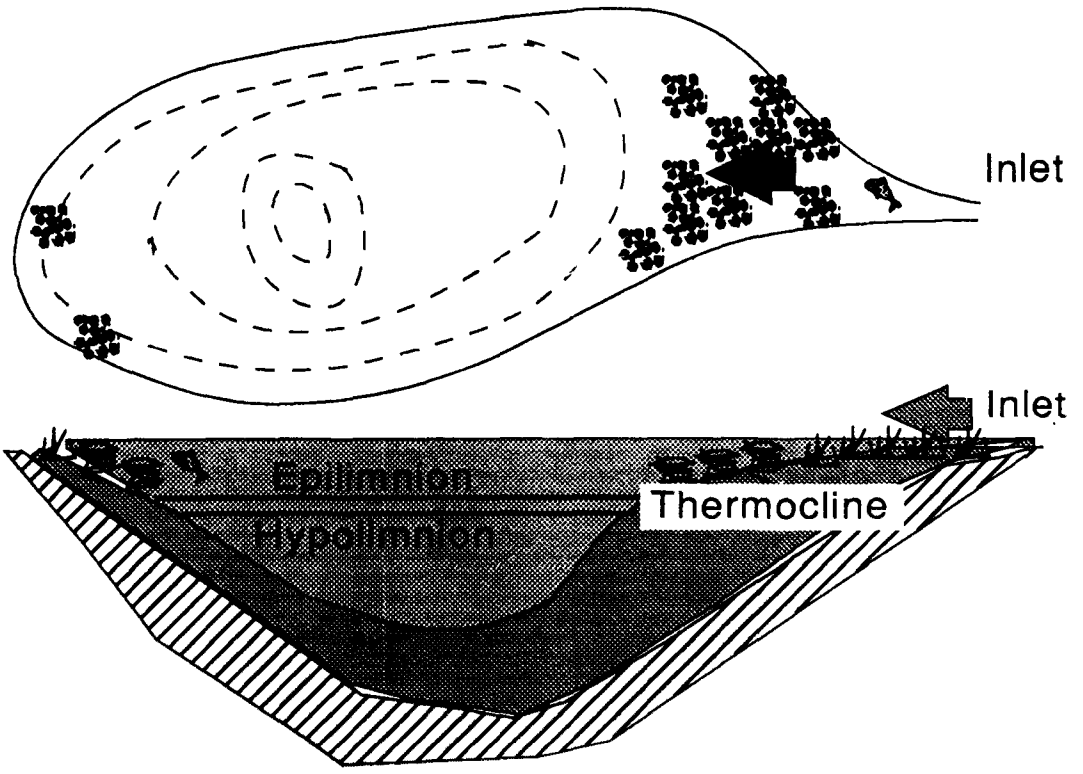
NOTES

STREAM MORPHOLOGY
Riffle-Pool Relationship



NOTES

LAKE SEDIMENT DISTRIBUTION

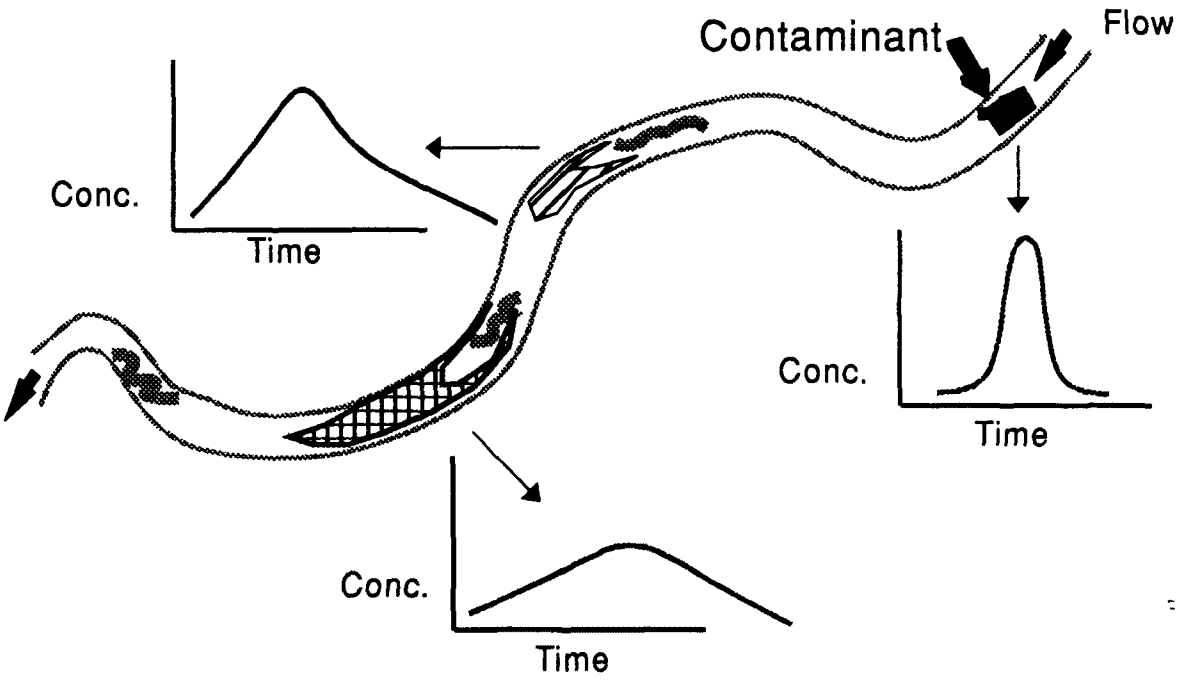


NOTES

SEDIMENT SAMPLING EQUIPMENT

NOTES

CONTAMINANT TRANSPORT



NOTES

WHAT AFFECTS DISPERSION?
Characteristics of the Setting

- Physical stratification
- Currents
- Ambient temperature

NOTES

WHAT AFFECTS DISPERSION?
Contaminant Attributes

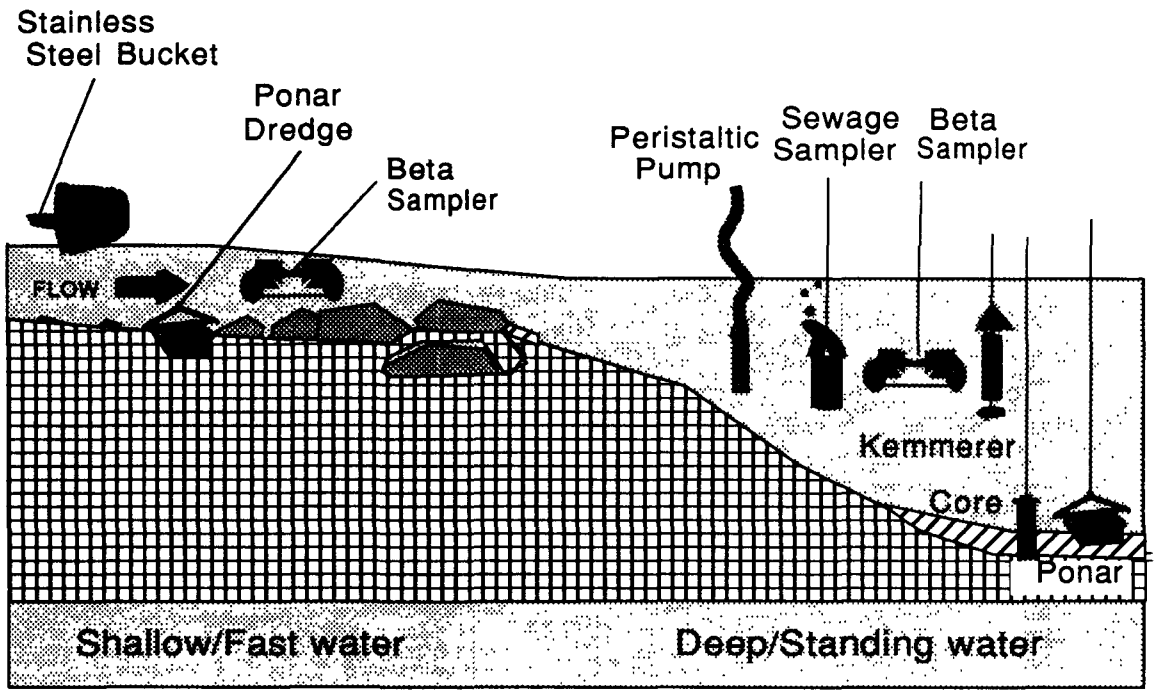
- Solubility
- Specific gravity
- Viscosity

NOTES

SAMPLING SAFETY

NOTES

SURFACE WATER/SEDIMENT SAMPLING



NOTES

SURFACE WATER AND SEDIMENT SAMPLING

INTRODUCTION

The usefulness of sampling in surface waters for evidence of a hazardous material release has been well documented. Surface waters exist in low-lying areas and function as biological "sinks," which often may show the first signs of a chemical release. Initial studies included investigations of the influence of point-source pollution from industrial and municipal facilities on waterways. Many of these early studies aided in developing the methodology used in hazardous waste site situations.

A surface water sampling study may require establishing several sampling locations to characterize a particular contaminant or background concentrations. Such site-specific considerations often include determining physical characteristics of the particular body of water in order to dictate sampling strategies and proper sampling devices.

SITE SELECTION

Aqueous environments can be divided into two broad categories: freshwater and saltwater. Within the freshwater category, situations exist where the waster is free flowing (i.e., rivers, streams, and creeks) or is relatively stationary (i.e., lakes, ponds, and lagoons). There are, however, situations where a transition exists between the various freshwater environments (e.g., impoundments, flowage) or between freshwater and saltwater (estuaries). The various characteristics of each of these situations will influence the approach that will be necessary to obtain samples representative of the water body or portion of the water body so that contaminant migration can be determined.

The size of the body of water will determine the site selection process, both in determining modes of personnel transport and types of sampling devices. Large streams and lakes accessible by boat have the obvious advantage of maneuverability and aid in performing activities at multiple sampling points. Smaller bodies of water may require wading, which requires personnel to carry all sampling equipment to and from access locations. Specific considerations exist when sampling from artificial structures (e.g., bridges, dams, and weirs). The problem of access combined with the number of sample locations outlined in the study objectives will undoubtedly affect the time and personnel assigned to this task.

Samples obtained from all aqueous environments can be roughly divided into three categories: water, sediment, and biological. The latter category requires somewhat separate approaches and methods particular to each organism. Biological samples are pertinent and necessary in numerous hazardous waste site settings. They can yield significant information on contaminant transport and fate. However, this discussion will emphasize water and sediment sampling. Sediment can be defined as solid material (mineral and organic) situated beneath an aqueous layer. Water contains organic matter, minerals, nutrients, and ions in varying amounts that are in constant physical contact with the underlying sediment. This water/sediment interface is an important location of many complex chemical interactions.

Rivers, Streams, and Creeks

The terms "creek" or "stream" generally refer to the relative size of the body of water. A river is larger than a stream, which is larger than a creek, and so on. Free-flowing bodies of water, regardless of size, have several common characteristics. In addition to the obvious function as water transport in the water cycle, streams serve to transport eroded mineral (e.g., sand, gravel, and rock) and have a complex biological function whereby organic matter (e.g., leaves, woody material, and soil) entering the system is used by various organisms, transported, and changed. Diurnal fluctuations in values such as dissolved oxygen, pH, conductivity, and various concentrations of many nutrients can vary widely depending on the time of day. The combined effect of physical and biological activity in moving water can result in longitudinal fluctuations of numerous water quality values. Dissolved oxygen levels can vary widely depending on whether the samples were taken upstream or downstream of a dam. These variations dictate that the water quality parameters be determined and recorded while samples are being collected.

All streams consist of alternating series of riffles (i.e., fast water velocity, shallow depth) and pools (i.e., slow water velocity, more depth) and will tend to form bends or meander, which is more pronounced in low gradient areas. The water moving in a given stream, or "in-stream flow" measurements like velocity, can vary widely in either cross section (lateral flow), along a water column (vertical flow), or even horizontally. In ordinary streams, water flow is best described as turbulent or nonuniform in nature. Friction from the underlying substrate and the surface air causes the maximum velocity within a stream cross section to usually be found in mid-channel just below the surface. The average or mean velocity usually occurs at six-tenths to eight-tenths of the total depth below the surface. Average stream flow and total discharge can only be determined by measuring several intervals along the stream cross section at measured depths at each particular interval.

Most hazardous waste investigations in running waters involve measuring contaminant concentrations originating from a source with a small volume release relative to the receiving waters. The sample station chosen to detect the contaminant may or may not be located downstream to a point of complete mixing. A tributary or point source will tend to remain near the bank for a considerable amount of time before adequate horizontal and vertical mixing has taken place. One solution could be to select multiple sampling sites across the cross section of the stream. Another possible solution could be to use fluorescent tracer dye data to demonstrate complete mixing. Selecting sample points just downstream of major features, such as riffles or dams, may prevent sampling of inadequately mixed surface water. Other suggestions include using multiple sampling points along the stream length (2–3 stations downstream) and "bracketing" additional tributaries or feature changes with additional sampling points.

The general rule for the correct number of samples necessary to characterize a stream varies with stream size. For small streams (<30 feet), a single grab sample taken at mid-channel below the surface will be adequate to represent the cross section. With larger streams, multiple samples at various measured depths may be necessary to adequately characterize the cross section. Sediment samples may be comprised of several grab samples in that cross section, but the various grab samples will be homogenized prior to placing the aliquot in its respective container. Samples, however, should be of similar composition or particle size within that composite. Sediment samples obtained at multiple sites along the stream length should also consist of a comparable substrate. In streams, it is difficult, if not impossible, to obtain sediment samples of identical consistency because of the

in-stream flow variability and the heterogeneous nature of the parent material. It is possible to find similar features that decrease water velocity (< 1 ft./sec), which may promote deposition of fine material. These microhabitats include areas immediately downstream of large obstructions, the upstream end of riffles, the middle of a slow pool, the insides of bends, and just upstream of dams or log jams.

Lakes, Impoundments, Ponds, and Lagoons

Standing water has a tendency to stratify during certain times of the year. The density difference imposed by the energy provided by sunlight creates two distinct layers of water. This stratification is more pronounced during the summer months where little mixing occurs between the upper and lower layers. Fall "turnover" occurs when the upper layer is cooled to the point where the temperature is vertically uniform. Complete mixing occurs rather abruptly where water and the upper layers of sediment intermix. Temperature stratification can also occur in large rivers. The exact location of the strata may be found by using a temperature probe to record the temperature at various depths to obtain a temperature profile. Samples may have to be obtained from various depths using a discrete "at depth" sampling device.

Lake morphology may have to be characterized to assess sampling needs. Sediment in ponds and lagoons is usually uniformly distributed with similar consistency so that a single bottom sample in the deepest area may be considered representative. Impoundments are usually dammed streams that are deepest near the dam. The finest sediments are usually found in this deep area, and coarser deposits are found near the headwaters of the reservoir. For large lakes, a transect or grid system may be developed to organize sample location and various sampling activities. Lakes with irregular shapes may require that certain bays or coves be considered separately.

Estuarine Waters

Estuaries are areas where freshwater systems meet the saline waters of the ocean. Tidal action and differences in density of the fresh and salt water are characterized by variable mixing. A freshwater/saltwater wedge can form which migrates according to the tidal action, or an increase in salinity can occur with no halocline present. These phenomena can be investigated using boat-mounted depth soundings in combination with data from a salinometer and a dissolved oxygen/temperature meter that generates vertical profiles. Samples may need to be obtained from discrete depths and sediment sampling points may need to be determined in reference to the particular mixing zone.

Investigations in estuary environments will likely involve a two-stage process during wet and dry times of the year. As during investigations in large bodies of water with complex physical characteristics, objectives of studies in estuaries must remain flexible to accommodate changes in sample location and time.

WATER AND SEDIMENT COLLECTION EQUIPMENT

Specific analytical categories have specific sample container requirements which can limit the type of sampling device used in collection. Volatile organic analysis (VOA) samples should be collected in a pair of 40 mL vials which must be immersed in the water sample by slowly tilting and gently allowing them to fill with as little agitation as possible. Absolutely no air bubbles should remain in either of the filled VOA containers. Prepreserved sample containers may require the use of a sampling device other than the container. In locations that are inaccessible, a properly decontaminated stainless steel or Teflon® dip-bucket with dedicated rope should be used. Any sample device that uses positive or negative pressure is not recommended.

Sampling for oil and grease involves partially filling the sample bottle without having to transfer water from a sampling device or container that could adsorb the contaminant and thus reduce the accuracy of analysis.

Certain *in-situ* water quality parameters can be measured directly, but most analyses will involve collecting the sample from the selected area and delivering it to an analytical laboratory. Collecting water for hazardous waste investigations involves obtaining a sample representative of the sample location. The accuracy of the sample collection is ensured by minimizing any physical and chemical influence prior to analysis. The scale or size of the body of water will determine the extent of sample site selection and appropriate sampling devices.

Small streams and shallow ponds or lagoons may require a single grab sample obtained by immersing the sample bottle directly into the middle of the water. By facing upstream in running water, the samples can be obtained without disturbing the bottom sediment. Caution should be exercised when entering unknown bottom substrate in severely impacted areas because solids may not support the weight of an individual. Another method is to use a hand-held or pole-mounted scoop which can allow a sampler to sample from the bank if waters are not wadable or footing is unreliable. A metal rod can also help when searching the bottom for fine-grained material. Sediment collection on small streams and ponds usually employs a sample device. Hand scoops of a nonreactive material are sometimes adequate, although more standardized methods exist using commercially available gravity corers, augers, and dredges. The top layer of sediment should be included in a bottom sample and many sampling devices or techniques can disturb this portion, thus reducing the accuracy of the analysis. The Peterson dredge is a heavy-duty design suited for sand/gravel substrate. The Ponar dredge is similar in design, but is tailored to travel through the water column with less disturbance to the underlying material. The Ekman dredge is a spring-loaded device best suited for soft substrate and is designed to travel through the water and reduce the shock wave which occurs prior to instrument impact. Depending on the size of the dredge being used, some may require a boat-mounted mechanical winch. Gravity corers also reduce the shock wave and yield a sample which may be sampled for a vertical profile. Very soft substrate can be collected using hand-held push tubes. In some cases, scuba diving may be used to ensure that site selection and sample collection are properly completed.

Larger bodies of water will require special water sampling equipment capable of sampling at discrete depths. Submersible pumps and peristaltic pumps can be effective in certain cases. Also, these pumps are advantageous because they may be manufactured from a variety of nonreactive materials. Other discrete depth sampling devices will collect a sample volume at various depths. They range from relatively simple pond sampler devices to more complicated devices such as the Kemmerer,

Bacon Bomb, and LaMotte samplers. These devices use a mechanical messenger that trips the sampler to close, allowing the sample to be retrieved and transferred to its proper container.

ADDITIONAL INFORMATION SOURCES

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GROUNDWATER SAMPLING

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Explain the difference between a confined and an unconfined aquifer
- Describe a properly installed monitoring well
- List the proper order of groundwater sample collection
- Describe the various groundwater sampling equipment and sample collection procedures

NOTES

GROUNDWATER MONITORING

BASIC PROPERTIES OF AQUIFERS

- Porosity
- Permeability

AQUIFER

A permeable geologic unit with the ability to store, transmit, and yield water in usable quantities

NOTES

UNCONFINED AQUIFER

- The water is in direct contact with the atmosphere
- There is no upper confining layer

CONFINED AQUIFER

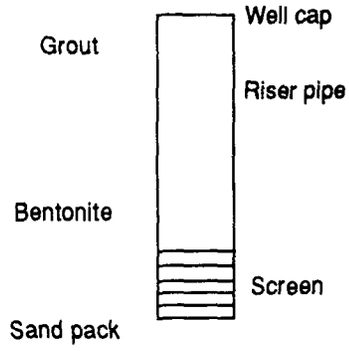
A permeable zone between two geologic formations of relatively low permeability

CASING AND SCREEN MATERIALS

- PTFE (Teflon®)
- Stainless steel
- Rigid, threaded PVC

NOTES

MONITORING WELL CONSTRUCTION



A WELL MUST BE PROPERLY:

- Designed
- Located
- Constructed
- Secured from tampering

GROUNDWATER SAMPLING

NOTES

FIELD MEASUREMENTS

- Water level
- Electrical conductivity
- pH
- Temperature

WATER LEVEL MEASUREMENT EQUIPMENT

WELL PURGING

A Compendium of Superfund Field Operations Methods, 1987

- Common procedure: three to five bore volumes
- Reliable method: stability of water measurements over three well volumes

NOTES

WELL VOLUME

$$\text{Well column (in feet)} \times \left[\text{Well radius (in inches)}\right]^2 \times \text{0.163 (conversion)} = \text{Well volume (in gallons)}$$

VERIFY PURGING BY

- Temperature
- pH
- Conductivity

COLLECTION ORDER

1. Volatile organics
2. Extractable organics
   - BNAs
   - Pesticides/PCBs
3. Total metals
4. Dissolved metals (if applicable)
5. Cyanide

NOTES

GROUNDWATER SAMPLING EQUIPMENT

EQUIPMENT

- Fultz pump
- Bladder pump
- Waterra inertial pump
- Bailers

FIELD FILTERING

- Used for dissolved inorganics
- Not used for
  - TOX (total organic halogens)
  - TOC (total organic carbon)
  - Organic analysis

NOTES

ALTERNATIVE SAMPLING TECHNIQUES

- Hydropunch®
- Geoprobe®
- Cone penetrometer

DOCUMENTATION

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Describe the best practices for field logbook use
- Describe the correct methods for field sample identification
- Describe the proper methods for photo documentation
- Define the proper circumstances of sample custody

NOTES

DOCUMENTATION

SAMPLE DOCUMENTATION

Field Logbooks - provide daily records of significant events, observations, and measurements during field investigations

FIELD DOCUMENTATION

Best Practices:

- Use a bound notebook
- Record all original data in nonerasable waterproof ink
- Correct errors by crossing a single line through the error and initialing and dating the correction

NOTES

FIELD DOCUMENTATION

Best Practices:

- Field records should be direct and succinct
- Documentor should sign and date each page

FIELD LOGBOOK ENTRIES

- Date and time of entry
- Purpose of sampling
- Name and address of field contacts (federal, state, and local representatives)

FIELD LOGBOOK ENTRIES

- Description of sample
- Description of sampling point
- Date and time of sample collection

NOTES

FIELD LOGBOOK ENTRIES

- Sample identification number
- Field observations
- Field measurements
  (e.g., pH, flammability)

SAMPLE IDENTIFICATION

All sample containers should be labeled with eight categories of identifying information

1. Project code
2. CLP case and sample number

SAMPLE IDENTIFICATION

3. Station location and number
4. Date and time of sample collection
5. Preservative

NOTES

SAMPLE IDENTIFICATION

6. Requested analysis
7. Signature(s)
8. Remarks

SAMPLE DOCUMENTATION

- Sample tags and labels
- Site maps
- Photographs
- Chain of custody
- Field documentation

SAMPLE CHAIN OF CUSTODY

A reconstruction of who had access to the sample from the time it was collected until produced in court

NOTES

SAMPLE CUSTODY

A sample is under custody if:

- It is in your possession
- It is in your view after being in your possession
- It was in your possession and then you locked it up to prevent tampering
- It is held in a designated secure area

VIDEO

DOCUMENTATION

taken from:

EPA/540/P-87/001
(OSWER Directive 9355.0-14)
December 1987

A COMPENDIUM OF SUPERFUND FIELD OPERATIONS METHODS (Section 4)

OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
OFFICE OF WASTE PROGRAMS ENFORCEMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

SECTION 4

SAMPLE CONTROL, INCLUDING CHAIN OF CUSTODY

4.1 SCOPE AND PURPOSE

This section describes procedures for sample identification and chain of custody. The purpose of these procedures is to maintain the quality of samples during collection, transportation, and storage for analysis. Sample control and chain-of-custody procedures specific to the Contract Laboratory Program (CLP) are presented in the *User's Guide to the Contract Laboratory Program*.

4.2 DEFINITIONS

Sample

Physical evidence collected for environmental measuring and monitoring. Evidence includes remote-sensing imagery and photographs.

Site Manager (SM)

The individual responsible for the successful completion of a work assignment within budget and schedule. The person is also referred to as the Site Project Manager or the Project Manager and is typically a contractor's employee (see Subsection 1.1).

4.3 APPLICABILITY

When environmental measuring or monitoring data are collected for the Environmental Protection Agency (EPA), workers should refer to the procedures in this section.

4.4 RESPONSIBILITIES

The SM or designee is responsible for monitoring compliance with these procedures. In general, it is desirable to appoint one person to be responsible for implementing sample control procedures (i.e., field operations leader). However, each sampler is responsible for the activities described in Subsections 4.5 and 4.6.

4.5 RECORDS

The following records are kept:

- Sample identification tags (varies with the EPA region; see Subsection 4.7 and Exhibit 5-7)
- Sample traffic reports (e.g., Special Analytical Services (SAS); see Exhibits 5-2, 5-3, and 5-9)
- Chain-of-custody (COC) forms and records (see Exhibits 5-4, 5-5, and 5-6)
- Receipt-for-samples forms (varies among EPA regions; see Subsection 4.7 and Exhibit 4-3)

- Field Investigation Team (FIT) receipt (for sample forms and field notebooks not serially numbered by the U.S. EPA)
- Field notebooks
- Airbills or bills of lading
- Dioxin analysis forms (as applicable)
- Photographic logs

Subsection 4.6 describes procedures for these records; Subsection 5.1.6 shows completed exhibits of the first three items.

4.6 PROCEDURES

Sample identification documents must be prepared to maintain sample identification and chain of custody. The following are sample identification documents:

- Sample identification tags
- Sample traffic reports
- Chain-of-custody records
- Receipt-for-samples forms
- Custody seals
- Field notebooks

These documents are usually numbered (serialized) by EPA. Some varieties of custody seals, field notebooks, or photographic logs may not be serialized.

The following additional forms are used for samples shipped to CLP laboratories:

- Organic traffic reports
- Inorganic traffic reports
- High-hazard traffic reports
- SAS request forms
- Dioxin shipment records (as applicable)

Completed examples of these forms are in Subsection 5.1.6 of this compendium.

The organization's document control officer (designated on exhibits in this subsection as the Regional Document Control Officer or RDCO) or another designated person maintains a supply of the documents listed above, including field note books. The document control officer is responsible for the inventory of serialized documents and the assignment of these documents to specific projects. Unused field documents are usually returned to the document control officer at the end of the field sampling event. The document control officer notes the return of these documents in the serialized document logbook. In some EPA regions, unused field documents are retained by the sampler to whom they were originally assigned for use on future projects. The sampler maintains a personal logbook in which is recorded the final disposition of all relevant field information. Unused, returned documents may be checked out to another project by the RDCO, as needed. A cross reference of serialized field documents is usually maintained for each project in the project files. A sample cross-reference matrix is shown in Exhibit 4-1.

The document control officer orders sample identification tags, receipt-for samples forms, custody seals, and chain-of-custody records from the EPA regional offices. Traffic reports and SAS request forms are obtained through the Sample Management Office (SMO) representative.

Exhibit 4-2 shows how the sample control documents can be integrated into the document control procedures used in an EPA project. The procedures for using each document are discussed below. Subsection 4.7 discusses regional variations; however, because procedures change and vary from region to region, the EPA Regional Sample Coordinating Center (RSCC) should be contacted during the planning of field activities to obtain the most current procedures. Appendix A of the *User's Guide to the CLP* contains a directory of RSCC contacts and telephone numbers.

4.6.1 Sample Identification Tags

Sample identification tags (see Exhibit 5-7) are distributed as needed to field workers by the SM (or designated representative). Procedures vary among EPA regions. Generally, the EPA serial numbers are recorded in the project files, the field notebook, and the document control officer's serialized document logbook. Individuals are accountable for each tag assigned to them. A tag is considered to be in an individual's possession until it has been filled out, attached to a sample, and transferred to another individual along with the corresponding chain-of custody record. Sample identification tags are not to be discarded. If tags are lost, voided, or damaged, the facts are noted in the appropriate field notebook, and the SM is notified.

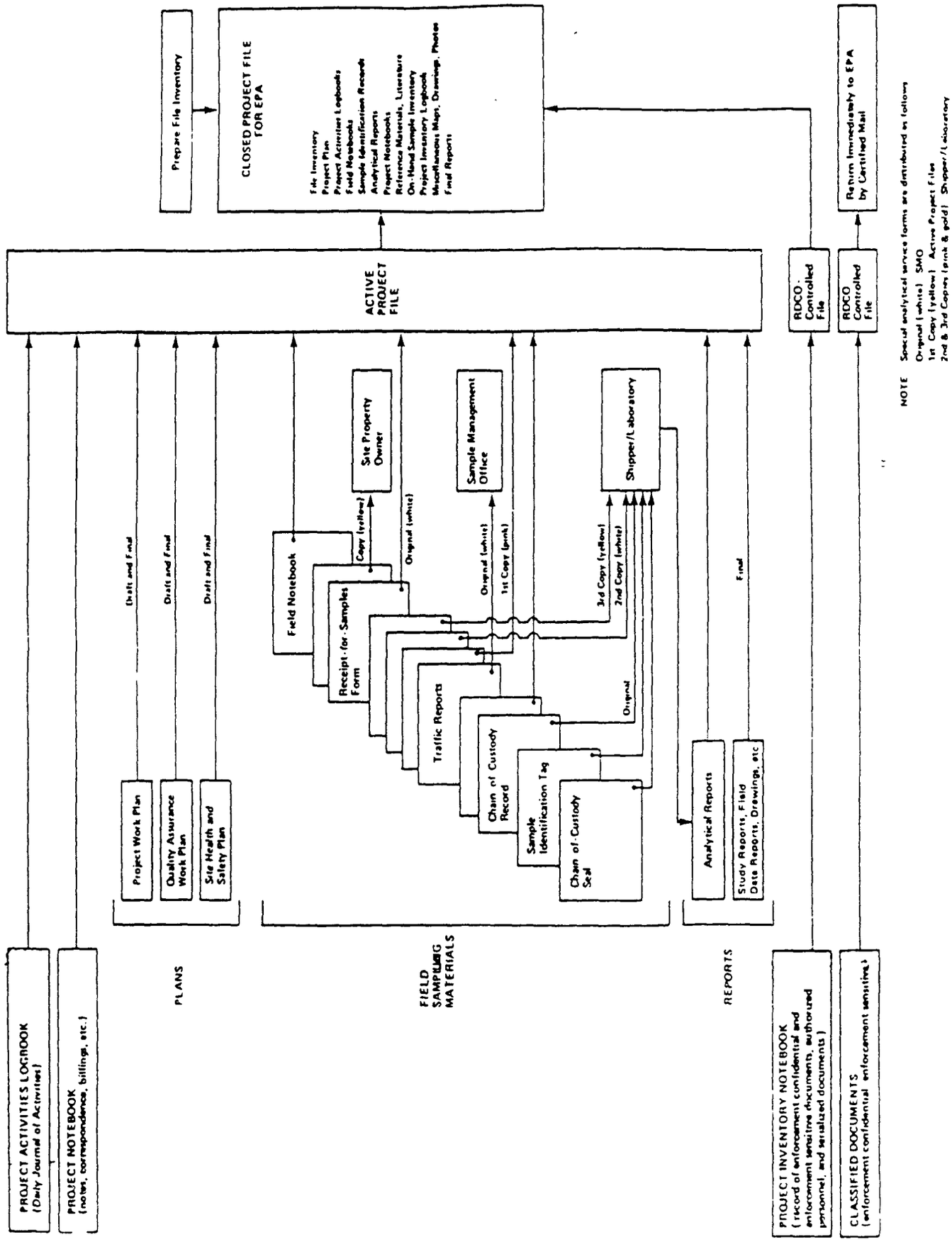
Upon the completion of the field activities, unused sample identification tags are returned to the document control officer, who checks them against the list of assigned serial numbers. Tags attached to those samples that are split with the owner, operator, agent-in-charge, or a government agency are accounted for by recording the serialized tag numbers on the receipt-for-samples form (Exhibit 4-3). Alternatively, the split samples are not tagged but are accounted for on a chain-of-custody form.

Samples are transferred from the sample location to a laboratory or another location for analysis. Before transfer, however, a sample is often separated into fractions, depending on the analysis to be performed. Each portion is preserved in accordance with prescribed procedures (see User's Guide to the CLP and Section 6 of this compendium) and is identified with a separate sample identification tag, which should indicate in the "Remarks" section that the sample is a split sample.

Exhibit 4-1
CROSS REFERENCE MATRIX FOR SERIALIZED DOCUMENTS

Sample Station	Sample Indentification Tag Number	Type of Analysis	Organic Traffic Report Number	Inorganic Traffic Report Number	High-Hazard Traffic Report Number	Dioxin Forms	Chain-of-Custody Record Number	Receipt-for-Samples Form Number	Airbill Number	Date Shipped

Exhibit 4-2
DOCUMENT CONTROL PROCEDURES



The following information is recorded on the tag:

- **CLP Case / SAS Number(s):** The unique number(s) assigned by SMO to identify the sampling event (entered under "Remarks" heading)
- **CLP Sample Number:** The unique sample identification number (from the TR, DSR, or PL) used to document that sample (entered under "Remarks" heading)
- **Project Code:** An assigned contractor project number
- **Station Number:** A unique identifier assigned to a sampling point by the sampling team leader and listed in the sampling plan
- **Date:** A six-digit number indicating the year, month, and day of collection
- **Time:** A four-digit number indicating the local standard time of collection using the 24-hour clock notation (for example, 1345 for 1:45 p.m.)
- **Station Location:** The sampling station description as specified in the sampling plan
- **Samplers:** Each sampler's name and signature
- **Preservative:** Whether a preservative is used and the type of preservative
- **Analysis:** The type of analysis requested
- **Tag Number:** A unique serial number, stamped on each tag
- **Batch Number:** The sample container cleaning batch number, recorded in the "Remarks" section
- **Remarks:** The sampler's record of pertinent information, such as batch number, split samples, and special procedures
- **Laboratory Sample Number:** Reserved for laboratory use

The tag used for water, soil, sediment, and biotic samples contains an appropriate place for identifying the sample as a grab or a composite, the type of sample collected, and the preservative used, if any. The tag used for air samples requires the sampler to designate the sequence number and identify the sample type. Sample identification tags are attached to, or folded around each sample, and are taped in place.

After collection, separation, identification and preservation, a traffic report is completed and the sample is handled using chain-of-custody procedures discussed in the following sections. If the sample is to be split, aliquots are placed into similar sample containers. Depending on the EPA region, sample identification tags are completed and attached to each split and marked with the tag numbers of the other portions and with the word "split." Blank or duplicate samples are labeled in the same manner as "normal" samples. Information on blanks or duplicate samples is recorded in the field notebook. Some EPA regions require that laboratories be informed of the number of blanks and duplicates that are shipped, but not the identity of the quality assurance samples.

The printed and numbered adhesive sample labels affixed to the traffic reports are secured to sample containers by the sampler. Forms are filled out with waterproof ink, if weather permits. If a pen will not function because of inclement conditions, an indelible pencil may be used. If a pencil is used, a note ex-

Exhibit 4-3
TYPICAL RECEIPT-FOR-SAMPLES FORM

United States
Environmental Protection Agency
Region 10

Environmental Services Division
U.S. Environmental Protection Agency Region 10
1200 Sixth Avenue, Seattle, Washington 98101

RECEIPT FOR SAMPLES

PROJECT NO | PROJECT NAME | Name of Facility

SAMPLER(S): *(Signature)* | Facility Location

Split Samples Offered ( ) Accepted ( ) Declined

Station Number	Date	Time	Corrs	Grab	Split Samples	Tag Numbers	Station Description	No. of Containers	Remarks

Transferred by *(Signature)* | Received by *(Signature)* | Telephone Number

Date | Time | Title | Date | Time

Distribution Original to Coordinator Field Files, Copy to Facility

№ 131

plaining the conditions must be included in the field notebook. When necessary, the label is protected from water and solvents with clear tape.

The original is sent to the SMO. The first copy is retained for the project file. The second and third copies are sent with the shipment to the laboratory. Complete instructions for the use of traffic reports are given in the *User's Guide to the CLP.*

4.6.2 Sample Traffic Report (TR)

The sample documentation system for the CLP sample preparation program is based on the use of the sample traffic report (TR), a four-part carbonless form printed with a unique sample identification number. One TR and its printed identification number is assigned by the sampler to each sample collected. The three types of TRs currently in use include organic, inorganic dioxin, and high-concentration TRs. (See Subsection 5.1.6 for examples of completed TRs.)

To provide a permanent record for each sample collected, the sampler completes the appropriate TR, recording the case number, site name or code and location, analysis laboratory, sampling office, dates of sample collection and shipment, and sample concentration and matrix. Numbers of sample containers and volumes are entered by the sampler, beside the analytical parameter(s) requested for particular sample portions.

4.6.3 Chain-of-Custody Forms and Records

Because samples collected during an investigation could be used as evidence in litigation, possession of the samples must be traceable from the time each is collected until it is introduced as evidence in legal proceedings. To document sample possession, chain-of-custody procedures are followed.

4.6.3.1 Definition of Custody

A sample is under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- It is in the sampler's view after being in possession.
- It was in the sampler's possession and then was locked up to prevent tampering.
- It is in a designated secure area.

4.6.3.2 Field Custody Procedures

Only enough of the sample should be collected to provide a good representation of the medium being sampled. To the extent possible, the quantity and types of samples and the sample locations are determined before the actual fieldwork. As few people as possible should handle the samples.

Field samplers are personally responsible for the care and custody of the samples collected by their teams until the samples are transferred or dispatched properly. A person is usually designated to receive

the samples from the field samplers after decontamination; this person maintains custody until the samples are dispatched.

The SM determines whether proper custody procedures were followed during the fieldwork and decides if additional samples are required.

4.6.3.3 Transfer of Custody and Shipment

Samples are accompanied by a chain-of-custody (COC) form or record (Exhibits 5-4 and 5-5). When transferring samples, the individuals relinquishing and receiving them should sign, date and note the time on the form. This form documents sample custody transfer from the sampler, often through another person, to the analyst, who is in a mobile or contract laboratory.

Samples are packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate COC record accompanying each shipment. Shipping containers are padlocked or sealed with custody seals for shipment to the laboratory. The method of shipment, courier name(s), and other pertinent information such as the laboratory name should be entered in the "Remarks" section of the COC record.

When samples are split with an owner, operator, or government agency, the event is noted in the "Remarks" section of the COC record. The note indicates with whom the samples are being split. The person relinquishing the samples to the facility or agency requests the signature of the receiving party on a receipt-for-samples form (Exhibit 4-3) (described in the following subsection), thereby acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this situation is noted in the "Remarks" section of the COC record. When appropriate, for example, when an owner's representative is unavailable, the COC record and receipt-for-samples form should contain a statement that the samples were delivered to the designated location at the designated time. A witness to the attempted delivery should be obtained. The samples shall be secured if no one is present to receive them.

All shipments are accompanied by a COC record identifying their contents. The original form accompanies the shipment; the copies are retained by the sampler and returned to the sampling coordinator.

If nonhazardous samples are sent by mail, the package is registered, and a return receipt is requested. Note: Hazardous materials shall not be sent by mail. If samples are sent by common carrier, a bill of lading is used. Air freight shipments are sent prepaid. Freight bills, postal service receipts, and bills of lading should be retained as part of the permanent documentation for the COC records.

4.6.3.4 Laboratory Custody Procedures

Laboratory personnel are responsible for the care and custody of samples from the time they are received until the samples are exhausted or returned to the laboratory sample custodian for ultimate disposal. Laboratory-specific variations exist; however, a generally accepted laboratory chain-of-custody procedure is presented below. Any laboratory used for the analysis of samples taken in the course of EPA remedial response must have an adequate chain-of-custody procedure. This procedure is required as an exhibit in the Quality Assurance Project Plan (QAPjP) if the laboratory is not in the CLP.

A designated custodian of laboratory samples accepts custody of the shipped samples and verifies that the information on the sample identification tags matches that on the COC records. Pertinent information on shipment, pickup, courier, and condition of samples is entered in the "Remarks" section. The custodian then enters the sample identification tag data into a bound logbook, which is arranged by project code and station number.

The laboratory custodian uses the sample identification tag number or assigns a unique laboratory number to each sample; the custodian transfers the samples to the proper analyst or stores them in the appropriate secure area. A limited number of named individuals are allowed access to the sample storage area. The appropriate analysts are responsible for the samples until they are returned to the custodian.

When sample analyses and necessary quality assurance (QA) checks have been completed, the unused portion of the sample and the sample containers must be disposed of properly (see Subsection 5.2.6.4). All identifying tags, data sheets, and laboratory records, are retained as part of the permanent documentation.

4.6.4 Receipt-for-Samples Form

Section 3007(a)(2) of the RCRA states "If the officer, employee, or representative obtains any samples, prior to leaving the premises he shall give to the owner, operator, or agent-in-charge, a receipt describing the samples obtained and, if requested, a portion of each such sample equal in volume or weight to the portion retained." Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), contains identical requirements.

Completing a receipt-for-samples form complies with these requirements; such forms should be used whenever splits are offered or provided to the site owner, operator, or agent-in-charge. The particular form used may vary between EPA regions; an example is shown in Exhibit 4-3. This form is 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 given to the SM and is retained in the project files. In addition, the contractor must provide analytical results from the samples collected to the owner, operator, or agent in charge, as mandated in SARA.

4.6.5 Custody Seals

When samples are shipped to the laboratory, they must be placed in padlocked containers or containers sealed with custody seals; a completed example is shown in Exhibit 5-6. Some custody seals are serially numbered. These numbers must appear in the cross-reference matrix (Exhibit 4-1) of the field document and on the COC report. Other types of custody seals include unnumbered seals and evidence tape.

When samples are shipped, two or more seals are to be placed on each shipping container (such as a cooler), with at least one at the front and one at the back, located in a manner that would indicate if the container were opened in transit. Wide, clear tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. Nylon packing tape may be used providing that it does not completely cover the custody seal. Completely covering the seal with this type of tape may allow the label to be peeled off. Alternatively, evidence tape may be substituted for custody seals.

If samples are subject to interim storage before shipment, custody seals or evidence tape may be placed over the lid of the jar or across the opening of the storage box. Custody during shipping would be the same as described above. Evidence tape may also be used to seal the plastic bags or metal cans that are used to contain samples in the cooler or shipping container. Sealing individual sample containers assures that sample integrity will not be compromised if the outer container seals are accidentally broken.

4.6.6 Field Notebooks

A bound field notebook must be maintained by the sampling team leader to provide daily records of significant events, observations, and measurements during field investigations. All entries are to be signed and dated. All members of the field investigation team are to use this notebook, which is to be kept as a permanent record. Observations or measurements that are taken in an area where contamination of the field notebooks may occur may be recorded in a separate bound and numbered logbook before being transferred to the project notebook. The original records are retained, and the delayed entry is noted as such.

Field notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during projects and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence. The field notebook entries should be factual, detailed, and objective.

4.6.7 Corrections to Documentation

Unless restricted by weather conditions, all original data recorded in field notebooks and on sample identification tags, chain-of-custody records, and receipt-for-samples forms are written in waterproof ink. These accountable serialized documents are <u>not</u> to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one person, that individual may make corrections simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. Any error discovered on an accountable document should be corrected by the person who made the entry. All corrections must be initialed and dated.

For all photographs taken, a photographic log is kept; the log records date, time, subject, frame and roll number, and photographer. For "instant photos," the date, time, subject, and photographer are recorded directly on the developed picture. The serial number of the camera and lens are recorded in the project notebook. The photographer should review the photographs or slides when they return from developing and compare them to the log, to assure that the log and photographs match. It can be particularly useful to photograph the labeled sample jars before packing them into shipping containers. A clear photograph of the sample jar, showing the label, any evidence tape sealing the jar, and the color and amount of sample, can be most useful in reconciling any later discrepancies.

4.7 REGION-SPECIFIC VARIANCES

Region-specific variances are common; the SM should contact the EPA RPM or the RSCC before any sampling campaign to ascertain the latest procedures. Future changes in variances will be incorporated in subsequent revisions to this compendium.

4.7.1 Region I

Region I uses a standard contractor serialized chain-of-custody form and an unnumbered chain-of-custody seal, which are placed on the outside of the shipping cooler. Numbered sample bottle labels are used for REM site work and numbered tags for FIT site work.

4.7.2 Region II

Region II uses an unnumbered chain-of-custody form and numbered sample bottle labels for all site work. Custody seals are placed on the outside of the shipping cooler.

4.7.3 Region III

Region III uses a serialized chain-of-custody form and numbered sampling tags. Chain-of-custody seals used by Region III are unnumbered and placed on the outside of the shipping cooler.

4.7.4 Region IV

Region IV has a detailed procedural discussion in the *Engineering Support Branch Standards Operating Procedures and Quality Assurance Manual*, U.S. EPA, Region IV, Environmental Services Division, 1 April 1986.

4.7.5 Region V

Region V uses a serialized chain-of-custody seal. Region V seals are color coded; orange is used for REM and FIT work. Seals are placed on the outside of the shipping cooler only if the samples are sent the same day as collected; otherwise, seals are placed across sample jar lids. FIT does not note whether or not samples were split on the chain-of-custody record. FIT includes the corresponding Traffic Report number under the remarks section of the tag. The bottle lot numbers or "batch numbers" are not recorded here, but on the "Chain-of Custody form."

4.7.6 Region VI

Region VI does not use a serialized number control system on custody seals.

4.7.7 Region VII

Region VII personnel provide onsite sample control. Samples are logged into a computer by regional personnel. Although contractor personnel do not seal and log samples, chain of custody is followed as described above.

4.7.8 Region VIII

Region VIII does not use a serialized number control system on custody seals.

4.7.9 Region IX

Region IX does not use a serialized number control system on chain-of-custody seals.

4.7.10 Region X

Region X does not use a serially numbered custody seal. Seals are signed, and the sample ID number is written on the seal.

4.8 INFORMATION SOURCES

Superfund Amendments and Reauthorization Act (SARA). Section 104(m), "Information Gathering Access Authorities."

U.S. Environmental Protection Agency. *NEIC Policies and Procedures*. EPA-330/9-78-001-R. May 1978. (Revised February 1983.)

U.S. Environmental Protection Agency. *REM IV Zone Management Plan.* Contract No. 68-01-7251, CH2M HILL and U.S. EPA.

U.S. Environmental Protection Agency. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response. December 1986.

U.S. Environmental Protection Agency. *Zone II REM/FIT Quality Assurance Manual.* Contract No. 68-01-6692, CH2M HILL and Hazardous Site Control Division.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT

EPA-330/9-78-001-R

NEIC POLICIES AND PROCEDURES

May 1978
[Revised August 1991]

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

Denver, Colorado

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FOREWORD

The National Enforcement Investigations Center (NEIC) is the organizational element of the Office of Enforcement which provides a full range of technical, investigative, and litigation support expertise for the Agency's administrative, civil, and criminal enforcement cases. NEIC focuses on those nationally and regionally significant enforcement initiatives which require:

- Development and/or application of new methods and procedures/approaches for enforcement investigations, case development/management and resolution;

- Methods/procedures developed and used for a specific project or case in one region which can be applied nationally or on a multi-regional basis for improving the EPA enforcement program and addressing and achieving risk reduction objectives;

- Evaluation, review and/or support of proposed pollution controls, abatement and remedial measures applying innovative engineering and scientific technology with subsequent widespread application;

- Investigation of special environmental compliance problems where an initial application and/or innovative interpretation of statutory and regulatory requirements is necessary;

- Defense of the methods and techniques used and/or positions taken by the government during legal proceedings/settlement negotiations;

- State-of-the-art litigation support, information/records management and evidence audits for the Agency's priority cases.

NEIC maintains expert staff and sophisticated equipment capabilities for conducting investigations throughout the United States. NEIC has the ability to:

- Plan and manage a wide range of environmental investigations

  - Conduct comprehensive multi-media investigations

  - Gather and analyze information on facilities and businesses from a variety of EPA and other databases

  - Perform industrial process evaluations

- Evaluate the adequacy and validity of data collection and analyses

- Review and develop analytical techniques, methodologies, and computer information systems

- Implement enforcement strategies in coordination with the Office of Enforcement, other EPA Headquarters and Regional Offices

  - Assist in the preparation of cases for litigation

  - Provide specialized and expert testimony on a wide variety of subjects

  - Provide assistance to EPA's delegated state enforcement programs including state criminal enforcement efforts

- Provide training to federal and state employees regarding environmental investigations and enforcement [1]

The primary objective of NEIC is to provide expertise and resources for development and support of Federal and State civil and criminal enforcement cases. To meet this objective, NEIC has established the following policies and procedures. These emphasize the need to (a) thoroughly understand the applicable environmental laws and regulations; (b) clearly identify project objectives; and (c) adequately plan and implement all field, laboratory, and other support activities.

The goal of this manual is to present procedures for collection and development of admissible and defensible evidence in support of the Agency enforcement programs. In instances where these prescribed procedures are inappropriate or inadequate, NEIC personnel may use alternate procedures after securing the approval of their supervisor or consulting with the Enforcement Specialist Office, as appropriate.

This manual contains policies and procedures developed solely to provide internal guidance to NEIC employees and its contractors. The policies and procedures which are set forth do not create any rights, substantive or procedural, enforceable at law by a party to litigation with EPA or the United States.

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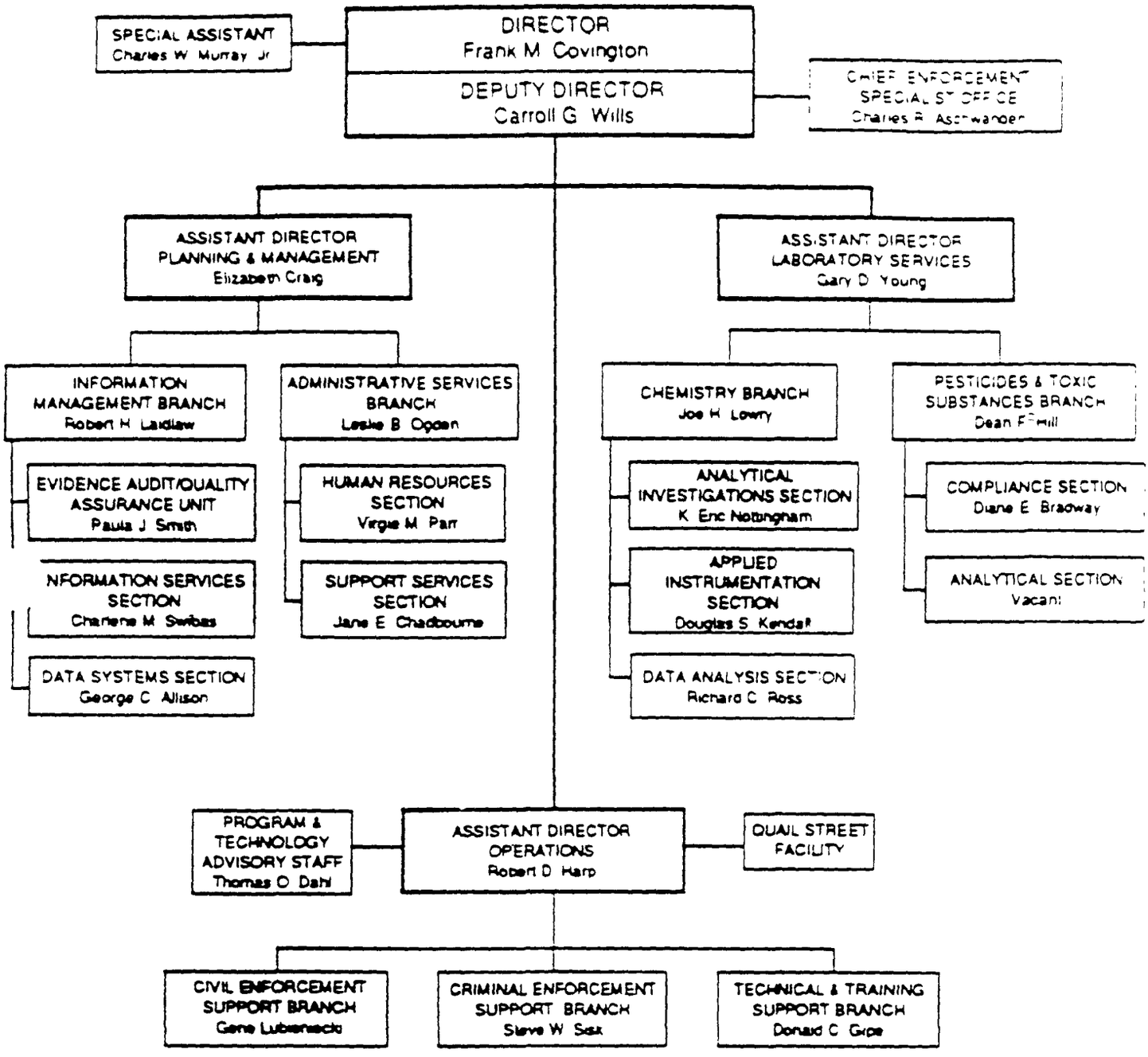
[1] *NEIC makes available, through various forums, the expertise it has developed by conducting enforcement investigations, supporting litigation/settlement negotiations, etc*

Environmental Protection Agency
Office of Enforcement - National Enforcement Investigations Center
P.O. Box 25227 DFC, Denver, CO 80225



08/06/91

I. GENERAL POLICIES AND PROCEDURES

CONFLICTS OF INTEREST, GIFTS AND GRATUITIES

Each NEIC employee is expected to promote public confidence in the integrity, reliability and dependability of the Environmental Protection Agency. Employees are required to perform their duties in a dignified, tactful, courteous and diplomatic manner, as the situation dictates. At all times they must comply with the regulations governing EPA employee conduct (40 CFR Part 3). Employees should consult their supervisors and/or the Enforcement Specialist Office for guidance on ethics issues. For general information regarding ethics refer to:

Ethics in a Nutshell ... Ethical Conduct for EPA Employees ... in Brief, U.S. EPA, Office of the Inspector General (March 1988)
U.S. EPA Employee Responsibilities and Conduct, U.S. EPA, Office of General Counsel (Feb. 1984).
EPA's Guidance on Ethics and Conflicts of Interest (Feb. 1984)

Employees shall avoid actual and apparent conflicts of interest through outside employment and other private interests or activities. A conflict of interest may exist whenever an EPA employee has a direct or indirect personal interest in a matter which is related to his official duties and responsibilities. Each NEIC employee must avoid even the appearance of a conflict of interest because the appearance of a conflict damages the integrity of the Agency and its employees in the eyes of the public. All employees must, therefore, avoid situations which are, or give the appearance of, conflicts of interest when dealing with others in or outside the Government. Any information acquired during an employee's duties is for official use only.

An employee is forbidden to solicit or accept any gift, gratuity, entertainment, favor, loan or any other item of monetary value from any person, corporation or group which has interests that may be substantially affected by such employee's official actions, or which conducts operations regulated by EPA. Further guidance on EPA's policy for accepting gifts, gratuities or entertainment may be found at 40 CFR 3.400.

PUBLIC RELATIONS

Good working relations should be established when dealing with the public, including personnel at facilities being investigated. This can best be accomplished by using diplomacy, tact and persuasion. Employees should not speak of any person, other regulatory agency, or facility in a derogatory

manner and should avoid providing a professional opinion on specific products or projects.

Good public relations and common sense dictate that employees dress appropriately for the activity in which they are engaged. This includes wearing the proper protective clothing and using safety equipment, as appropriate.

ENTERING FACILITIES

Authority

Federal environmental statutes grant EPA enforcement personnel authority to enter and inspect facilities [Table 1]. Each authority is similar to that stated below from Section 308 of the Clean Water Act:

"(a)(B) the Administrator or his authorized representative ... upon presentation of his credentials

(i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained ... are located, and

(ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method... and sample any effluents which the owner or operator of such source is required to sample."

For investigations conducted pursuant to the Safe Drinking Water Act (SDWA), Toxic Substances Control Act (TSCA), or Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the investigator must provide a responsible official of the facility with a written notice of inspection. In addition, during TSCA inspections, TSCA Confidentiality Notice forms should be offered. At the completion of the TSCA inspection, a Declaration of Confidential Business Information and Receipt for Samples and Documents forms are completed, as appropriate.

Many NEIC inspections are conducted after obtaining consent from the person(s) in charge of a site. Consent means the intentional foregoing of right to privacy which is not the result of either fear, ignorance or trickery. When obtaining consent, do not suggest that civil or criminal consequences will result from denial of entry. Consent to photograph onsite activities during any consensual administrative/civil investigation should be obtained before any photographs are taken. In administrative/civil matters, if the element of surprise is critical to the inspection, the site is unoccupied, or prior behavior indicates that entry may be denied, an administrative search warrant may be needed. If so, employees should consult the Enforcement Specialist Office before the inspection is attempted.

Table 1

AUTHORITIES GRANTED UNDER FEDERAL ENVIRONMENTAL LAWS AND REGULATIONS
FOR ADMINISTRATIVE/CIVIL INVESTIGATIONS

	Air	Water	Superfund	Pesticides	Solid Waste	Drinking Water	Toxics
Inspection Authority	CAA 114 40 CFR 80 4, 86*	CWA 308, 402 40 CFR 122 41, 233 7	CERCLA 104	FIFRA 8, 9 40 CFR 160 15, 169 3	RCRA 3007, 9005 40 CFR 270 30	SDWA 1445 40 CFR 144 51, 142 34	TSCA 11 40 CFR 717 17, 792.15
Recordkeeping Authority	CAA 114, 208, 311 40 CFR 51, 60, 79**	CWA 308, 402 40 CFR 122 41, 122 48, 233 7, 233.11	CERCLA 103	FIFRA 4, 8 40 CFR 160 63, 160 185-195, 169, 171 11	RCRA 3001, 3002, 3003, 3004, 9003 40 CFR 262 40, 263 22, 264 74, 264 279, 264 309, 265 74, 265 94, 265 279, 265 309, 270 30, 270 31	SDWA 1445 40 CFR 144 51, 144 54 141 31 33	TSCA 8 40 CFR 704 710, 717 5, 720 78, 761 761 180, 762 60, 763 144, 792 185 195
Confidential Information [illegible] 201 2 215]	CAA 208, 307 40 CFR 2 301, 53, 57, 80	CWA 308 40 CFR 2 302, 122 7, 233 18	CERCLA 104	FIFRA 7, 10 40 CFR 2 307	RCRA 3007, 9005 40 CFR 2 305, 260 2, 270 12	SDWA 1445 40 CFR 2 304, 144 5	TSCA 14 40 CFR 2 306, 704 7, 707 75, 710 7, 712 15, 717 19, 720 85 95 750 16, 750 36 762 60, 763 74
Emergency Authority	CAA 303	CWA 504 40 CFR 233 38	CERCLA 104, 106	FIFRA 27 40 CFR 164, 166	RCRA 7003 40 CFR 122 7	SDWA 1431 40 CFR 144 34	TSCA 7
Employee Protection	CAA 322	CWA 507	CERCLA 110		RCRA 7001	SDWA 1450	TSCA 23
Penalties	CAA 113	CWA 309 40 CFR 233 28	CERCLA 103, 112 EPC 325	FIFRA 12, 14	RCRA 3008, 9006	SDWA 1423 1424, 1431, 1432, 1441	TSCA 15, 16

* *86 077-7, 86 078-7, 86 441-78, 86 606, 86 1006 89*

** *51 320-328, 57.105, 57.305, 57.404, 58, 60 7, 61.10, 61 24, 61 69-71, 79 5, 85.407, 85 1086, 85 1906, 86 077 7, 86 084 39 and 40, 86 144 78 through 82, 86 542 78 86 609, 86 1009-84*

While consent may not be necessary for entering a public area or for acting under emergency conditions, no forcible nonemergency entry is permitted into a private area without a search warrant. When consent is withdrawn after the inspection has begun, the team shall leave the area and follow the procedures for denial of entry as detailed below.

Entry Procedures

To comply with statutory requirements during civil/administrative investigations, a facility should be entered in the following manner:

- The plant premises should be entered through the main gate or through the entrance designated by the facility personnel.

- The inspectors should introduce themselves in a dignified, courteous manner to a responsible plant official, clearly identify the organization they represent, and briefly describe the purpose of the inspection. Identification credentials will always be presented before an inspection is commenced. A responsible plant official may be the owner, operator, officer or agent-in-charge of the facility, including a person responsible for the plant's environmental affairs.

- If there is only a guard present at the entrance, the employee should present credentials and ask the guard to call his supervisor or the responsible official.

- If the company provides a blank sign-in sheet, log or visitors' register, it is acceptable to sign it. However, NEIC employees must not sign a release of liability (waiver) or any statement which would place limits on EPA's use of the information for enforcement purposes.

- When problems or questions arise, the NEIC employee should call his supervisor or the Enforcement Specialist Office.

Denial Of Entry Procedures

If entry is denied, the employee should not contest the issue with the facility representative, but immediately do the following:

- Cite the appropriate EPA administered legislation and inspection authority, ask if he/she heard and understood the reason for your presence, and record the answer and any reasons given for denial of entry.

- Record the name, title and telephone number of the individual denying entry as well as the date and time.

- Leave the premises.

- If consent is withdrawn after the inspection is already underway, retain all notes, records and samples and remove all equipment taken into the facility.

After leaving the facility, the inspector should, at the earliest opportunity, document the events related to the denial of entry and inform the appropriate NEIC supervisory personnel and the Enforcement Specialist Office.

INVESTIGATIONS OF ALLEGED CRIMINAL ACTIVITY

Participants in criminal investigations may be subject to additional requirements governing such investigations. Because of the severe penalties that may be imposed on the individuals convicted of violating the criminal provisions of the environmental laws or other statutes, there is closer scrutiny of constitutional safeguards to protect the individual's rights. Special Agents of the EPA, Criminal Investigations Division, will provide instructions regarding these safeguards to the project team on all investigations in which they are involved. From the beginning of such an investigation until it is completed, the rights of all individuals must be fully protected.

If, during the course of a civil/administrative inspection, aspects of criminal activity become apparent, the inspector should obtain all the evidence documenting the possible violation. The Criminal Investigations Division, or the appropriate Special Agent-in-Charge must then be apprised immediately. If a criminal investigation is opened, any files will be maintained separately from the current (or planned) civil investigation. Where applicable, the Agency's policy on parallel criminal and civil enforcement proceedings shall be followed.

COMMUNICATIONS EXTERNAL TO THE OFFICE OF ENFORCEMENT

In the course of business, NEIC employees communicate with persons outside the Agency's Office of Enforcement. Untimely releases of information and expressions of opinions can greatly hinder NEIC's investigative activities. Judgment is required, and supervisors should be consulted and kept informed of all such communications. For communications regarding matters in litigation and criminal investigations the Enforcement Specialist Office must be consulted.

NEIC has established internal distribution and filing procedures for all correspondence. Employees producing correspondence should do so

through their secretaries or check with their secretaries regarding the internal distribution of correspondence.

Table 2 contains requirements for transmittal of specific documents and correspondence, external to the Office of Enforcement.

Requesting Information from Persons Subject to Regulation

NEIC employees may request information from a facility before, during or after an on-site investigation. The environmental statutes require those regulated to keep various records and to make them available to EPA upon request. Several statutes also protect the trade secrets and confidential information of the regulated community.

Any confidential information received in the mail or hand-delivered shall be marked Confidential and handled as Confidential Business Information. In compliance with EPA regulations, any written request for company information, pursuant to statutory authority, must contain a statement notifying the facility that it may designate all or part of the information requested by the Agency as confidential in accordance with 40 CFR Part 2.

NEIC personnel should not accept confidential information unless it is needed. When confidential information is entered into an inspector's logbook the entire logbook must be treated as confidential. The Evidence Audit Unit (EAU) will provide the inspectors with adhesive labels and/or stamps to mark information submittals or logbook notes of observations which are claimed to be confidential. Where documents are provided by the company, the company officials should be requested to mark the document to identify the material which they claim is confidential. Confidentiality claims, which cover portions of otherwise nonconfidential documents, should be clearly identified by company officials. Logbooks must be marked as confidential by the inspector; in no case shall company officials be permitted to copy or review logbooks. See Chapter III of this manual for additional information on the treatment of confidential business information.

By statute, certain information, including effluent, emission, health and safety data is not entitled to confidential treatment.

Disclosure of Official Information to the Public

EPA policy is to make information about EPA and its work available, freely and equally, to all individuals, groups and organizations. This policy, however, does not extend to confidential business information or investigatory information relating to the suspected violation of federal laws.

Table 2

TRANSMITTAL OF NEIC DOCUMENTS AND CORRESPONDENCE EXTERNAL TO THE OFFICE OF ENFORCEMENT

Subject Matter Transmitted	Signature Required	Recipient
Response to Request for NEIC Assistance	Director/Deputy Director/Assistant Director (or delegatee)	Division Director and Regional Counsel and/or other requestors
Project plans	Director/Deputy Director/Assistant Director	Division Director and Regional Counsel and/or other requestors
Correspondence with facility officials	Chief, Enforcement Specialist Office or Regional Counsel	Facility being inspected
Requests for information	Director or appropriate Regional or Headquarters officials[1]	Facility being inspected, regulated entity or appropriate individual
Draft and Final reports	Chief, Enforcement Specialist Office	Division Director and Regional Counsel and/or other requestors
Reports, draft and final, and other information involving criminal investigations	Chief, Enforcement Specialist Office	Department of Justice, U S Attorneys, State Prosecutors, FBI and other criminal investigative agencies
Technical reviews and any documents related to enforcement cases	Chief, Enforcement Specialist Office	Division Director and Regional Counsel and/or other requestors
Project costs/contract costs	Director/Deputy Director/Assistant Director Planning and Management	Requestor and Regional Counsel
Procedures and Operating manuals	Library	As appropriate
Nonenforcement related documents[2]	Author	Requestor
FOIA Denials	Director	Requestor

1 *NEIC may also prepare information requests for transmittal by appropriate Regional or Headquarters Officials*

2 *Technical guidance documents, professional papers, requests for technical information unrelated to enforcement activities*

Any NEIC employee who receives a request, written or verbal, for the inspection or disclosure of NEIC investigatory records or confidential information, including those made under judicial discovery procedures, the Privacy Act or the Freedom of Information Act, shall immediately advise the Chief, Enforcement Specialist Office.

FOIA Response Procedures

The NEIC Director is delegated the authority to respond to Freedom of Information Act (FOIA) requests directed to NEIC. This delegation authorizes the Director to make the initial determination concerning the release of NEIC records. The FOIA procedures and requirements contained in 40 CFR Part 2 Subpart A, EPA Order 1550.1C and the FOIA manual apply to such determinations.

Any NEIC employee, including NEIC contractors, who receive a written request to disclose records, must immediately forward the request, together with its envelope, to the Enforcement Specialist Office (ESO) which will initiate efforts to identify and locate responsive records. Responsive records will not necessarily be released. There are numerous exemptions which permit or even require NEIC to deny the request in whole or in part. No acknowledgement of the request is necessary.

The ESO will date-stamp and log in the request; coordinate collection of relevant documents; coordinate with appropriate Regional, Headquarters and Department of Justice (DOJ) attorneys; and prepare the response to the FOIA request.

Denials shall include the basis for withholding the documents requested and a statement that the requestor has the right to appeal the denial. Only the NEIC Director has the authority to deny disclosure of requested records, in whole or part.

II. PROJECT MANAGEMENT

This section discusses how NEIC activities should be planned and implemented so that work is conducted in a timely manner and meets case objectives.

Projects undertaken by NEIC span a wide variety of activities ranging from one employee performing technical or administrative tasks to numerous employees from diverse disciplines working as a team to accomplish a series of complex tasks. NEIC projects can include any or all of these phases:

Project Request
Project Team Formation
Background Information Review
Project Plan Preparation
Project Plan Implementation
Report Preparation
Enforcement Case Support

This section of the manual discusses each phase and outlines pertinent NEIC policies [See Figure 1].

Not all of these phases are required for each NEIC project. Moreover, these phases are not necessarily discrete steps to be performed in order, before going on to the next phase. A project team may repeat or return to any phase during the life of the project and may work on several phases simultaneously.

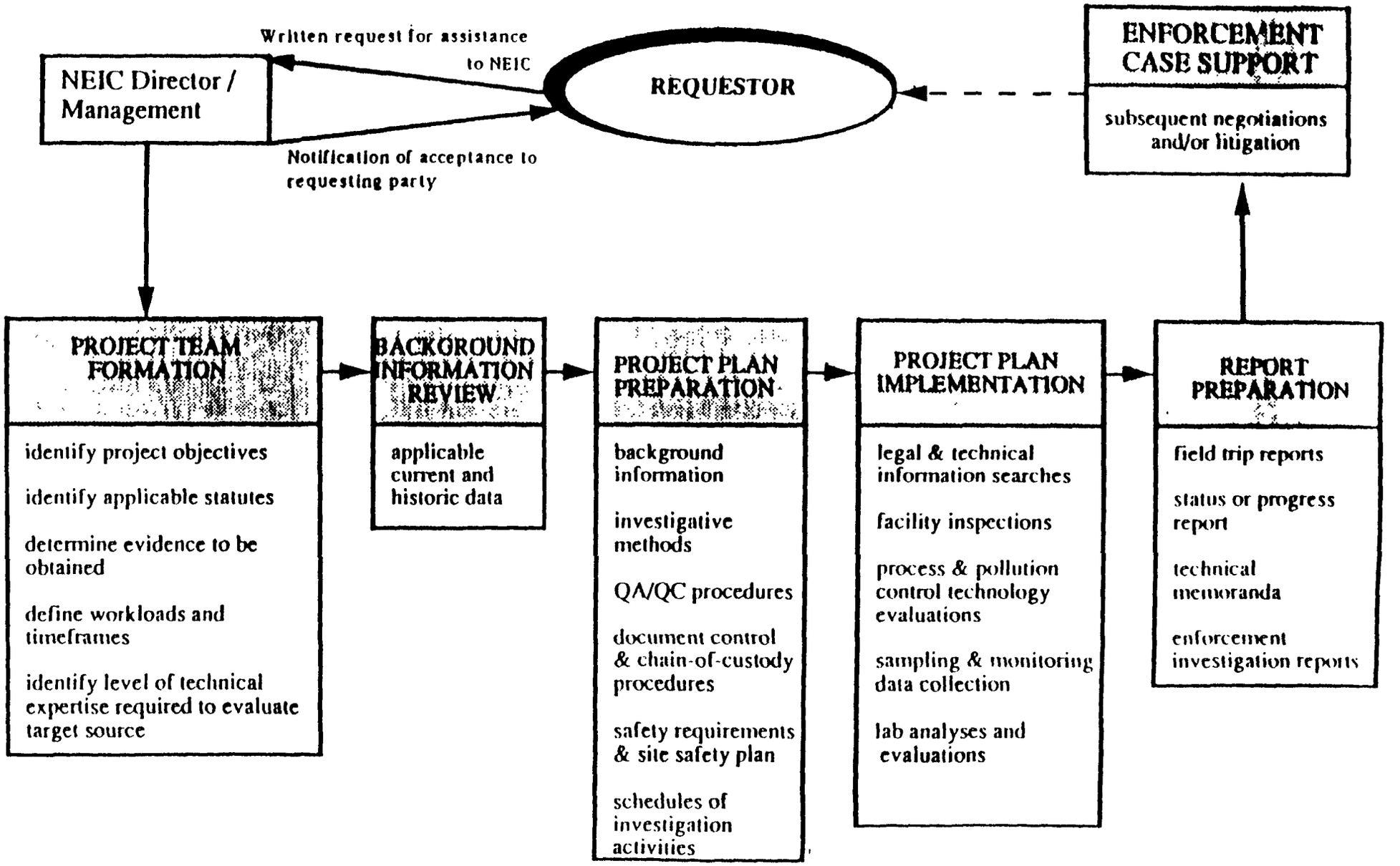
PROJECT REQUEST

Requests may be received from other offices of EPA, other Federal agencies, State agencies and local governments. Unless otherwise directed, all requests should be sent to the Director of NEIC. Prior to preparing a request, requesting parties are encouraged to make a preliminary inquiry to determine if NEIC can provide the assistance required. Depending on the type of assistance needed, NEIC may respond to verbal requests. Acceptance of a verbal request is normally given on a tentative basis pending receipt of a written request. Any request should detail the objectives, relate those objectives to the enforcement actions anticipated, specify general time frames for the work and identify the technical and/or legal contact(s) of the requesting office. A written request facilitates understanding of the request by all involved parties. However, routine or recurring requests may not require any written request and NEIC, at its option, may accept any project without a written request.

Requests received by NEIC have included those which require extensive field investigative work on environmental problems (e.g., multi-

_ure 1

PROJECT MANAGEMENT PROCEDURES



media investigations), as well as others which require only a limited technical or legal review of a remedial or abatement proposal, or analytical support for Regional enforcement cases. Other requests have involved development of enforcement cases, performance audits, compliance evaluation inspections, pesticide investigations, ground water investigations and pollution control technology assessments.

NEIC usually will notify the requesting party in writing when it accepts the project. When possible, the notification also will include a tentative schedule. Specific NEIC employees should be named as the contacts for coordination with the requesting party. In addition, the acceptance notice should identify any further information needed by NEIC.

PROJECT TEAM FORMATION

Civil Investigations

Once a project is accepted, a project team is organized. It will include representatives from those NEIC organizational units participating in the project. As appropriate, representatives from outside NEIC (e. g., the U.S. Department of Justice) may also participate in team activities and discussions.

The initial functions of the project team are to determine:

- The applicable statutory/regulatory provisions
- The evidence which must be obtained to address project objectives
- The resources and scheduling necessary to achieve objectives
- The technical expertise necessary to evaluate the target or source.

The team has the responsibility to identify and minimize potential problems. Team members must be knowledgeable about their respective units' activities in the particular project, and are responsible for describing or defending that activity in subsequent negotiations and/or legal proceedings.

NEIC names a specific individual from the project team as the coordinator. This person generally serves as a central point of contact with the requesting party and is responsible for communicating and coordinating project requirements and information with all involved parties. In addition, this person must assure that a requestor's needs are met, including preparation of the necessary documents and reports.

The makeup and coordination of the project team is dictated by the type of investigation conducted. Sometimes a "team" may consist of only one person.

Criminal Investigations

In criminal investigations, the NEIC project coordinator is responsible for sampling, analysis and other technical activities and works with the EPA Special Agent, FBI agent and/or the appropriate U.S. Attorneys' Office.

BACKGROUND INFORMATION REVIEW

The purpose of a background information review is to gather information pertinent to the project. This review usually begins before a project plan is written and continues throughout the course of a project. The information obtained is used to prepare the project plan, conduct the field investigation, and write the report.

The scope and duration of the background review are related to the project objectives and vary with project complexity. Background information is available through the in-house and affiliated libraries and the NEIC computerized data retrieval systems. Meetings may be held with EPA Headquarters, Regional offices and/or State and local agencies and other Federal agencies to discuss the project, and to review and obtain copies of relevant files. Where necessary, a site reconnaissance and/or preliminary site visit provides verification and/or updating of background information. Examples of information obtained and/or reviewed may include:

- Applicable (current and previous) State and Federal laws and regulations
- Current and previous facility permits and permit applications
- Previous inspection reports
- Case files from previous and pending enforcement actions/litigation
- Correspondence between regulatory agencies and the facility
- Administrative Orders, settlement agreements, compliance schedules
- Headquarters/Regional legal strategy and/or policy related to the NEIC investigation

- Specific descriptions of facility processes and pollution control systems

- Self-monitoring data

- Alternative control and treatment technology applicable to the facility(ies) being investigated

- Available and state-of-the-art sampling and analytical methods

- Information received through interviews of informants

In all investigations requiring field activities, knowledge of the potential and existing safety hazards associated with the facilities or targets, and local emergency services, is essential.

PROJECT PLAN PREPARATION

The format of a project plan will depend on the scope of the project. Some projects require a detailed plan, describing the objectives, enforcement history, facility operation, investigative methods, safety protocols, etc. In others, a memorandum defining the objectives, tasks and schedules may suffice. A general outline of NEIC project activities may be included in the written response to a requesting party. After sufficient background information has been obtained and evaluated, a detailed project plan can be prepared. In many cases the plan is not completed until planning meetings have been held, files have been reviewed, and a preliminary site visit has been made. Projects requiring only analytical services may not require a project plan. In some cases, the NEIC project acceptance letter is a sufficient project plan, as long as safety issues are addressed, as necessary, in the letter or in a separate safety plan.

The project coordinator, in conjunction with other team members, prepares the project plan detailing the scope, logistics, and objectives. In addition, other items usually addressed in a project plan include:

- Background information. For example, background information for a hazardous waste treatment, storage and disposal facility investigation or an industrial facility evaluation, may include a summary of processes, sources of pollution - their control or treatment, applicable regulations and permit requirements. In those investigations where there is, or a potential exists for groundwater pollution, information on the geologic and hydrogeologic conditions, and on-site hazardous waste disposal operations, are necessary for plan development.

- Investigative methods. For example, this should include a description of sampling locations and procedures, analytical requirements, the on-site records review and collection of operating process data and information.

- Quality assurance/quality control procedures

- Document control and chain-of-custody procedures

- Safety requirements and safety plan for on-site activities

- Schedules for investigative activities. This should include schedules for field work, analyses, reports, etc.

Prior to commencing a field investigation, a briefing session with all project team members should be held. At that time, those aspects of the investigation such as communication with facility personnel, sampling and monitoring requirements, test procedures and analyses, special technical needs, legal aspects and safety requirements can be discussed.

The project coordinator, as the identified contact person representing the project team, should communicate closely with the requestor during the planning phase to ensure the identified objectives are addressed. The completed project plan represents an agreement between the requestor and NEIC.

Project plans (draft or final) for activities related to administrative/civil enforcement cases will usually be transmitted by an Assistant Director or the Deputy Director [Table 2]. The project coordinator numbers draft copies in red ink and maintains a record showing who received draft copies and when such copies were returned. The project coordinator should have all draft copies returned. Changes and modifications desired by the requestor should be communicated to the project coordinator who will assure that all affected parties are apprised of the requested changes and provided an opportunity to respond. Once all concerned parties agree to the project plan, it serves as a reference document for the project. The plan is subject to change as circumstances warrant and should contain a statement to that effect. Any change(s) should be documented and appropriate parties notified.

Because of the greater sensitivity associated with criminal investigations, the distribution and review of planning documents will be limited. Transmittal external to the Office of Enforcement of any technical document prepared by NEIC for a criminal investigation must be by the Chief, Enforcement Specialist Office.

PROJECT PLAN IMPLEMENTATION

Project activities include legal and technical information searches, facility inspections, process and pollution control technology evaluations, sampling, monitoring, laboratory analyses, laboratory evaluations and analytical data reviews. To the extent possible, these activities are conducted following established NEIC techniques and standard operating procedures, EPA policy and program guidance and promulgated regulations. When new methods or modifications to existing procedures are appropriate, these changes will be documented.

Each team member must assure that all work is conducted safely and that required safety equipment is used. All participants must adhere to the applicable safety requirements.

Because the information generated during an investigation can be subjected to close scrutiny during subsequent negotiations and/or litigation, procedures ensuring the integrity and security of all evidence must be followed throughout any project. See Part III, Evidence Management.

REPORT PREPARATION

NEIC prepares various reports in carrying out its enforcement program responsibilities. These reports include field trip reports, status or progress reports, technical memoranda and enforcement investigation reports all of which detail the who, what, where, when, and how of the enforcement activity. NEIC reports can be used by Regional and Headquarters offices, other law enforcement organizations, the U.S. Department of Justice and U.S. Attorneys to support enforcement actions. Other reports prepared by NEIC include internal procedures and operating manuals, technical reports and papers (e.g., a report on an NEIC-developed laboratory procedure or field investigation technique). Report format, including the color of the cover, should be in accordance with the NEIC Report Services Operating Procedures Manual.

Enforcement reports are prepared by the appropriate individual or project team members. All participants in the report preparation process must assure that their individual contributions to the report and other documents are accurate, fully supportable and commensurate with Agency and NEIC policies. Although the overall responsibility for preparation and content of the reports (including all supporting documents) rests with the project coordinator, all team members must accept responsibility for the quality, accuracy and admissibility of the information in the final report.

Reports are reviewed internally prior to distribution in either draft or final form outside of NEIC. The NEIC reviewers can include the team members and others directly involved in the project and report preparation process, as well as appropriate Assistant Directors and their Branch Chiefs, the Deputy Director and the Chief, Enforcement Specialist Office.

External review drafts should be transmitted according to Table 2. All external review drafts will be numbered in red ink and stamped on the cover page with the following statement: DRAFT REPORT - FOR AGENCY REVIEW ONLY, DO NOT DUPLICATE. All other pages of the draft will also be marked DRAFT.

Reports prepared for criminal investigations will receive limited distribution. Any draft or final report prepared by NEIC for a criminal investigation which must be sent external to the Office of Enforcement will be transmitted by the Chief, Enforcement Specialist Office.

Copies of NEIC civil enforcement reports are maintained by the library. NEIC reports may receive public distribution through the National Technical Information Service (NTIS). Their availability to the public is announced through the NTIS publication "Government Reports Announcement" and a fee is set by the NTIS for their reproduction and distribution in either paper or microfiche form.

External distribution of enforcement reports not available through NTIS must be authorized through the Chief, Enforcement Specialist Office who will consult with the project coordinator and the appropriate EPA Office of Regional Counsel.

Distribution is also restricted for reports that contain confidential business information. Under several environmental laws, including TSCA, businesses may claim certain information given to EPA to be confidential business information. When a report contains confidential business information, the title page and every page containing that information is marked CONFIDENTIAL.

All reports containing confidential information will be kept in secure areas until restrictions are removed. Questions concerning the availability of reports should be directed to the Enforcement Specialist Office.

ENFORCEMENT CASE SUPPORT

Completion and transmittal of a report does not signify the end of NEIC involvement in an investigation. When the initial assistance activity leads to an enforcement action, NEIC staff are available to:

- Participate in the preparation of the enforcement case and in subsequent legal proceedings
- Assist in negotiations
- Provide further technical consultation and assistance (e.g., additional field work as necessary)

As necessary, NEIC personnel are available to serve as witnesses (fact and expert) and to provide technical and legal assistance to government attorneys before and during depositions, pretrial hearings and trials.

The project coordinator is responsible for tracking any enforcement action planned or being taken by the requesting party. In conjunction with the Enforcement Specialist Office, this individual is also responsible for identifying and offering any other support NEIC can provide.

III. EVIDENCE MANAGEMENT

SAMPLE CONTROL

A sample is one type of physical evidence collected during an investigation. An essential part of all NEIC enforcement investigations is accounting for the evidence gathered. To ensure the integrity of the evidence, the following sample identification and chain-of-custody procedures have been established. The use of alternative procedures must be documented.

Sample Identification

When *in-situ* measurements are made, the data are recorded directly into logbooks or are electronically recorded, with identifying information (project code, station number, station location, date, time and samplers), field observations and remarks. Examples of *in-situ* measurements include pH, temperature, conductivity, flow measurement, continuous air monitoring and stack gas analysis.

Samples, other than *in-situ* measurements, are identified by a sample tag or other appropriate identification. These samples are removed and transported from the sampling location to a laboratory or other location for analysis. Whenever a sample is separated into portions to be provided to another party each portion is identified by a sample tag marked "split." In a similar fashion, tags will be marked for "Blank" or "Replicate" samples. The information recorded on the sample tag includes:

- Project Code (A three-alpha-numeric digit assigned by NEIC)
- Project Name
- Station Location (Description)
- Station No. (Usually a two digit code)
- Date
- Time
- Samplers' signatures
- Remarks (The samplers record pertinent information including preservatives used)

After collection, the samples are maintained in accordance with the chain-of-custody procedures discussed below.

Blank, uniquely numbered sample tags, logbooks and other accountable documents are provided by the Evidence Audit Unit.

Split Samples

NEIC policy is that sample splits will be offered to facility officials whenever samples are collected during a civil investigation. Section 3007(a)(2) of the Resource Conservation and Recovery Act (RCRA) states ". . .If the officer, employee or representative obtains any samples, prior to leaving the premises, he shall give to the owner, operator or agent-in-charge a receipt describing the samples obtained and if requested a portion of each such sample equal in volume or weight to the portion retained." Section 104 of CERCLA contains similar requirements. Samples may also be split with other Government agencies. Whether split samples should be collected or given to facility personnel in a criminal investigation is a decision to be made by the EPA Special Agent assigned to the case and the prosecuting attorney (e.g. Assistant U.S. Attorney).

When samples are split, a separate Receipt for Samples form [Figures 2 and 3] is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the split samples to the facility or agency should request the signature of the party or his representative acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When splits are offered but refused, such refusal should be documented on the Receipt for Samples form or in the logbook or elsewhere.

Chain-of-Custody for Samples

Due to the evidentiary nature of samples collected during enforcement investigations, possession must be traceable from the time the samples are collected until they or the data derived from the samples are introduced as evidence in legal proceedings. To maintain and document sample possession, chain-of-custody procedures are followed.

Sample Custody

All samples collected as evidence are to be maintained under secure conditions and documented chain-of-custody procedures. In general, as few people as possible should be a part of the chain-of-custody. A sample is under custody if:

- It is in your possession.
- It is in your view, after being in your possession.
- You secured the sample in an appropriate container and made arrangements to transport it to the laboratory.

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
Building 53, Box 25227, Denver Federal Center
Denver, Colorado 80225

RECEIPT FOR SAMPLES

PROJ. NO | PROJECT NAME | Name of Facility

SAMPLERS (Signature)

Facility Location

Split Samples Offered

( ) Accepted ( ) Declined

STATION NO.	DATE	TIME	COMP	GRAB	SPLIT SAMPLES	TAG NUMBERS	STATION DESCRIPTION	NO. OF CONTAINERS	REMARKS

Transferred by (Signature)

Date | Time

Received by (Signature) | Telephone

Title | Date | Time

Distribution: Original to Coordinator, Field Files; Copy to Facility

N 3151

FIGURE 2 - RECEIPT FOR SAMPLES

Best available copy.

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
Building 53 Box 25227 Denver Federal Center
Denver, Colorado 80225

RECEIPT FOR SAMPLES

PROJ NO: 31-B
PROJECT NAME: Tom's Recycling
SAMPLERS (Signature): Lizzie Borden, Jim Fixem
Split Samples Offered: ( ) Accepted ( ) Declined

Name of Facility: Tom's Recycling Center
Facility Location: 1234 Maple Street, OAKview, USA

STA NO	DATE	TIME	SOIL	WATER	SPLIT SAMPLES	TAG NUMBERS	STATION DESCRIPTION	NO OF CONTAINERS	REMARKS
01	2/6/90	1028		✓		N1300-1301	Soil from N.E. end of green drum	2	
02	2/6/90	1045	✓			N1302, N1303, N1304	Pool of water at S.W. end of green drum	3	
03	2/6/90	1115		✓		N1305-1306	Green drum under large oak tree	2	

Relinquished by (Signature)
Date: Time:

Received by (Signature): Jean Mauck
Title: Chemist
Date: 2/7/90
Time: 1023
Telephone: 555 9876

Distribution: Original to Coordinator, Field Files. Copy to Facility

N 2405

FIGURE 3 - COMPLETED RECEIPT FOR SAMPLES

Best available copy.

- You transferred the sample to authorized personnel.
- It is held in a secure area.

Transfer of Custody and Shipment

- Samples are accompanied by a Chain-of-Custody Record [Figure 4]. 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. Figure 5 illustrates a completed Chain-of-Custody Record.

- Samples will be packaged properly* for shipment and dispatched to the appropriate laboratory for analysis, with a separate Chain-of-Custody Record accompanying each shipment. Shipping containers will be padlocked or otherwise sealed for shipment to the laboratory.

- All shipments should be accompanied by the completed Chain-of-Custody Record. The original record will accompany the shipment, and a copy will be retained by the Project Coordinator.

- Freight bills, post office receipts and Bills of Lading must be retained as part of the permanent documentation.** If samples can be sent by mail (not those samples suspected of containing hazardous materials), the package should be registered with return receipt requested.

Laboratory Custody

- Laboratories at NEIC are locked at all times. Access is limited to authorized personnel and accompanied visitors.

- Laboratory personnel accept custody of the shipped samples and verify that the information on the sample tags matches that on the Chain-of-Custody Record. Pertinent information as to shipment, pickup, courier, etc. is entered in the "Remarks" section. The laboratory recipient of the samples assures that all samples are transferred to the proper analyst or stored in the appropriate secure area.

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* *See NEIC Standard Operating Procedures for Packaging, Marketing, Labeling and Shipping of Samples (DOT requirements).*

** *Copies of the bills and receipts may be provided to the NEIC Office of Planning and Management to assure proper payment. Originals of these documents are retained for the project file.*

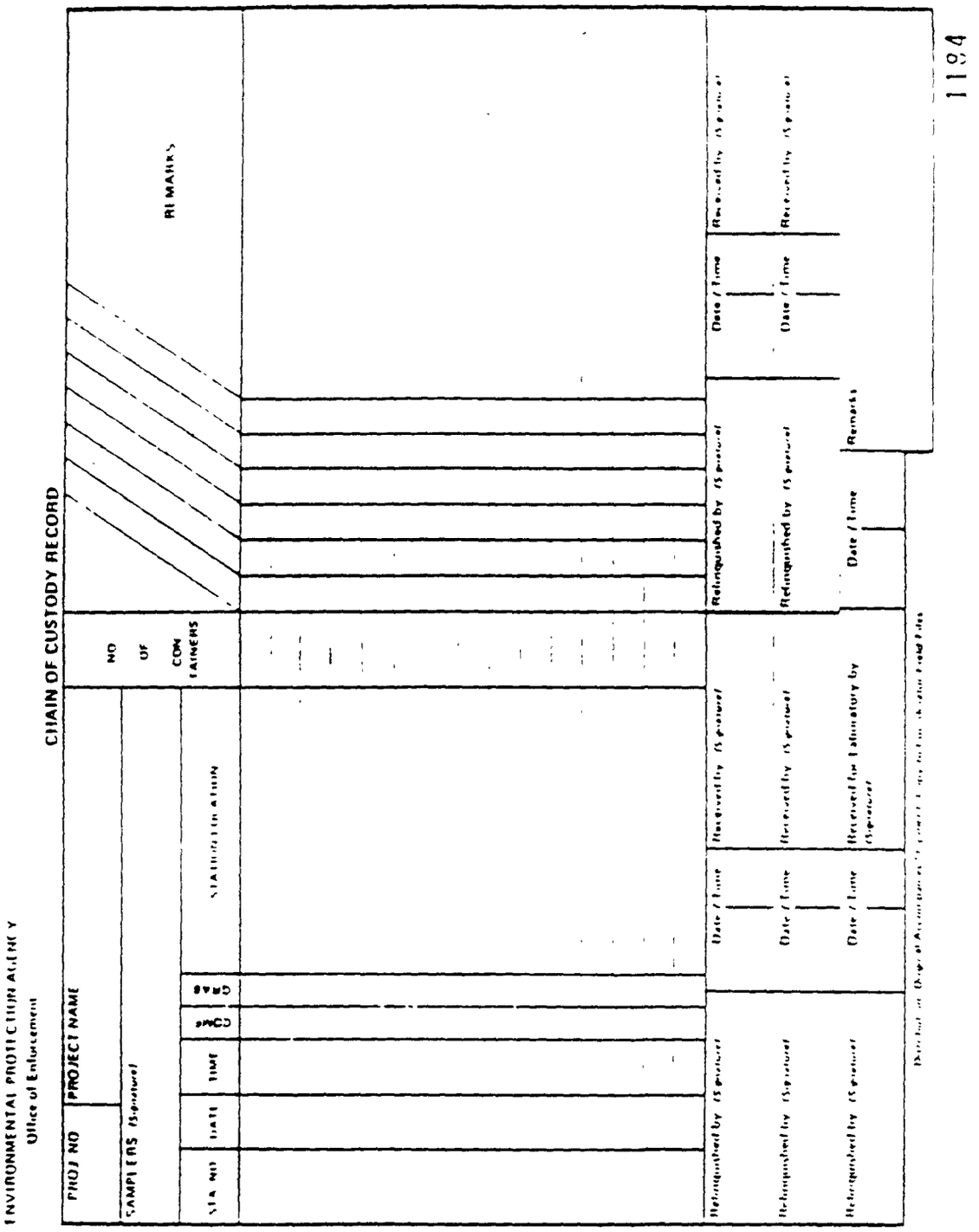

FIGURE 4 - CHAIN-OF-CUSTODY RECORD

Best available copy.

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
Building 53, Box 25227, Denver Federal Center
Denver, Colorado 80225

CHAIN OF CUSTODY RECORD

PROJ NO: 31-B
PROJECT NAME: Tom's Recycling
SAMPLERS (Signature): Lizzie Borden, Jim Bryant

STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO OF CONTAINERS	Semi-volatile Organic	RCRA Characteristic	RCRA Listed waste			Sample Type Identification	REMARKS / TAG NUMBER
01	2/6/90	1028		/	Soil Sample	2	✓		✓				N1300 1301 / F002 Solvents
02	2/6/90	1045	/		Water from pool	3	✓	✓	✓				N1302, N1303, N1304
03	2/6/90	1115		/	Drum Sample	2	✓	✓					N1305-1306 / [illegible]

Relinquished by (Signature)	Date / Time	Received by (Signature)	Relinquished by (Signature)	Date / Time	Received by (Signature)
Jim Bryant	2/6/90 1431				
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): Vicki Claull	Date / Time: 2/7/90 1023	Remarks: Shipped Federal Express	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

N 4164

FIGURE 5 - COMPLETED CHAIN-OF-CUSTODY RECORD

Best available copy.

- The laboratory will use the sample tag number, sample station number or assign a unique laboratory number to identify each sample.

- Laboratory personnel are responsible for the care and custody of samples from the time they are received until the sample is exhausted or while it is in storage.

- Each Laboratory Services Branch will follow a system for tracking samples through the laboratory and identifying the documents generated during the analysis of those samples. Each employee must understand the Standard Operating Procedures applicable to his/her respective Branch.

- After sample analyses and necessary quality assurance checks have been completed, the remaining portion of the sample, will be kept secured as evidence until disposal is authorized as described below. All identifying tags, data sheets and laboratory records must be retained as part of the permanent documentation unless they are contaminated. If records are contaminated they can be enclosed in plastic and copied before being disposed of as hazardous waste.

- The Assistant Director, Laboratory Services, in coordination with the Chief, Enforcement Specialist Office, and the project coordinator will authorize disposal of samples and remaining sample portions for all administrative/civil investigations. For criminal investigations, the Assistant Director, Laboratory Services, will contact the EPA Criminal Investigations Division or other appropriate offices (e.g. FBI, DOJ) to coordinate the disposal of samples collected in support of criminal investigations.

DOCUMENT CONTROL

The goals of document control are: (1) to assure that all documents generated or obtained by NEIC personnel will be accounted for when the project is completed and (2) to prevent premature or inadvertent disclosure of information. This program includes a serialized document system, a document inventory procedure and an evidentiary filing system, operated and controlled by the Evidence Audit Unit (EAU). The Document Control Officer (DCO) maintains separate locked files for confidential business information. The protocol for the transmittal of documents generated during an enforcement investigation is, in large part, implemented and monitored by the Enforcement Specialist Office [See Table 2].

To provide document accountability for technical investigations, each of the document categories discussed below features a unique serialized number assigned by EAU for each item within the category. Accountable documents used or generated by NEIC employees include logbooks, sample tags, graphs, Chain-of-Custody forms, Receipt for Samples forms, and bench sheets. The project coordinator disposes of any unused serialized documents or may return them to EAU. Unless prohibited by weather, waterproof ink should be used to record all data. When weather conditions prohibit use of waterproof ink, entries should be made using a non smear lead pencil (e.g. 2H or 3H).

Project Logbooks

The project coordinator is responsible for the transfer of logbooks to field team members. Each person signs their logbook upon receipt and records all information pertinent to the project in that logbook. A separate logbook is used for each project.

Logbook entries should be dated, legible and contain an accurate, factual and complete account of the investigation. Because the logbook is the basis for the later written reports, it must contain only facts and observations. Language should be objective, factual and free of the inspector's personal feelings, characterizations, speculation, or other terminology which is inappropriate. Entries made by individuals other than the person to whom the logbook was assigned must be dated and signed by the individual making the entry.

All project logbooks are the property of NEIC and are to be returned by the project coordinator to the Evidence Audit Unit when a project has been concluded. Representatives of facilities being inspected shall not be permitted to copy or review logbook notes.*

Sample Tags

Serialized sample tags are used to identify samples. After the tag has been completed, it is attached to a sample. Transfer to another individual is by use of a Receipt for Samples form [Figures 2 & 3]. Sample tags contaminated with a hazardous substance will not be saved. The serial number of the contaminated tag must be noted in the appropriate logbook and the project coordinator notified. All information from contaminated tags is recorded and the tags are photocopied, if possible, and disposed of. At the completion of the field activities, all unused tags (including those damaged or voided) must be returned to the project coordinator for disposal or returned to EAU.

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* *As appropriate, the inspector may copy document and/or photograph logs for facility representatives.*

Chain-of-Custody Records

Serialized Chain-of-Custody Records are distributed in a manner similar to that used for sample tags. When samples are transferred to laboratory personnel, the recipient, after signing, files it in a secure place. When dispatching samples via common carrier the original accompanies the shipment and is signed by the receiving laboratory personnel. Employees of common carriers do not sign the Chain-of-Custody form.

When samples are split with the source or another Government agency, this is documented on a Receipt for Samples form. The tag serial numbers from all splits are recorded on the form and a copy of the form is provided for the source or agency. The white originals are returned to the project coordinator.

Lidar Magnetic Tapes

Lidar data are recorded on the on-board computer. This computer is used to analyze data and print results in report format. After analysis the data are archived to a magnetic tape and maintained as an evidence record.

Laboratory Records

The instrument logbooks, bench sheets and the analyst's personal notebook(s) must contain information sufficient to recall and describe each step of the analysis performed. Sufficient detail also is necessary to enable others to reconstruct the procedures followed should the original analyst be unavailable for testimony. Any irregularities observed during the testing process need to be noted. If, in the technical judgment of the analyst, it is necessary to modify a particular method to perform an analysis, the modification must be justified and properly documented.

The numbered laboratory notebook assigned to an individual can be used for more than one project; however, only one project should be discussed on each page. That page must be labeled with the project code, dated and signed by the individual.

Where applicable, a numbered instrument logbook is used to record information relating to calibration and maintenance of a particular laboratory instrument.

In addition to information documenting the analyses performed, field analysts should document in their project logbooks, in their laboratory notebooks, or on bench sheets the date and calibration results for mobile laboratory equipment. A record is also kept of any incidents; for example, the disruption of electrical service to the laboratory, tampering with Government vehicles or equipment, etc. Appropriate notations regarding

visitors to the mobile laboratory, such as facility personnel, are entered in the logbook.

Photographs

When photographs or videotapes are taken which show aspects of an investigation, descriptions of those photographs or videotapes are entered in a logbook. Identifying information (e.g. photographer, date, time, site location, etc.) is normally entered into the logbook as photos (or groups of photos) are taken. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. Special lenses, films, filters or other image enhancement techniques must be noted in the logbook, if they could distort or misrepresent what is depicted in the photographs. Logbook notations and other documentation used to account for film processing must be maintained. Once developed, the slides or photographic prints are identified to correspond with the logbook descriptions.

Corrections to Documentation

If an error is made on an accountable document assigned to one individual, that individual may make contemporaneous corrections simply by drawing a line through the error, initialing it and entering the correct information. Any subsequent error discovered should be corrected by the person who made the entry, the person who discovered the error, or another person familiar with the work. All subsequent corrections must be initialed and dated.

If a sample tag is separated from a sample and lost in shipment, or a tag was never prepared for a sample, or a properly tagged sample was not transferred with a formal NEIC Chain-of-Custody Record, a written statement should be prepared detailing how, when, and to whom the sample was collected, air-dispatched, or hand-transferred. The statement should include all pertinent information, such as entries in field logbooks regarding the sample, whether the sample was in the sample collector's physical possession or in a locked compartment until hand-transferred to the laboratory, etc. Copies of the statement are distributed to the project coordinator and the appropriate Branch project files.

Consistency of Documentation

Each Branch or Division assembles its documents and cross-checks information on corresponding sample tags, custody records, bench sheets, analyst notebooks and other logbooks to ensure that data pertaining to each particular sample is complete and consistent throughout the record. The file should be arranged according to the procedures described in this manual under "Evidentiary File." The project coordinator concurrently performs a cross-check of field documents (logbooks, custody records, etc.)

to ensure that the field information is complete. The laboratory similarly reviews their documentation for completeness. The EAU will review files after these have been transferred to EAU. Criminal case files are inventoried and numbered at the time of file assembly by the EAU or the respective NEIC Branches/Divisions involved in the case.

Branch/Division Files

After a Branch has completed its work for a particular investigation, all documents generated from that project should be assembled in the Branch or Division file. Individuals may retain clean (no handwritten comments) copies of documents for their personal files but only after personally verifying that the original or similar copy is in the file. Each project coordinator is responsible for assuring the collection and assembly of all documents relative to a project at the time the project objectives are completed. The technical investigation portion of criminal case files is numbered, inventoried and transferred to EAU for storage. Any record leaving the file after it has been transferred to EAU must be signed out.

Evidentiary Files

When NEIC has completed the project objectives, all inventoried Branch and Division file documents are reviewed and submitted to EAU, as specified above. The evidentiary file should be organized into the following document classes in this sequence:

- Privileged or Confidential Information
- Project Plan
- Project logbooks
- Sampling documentation
  - Sample tags
  - Chain-of-Custody Records
  - Receipt for Samples forms
- Laboratory records (logbooks, bench sheets, etc.)
- Project Correspondence
- Documents obtained from facilities being investigated
- Background information
- Report notes, calculations, etc.
- Photos, maps and drawings
- Final report(s)
- Litigation/settlement documents
- Other documents, as appropriate.

Once deposited in the evidentiary file, documents may only be checked out through the EAU document control personnel.

Litigation Documents

Any litigation reports, letters, memoranda, draft court documents, etc. from the Enforcement Specialist Office or other Government attorney which discuss legal matters or strategies should be separately identified in individual Branch and Division files. These documents should be marked to identify the privileged nature of their contents. Internal distribution is limited to the appropriate project participants and their supervisors.

Confidential Business Information

Some information requested and obtained by NEIC may contain trade secrets which companies may request be guarded as confidential business information (CBI). In general, NEIC employees who have a need to know may have access to CBI. When CBI is obtained, NEIC employees must follow specific requirements to protect the information. The regulations to be complied with by every employee are at 40 CFR Part 2, Subpart B. Those requirements vary with the particular law involved. If in doubt regarding the requirements governing the handling of documents identified as"confidential" or "trade secret," employees should consult the Enforcement Specialist Office.

Of particular importance are the provisions of Section 14 of the Toxic Substances Control Act (TSCA). A company may make confidentiality claims for any and all information provided to the Agency with the condition that specific criteria under TSCA are met. Once confidentiality under TSCA is claimed, stringent procedures are followed to maintain the confidentiality of that information. Refer to the TSCA Confidential Business Information Security Manual, U.S. EPA, Office of Toxic Substances (Approved Nov. 1, 1985), for guidance. Before obtaining access to any CBI protected under TSCA, every person must obtain TSCA CBI clearance through the EAU.

All analytical work conducted on confidential samples will be performed in a manner to preserve the confidentiality of the information generated. The resulting documentation will be isolated from the Branch or Division files when the records are called in by EAU.

EVIDENCE AUDIT

The Evidence Audit Unit (EAU) provides a continuing evaluation of enforcement investigation activities. This evaluation addresses sample control, document control, chain-of-custody, file assembly and evidence security.

Some projects may be selected for an audit. The audit may include an evaluation of sampling, sample custody, data recording and any supporting documentation.

For administrative/civil investigations and the technical portions of criminal investigations, EAU requires submission of all records for inclusion in the evidentiary file at the completion of a project. These files are reviewed to assure that all documents generated or obtained during the course of the investigation are present. Any discrepancies are brought to the attention of the project coordinator and the Chief, Enforcement Specialist Office.

QUALITY ASSURANCE

A Quality Assurance (QA) program is established at NEIC to assure that data produced are of known and documented quality. QA program requirements cover all measurement activities performed, supported or required by NEIC. The authority and responsibility for directing QA activities within NEIC are delegated to the QA Officer (QAO). QA direction and guidance are specified in the NEIC QA Program Plan.

The Quality Assurance Officer's responsibilities include development, evaluation and documentation of QA policies and procedures at NEIC. The QAO is assisted by QA division representatives in implementing and coordinating the QA program. All employees involved in sampling or measurement activities are responsible for carrying out quality assurance requirements in accordance with the QA Program Plan and any NEIC standard operating procedure and for informing the QAO or QA coordinators of the need for corrective actions.

The QAO develops and conducts system audits to monitor the QA program and the quality of data produced.

APPENDIX

WITNESS GUIDELINES

WITNESS GUIDELINES

The following suggestions are made for prospective witnesses in order to lessen the fears and apprehensions which almost everyone has when first testifying before a board, commission, hearing officer or in court. Even those who have testified previously encounter a certain anxiety when called for a repeat performance. When a witness is properly prepared, both with regard to the subject matter of testimony and conduct on the witness stand, there should be little fear about testifying.

It is of utmost importance that the witness be thoroughly prepared on the subject matter of the testimony. Only the witness can recall what occurred in the field and/or laboratory and why. Since many cases are tried substantially after the field and laboratory activities have been conducted, it is imperative that adequate documentation be originally prepared in order that a witness' memory may be refreshed. A thorough and detailed review of all relevant documents is the only way prospective witnesses can be adequately prepared.

In order to assist witnesses on how they should conduct themselves the following suggestions are given.

The witness will be required to take an oath to tell the truth. The important point is to remember that there are two ways to tell the truth - one is a halting, stumbling, hesitant manner, which makes the trier of fact (the hearing officer, judge or jury) doubt that the witness is telling all the facts in a truthful way; and the other way is in a confident, straightforward manner, which inspires faith in what is being said. It is most important that the witness testify credibly. To assist a witness in testifying in such a manner, a list of time-proven hints and aids are provided below.

GENERAL INSTRUCTIONS FOR A WITNESS

If you are to be a witness in a case involving testimony concerning the appearance of an object, place, condition, etc., try to refresh your recollection by again inspecting the object, place, condition, field notes and records, etc., before the hearing or trial. While making such inspection, close your eyes and try to picture the item and recall, if you can, the important points of your testimony. Repeat this until you have thoroughly familiarized yourself with the features of your testimony that will be given.

Before you testify, visit a court room trial or administrative hearing and listen to other witnesses testifying. This will make you familiar with such surroundings and help you understand some of the things you will come up against when you testify. You should consider being present at the hearing of the matter in which you are to testify in sufficient time to hear other witnesses testify before you take the witness chair. This, however, may not always be possible since, on occasion, witnesses are excluded from the court room until they testify.

A good witness listens to the question and then answers calmly and directly in a sincere manner. The facts should be well known so they can be communicated. Testimony in this manner applies to cross-examination as well as direct examination.

Wear neat, clean clothes when you are to testify. Dress conservatively. Do not chew gum while testifying or taking an oath. Speak clearly and do not mumble.

DIRECT EXAMINATION

In a discussion on administrative procedures, E. Barrett Prettyman, Retired Chief Judge, U.S. Court of Appeals for the District of Columbia, gave the following advice:

> The best form of oral testimony is a series of short, accurate and complete statements of fact. Again, it is to be emphasized that the testimony will be read by the finder of the facts, and that he will draw his findings from what he reads. Confused, discursive, incomplete statements of fact do not yield satisfactory findings.

Stand upright when taking the oath. Pay attention and say "I do" clearly. Do not slouch in the witness chair.

Do not memorize what you are going to say as a witness. If you have prepared answers to possible questions, by all means do not memorize such answers. It is, however, very important that you familiarize yourself as much as possible with the facts about which you will be called upon to testify.

During your direct examination, you may elaborate and respond more fully than is advisable on cross-examination. However, when you elaborate, do not ramble and do not stray from the main point raised by the lawyer's question. The taking of testimony is a dialogue, not a monologue. If your testimony concerns a specialized technical area, the Court or hearing officer will find it easier to understand if it is presented in the form of short answers to a logical progression of questions. In addition, by letting the lawyer control the direction of your testimony, you will avoid making remarks which are legally objectionable or tactically unwise.

Be serious at all times. Avoid laughing and talking about the case in the halls, restrooms or any place in the building where the hearing or trial is being held.

While testifying, look at the judge, hearing officer or jury most of the time, and speak frankly and openly as you would to any friend or neighbor. Do not cover your mouth with your hand. Speak clearly and loudly enough

so that anyone in the hearing room or courtroom can hear you easily. At all times make certain that the reporter taking the verbatim record of your testimony is able to hear you and record what you actually say. The case will be decided entirely on the words that are finally reported as having been the testimony given at the hearing or trial. Always make sure that you give a complete statement in a complete sentence. Half statements or incomplete sentences may convey your thought in the context of the hearing, but may be unintelligible when read from the cold record many months later.

CROSS-EXAMINATION

Concerning cross-examination, Judge Prettyman gives the following advice to prospective witnesses:

> Don't argue. Don't fence. Don't guess. Don't make wisecracks. Don't take sides. Don't get irritated. Think first, then speak. If you do not know the answer but have an opinion or belief on the subject based on information, say exactly that and let the hearing officer decide whether you shall or shall not give such information as you have. If a 'yes or no' answer to a question is demanded but you think that a qualification should be made to any such answer, give the 'yes or no' and at once request permission to explain your answer. Don't worry about the effect an answer may have. Don't worry about being bulldozed or embarrassed; counsel will protect you. If you know the answer to a question, state it as precisely and succinctly as you can. The best protection against extensive cross-examination is to be brief, absolutely accurate, and entirely calm.

Unless you are testifying as an expert, the hearing officer or judge will permit only testimony, based upon direct knowledge, as to the facts. You usually will not be allowed to testify about what someone else has told you (hearsay), and will not be allowed to provide your opinions or conclusions.

Always be polite, even to the attorney for the opposing party.

Do not be a smart aleck or cocky witness. This will cost you your credibility and the respect of the trier of the facts in the case.

Do not exaggerate or embroider your testimony.

Stop instantly when the judge or hearing officer interrupts, or when the other attorney objects to what you say. Do not try to "sneak" your answer into the record.

Do not nod your head for a "yes" or "no" answer. Speak out clearly. The reporter must hear an answer to record it.

If the question is about distances or time and your answer is only an estimate, be certain that you say it is only an estimate.

Listen carefully to the question asked of you. No matter how nice the other attorney may seem on cross-examination, he may be trying to hurt you as a witness. Understand the question. Have it repeated if necessary; then give a thoughtful, considered answer. Do not give a snap answer without thinking. You cannot be rushed into answering, although, of course, it would look bad to take so much time on each question that the judge, hearing officer or jury would think that you are making up the answers.

Answer the question that is asked, not the question that you think the examiner (particularly the cross-examiner) intended to ask. The printed record shows only the question asked, not what was in the examiner's mind and a nonresponsive answer may be very detrimental to your side's case. This situation exists when the witness thinks "I know what he is after but he hasn't asked for it." Answer only what is asked.

Explain your answers if necessary. This is better than a simple "yes" or "no." Give an answer in your own words. If a question cannot be answered truthfully with a "yes" or "no," you have a right to explain the answer.

Answer directly and simply the question asked you and then stop. Never volunteer information.

If by chance your answer was wrong, correct it immediately; if your answer was not clear, clarify it immediately.

You are sworn to tell the truth. Tell it. Every material truth should be readily admitted, even if not to the advantage of the party for whom you are testifying. Do not stop to figure out whether your answer will help or hurt your side. Just answer the question to the best of your ability.

Give positive, definite answers when at all possible. Avoid saying "I think," "I believe," "in my opinion." If you do not know, say so. Do not make up an answer. You can be positive about the important things which you naturally would remember. If asked about little details which a person naturally would not remember, it is best to say that you do not remember.

Do not act nervous. Avoid mannerisms which will make it appear that you are scared, or not telling the truth; or all that you know.

Above all, it is most important that you do not lose your temper. Testifying at length is tiring. It causes fatigue. You will recognize fatigue

by certain symptoms: (a) tiredness, (b) crossness, (c) nervousness, (d) anger, (e) careless answers, (f) willingness to say anything or answer any questions in order to leave the witness stand. When you feel these symptoms, recognize them and strive to overcome fatigue. Remember that some attorneys on cross-examination are trying to wear you out so you will lose your temper and say things that are not correct, or that will hurt you or your testimony. Do not let this happen.

If you do not want to answer a question, do not ask the judge or hearing officer member whether you must answer it. If it is an improper question, your attorney will object for you. Do not ask the presiding officer, judge or board member for advice.

Do not look at your attorney or at the judge or hearing officer for help in answering a question. You are on your own. If the question is an improper one, your attorney will object. If the judge or hearing officer then says to answer it, do so.

Do not hedge or argue with the opposing attorney.

There are several questions which are known as "trick" questions. That is, if you answer them the way the opposing attorney hopes you will, he can make your answer sound bad. Here are two of them:

"Have you talked to anybody about this matter?" If you say "no," the hearing officer or judge, or a seasoned jury, will know that is not true because good lawyers always talk to the witnesses before they testify. If you say "yes," the lawyer may try to imply that you were told what to say. The best thing to say is that you have talked to the attorney and that you were just asked what the facts were and to testify truthfully.

"Are you getting paid to testify in this matter?" The lawyer asking this hopes your answer will be "yes," thereby implying that you are being paid to say what your side wants you to say. Your answer should be something like "No, I am not getting paid to testify; I am on salary and there is no other compensation for my time beyond the reimbursement for my travel"

SAMPLE PACKAGING AND SHIPPING

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Identify the appropriate U.S. Department of Transportation (DOT) regulations covering the packaging and shipping of samples for laboratory analysis
- Identify the appropriate table to determine the class and packing group of a particular sample
- Describe the shipping requirements for a sample labeled "Environmentally hazardous substances, solid, n.o.s."
- List the hierarchy of subsidiary risk
- Review the necessary documentation for sample transport

NOTES

SAMPLE PACKAGING AND SHIPPING

RULES GOVERNING TRANSPORTATION OF SAMPLES

49 CFR 171-179

- New regulations published: December 21, 1990
- Effective date: October 1, 1991

NEW RULING

- Adopts UN labels and placards
- Adopts UN identification numbers for hazardous materials
- Provides packing standards based on performance criteria
- Makes US standards compatible with international standards

NOTES

PACKAGING CLASSES

- Packing Group I - great danger
- Packing Group II - medium danger
- Packing Group III - minor danger

Note: Most samples are in Packing Group III

COMPLIANCE DEADLINES (Performance-Oriented Packaging)

- October 1, 1991
  - Effective date of HM-181 (revised September 18, 1991)
  - Hazard communication requirement for new explosives (mandatory)

COMPLIANCE DEADLINES (Performance-Oriented Packaging)

- October 1, 1992 - Hazard communication requirement for materials poisonous by inhalation and for infectious substances (mandatory)
- October 1, 1993 - Hazard communication requirement for all hazardous materials

NOTES

COMPLIANCE DEADLINES

- October 1, 1994
  - Old DOT-specific packagings are eliminated under final rule
  - New packages must be manufactured in accordance with Parts 173 and 178
  - New placard system required

COMPLIANCE DEADLINES

- October 1, 1996 - Marks end of transition period

TRAINING FOR SAFE TRANSPORTATION OF HAZARDOUS MATERIALS

49 CFR Part 172.700

- Final rule
  - Published May 15, 1992
  - 57 FR 95 20944
- Effective date: July 1, 1992

NOTES

SCOPE OF TRAINING REQUIREMENTS

- Persons involved in transportation of hazardous materials
- Categories
  - General awareness/familiarization training
  - Function-specific training
  - Safety training
  - Driver training

SCOPE OF TRAINING REQUIREMENTS

- Initial training before October 1, 1993 (if hired before July 2, 1993)
- Train within 90 days of employment
- Refresher training once every 2 years
- DOT, private agency, or employer can provide training (must have Section 172.704 criteria)

HAZARDOUS MATERIALS

A substance or material in a quantity or form capable of posing an unreasonable risk to health, safety, and property when transported in commerce

NOTES

SAMPLES NOT REGULATED BY DOT

- Unpreserved environmental samples
- Preserved environmental samples

SAMPLES NOT REGULATED BY DOT (Preserved Environmental Samples)

Substance in Water Solution	*Concentration*
HCl	<0.04% by weight
$HgCl_2$	0.004%
HNO_3	0.35%
H_2SO_4	0.35%
NaOH	0.08%
H_3PO_4	2<pH<4

MINIMUM REQUIREMENTS FOR NONREGULATED SAMPLES

40 CFR 261.4d2ii A and B

- Sample collector's name, address, and telephone number
- Laboratory's name, mailing address, and telephone number
- Quantity of sample

NOTES

MINIMUM REQUIREMENTS FOR NONREGULATED SAMPLES

40 CFR 261.4d2ii A and B

- Date of shipment
- Description of sample
- Sample packaged to contain leaks or spills

PACKAGING REQUIREMENTS FOR LIMITED QUANTITIES

49 CFR 173.155

- Inner packagings
  - Not over 4.0 L (1 gallon) for liquids
  - Not over 5.0 kg (11 lbs) for solids
- Outer packagings
  - Not to exceed 30 kg (66 lbs)

PACKAGING LABORATORY SAMPLES

49 CFR

Determine proper shipping name, hazard class, and ID number	172.101 (table)
Determine packaging requirements and Ltd Qty exceptions	173.24 or 173.150-156
Mark package	172.301

NOTES

PACKAGING LABORATORY SAMPLES

49 CFR

Label package and additional labeling requirements	172.101 (4) 172.402-448
Prepare shipping papers	172.200-204
Placard (if necessary)	172.500

UNIDENTIFIED SAMPLES FROM CERCLA/RCRA/DOD SITES

Hazardous Materials Table 172.101

- Environmentally hazardous substances, liquid or solid, n.o.s.
- Hazard Class 9
- Packing Group III

UNIDENTIFIED SAMPLES FROM CERCLA/RCRA/DOD SITES

Hazardous Materials Table 172.101

- UN 3082 for liquids
- UN 3077 for solids
- Ltd Qty

NOTES

PACKAGING LTD QTY
Environmentally Hazardous Substances

40 CFR 173.155 (b)

- Inner packagings - VOA vials or glass jars
- Strong outer packagings
- Sufficient adsorptive and cushioning material to prevent breakage and leakage

HAZARD PRIORITY FOR SUBSIDIARY RISK

49 CFR 173.2a

1. Radioactive materials
2. Poisonous gases
3. Flammable gases
4. Nonflammable gases

HAZARD PRIORITY FOR SUBSIDIARY RISK

49 CFR 173.2a

5. Poisonous liquids or poisonous-by-inhalation
6. Pyrophoric material
7. Self-reactive material

NOTES

HAZARD PRIORITY FOR SUBSIDIARY RISK

49 CFR 173.2a

8. Flammable liquids, corrosive materials, flammable solids, spontaneously combustible materials, dangerous when wet materials, oxidizers, or poisonous liquids or solids

HAZARD PRIORITY FOR SUBSIDIARY RISK

49 CFR 173.2a

9. Combustible liquids
10. Miscellaneous hazardous materials

SHIPPING PAPERS

49 CFR 172.200

- Required for shipment if sample is a hazardous material
- Must include
  - Contents
  - Emergency response telephone number

NOTES

SHIPPING PAPERS
Description of Hazardous Materials

- Proper shipping name (Table 172.101)
- Hazard class or division
- Identification number
- Packing group
- Total quantity (e.g., 40 mL)

SHIPPING PAPERS
Additional Description Requirements

49 CFR Subpart C 172.200

- Exemptions
- Ltd Qty
- Hazardous substances
- Radioactive material

SHIPPING PAPERS
Additional Description Requirements

49 CFR Subpart C 172.200

- Empty packaging - residue
- Transportation method - air, rail, road, or water
- Dangerous when wet material

NOTES

SHIPPING PAPERS
Additional Description Requirements

49 CFR Subpart C 172.200

- n.o.s.
- Poisonous materials
- Elevated temperature materials

EPA PACKAGING RECOMMENDATIONS

EPA PACKAGING

Low-Concentration Sample

The contaminant of highest concentration is present at <10 ppm

Example: background environmental samples

Source: *A Compendium of Superfund Field Operations Methods*, section 6, page 6-1.

NOTES

EPA PACKAGING

Medium-Concentration Sample

The contaminant of highest concentration is present at >10 ppm and <15% (150,000 ppm)

Example: onsite weathered materials

Source: *A Compendium of Superfund Field Operations Methods*, section 6, page 6-1.

EPA PACKAGING

High-Concentration Sample

At least one contaminant is present at a level >15%

Example: samples from tanks and drums

Source: *A Compendium of Superfund Field Operations Methods*, section 6, page 6-1.

ENVIRONMENTAL SAMPLES

- Label and seal sample jar
- Place sample jar in plastic bag
- Place jars in cooler with vermiculite and ice
- Place shipping papers and chain of custody in cooler

NOTES

ENVIRONMENTAL SAMPLES

- Tape cooler shut
- Affix custody seals on cooler
- Ship by fastest available method

HAZARDOUS SAMPLES

- Label and seal sample jar
- Place sample jar in plastic bag
- Place jar in paint can with vermiculite
- Place paint cans in cooler with vermiculite and ice

HAZARDOUS SAMPLES

- Place shipping papers and chain of custody in cooler
- Tape cooler shut
- Affix custody seals on cooler
- Include shipper's certification
- Ship by fastest available method

NOTES

EPA RECOMMENDATIONS

- DOT regulations are legally binding
- EPA is reconsidering their recommendations in response to new DOT regulations

IATA

- International Air Transport Association (IATA) regulations on specific samples may be more stringent than EPA or DOT regulations

POTENTIAL PROBLEMS WITH SAMPLE SHIPMENT AND ANALYSIS

- Incorrect or incomplete paperwork
- Laboratory receipt of incorrect samples
- Insufficient volume for analysis requested

Source: *User's Guide to the Contract Laboratory Program,* December 1986.

NOTES

POTENTIAL PROBLEMS WITH SAMPLE SHIPMENT AND ANALYSIS

- Broken or leaking samples
- Matrices other than water or soil
- Nonhomogeneous, multiphase water or soil samples

Source: *User's Guide to the Contract Laboratory Program,* December 1986.

SAMPLE PACKAGING AND SHIPPING

DEPARTMENT OF TRANSPORTATION REGULATIONS

On December 21, 1990, the U.S. Department of Transportation (DOT) published their new transportation regulations in the *Federal Register*. These regulations modified the U.S. regulations to agree more completely with the U.N. transportation regulations. In terms of shipping samples for laboratory analysis, the regulation changes have caused some changes in the way samples may be packaged, labeled, and shipped. **Figures 1a and 1b** are a decision tree for use when shipping potentially hazardous samples. This chart is primarily for use when the sample is from an uncontrolled hazardous waste site, as opposed to an operating industrial facility sampled under the Resource Conservation and Recovery Act (RCRA). At a RCRA facility, the components of the sample should be known with some confidence and packaged according to the substance. At an uncontrolled site, however, little, if anything, may be known about the soil or drum sample.

If a sample is an offsite environmental sample, a background sample, or a sample from a domestic water well at which no contamination is known, the sample would not fall under DOT regulations and should be packaged according to the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) protocols. This involves placing the sample in a plastic bag and putting the bag in a metal or plastic cooler with bagged ice for coolant if necessary. The cooler should then be filled with enough absorbent material (e.g., vermiculite) around the sample container to absorb any spillage and prevent breakage. DOT has determined that the levels of preservatives such as nitric acid in the samples do not cause them to fall under DOT regulations as a hazardous substance. The package is then labeled and shipped by overnight carrier. Generally, the shipment is identified as an "Environmental Laboratory Sample."

If the sample is an onsite soil suspected of being contaminated with a known substance or of being hazardous by characteristic, it should be subjected to the same onsite characterization as a drum sample. However, if nothing is known about the sample (and it is not hazardous by characteristic), then it may be shipped as "Environmentally hazardous substances, liquid, n.o.s. or Environmentally hazardous substances, solid, n.o.s.." **Table 1** from 40 CFR 172.102 shows this to be a Class 9, Packing Group III, substance. The Class 9 label (**Figure 2**) is affixed to the package. The UN designation number is UN 3082 for a liquid and UN 3077 for a solid. Class 9 shipments fall under the limited quantity exception for placarding. A limited quantity is defined as inner packages not to exceed 4 L for liquids and 5 kg for solids, and strong outer packaging not to exceed 30 kg gross weight. A metal- or plastic-covered cooler will meet this specification. A shipper's declaration of dangerous goods (**Figure 3**) must be included in addition to the standard chain of custody and laboratory request forms.

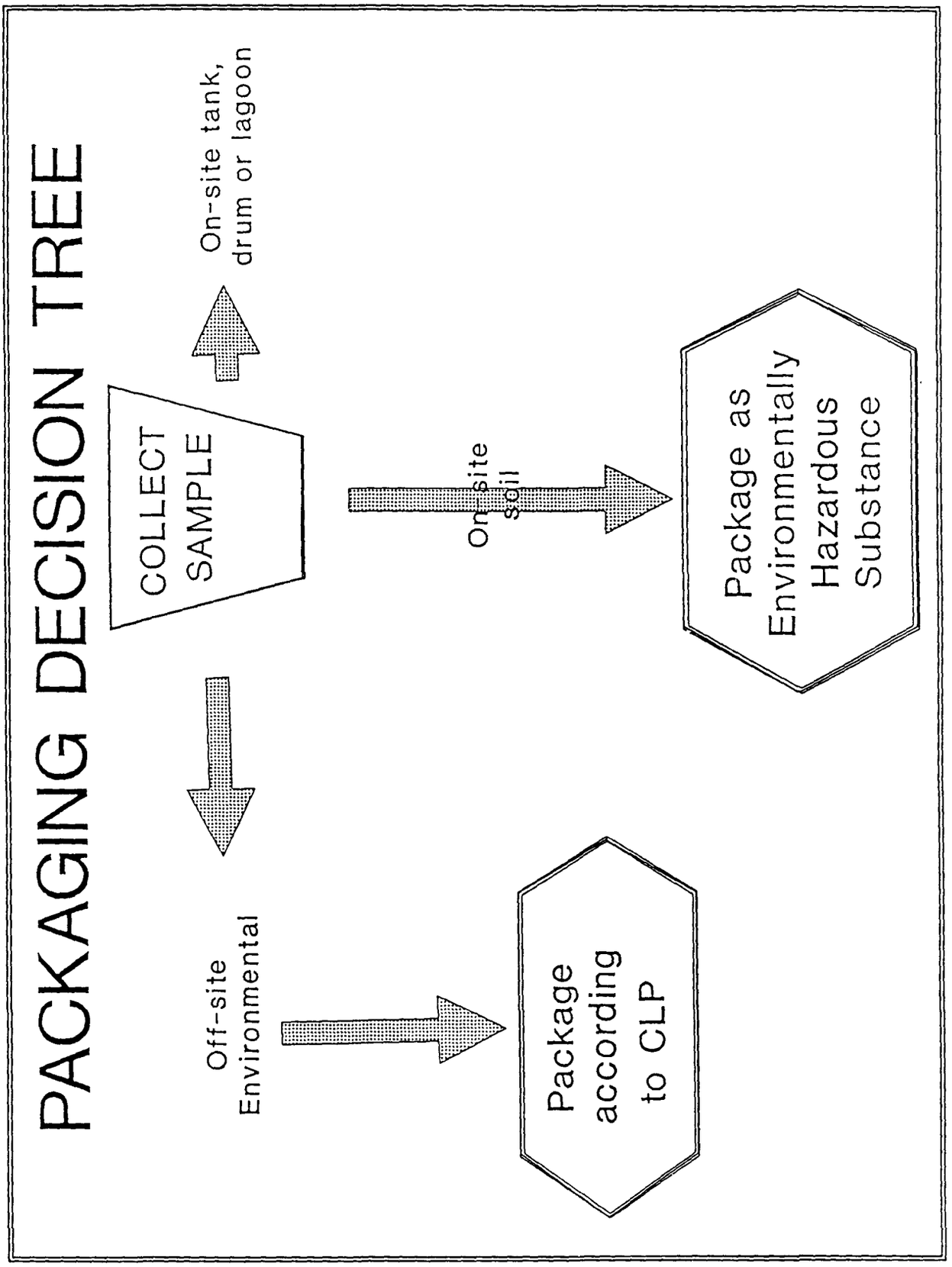


FIGURE 1a. PACKAGING DECISION TREE

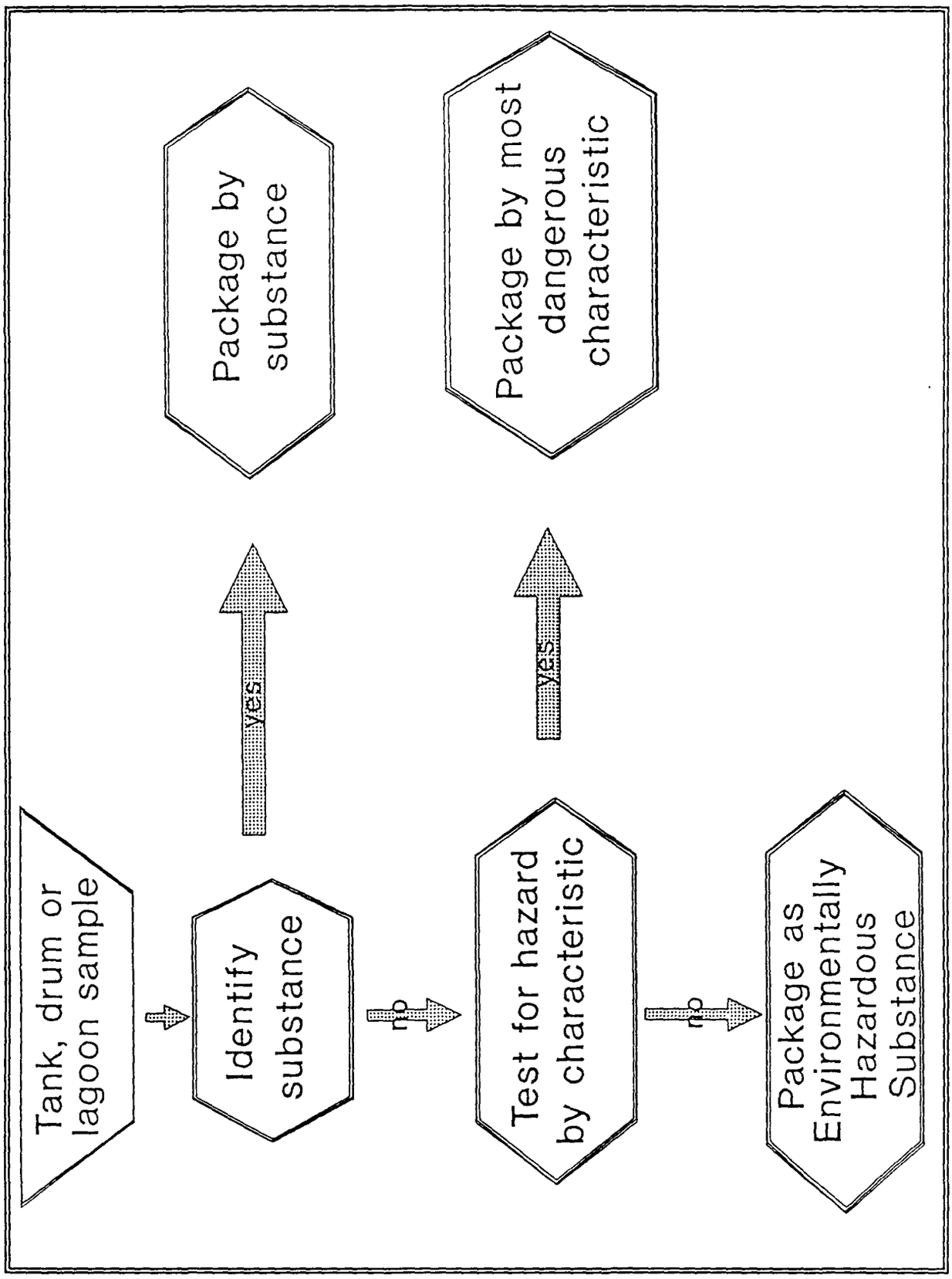


FIGURE 1B. PACKAGING DECISION TREE

Symbols (1)	Hazardous materials descriptions and proper shipping names (2)	Hazard class or Division (3)	Identification Numbers (4)	Packing group (5)	Label(s) required (if not excepted) (6)	Special provisions (7)	(8) Packaging authorizations (§173 ***) Exceptions (8A)	Non-bulk packaging (8B)	Bulk packaging (8C)	(9) Quantity limitations Passenger aircraft or railcar (9A)	Cargo aircraft only (9B)	(10) Vessel stowage requirements Vessel stowage (10A)	Other stowage provisions (10B)
	Dodecyltrichlorosilane	8	UN1771	II	CORROSIVE	A7, B2, B6, N34, T8, T26.	None	202	242	Forbidden	30 L	C	40
	Dry ice *see* Carbon dioxide, solid												
	Dyes, liquid, n.o.s. *or* dye intermediates, liquid, n.o.s. *corrosive*	8	UN2801	II	CORROSIVE	11, B2, T14	154	202	242	1 L	30 L	A	23, M3
				III	CORROSIVE	11, T14	154	203	241	5 L	60 L	A	23 M3
	Dyes liquid, n.o.s. *or* dye intermediates, liquid, n.o.s. *poisonous*	6.1	UN1602	II	POISON		None	202	243	5 L	60 L	A	M3
				III	KEEP AWAY FROM FOOD		153	203	241	60 L	220	A	M3
	Dyes, solid, n.o.s. *or* Dye intermediates, solid, n.o.s. *corrosive*	8	UN3147	II	CORROSIVE		154	212	240	15 kg	50 kg	A	M3
				III	CORROSIVE		154	213	240	25 kg	100 kg	A	M3
	Dyes, solid, n.o.s. *or* dye intermediates, solid, n.o.s. *poisonous*	6.1	UN3143	I	POISON	A5	None	211	242	5kg	50kg	A	M3
				II	POISON		None	212	242	25 kg	100 kg	A	M3
				III	KEEP AWAY FROM FOOD.		153	213	240	100 kg	200 kg	A	M3
	Dynamite, see Explosive, blasting, type A												
	EDTA, *see* Ethylenediaminetetraacetic acid												
	Electrolyte (acid or alkali) for batteries, see Battery fluid, acid *or* Battery fluid, alkali.												
	Engines, internal combustion, *see* Vehicle, self-propelled												
	Engine starting fluid, *with flammable gas*	2.1	UN1960		FLAMMABLE GAS.	B13	306	304	244	Forbidden	150 kg	D	40
	Environmentally hazardous substances, liquid, n.o.s.	9	UN3082	III	CLASS 9	8	155	203	241	None	None	A	M6
	Environmentally hazardous substances, solid, n.o.s.	9	UN3077	III	CLASS 9	8, B54	155	213	240	None	None	A	M6
	Epibromohydrin	6.1	UN2558	I	POISON		None	201	243	Forbidden	Forbidden	D	40
	Epichlorohydrin	6.1	UN2023	II	POISON		None	202	243	5 L	60 L	A	40
	1,2-Epoxy-3-ethoxypropane	3	UN2752	III	FLAMMABLE LIQUID.	B1, T1	150	203	242	60 L	220 L	A	
	Etching acid, liquid, n.o.s., see Hydrofluoric acid, solution												
	Ethane, compressed	2.1	UN1035		FLAMMABLE GAS.	B13	306	304	302	Forbidden	150 kg	E	40
D	Ethane-Propane mixture, refrigerated liquid (*cryogenic liquid*)	2.1	NA1961		FLAMMABLE GAS.	B13	None	316	314, 315	Forbidden	Forbidden	D	40
	Ethane, refrigerated liquid (*cryogenic liquid*)	2.1	UN1961		FLAMMABLE GAS.	B13	None	316	315	Forbidden	Forbidden	D	40
	Ethanol amine dinitrate	Forbidden											
	Ethanolamine *or* Ethanolamine solutions	8	UN2491	III	CORROSIVE	T7	154	203	241	5 L	60 L	A	
	Ethanol, (ethyl alcohol) *or* Ethanol Solutions, (ethyl alcohol solutions)	3	UN1170	II	FLAMMABLE LIQUID.	T1	150	202	242	5 L	60 L	A	
				III	FLAMMABLE LIQUID.	B1, T1	150	203	242	60 L	220 L	A	
	Ether, see Diethyl ether												
	Ethyl acetate	3	UN1173	II	FLAMMABLE LIQUID.	T2	150	202	242	5 L	60 L	B	
	Ethylacetylene, inhibited	2.1	UN2452		FLAMMABLE GAS	B13	None	304	244	Forbidden	150 kg	B	40
	Ethyl acrylate, inhibited	3	UN1917	II	FLAMMABLE LIQUID.	T8	150	202	242	5 L	60 L	B	40, M12
	Ethyl alcohol, *see* Ethanol												
	Ethyl aldehyde, see Acetaldehyde												
	Ethylamine	2.1	UN1036		FLAMMABLE GAS.	B13, B64, B77	None	321	244	Forbidden	Forbidden	D	40
	Ethylamine, aqueous solution *with not less than 50 per cent but not more than 70 per cent ethylamine*	3	UN2270	II	FLAMMABLE LIQUID.	T14	150	202	242	5 L	60 L	E, B	40
	Ethyl amyl ketone	3	UN2271	III	FLAMMABLE LIQUID.	B1, T1	150	203	242	60 L	220 L	A	

TABLE 1. HAZARDOUS MATERIALS TABLE, 40 CFR 172.102

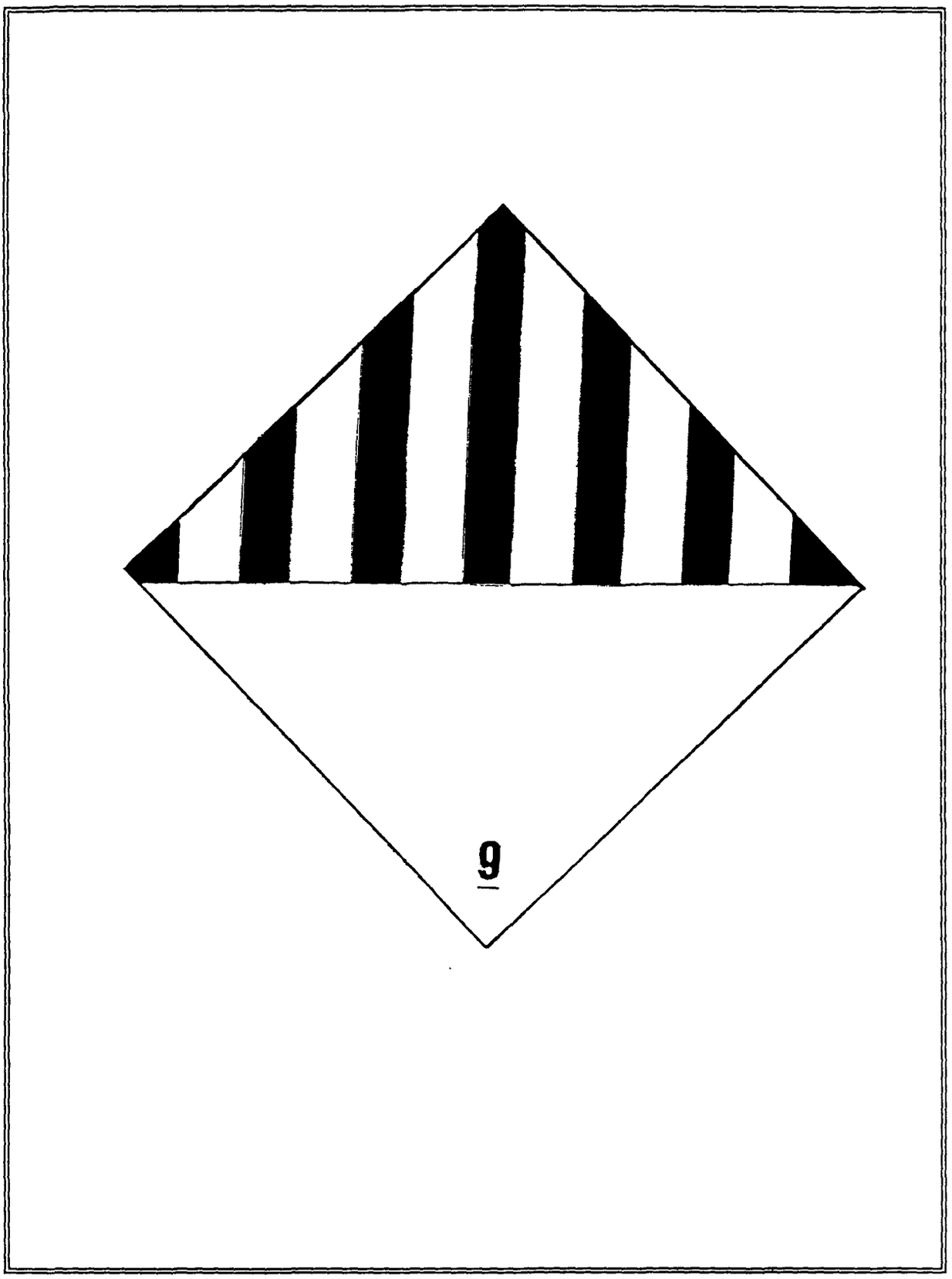


FIGURE 2. CLASS 9 LABEL

SHIPPER'S DECLARATION FOR DANGEROUS GOODS (Provide at least two copies to the airline.)

Shipper	Air Waybill No Page of Pages Shipper's Reference Number (optional)
Consignee	
Two completed and signed copies of this Declaration must be handed to the operator	WARNING Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for: *(delete non-applicable)* PASSENGER AND CARGO AIRCRAFT / CARGO AIRCRAFT ONLY	Airport of Departure
Airport of Destination:	Shipment type: *(delete non-applicable)* NON-RADIOACTIVE / RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS *(See Sub-Section 8.1 of IATA Dangerous Goods Regulations)*

Dangerous Goods Identification						
Proper Shipping Name	Class or Division	UN or ID No.	Subsidiary Risk	Quantity and type of packing	Packing Inst.	Authorization

Additional Handling Information

24 hr Emergency Contact Tel No _____

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 labelled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.	Name/Title of Signatory Place and Date Signature *(see warning above)*

FIGURE 3. SHIPPER'S DECLARATION OF DANGEROUS GOODS

Samples from drums, tanks, lagoons, sludge pits, or settling ponds will be the most likely to yield high concentration or high hazard samples. The first step is to identify the sample by substance (e.g., benzene). If identification is possible, the sample should be packaged by the substance according to the hazardous materials table in 40 CFR 172.102. If the substance cannot be identified, then the sample should be classified by characteristic, such as flammable or corrosive. Field characterization tests can be performed for most characteristics, including radioactivity, the highest hazard class. If the substance is hazardous by characteristic, it should be packaged accordingly. If it is a mixture, the hierarchy of hazards and exceptions in 40 CFR 173.2a should be referred to. If the sample cannot be identified by substance and if it is not hazardous by characteristic, then it should be classified as "Environmentally hazardous substances, liquid, n.o.s." or " Environmentally hazardous substances, solid, n.o.s." and packaged as above.

PACKAGING, LABELING, AND SHIPPING

taken from:

EPA/540/P-87/001
(OSWER Directive 9355.0-14)
December 1987

A COMPENDIUM OF SUPERFUND FIELD OPERATIONS METHODS (Section 6)

OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
OFFICE OF WASTE PROGRAMS ENFORCEMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

6.2 PACKAGING, LABELING AND SHIPPING

6.2.1 Scope and Purpose

This subsection describes the packaging, labeling and shipping used for environmental and hazardous samples collected at a waste site.

6.2.2 Definitions

Low-Concentration Sample
The contaminant of highest concentration is present at less than 10 parts per million (ppm). Examples include background environmental samples.

Medium-Concentration Sample
The contaminant of highest concentration is present at a level greater than 10 ppm and less than 15 percent (150,000 ppm). Examples include material onsite that is obviously weathered.

High-Concentration Sample
At least one contaminant is present at a level greater than 15 percent. Samples from drums and tanks are assumed to be high concentration unless information indicates otherwise.

Routine Analytical Services (RAS)
Analysis of a soil or water sample on a 30- to 45-day turnaround time for a list of 126 organics, 23 metals, and cyanide.

Site Manager (SM)
The individual responsible for the successful completion of a work assignment within budget and schedule. The person is also referred to as the Site Project Manager or the Project Manager and is typically a contractor's employee (see Subsection 1.1).

6.2.3 Applicability

The procedures described in this subsection apply to samples collected at a waste site. They must be followed whether shipping to a CLP laboratory or a noncontract laboratory.

The shipment of hazardous materials is governed by the Transportation Safety Act of 1974. Following is a list of references that detail the regulations:

- Title 49 CFR
  - Parts 100-177 – Shipper Requirements and Hazardous Material Table
  - Parts 178-199 – Packaging Specifications
  - Section 262.20 – Hazardous Waste Manifest
- International Civil Aviation Regulations (ICAO)
  - Technical Instructions for the Safe Transport of Dangerous Goods by Air (lists mandatory international and optional domestic regulations)
- International Air Transport Association (IATA)
  - Dangerous Goods Regulations (This tariff incorporates 49 CFR, ICAO, and additional IATA regulations. Most international and domestic airlines belong to IATA and require conformance to all applicable regulations.)
- Tariff BOE-6000-D (reprint of 49 CFR with updates)

6.2.4 Responsibilities

Detailed responsibilities are described in the procedures subsection. General responsibilities are assigned as follows:

- Site Managers will state, to the best of their knowledge, whether samples planned for collection are environmental or hazardous samples.
- Equipment manager will procure shipping supplies (metal cans, shipping labels, vermiculite, etc.) using RSCC whenever needed.
- Sampling personnel will properly label and package the samples.

6.2.5 Records

The user should refer to Section 4 for discussion of the records associated with sample collection and chain-of-custody forms.

The following records are associated with the labeling and shipping process:

- Sample tag or label
- Traffic report label

- Custody seal
- Chain-of-custody (COC) form
- Bill of lading (airbill or similar document)

Examples of the first four documents are given in Subsections 4.6 and 5.1.6; an example of an airbill is given in Subsection 6.2.

6.2.6 Procedures

The procedures described in this subsection are carried out after the sample preservation described in Subsection 6.1.6.2. They are generic in nature; an approach to regional differences is presented in Subsection 6.2.7.

6.2.6.1 Environmental Samples

Low-concentration samples are defined as environmental samples and should be packaged for shipment as follows:

1. A sample tag is attached to the sample bottle. Examples of properly completed sample tags are given in Exhibit 5-7.

2. All bottles, except the volatile organic analysis (VOA) vials, are taped closed with electrical tape (or other tape as appropriate). Evidence tape may be used for additional sample security.

3. Each sample bottle is placed in a separate plastic bag, which is then sealed. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape for additional security.

4. A picnic cooler (such as a Coleman or other sturdy cooler) is typically used as a shipping container. In preparation for shipping samples, the drain plug is taped shut from the inside and outside, and a large plastic bag is used as a liner for the cooler. Approximately 1 inch of packing material, such as asbestos-free vermiculite, perlite, or styrofoam beads, is placed in the bottom of the liner. Other commercially available shipping containers may be used. However, the use of such containers (cardboard or fiber boxes complete with separators and preservatives) should be specified in the sampling plan and approved by the EPA RSCC if CLP is used.

5. The bottles are placed in the lined picnic cooler. Cardboard separators may be placed between the bottles at the discretion of the shipper.

6. Water samples for low or medium-level organics analysis and low-level inorganics analysis <u>must</u> be shipped cooled to 4°C with ice. <u>No ice</u> is to be used in shipping inorganic low-level soil samples or medium / high-level water samples, or organic high-level water or soil samples, or dioxin samples. Ice is not required in shipping soil samples, but may be utilized at the option of the sampler. All cyanide samples, however, must be shipped cooled to 4°C.

7. The lined cooler is filled with packing material (such as asbestos-free vermiculite, perlite, or styrofoam beads), and the large inner (garbage bag) liner is taped shut. Sufficient packing material should be used to prevent sample containers from making contact during shipment. Again, evidence tape may be used.

8. The paperwork going to the laboratory is placed inside a plastic bag. The bag is sealed and taped to the inside of the cooler lid. A copy of the COC form should be included in the paperwork sent to the laboratory. Exhibit 5-4 gives an example of a properly completed COC form. The last block on the COC form should indicate the overnight carrier and airbill number. The airbill must be filled out before the samples are handed over to the carrier. The laboratory should be notified if another sample is being sent to another laboratory for dioxin analysis, or if the shipper suspects that the sample contains any other substance for which the laboratory personnel should take safety precautions.

9. The cooler is closed and padlocked or taped shut with strapping tape (filament-type).

10. At least two signed custody seals are placed on the cooler, one on the front and one on the back. Additional seals may be used if the sampler or shipper thinks more seals are necessary. Exhibit 5-6 gives an example of the two types of custody seals available.

11. The cooler is handed over to the overnight carrier, typically Federal Express. A standard airbill is necessary for shipping environmental samples. Exhibit 6-4 shows an example of the standard Federal Express airbill.

6.2.6.2 Hazardous Samples

Medium- and high-concentration samples are defined as hazardous and must be packaged as follows:

1. A sample tag is attached to the sample bottle. Examples of properly completed sample tags are shown in Exhibit 5-7.

2. All bottles, except the VOA vials, are taped closed with electrical tape (or other tape as appropriate). Evidence tape may be used for additional security.

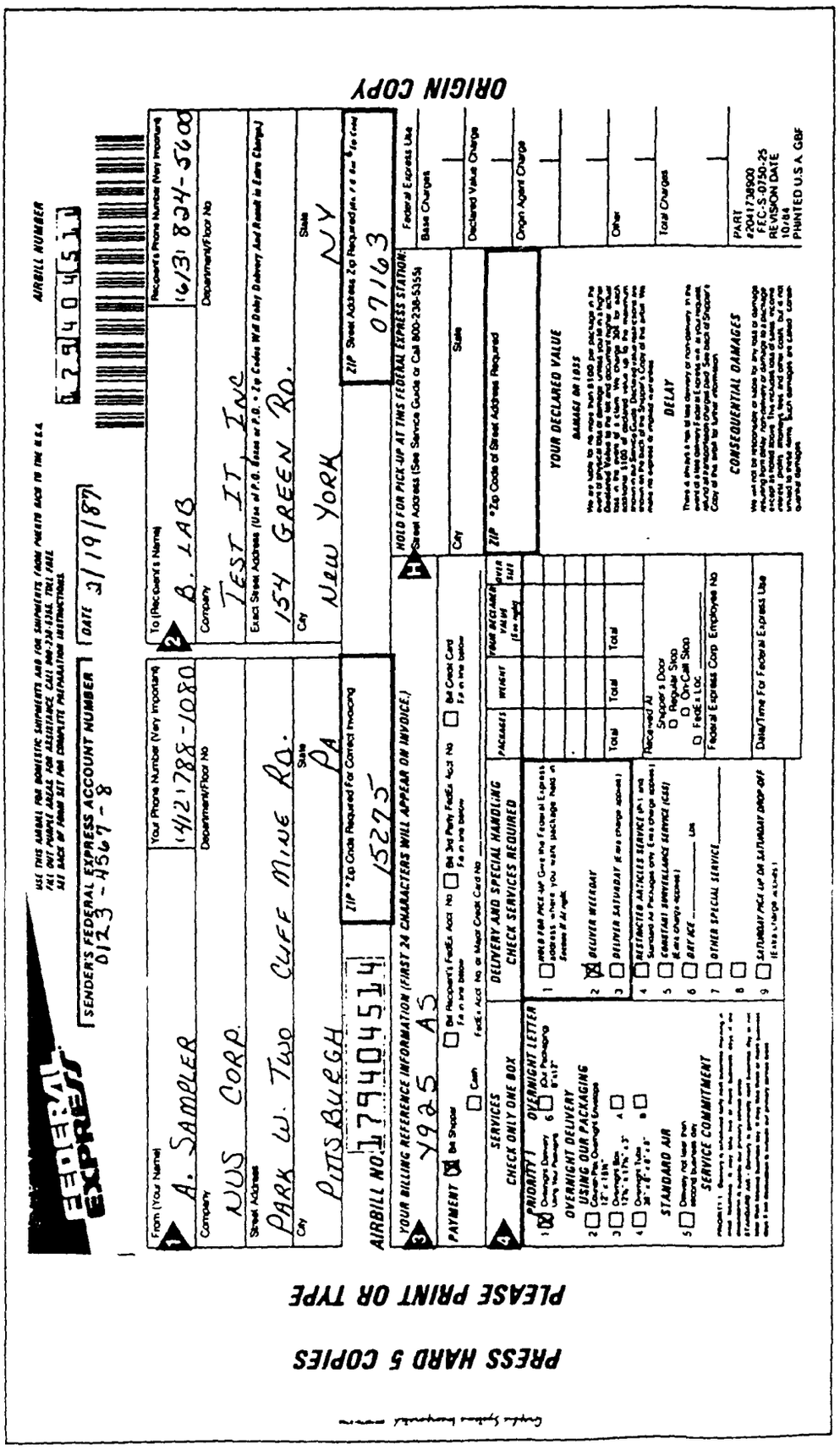
3. Each sample bottle is placed in a plastic bag, and the bag is sealed. For medium-concentration water samples, each VOA vial is wrapped in a paper towel, and the two vials are placed in one bag. As much air as possible is squeezed from the bags before sealing. Evidence tape may be used to seal the bags for additional security.

4. Each bottle is placed in a separate paint can, the paint can is filled with vermiculite, and the lid is fixed to the can. The lid must be sealed with metal clips or with filament or evidence tape; if clips are used, the manufacturer typically recommends six clips.

5. Arrows are placed on the can to indicate which end is up.

6. The outside of each can must contain the proper DOT shipping name and identification number for the sample. The information may be placed on stickers or printed legibly. A liquid sample of an uncertain nature is shipped as a flammable liquid with the shipping name "FLAMMABLE LIQUID, N.O.S." and the identification number "UN1993." A solid sample of uncertain nature is shipped as a flammable solid with the shipping name "FLAMMABLE SOLID, N.O.S."

Exhibit 6-4
STANDARD FEDERAL EXPRESS AIRBILL



and the identification number "UN1325." If the nature of the sample is known, 49 CFR-171-177 is consulted to determine the proper labeling and packaging requirements.

7. The cans are placed upright in a cooler that has had its drain plug taped shut inside and out, and the cooler has been lined with a garbage bag. Vermiculite is placed on the bottom. Two sizes of paint cans are used: half-gallon and gallon. The half-gallon paint cans can be stored on top of each other; however, the gallon cans are too high to stack. The cooler is filled with vermiculite, and the liner is taped shut.

8. The paperwork going to the laboratory is placed inside a plastic bag and taped to the inside of the cooler lid. A copy of the COC form, an example of which is shown in Exhibit 5-4, should be included in the paperwork sent to the laboratory. The sampler keeps one copy of the COC form. The laboratory should be notified if a parallel sample is being sent to another laboratory for dioxin analysis, or if the sample is suspected of containing any substance for which laboratory personnel should take safety precautions.

9. The cooler is closed and sealed with strapping tape. At least two custody seals are placed on the outside of the cooler (one on the front and one on the back). More custody seals may be used at the discretion of the sampler.

10. The following markings are placed on the top of the cooler:

- Proper shipping name (49 CFR 172.301)
- DOT identification number (49 CFR 172.301)
- Shipper's or consignee's name and address (49 CFR-172.306)
- "This End Up" legibly written if shipment contains liquid hazardous materials (49 CFR 172.312)

Other commercially available shipping containers may be used. The SM should ascertain that the containers are appropriate to the type of sample being shipped. The SM should clearly specify the type of shipping container to be used in the QAPjP.

11. The following labels are required on top of the cooler (49 CFR 172.406e):

- Appropriate hazard class label (placed next to the proper shipping name)
- "Cargo Aircraft Only" (if applicable as identified in 49 CFR 172.101)

12. An arrow symbol(s) indicating "This Way Up" should be placed on the cooler in addition to the markings and labels described above.

13. Restricted-article airbills are used for shipment. Exhibit 6-5 shows an example of a restricted article Federal Express airbill. The "Shipper Certification for Restricted Articles" section is filled out as follows for a flammable solid or a flammable liquid:

- Number of packages or number of coolers
- Proper shipping name: if unknown, use
  - Flammable solid, N.O.S., or
  - Flammable liquid, N.O.S.

- Classification; if unknown, use
  - Flammable solid or
  - Flammable liquid

- Identification number; if unknown, use
  - UN1325 (for flammable solids) or
  - UN1993 (for flammable liquids)

- Net quantity per package or amount of substance in each cooler

- Radioactive materials section (Leave blank.)

- Passenger or cargo aircraft (Cross off the nonapplicable. Up to 25 pounds of flammable solid per cooler can be shipped on a passenger or cargo aircraft. Up to 1 quart of flammable liquid per cooler can be shipped on a passenger aircraft, and up to 10 gallons of flammable liquid per cooler can be shipped on a cargo aircraft.)

- Name and title of shipper (printed)

- An emergency telephone number at which the shipper can be reached within the following 24 to 48 hours

- Shipper's signature

Note: The penalties for improper shipment of hazardous materials are severe; a fine of $25,000 and 5 years imprisonment can be imposed for each violation. The SM or designee is urged to take adequate precautions.

6.2.7 Regional Variances

There are no known regional variances for the shipment of hazardous samples. However, regional variances for the shipment of environmental samples (low concentration) are common. Information in a compendium on such variances can become dated rapidly. Thus, users are urged to contact the EPA RPM or the RSCC for the latest regional variances.

1. Region I includes the five-digit laboratory number of each sample in the "Remarks" section of the chain-of-custody form to act as a cross check on sample identification.

2. Separators must be placed between the bottles of samples shipped from a Region IV site. ESD also tapes the VOA vials and uses blue ice.

3. Region V tapes the VOA vials and does not line the cooler with a plastic bag. Region V FIT indicates the OTR / ITR number, bottle lot numbers, sample concentrations, and matrix in the right-hand portion of the "Remarks" section of the chain-of-custody form. The custody seal numbers, airbill number, and "samples shipped via Federal Express" are included in the lower right-hand section.

4. Region VI does not tape sample bottles, put sample bottles in plastic bags, or line coolers with plastic. Glass bottles are wrapped with "bubble wrap" instead of cardboard separators. In addition, the traffic report stickers are placed at the liquid level on the sample bottles to allow the laboratories to check for leakage.

5. Region VIII does not put the sample in a plastic bag.

Because information on variances can become dated rapidly, the user should contact the EPA RPM or RSCC for current regional practices and requirements. Future changes and additional regional variances will be incorporated in Revision 01 of this document.

6.2.8 Information Sources

CH2M HILL. *REM/FIT Documentation Protocol for Region V.* May 1984.

Code of Federal Regulations, Title 49, Parts 171 to 177, Transportation.

U.S. Environmental Protection Agency. *Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual.* Region IV, Environmental Services Division. 1 April 1986.

U.S. Environmental Protection Agency. *The User's Guide to the Contract Laboratory Program.* Office of Emergency and Remedial Response. December 1986.

FIELD EXERCISE

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- Sample groundwater, soil, sediment, surface water, and containerized waste using the proper tools and techniques
- List the appropriate sampling equipment according to media and the advantages and disadvantages of each
- Properly label all types of sample containers
- Properly complete the necessary shipping documentation
- Correctly complete the chain of custody for each collected sample

FIELD EXERCISE DESCRIPTION

STATION ONE: SOIL SAMPLING

The following equipment is available:

Bucket augers	Push tube sampler
Hand trowels	Stainless steel pans
Soil trier	Split spoon sampler

Each team will collect one composite sample for semivolatile analysis and one grab sample for volatile analysis.

STATION TWO: FIELD DECONTAMINATION

The following equipment will be available:

Isopropyl alcohol	Brushes
Buckets	Detergent and water
Spray and squirt bottles	Aluminum foil
Catch basins	

Each team will field decontaminate at least two different pieces of sampling equipment from the soil and/or groundwater station. Each team will collect a field blank for volatiles.

STATION THREE: SOIL GAS SAMPLING

The following equipment will be demonstrated:

Soil gas probe and slam bar	HW 101 Hnu photoionization detector
Gillian pump and desiccator	

STATION FOUR: SURFACE WATER AND SEDIMENT SAMPLING

The following equipment is available:

LaMotte sampler	Ponar dredge
Bacon bomb	Peristaltic pump
Kemmerer sampler	Hand auger
Gravity corer	Alpha sampler
Ekman dredge	Beta sampler

Each team will collect a grab sample of surface water for cyanide analysis and a sediment sample for metals analysis.

STATION FIVE: GROUNDWATER SAMPLING

The following equipment is available:

Water level indicator	Bailers (PVC, PTFE, stainless steel)
Bladder pump	Peristaltic pump
pH meter	Waterra pump

Each team will collect two 40 mL vials for volatile analysis from each well and take water level and pH measurements from the appropriate well.

STATION SIX: CONTAINERIZED WASTE SAMPLING—55-GALLON DRUMS

The following equipment is available:

COLIWASA	Drum thief
Bacon bomb	Bung wrenches
Grain thief	Mucksucker

Each team will collect a representative sample from a drum for pesticide/PCB analysis.

WORK ORDER #_____ CUSTODY №

PROJECT_____ SAMPLED BY_____

LOCATION_____

CHAIN OF CUSTODY RECORD

SAMPLE NUMBER	DATE	TIME	SAMPLE LOCATION	MATRIX	COMPOSITE OR GRAB	FIELD MEASUREMENTS	NO. OF CONTAINERS	ANALYSIS REQUIRED							REMARKS (PRESERVATION, ETC.)

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 by: (Signature)	Shipped/Delivered:	Date	Time	
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Remarks.			
Relinquished by: (Signature)	Date	Time	Received for Laboratory by. (Signature)				

INDIVIDUAL DRUM LOG SHEET

Job #_____ Date_____ Page_____ of_____

Client_____

==========

Drum #_____ Sample #_____

Drum Size: ☐ 85 Gallon ☐ 55 Gallon ☐ 42 Gallon ☐ 30 Gallon
☐ 15 Gallon ☐ 5 Gallon ☐ Other_____

Type of Drum: ☐ Fiber ☐ Poly ☐ Steel ☐ Open Top ☐ Tight Head ☐ Other_____

==========

Description of Sample: HNU Reading_____

LAYER 1 (TOP)

Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge

_____

_____

LAYER 2 (MIDDLE)

Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge

_____

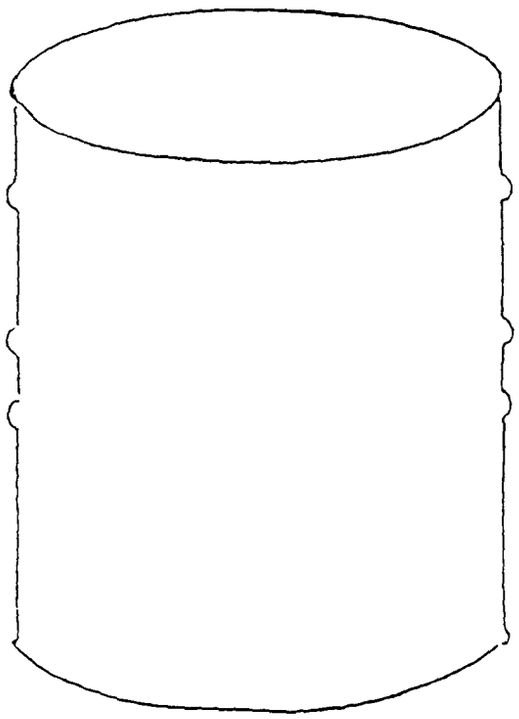
_____

LAYER 3 (BOTTOM)

Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge

_____

_____



Amount in Drum: ☐ Empty (< 1" residuals) ☐ 1/4 ☐ 1/2 ☐ 3/4 ☐ Full

==========

Description of Drum (Drum Label, Markings and Conditions): Overpack Needed? ☐ Yes ☐ No

_____

_____

_____

Compatibility Group:_____ Composite Number_____

Time_____ Sampled by_____ Witness_____

PROBLEM SESSION: SAMPLE PLAN DEVELOPMENT EXERCISE

PERFORMANCE OBJECTIVES

At the end of this lesson, participants will be able to:

- List the elements of a phased sampling plan
- Perform the initial elements of a sampling event from background data analysis through field data point selection, collection, and analysis

SAMPLING FOR HAZARDOUS MATERIALS

Sample Plan Development Exercise
American Creosote Works, Inc., Winnfield, Louisiana

PROJECT OBJECTIVE

Your environmental consulting firm, _____, has been contracted by the U.S. Environmental Protection Agency (EPA) to develop a sampling plan for the American Creosote Works, Inc., (ACWI) facility. The site may be evaluated using background data, field screening techniques, and some limited sampling of water and sediment. Finally, your firm is to outline in a class presentation its recommendations of further sampling points, including monitoring wells.

PROJECT SCOPE

Phase I: Background Data Search

You will do a thorough background search of the information available. This information will assist you in establishing the objectives for the remaining phases of the project. This information will be provided to you and the cost of obtaining the information will be subtracted from your total budget for Phases I and II. This phase will include a site walkover.

Phase II: Selection and Implementation of Field Screening Techniques

Choose the field screening technique, level of analytical support, and location of sampling points. Once you have decided where to sample, visit the instructors at the "data table" and purchase your field data. Your budget for Phases I and II is $27,000. You may not exceed your budget. Phase II should be broken down into discrete sampling events as if the sampling were proceeding on a day-by-day basis. In other words, get a few boring logs and some soil gas data, review them, and then decide where to sample next.

Phase III: Development of a Sampling and Analysis Plan

Evaluate your preliminary data from Phases I and II and develop a sampling and analysis plan for the next step in the investigation of the ACWI site. Select the sample locations, media, analytical support level, procedures, etc.

Phase IV : Results and Conclusions

Present your sampling and analysis plan (as well as any conclusions and recommendations) to the class. Choose a spokesperson to present your firm's efforts. By preparing this presentation, you

will have to organize your findings, develop a reasonable conceptual model, and make your recommendations understandable to someone outside your group. Though a rough budget should be presented, this is not an exercise in finding the low bidder. The presentation should concentrate on the proposed sampling locations; the screening phase should be only **briefly** summarized.

BUDGET WORKSHEET

Phase I: Background Data Search (Total Cost - $1500.00)

Phase II: Selection and Implementation of Field Screening Techniques

Your estimate indicates the approximate costs for the completion of Phase II.

Mobilization fee	$3000.00	$3000.00
Ambient air monitoring for entire site (OVA-128, GC mode, tentative identification)	$1100.00	_____
Shallow soil boring, stratigraphic identification	$500.00 ea.	_____
Soil gas survey in 4 × 0.25-acre sets	$1000.00/acre	_____
Water analysis of drive points (volatiles and base/neutral and acid extractables [BNAs] only)	$500.00/point	_____
Surface water and sediment analysis (volatile organic analysis [VOA] and BNAs only)	$500.00/sample	_____

This price schedule does not take into account any surcharge for higher levels of protection than Level D. **IMPORTANT:** you must do an air monitoring survey before **any** other work is performed on the site. This will allow you to make a determination of the level of protection appropriate for the site. However, no surcharge for higher levels of protection will be added at this time.

TOTAL BUDGET FOR PHASES I AND II = $27,000.00

BUDGET WORKSHEET

Phase III: Development of a Sampling and Analysis Plan

Phase IV: Results and Conclusions

Your recommendations may include the following analytical support. The prices provided must be used to approximate the cost of your recommendations. Calculate the amount spent on each phase, particularly the cost of your Phase III sampling effort.

Data interpretation, report preparation	$ 5500.00	$ 5500.00
VOAs	$ 400.00	_____
BNAs	$ 750.00	_____
Pesticides/PCBs	$ 440.00	_____
Total inorganics	$ 625.00	_____
Benzene, toluene, ethylbenzene, and xylenes (BTEX)	$ 100.00	_____
Exploratory borings		_____
Monitoring wells		_____
Heavy equipment		_____
Geophysical surveys		_____

Drilling and sampling will be $50.00 per foot (the same as Phase II). To construct a monitoring well in the boring, add $500.00 for materials and installation. Again, no surcharge will be assessed for increased levels of protection (above Level D). However, you must determine what level of protection is appropriate. Be sure to include the appropriate number of quality assurance and quality control samples and their cost. Figure an additional 10% surcharge to complete the chain-of-custody paperwork and properly package the samples for shipment.

TOTAL BUDGET FOR PHASES I AND II _____

TOTAL BUDGET FOR PHASE III _____

TOTAL PROJECT BUDGET _____

PHASE I: BACKGROUND DATA

Louisiana Department of Environmental Quality Files

The Louisiana Department of Environmental Quality (LDEQ) had reports of potential waste management problems at the ACWI site in Winnfield. LDEQ issued a Compliance Order 2 years previous. Last year, LDEQ found the site abandoned and the case was referred to EPA. EPA is the now the lead agency on the environmental assessment and, as such, all pertinent file information has been transferred to EPA.

U.S. Army Corps of Engineers' Files

The U.S. Army Corps of Engineers' files show no record of an application by American Creosote Works, Inc., to fill, build upon, or otherwise alter a wetland. No further information is available regarding ACWI.

Louisiana Geological Survey

Winnfield, Louisiana, is within the Mississippi embayment section of the Gulf Coastal Plain. Deposits in this region consist mainly of braided stream channel deposits (sand, silts, and clays with associated interspersed gravel).

The ACWI facility is located on the Cockfield Formation. This formation was deposited during the Tertiary Period (65 to 10 million years before present). It consists primarily of interbedded clays, silts, and sands with significant lignite (a brownish-black coal that is intermediate in coalification between peat and a subbituminous coal) deposits.

Soil Conservation Survey Data

The Soil Conservation Service (SCS) survey for the area is incomplete at this time. Preliminary data indicate that the soil type is composed of fine-grained, organic-rich material characteristic of flood plain or marsh deposits.

Information from the Chamber of Commerce

The ACWI site has been operating under various names and owners in this location for about ninety years. It has been the site of wood-preserving operations since approximately 1910, when it was bought by the Louisiana Creosoting Company. The major product lines in recent years have been telephone poles and railroad ties.

Interview with the Site Owner

The site owner's representative refused to divulge any information when he found out your company was working on a site characterization of ACWI. He suggested you speak with the facility's legal representative.

State of Louisiana Water Supply Board Files

The State of Louisiana Water Supply Board files indicate that there are no known water supply wells in the vicinity of the ACWI site. The wells for the city of Winnfield are located over a mile from the site and are screened in the Sparta formation at a depth of about 600 feet below ground surface.

Information from the Tax Assessor's Office

The American Tie & Telephone Company is located in the town of Winnfield, Louisiana, on a small access road. It is near several major truck routes and railroad lines. All taxes are currently paid.

The property consists of two large and three small buildings, as well as a number of vertical storage tanks and pressure vessels.

Climatological Data

The climate in Winnfield, Louisiana, is subtropical. The average temperature (1951-1980) ranges from 47° in January to 81° in July and August. The average net annual rainfall is 50 inches. The heaviest rainfall is in April and May and the lightest is in October. Tropical storms and hurricanes occasionally pass through the area. Flood-producing rains may occur during any month of the year.

Historical precipitation data:

2 yr 30 min	1.7 in.
10 yr 30 min	2.4 in.
100 yr 30 min	3.5 in.
2 yr 1 hr	2.2 in.
10 yr 1 hr	3 in.
100 yr 1 hr	4 in .
2 yr 6 hr	3.5 in.
10 yr 6 hr	5.5 in.
100 yr 6 hr	8 in.
2 yr 24 hr	4.5 in.
10 yr 24 hr	8.5 in.
100 yr 24 hr	11 in.

Mean annual lake evaporation is 48 inches.

Interview with Local Residents

The local fire department was contacted to determine whether any fire-related problems had been attributed to the facility. Fire department records did not indicate that any fires had occurred at the facility. Mr. Mercer, the fire chief, did recall that the fire department had been asked to provide help at the publicly owned treatment works (POTW) to remove siltation within one of the construction areas. Sediments from Creosote Branch had backwashed into one of the concrete basins under construction and needed to be removed. During removal, members of the construction crew experienced blistered skin and breathing difficulties. Creosote was reportedly smelled. Mr. Mercer did not know whether anyone had received medical attention for injuries specific to the removal efforts.

Hydrologic Information

The groundwater table in the vicinity of the site is shallow, as indicated by the numerous marshy areas surrounding the site. At the site, groundwater was encountered within 10 feet of the ground surface. Using a limited number of shallow wells in the area, the near-surface aquifer flow direction and velocity were estimated using the triangulation method and Darcy's law. The direction of groundwater flow is generally to the north in the general area of the site. Groundwater seepage velocity is approximately 0.9 feet per day.

The local residents are all on city water, which is obtained from four wells. Each of the wells is screened in the Sparta Sand Formation. Water analysis shows no contaminants in the water supply at this time.

The ACWI site is located in Winn Parish, in the town of Winnfield, Louisiana, and is a part of the flood plain of the Mississippi River. The region is heavily forested, primarily with tall standing white pines and some cedar. It is located within easy access to several truck routes and railroad lines. The property is relatively flat, with a total relief of 19 feet. Drainage is to the north and east into Creosote Branch and is enhanced by the presence of two major drainage ditches (**Figure 1**). A third smaller drainage ditch is also present on the site.

Access to the site is limited, largely due to the surrounding wetlands and heavily forested areas. A perimeter reconnaissance of the site was performed in August 1989. At the time of the reconnaissance, several storage tanks were present at the facility. There was a large (approximately 100 ft by 300 ft) tar stain on the ground surface in the eastern portion of the site. In addition to the stained area, three areas of disturbed soil were noted in the north, central, and southern portions of the site. The investigators on the reconnaissance suspected that these areas were covered tar pits. Five buildings were present on the site. One was used for offices/administrative purposes, one was used as a laboratory, and the others were used for industrial processing. Six large pressure vessels were present in the processing buildings. There was some soil staining around the pressure vessels.

Ambient air monitoring of the site indicated elevated levels of volatile organic compounds, with the highest levels being in the vicinity of the surface tar pit.

A memorandum from a chemical engineer whose specialty is process design was found in some files left onsite. It stated that compounds that might be expected at a wood preservative plant include, but are not limited to, naphthalene, 2-methylnaphthalene, 1-methylnaphthalene, 2,6-dimethylnaphthalene, pentachlorophenol, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, as well as several different volatile organic compounds. Other records found onsite gave some information about the magnitude of the operation. For a 7-month period ending July 31, 1966, more than 750,000 gallons of petroleum distillate, 40,000 gallons of creosote, and 54,000 pounds of pentachlorophenol were used to treat approximately 7.5 million board-feet of wood. After 1981, however, the site was purchased after the previous site owner declared bankruptcy. The new owner ran the operation on a much smaller scale from the operations of the 1960s.

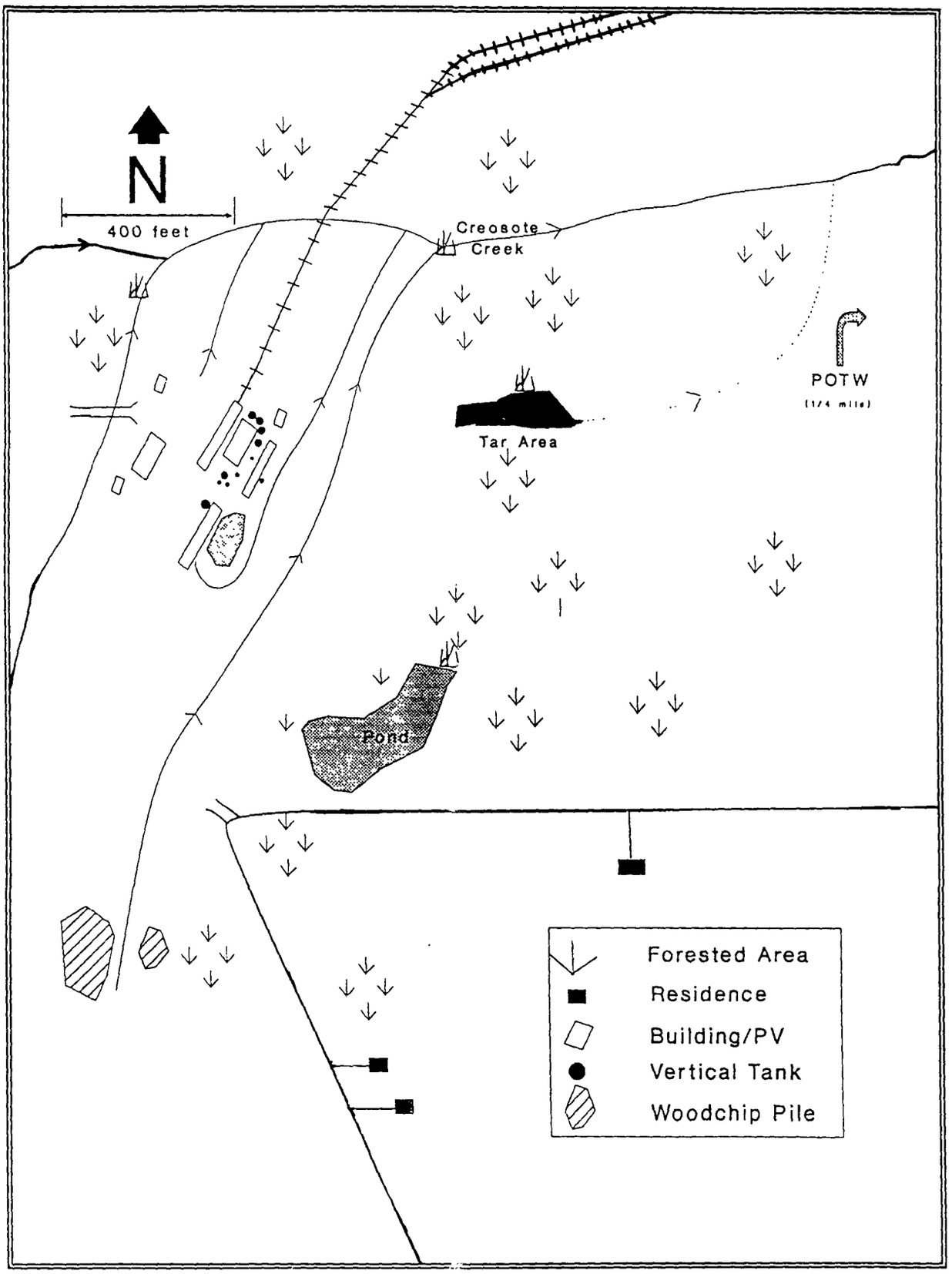


FIGURE 1. ACWI SITE MAP

APPENDIX A

Removal Program
Representative Sampling Guidance

Volume I: Soil

OSWER Directive 9360.4-10
November 1991

REMOVAL PROGRAM

REPRESENTATIVE SAMPLING GUIDANCE

VOLUME 1: SOIL

Interim Final

Environmental Response Branch
Emergency Response Division

Office of Emergency and Remedial Response
Office of Solid Waste and Emergency Response

U.S. Environmental Protection Agency
Washington, DC 20460

Prepared by:

The U.S. EPA Committee on Representative Sampling for the Removal Program

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Notice

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The policies and procedures established in this document are intended solely for the guidance of government personnel, for use in the Superfund Removal Program. They are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States. The Agency reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

For more information on Soil Sampling and Surface Geophysics procedures, refer to the *Compendium of ERT Soil Sampling and Surface Geophysics Procedures*, OSWER directive 9360.4-02, EPA/540/P-91/006. Topics covered in this compendium include Sampling Equipment Decontamination, Soil Sampling, Soil Gas Sampling, and General Surface Geophysics. The compendium describes procedures for collecting representative soil samples and provides a quick means of waste site evaluation. It also addresses the general procedures used to acquire surface geophysical data.

Questions, comments, and recommendations are welcomed regarding the *Removal Program Representative Sampling Guidance, Volume 1 – Soil*. Send remarks to:

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1.0 INTRODUCTION

1.1 OBJECTIVE AND SCOPE

This is the first volume in a series of guidance documents that assist Removal Program On-Scene Coordinators (OSCs) and other field staff in obtaining representative samples at removal sites. The objective of representative sampling is to ensure that a sample or a group of samples accurately characterizes site conditions. This document specifically addresses representative sampling for soil. The following chapters are designed to assist field personnel in representative sampling within the objectives and scope of the Removal Program. This includes: assessing available information; selecting an appropriate sampling approach; selecting and utilizing geophysical, field analytical screening, and sampling equipment; utilizing proper sample preparation techniques; incorporating suitable types and numbers of QA/QC samples; and interpreting and presenting the analytical and geophysical data.

As the Superfund program has developed, the Removal Program has expanded its emphasis beyond emergency response and short-term cleanups. Longer, more complex removal actions must meet a variety of sampling objectives, including identifying threat, delineating sources and extent of contamination, and confirming the achievement of clean-up standards. Many important and potentially costly decisions are based on the sampling data, making it very important that OSCs and field personnel understand how accurately the sampling data characterize the actual site conditions. In keeping with this strategy, this document emphasizes field analytical screening and geophysical techniques as cost effective approaches to characterize the site and to select sampling locations.

1.2 REMOVAL PROGRAM SAMPLING OBJECTIVES

Although field conditions and removal activities can vary greatly from site to site, the primary Removal Program soil sampling objectives include obtaining data to:

1. Establish threat to public health or welfare or to the environment;
2. Locate and identify potential sources of contamination;
3. Define the extent of contamination;
4. Determine treatment and disposal options; and
5. Document the attainment of clean-up goals.

These objectives are discussed in detail in section 2.5.

1.3 REPRESENTATIVE SAMPLING

Representative soil sampling ensures that a sample or group of samples accurately reflects the concentration of the contaminant(s) of concern at a given time and location. Analytical results from representative samples reflect the variation in pollutant presence and concentration throughout a site.

This document concentrates on the variables that are introduced in the field -- namely, those that relate to the site-specific conditions, the sampling design approach, and the techniques for collection and preparation of samples. The following variables affect the representativeness of samples and subsequent measurements:

- Geological variability -- Regional and local variability in the mineralogy of rocks and soils, the buffering capacity of soils, lithologic permeability, and in the sorptive capacity of the vadose zone.
- Contaminant concentration variability -- Variations in the contaminant concentrations throughout the site.
- Collection and preparation variability -- Deviations in analytical results attributable to bias introduced during sample collection, preparation, and transportation (for analysis).
- Analytical variability -- Deviations in analytical results attributable to the manner in which the sample was stored, prepared, and analyzed by the on-site or off-site laboratory. Although analytical variability cannot be corrected

through representative sampling, it can falsely lead to the conclusion that error is due to sample collection and handling procedures.

1.4 EXAMPLE SITE

An example site, presented at the end of each chapter, illustrates the development of a representative soil sampling plan that meets Removal Program objectives.

2.0 SAMPLING DESIGN

2.1 INTRODUCTION

The following procedures are recommended for developing a sound sampling design. Many steps can be performed simultaneously, and the sequence is not rigid.

- Review existing historical site information;
- Perform a site reconnaissance;
- Evaluate potential migration pathways and receptors;
- Determine the sampling objectives;
- Establish the data quality objectives;
- Utilize field screening techniques;
- Select parameters for which to be analyzed;
- Select an appropriate sampling approach; and
- Determine the locations to be sampled.

Real-time field analytical screening techniques can be used throughout the removal action. The results can be used to modify the site sampling plan as the extent of contamination becomes known.

2.2 HISTORICAL DATA REVIEW

Unless the site is considered a classic emergency, every effort should be made to first thoroughly review relevant site information. An historical data review examines past and present site operations and disposal practices, providing an overview of known and potential site contamination and other site hazards. Sources of information include federal, state and local officials and files (e.g., site inspection reports and legal actions), deed or title records, current and former facility employees, potentially responsible parties, local residents, and facility records or files. For any previous sampling efforts, obtain information regarding sample locations (on maps, if possible), matrices, methods of collection and analysis, and relevant contaminant concentrations. Assess the reliability and usefulness of existing analytical data. Even data which are not substantiated by documentation or QA/QC controls may still be useful.

Collect information that describes any specific chemical processes used on site, as well as descriptions of raw materials used, products and wastes, and waste storage and disposal practices. Whenever possible, obtain site maps, facility blueprints, and historical aerial photographs, detailing past and present storage, process, and waste disposal locations. The local Agricultural Extension Agent, a Soil Conservation Service (SCS) representative, has information on soil types and drainage patterns. County property and tax records, and United States Geological Survey (USGS) topographic maps are also useful sources of site and regional information.

2.3 SITE RECONNAISSANCE

A site reconnaissance, conducted either prior to or in conjunction with sampling, is invaluable to assess site conditions, to evaluate areas of potential contamination, to evaluate potential hazards associated with sampling, and to develop a sampling plan. During the reconnaissance, fill data gaps left from the historical review by:

- Interviewing local residents, and present or past employees about site-related activities;
- Researching facility files or records (where records are made accessible by owner/operator);
- Performing a site entry, utilizing appropriate personal protective equipment and instrumentation. Observe and photo-document the site; note site access routes; map process and waste disposal areas such as landfills, lagoons, and effluent pipes; inventory site wastes; and map potential transport routes such as ponds, streams, and irrigation ditches. Note topographic and structural features, dead animals and dead or stressed vegetation, potential safety hazards, and visible label information from drums, tanks, or other containers found on the site.

2.4 MIGRATION PATHWAYS AND RECEPTORS

The historical review and site visit are the initial steps in defining the source areas of contamination which could pose a threat to human health and the environment. This section addresses how to delineate the spread of contamination away from the source areas. Included are pollutant migration pathways and the routes by which persons or the environment may be exposed to the on-site chemical wastes.

2.4.1 Migration Pathways and Transport Mechanisms

Migration pathways are routes by which contaminants have moved or may be moved away from a contamination source. Pollutant migration pathways may include man-made pathways, surface drainage, vadose zone transport, and wind dispersion. Human activity (such as foot or vehicular traffic) also transports contaminants away from a source area. These five transport mechanisms are described below.

- Man-made pathways -- A site located in an urban setting has the following man-made pathways which can aid contaminant migration: storm and sanitary sewers, drainage culverts, sumps and sedimentation basins, French drain systems, and underground utility lines.

- Surface drainage -- Contaminants can be adsorbed onto sediments, suspended independently in the water column, or dissolved in surface water runoff and be rapidly carried into drainage ditches, streams, rivers, ponds, lakes, and wetlands. Consider prior surface drainage routes; historical aerial photographs can be invaluable for delineation of past surface drainage patterns. An historical aerial photograph search can be requested through the EPA Regional Remote Sensing Coordinator.

- Vadose zone transport -- Vadose zone transport is the vertical or horizontal movement of water and of soluble and insoluble contaminants within the unsaturated zone of the soil profile. Contaminants from a surface source or a leaking underground storage tank can percolate through the vadose zone and be adsorbed onto subsurface soil or reach groundwater.

- Wind dispersion -- Contaminants deposited over or adsorbed onto soil may migrate from a waste site as airborne particulates. Depending on the particle-size distribution and associated settling rates, these particulates may be deposited downwind or remain suspended, resulting in contamination of surface soils and/or exposure of nearby populations.

- Human and animal activity -- Foot and vehicular traffic of facility workers, response personnel, and trespassers can move contaminants away from a source. Animal burrowing, grazing, and migration can also contribute to contaminant migration.

2.4.2 Receptors

Once the migration pathways have been determined, identify all receptors (i.e., potentially affected human and environmental populations) along these pathways. Human receptors include on-site and nearby residents and workers. Note the attractiveness and accessibility of site wastes (including contaminated soil) to children and other nearby residents. Environmental receptors include Federal- or state-designated endangered or threatened species, habitats for these species, wetlands, and other Federal- and state-designated wilderness, critical, and natural areas.

2.5 REMOVAL PROGRAM SAMPLING OBJECTIVES

Collect samples if any of the following Removal Program sampling objectives in the scope of the project are not fulfilled by existing data.

1. Establishing Threat to Public Health or Welfare or to the Environment -- The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) and the National Contingency Plan (NCP) establish the funding mechanism and authority which allow the OSC to activate a Federal removal action. The OSC must establish (often with sampling) that the site poses a threat to public health or welfare or to the environment.

2. Locating and Identifying Potential Sources of Contamination -- Sample to identify the

locations and sources of contamination. Use the results to formulate removal priorities, containment and clean-up strategies, and cost projections.

3. Defining the Extent of Contamination -- Where appropriate, sample to assess horizontal and vertical extent of contaminant concentrations. Use the results to determine the site boundaries (i.e., extent of contamination), define clean areas, estimate volume of contaminated soil, establish a clearly defined removal approach, and assess removal costs and timeframe.

4. Determining Treatment and Disposal Options -- Sample to characterize soil for in situ or other on-site treatment, or excavation and off-site treatment or disposal.

5. Documenting the Attainment of Clean-up Goals -- During or following a site cleanup, sample to determine whether the removal goals or clean-up standards were achieved, and to delineate areas requiring further treatment or excavation when appropriate.

2.6 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) state the level of uncertainty that is acceptable from data collection activities. DQOs also define the data quality necessary to make a certain decision. Consider the following when establishing DQOs for a particular project:

- Decision(s) to be made or question(s) to be answered;
- Why environmental data are needed and how the results will be used;
- Time and resource constraints on data collection;
- Descriptions of the environmental data to be collected;
- Applicable model or data interpretation method used to arrive at a conclusion;
- Detection limits for analytes of concern; and
- Sampling and analytical error.

In addition to these considerations, the quality assurance components of precision, accuracy (bias), completeness, representativeness, and comparability should also be considered. Quality assurance components are defined as follows:

- Precision -- measurement of variability in the data collection process.
- Accuracy (bias) -- measurement of bias in the analytical process. The term "bias" throughout this document refers to the QA/QC accuracy component.
- Completeness -- percentage of sampling measurements which are judged to be valid.
- Representativeness -- degree to which sample data accurately and precisely represent the characteristics of the site contaminants and their concentrations.
- Comparability -- evaluation of the similarity of conditions (e.g., sample depth, sample homogeneity) under which separate sets of data are produced.

Quality assurance/quality control (QA/QC) objectives are discussed further in chapter 5.

2.7 FIELD ANALYTICAL SCREENING AND GEOPHYSICAL TECHNIQUES

There are two primary types of analytical data which can be generated during a removal action: laboratory analytical data and field analytical screening data. Field analytical screening techniques (e.g., using a photoionization detector (PID), portable X-ray fluorescence (XRF) unit, and hazard categorization kits) provide real-time or direct reading capabilities. These screening methods can narrow the possible groups or classes of chemicals for laboratory analysis and are effective and economical for gathering large amounts of site data. Once an area is identified using field screening techniques, a subset of samples can be sent for laboratory analysis to substantiate the screening results. Under a limited sampling budget, field analytical screening (with laboratory confirmation) will generally result in more analytical data from a site than will sampling for off-site laboratory analysis alone. To minimize the

potential for false negatives (not detecting on-site contamination), use only those field analytical screening methods which provide detection limits below applicable action levels. It should be noted, that some field analytical screening methods which do not achieve detection limits below site action levels can still detect grossly contaminated areas, and can be useful for some sampling events.

Geophysical techniques may also be utilized during a removal action to help depict locations of any potential buried drums or tanks, buried waste, and disturbed areas. Geophysical techniques include ground penetrating radar (GPR), magnetometry, electromagnetic conductivity (EM) and resistivity surveys.

2.8 PARAMETERS FOR ANALYSIS

If the historical data review yields little information about the types of waste on site, use applicable field screening methods to narrow the parameters for analysis by ruling out the presence of high concentrations of certain contaminants. If the screening results are inconclusive, send a subset of samples from the areas of concern for a full chemical characterization by an off-site laboratory. It is advised that samples from known or suspected source areas be sent to the laboratory for a full chemical characterization so that all contaminants of concern can be identified (even at low detection levels), and future sampling and analysis can then focus on those substances.

Away from source areas, select a limited number of indicator parameters (e.g., lead, PAHs) for analysis based on the suspected contaminants of concern. This will result in significant cost savings over a full chemical characterization of each sample. Utilize EPA-approved methodologies and sample preparation, where possible, for all requested off-site laboratory analyses.

2.9 REPRESENTATIVE SAMPLING APPROACHES

Selecting sampling locations for field screening or laboratory analysis entails choosing the most appropriate sampling approach. Representative sampling approaches include **judgmental, random, stratified random, systematic grid, systematic random, search, and transect sampling.** A representative sampling plan may combine two or more of these approaches. Each approach is defined below.

2.9.1 Judgmental Sampling

Judgmental sampling is the subjective selection of sampling locations at a site, based on historical information, visual inspection, and on best professional judgment of the sampling team. Use judgmental sampling to identify the contaminants present at areas having the highest concentrations (i.e., worst-case conditions). Judgmental sampling has no randomization associated with the sampling strategy, precluding any statistical interpretation of the sampling results.

2.9.2 Random Sampling

Random sampling is the arbitrary collection of samples within defined boundaries of the area of concern. Choose random sample locations using a random selection procedure (e.g., using a random number table). Refer to U.S. EPA, 1984a, for a random number table. The arbitrary selection of sampling points requires each sampling point to be selected independent of the location of all other points, and results in all locations within the area of concern having an equal chance of being selected. Randomization is necessary in order to make probability or confidence statements about the sampling results. The key to interpreting these probability statements is the assumption that the site is homogeneous with respect to the parameters being monitored. The higher the degree of heterogeneity, the less the random sampling approach will adequately characterize true conditions at the site. Because hazardous waste sites are very rarely homogeneous, other statistical sampling approaches (discussed below) provide ways to subdivide the site into more homogeneous areas. These sampling approaches may be more appropriate for removal activities than random sampling. Refer to U.S. EPA, February 1989, pages 5-3 to 5-5 for guidelines on selecting sample coordinates for random sampling. Figure 1 illustrates a random sampling approach.

2.9.3 Stratified Random Sampling

Stratified random sampling often relies on historical information and prior analytical results (or field screening data) to divide the sampling area into smaller areas called strata. Each strata is more

Figure 1: Random Sampling **

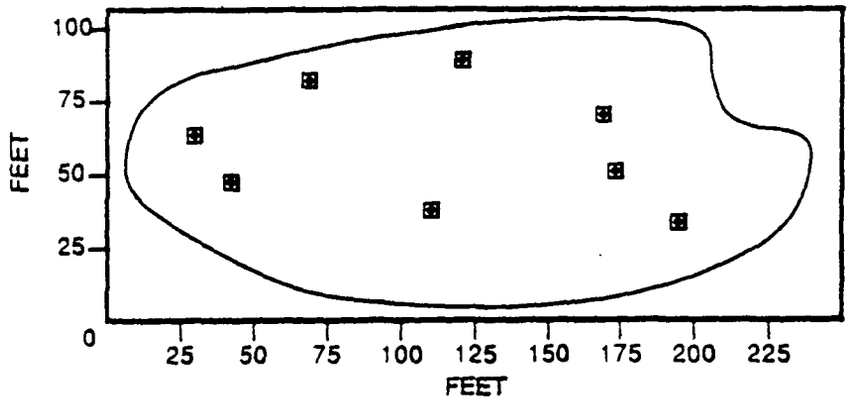


Figure 2: Stratified Random Sampling

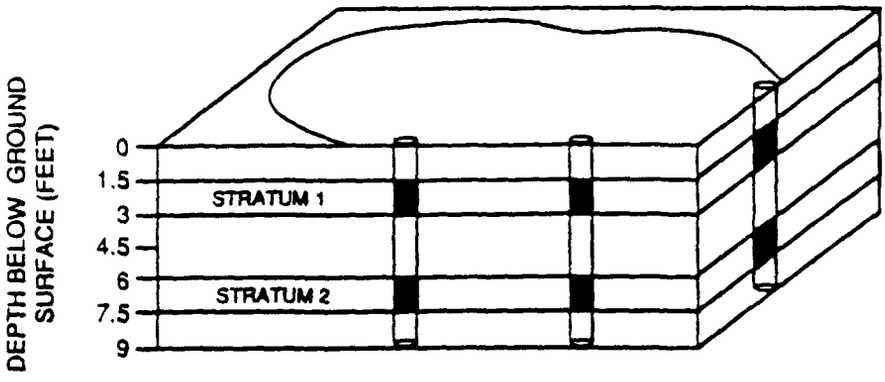
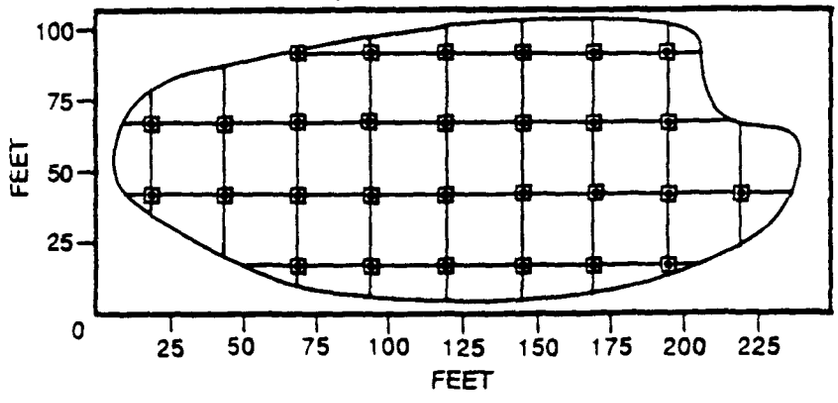
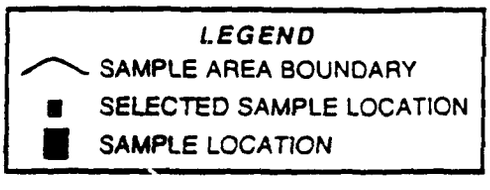


Figure 3: Systematic Grid Sampling **



** After U.S. EPA, February, 1989



homogeneous than the site is as a whole. Strata can be defined based on various factors, including: sampling depth, contaminant concentration levels, and contaminant source areas. Place sample locations within each of these strata using random selection procedures. Stratified random sampling imparts some control upon the sampling scheme but still allows for random sampling within each stratum. Different sampling approaches may also be selected to address the different strata at the site. Stratified random sampling is a useful and flexible design for estimating the pollutant concentration within each depth interval or area of concern. Figure 2 illustrates a stratified random sampling approach where strata are defined based on depth. In this example, soil coring devices are used to collect samples from given depths at randomly selected locations within the strata.

2.9.4 Systematic Grid Sampling

Systematic grid sampling involves subdividing the area of concern by using a square or triangular grid and collecting samples from the nodes (intersections of the grid lines). Select the origin and direction for placement of the grid using an initial random point. From that point, construct a coordinate axis and grid over the whole site. The distance between sampling locations in the systematic grid is determined by the size of the area to be sampled and the number of samples to be collected. Systematic grid sampling is often used to delineate the extent of contamination and to define contaminant concentration gradients. Refer to U.S. EPA February 1989, pages 5-5 to 5-12, for guidelines on selection of sample coordinates for systematic grid sampling. Figure 3 illustrates a systematic grid sampling approach.

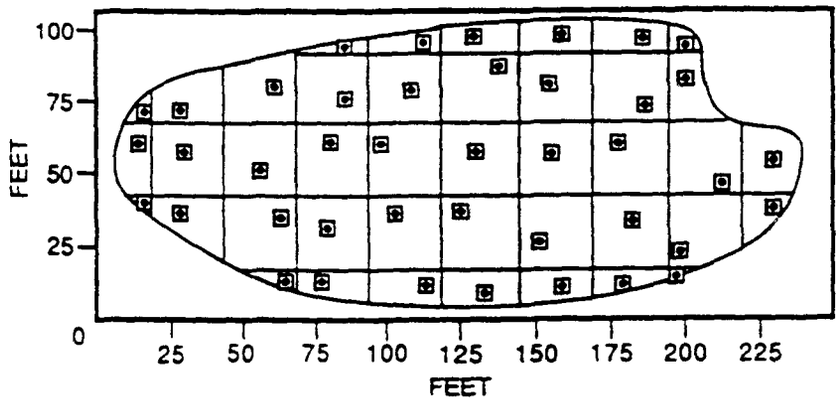
2.9.5 Systematic Random Sampling

Systematic random sampling is a useful and flexible design for estimating the average pollutant concentration within grid cells. Subdivide the area of concern using a square or triangular grid (as described in section 2.9.4) then collect samples from within each cell using random selection procedures. Systematic random sampling allows for the isolation of cells that may require additional sampling and analysis. Figure 4 illustrates a systematic random sampling approach.

2.9.6 Search Sampling

Search sampling utilizes either a systematic grid or systematic random sampling approach to search for areas where contaminants exceed applicable clean-up standards (**hot spots**). The number of samples and the grid spacing are determined on the basis of the acceptable level of error (i.e., the chance of missing a hot spot). Search sampling requires that assumptions be made about the size, shape, and depth of the hot spots. As illustrated in figure 5, the smaller and/or narrower the hot spots are, the

Figure 4: Systematic Random Sampling



After: U.S. EPA, February, 1989

smaller the grid spacing must be in order to locate them. Also, the smaller the acceptable error of missing hot spots is, the smaller the grid spacing must be. This, in effect, means collecting more samples.

Once grid spacing has been selected, the probability of locating a hot spot can be determined. Using a systematic grid approach, table 1 lists approximate probabilities of missing an elliptical hot spot based on the grid method chosen as well as the dimensions of the hot spot. The lengths of the long and short axes (L and S) are represented as a percentage of the grid spacing chosen. The triangular grid method consistently shows lower probabilities of missing a hot spot in comparison to the block grid method. Table 1 can be used in two ways. If the acceptable probability of missing a hot spot is known, then the size of the hot spot which can be located at that probability level can be determined. Conversely, if the approximate size of the hot spot is known, the probability of locating it can be determined. For example, suppose the block grid method is chosen with a grid spacing of 25 feet. The OSC is willing to accept a 10% chance of missing an elliptical hot spot. Using table 1, there would be a 90% probability of locating an elliptical hot spot with L equal to 90% of the grid spacing chosen and S equal to 40% of the grid spacing chosen. Therefore the smallest elliptical hot spot which can be located would have a long axis L = 0.90 × 25ft. = 22.5 ft. and a short axis S = 0.40 × 25ft. = 10 ft.

Similarly, if the approximate size of the hot spot being searched for is known, then the probability of missing that hot spot can be determined. For example, if a triangular grid method was chosen with a 25 foot grid spacing and the approximate shape of the hot spot is known, and L is approximately 15 feet or 60% of the grid spacing, and S is approximately 10 feet or 40% of the grid spacing, then there is approximately a 15% chance of missing a hot spot of this size and shape.

2.9.7 Transect Sampling

Transect sampling involves establishing one or more transect lines across the surface of a site. Collect samples at regular intervals along the transect lines at the surface and/or at one or more given depths. The length of the transect line and the number of samples to be collected determine the spacing between sampling points along the transect. Multiple transect lines may be parallel or non-parallel to one another. If the lines are parallel, the sampling objective is similar to systematic grid sampling. A primary benefit of transect sampling over systematic grid sampling is the ease of establishing and relocating individual transect lines versus an entire grid. Transect sampling is often used to delineate the extent of contamination and to define contaminant concentration gradients. It is also used, to a lesser extent, in compositing sampling schemes. For example, a transect sampling approach might be used to characterize a

Figure 5: Search Sampling

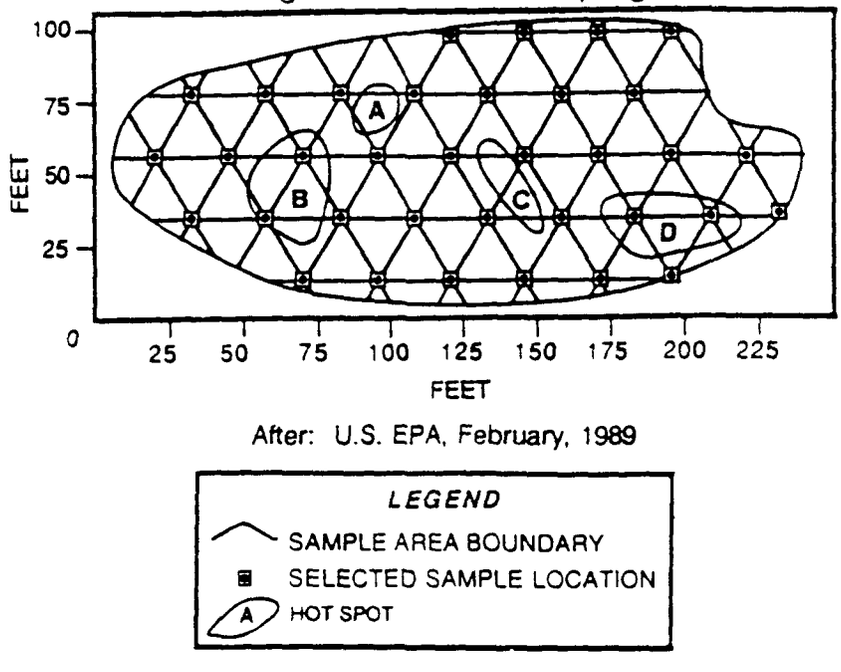


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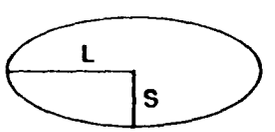
Table 1: Probability of Missing an Elliptical Hot Spot

LENGTH OF SHORT AXIS AS A PERCENTAGE OF GRID SPACING

LENGTH OF LONG AXIS AS A PERCENTAGE OF GRID SPACING	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10%	0.97 / 0.95									
20%	0.95 / 0.92	0.88 / 0.85								
30%	0.92 / 0.87	0.83 / 0.78	0.72 / 0.66							
40%	0.88 / 0.85	0.75 / 0.71	0.65 / 0.55	0.50 / 0.41						
50%	0.85 / 0.82	0.69 / 0.63	0.54 / 0.44	0.38 / 0.27	0.21 / 0.08					
60%	0.80 / 0.80	0.62 / 0.58	0.45 / 0.35	0.27 / 0.15	0.12 / 0.03	0.06 / 0.0				
70%	0.77 / 0.77	0.56 / 0.54	0.38 / 0.29	0.18 / 0.12	0.07 / 0.01	0.03 / 0.0	0.0 / 0.0			
80%	0.75 / 0.75	0.54 / 0.50	0.32 / 0.23	0.12 / 0.08	0.05 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0		
90%	0.72 / 0.72	0.51 / 0.45	0.30 / 0.21	0.10 / 0.06	0.03 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	
100%	0.70 / 0.66	0.45 / 0.37	0.24 / 0.18	0.08 / 0.04	0.01 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0

From tables in: Gilbert, 1987

L = length of long axis
S = length of short axis



BLOCK GRID 0.97 / 0.95 TRIANGULAR GRID

linear feature such as a drainage ditch. A transect line is run down the center of the ditch, along its full length. Sample aliquots are collected at regular intervals along the transect line and are then composited. Figure 6 illustrates transect sampling. Table 2 summarizes the various representative sampling approaches and ranks the approaches from most to least suitable, based on the sampling objective. Table 2 is intended to provide general guidelines, but it cannot cover all site-specific conditions encountered in the Removal Program.

2.10 SAMPLING LOCATIONS

Once a sampling approach has been selected, the next step is to select sampling locations. For statistical (non-judgmental) sampling, careful placement of each sampling point is important to achieve representativeness.

Factors such as the difficulty in collecting a sample at a given point, the presence of vegetation, or discoloration of the soil could bias a statistical sampling plan.

Sampling points may be located with a variety of methods. A relatively simple method for locating random points consists of using either a compass and a measuring tape, or pacing, to locate sampling points with respect to a permanent landmark, such as a survey marker. Then plot sampling coordinates on a map and mark the actual sampling points for future reference. Where the sampling design demands a greater degree of precision, locate each sample point by means of a survey. After field sample collection, mark each sample point with a permanent stake so that the survey team can identify all the locations.

2.11 EXAMPLE SITE

2.11.1 Background Information

The ABC Plating Site is located in Carroll County, Pennsylvania, approximately 1.5 miles north of the town of Jonesville (figure 7). The site covers approximately 4 acres, and operated as an electroplating facility from 1947 to 1982. During its years of operation, the company plated automobile and airplane parts with chromium, nickel, and copper. Cyanide solutions were used in the plating process. ABC Plating deposited electroplating wastes into two shallow surface settling lagoons in the northwest sector of the site. The county environmental health department was attempting to enforce cleanup by the site owner, when, in early 1982, a fire on site destroyed most of the process building. The owner then abandoned the facility and could not be located by enforcement and legal authorities. The county contacted EPA for an assessment of the site for a possible removal action.

Figure 6: Transect Sampling

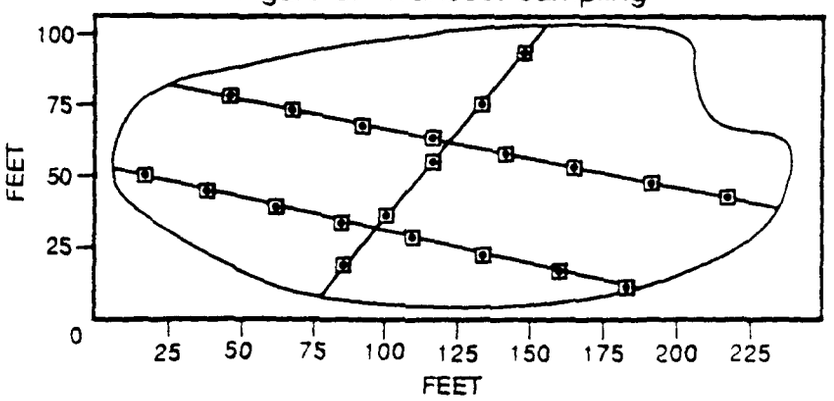


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Table 2: Representative Sampling Approach Comparison

SAMPLING OBJECTIVE	SAMPLING APPROACH						
	JUDGMENTAL	RANDOM	STRATIFIED RANDOM	SYSTEMATIC GRID	SYSTEMATIC RANDOM	SEARCH	TRANSECT
ESTABLISH THREAT	1	4	3	2 [a]	3	3	2
IDENTIFY SOURCES	1	4	2	2 [a]	3	2	3
DELINEATE EXTENT OF CONTAMINATION	4	3	3	1 [b]	1	1	1
EVALUATE TREATMENT AND DISPOSAL OPTIONS	3	3	1	2	2	4	2
CONFIRM CLEANUP	4	1 [c]	3	1 [b]	1	1	1 [d]

1 - PREFERRED APPROACH
2 - ACCEPTABLE APPROACH
3 - MODERATELY ACCEPTABLE APPROACH
4 - LEAST ACCEPTABLE APPROACH
a - SHOULD BE USED WITH FIELD ANALYTICAL SCREENING
b - PREFERRED ONLY WHERE KNOWN TRENDS ARE PRESENT
c - ALLOWS FOR STATISTICAL SUPPORT OF CLEANUP VERIFICATION IF SAMPLING OVER ENTIRE SITE
d - MAY BE EFFECTIVE WITH COMPOSITING TECHNIQUE IF SITE IS PRESUMED TO BE CLE AN

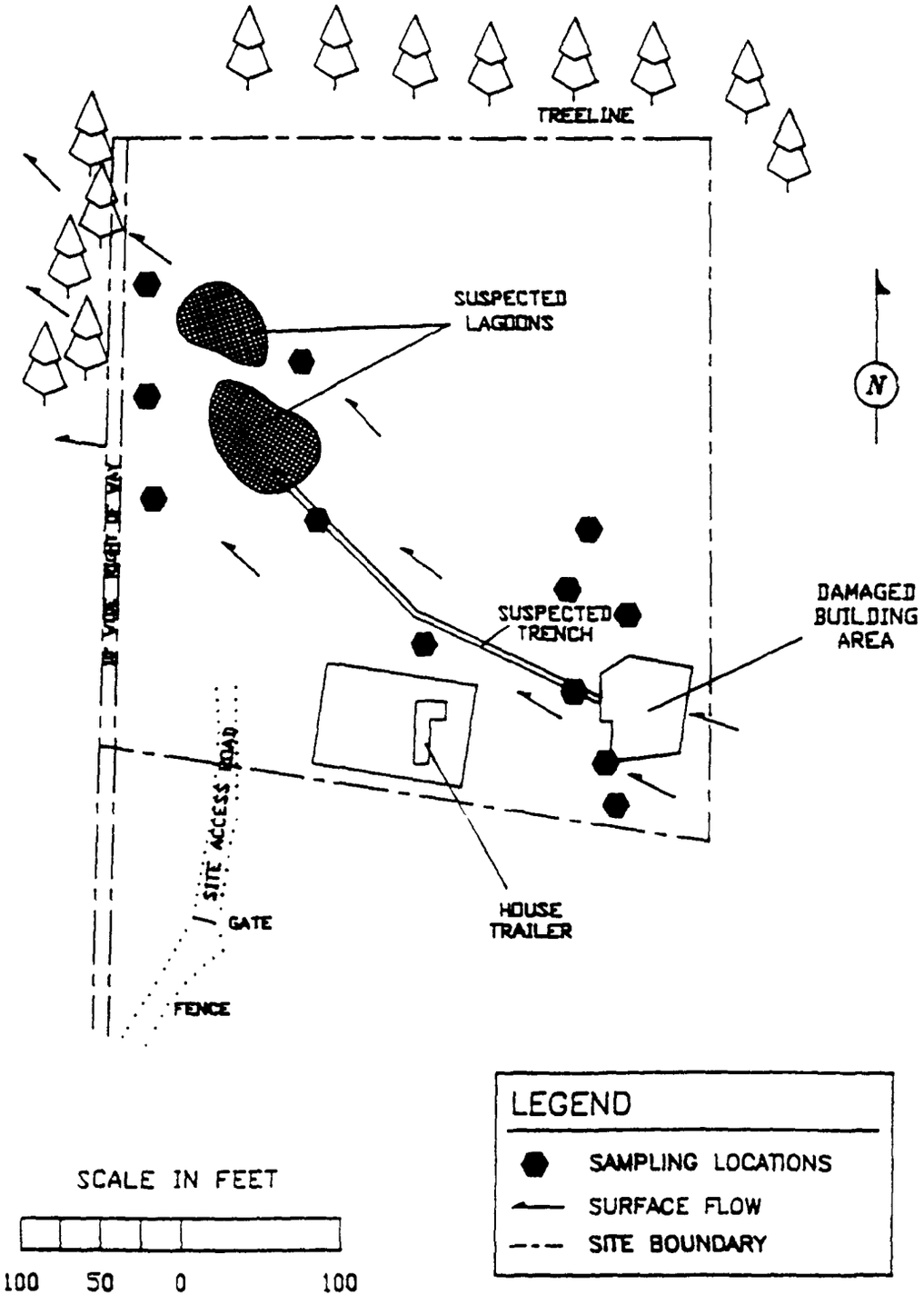
2.11.2 Historical Data Review and Site Reconnaissance

The EPA On-Scene Coordinator (OSC) reviewed the county site file, finding that in 1974, the owner was cited for violating the Clean Streams Act and for storing and treating industrial waste without a permit. The owner was ordered to file a site closure plan and to remediate the storage lagoons. The owner, however, continued operations and was then ordered to begin remediation in 90 days or be issued a cease and desist order. Soon after, a follow-up inspection revealed that the lagoons had been backfilled without removing the waste.

The OSC and members of the Technical Assistance Team (TAT) arrived on site to interview local officials, fire department officers, neighboring residents (including a past facility employee), and county representatives, regarding site operating practices and other site details. A past employee sketched facility process features on a map which was obtained from the county (figure 7). The features included two settling lagoons and a feeder trench which transported plating wastes from the process building to the lagoons. The OSC obtained copies of aerial photographs of the site area from the district office of the U.S. Soil Conservation Service. The county also provided the OSC with copies of all historical site and violation reports.

The OSC and TAT made a site entry utilizing appropriate personal protective equipment and instrumentation. They observed 12 vats, likely containing plating solutions, on a concrete pad where the original facility building once stood. Measurements of Ph ranged from 1 to 11. In addition, 50 drums and numerous smaller containers (some on the concrete pad, others sitting directly on

Figure 7: Site Sketch and Phase 1 Soil Sampling Locations
ABC Plating Site



the ground) were leaking and bulging, due to the fire. TAT noted many areas of stained soil, which indicated container leakage, poor waste handling practices, and possible illegal dumping of wastes.

2.11.3 Identification of Migration Pathways, Transport Mechanisms and Receptors

During the site entry, the OSC and TAT noted that several areas were devoid of vegetation, threatening wind erosion which could transport heavy metal- and cyanide-contaminated soil particulates off site. These particulates could be deposited on residential property downwind or be inhaled by nearby residents.

Erosion gullies located on site indicated soil erosion and fluvial transport due to storms. Surface drainage sloped towards the northwest. TAT observed stressed and discolored vegetation immediately off site, along the surface drainage route. Surface drainage of heavy metals and cyanide was a direct contact hazard to local residents. Further downgradient, runoff enters an intermittent tributary of Little Creek. Little Creek in turn feeds Barker Reservoir, the primary water supply for the City of Jonesville and neighboring communities, which are located 2.5 miles downgradient of the site. The site entry team observed that the site was not secure and there were signs of trespass (confirming a neighbor's claim that children play at the facility). These activities could lead to direct contact with cyanide and heavy metal contaminants, in addition to the potential for chemical burns from direct contact with strong acids and bases.

2.11.4 Sampling Objectives

The OSC selected three specific sampling objectives, as follows:

- Phase 1 -- Determine whether a threat to public health, welfare, and the environment exists. Identify sources of contamination to support an immediate CERCLA-funded activation for containment of contaminants and security fencing.

- Phase 2 -- Define the extent of contamination at the site and adjacent residential properties. Estimate the volume of contaminated soil and the associated removal costs.

- Phase 3 -- After excavation (or treatment), document the attainment of clean-up goals. Assess that cleanup was completed to the selected level.

2.11.5 Selection of Sampling Approaches

The OSC selected a judgmental sampling approach for Phase 1. Judgmental sampling supports the Action Memorandum process by best defining on site contaminants in the worst-case scenario in order to evaluate the threat to human health, welfare, and the environment. Threat is typically established using a relatively small number of samples (less than 20) collected from source areas, or suspected contaminated areas based on the historical data review and site reconnaissance. For this site, containerized wastes were screened to categorize the contents and to establish a worst-case waste volume, while soil samples were collected to demonstrate whether a release had already occurred.

For Phase 2, a stratified systematic grid design was selected to define the extent of contamination. The grid can accommodate field analytical screening and geophysical surveys and allow for contaminated soil excavation on a cell-by-cell basis. Based on search sampling conducted at similar sites, the hot spots being searched for were assumed to be elliptical in shape and 45 feet by 20 feet in size. Under these assumptions, a block grid, with a 50 foot grid spacing, was selected. This grid size ensured a no more than 10% probability of missing a hot spot (see table 1). The grid was extended to adjacent residential properties when contaminated soil was identified at grid points near the boundary of the site.

Phase 3 utilized a systematic grid sampling approach to confirm the attainment of clean-up goals. Following cleanup, field analytical screening was conducted on excavated soil areas using a transportable X-ray fluorescence (XRF) unit mounted in a trailer (mobile laboratory instrument). Based on the results, each area was documented as clean, or was excavated to additional depth, as necessary.

2.11.6 Field Analytical Screening, Geophysical Techniques, and Sampling Locations

During Phase 1 operations, containerized wastes were screened using hazard categorization techniques to identify the presence of acids, bases, oxidizers, and flammable substances. Following this procedure, photoionization detector (PID) and flame ionization detector (FID) instruments, a radiation meter, and a cyanide monitor were used to detect the presence of volatile organic compounds, radioactive substances, and cyanide, respectively, in the containerized wastes. Phase 1 screening indicated the presence of strong acids and bases and the absence of volatile organic compounds. TAT collected a total of 12 surface soil samples (0-3 inches) during this phase and sent them to a laboratory for analysis. The soil sampling locations included stained soil areas, erosion channels and soil adjacent to leaking containers. Background samples were not collected during Phase 1 because they were unnecessary for activating funding. Phase 1 sampling locations are shown in figure 7. Based on Phase 1 analytical results, consultation with a Regional EPA toxicologist and with the Agency for Toxic Substances and Disease Registry (ATSDR), an action level of 100 ppm for chromium was selected for cleanup.

During Phase 2 sampling activities, the OSC used a transportable XRF unit installed in an on-site trailer to screen samples for total chromium in order to limit the number of samples to be sent for off-site laboratory analysis. The transportable XRF (rather than a portable unit) was selected for field analytical screening to accommodate the 100 ppm action level for chromium. Sampling was performed at all grid nodes at the surface (0-4 inches) and subsurface (36-40 inches) (figure 8). The 36-40 inch depth was selected based on information obtained from county reports and local interviews which indicated the lagoon wastes were approximately 3 feet below ground surface. The samples were homogenized and sieved (discussed in chapter 4), then screened for chromium using the XRF. The surface and subsurface samples from areas downgradient of the original facility (21 grid nodes) and three upgradient (background) locations were sent for off-site laboratory analysis following XRF screening. The analytical results from these samples allowed for site-specific calibration of the XRF unit. Once grid nodes with a contamination level greater than the selected action level were located, composite samples were collected from each adjoining cell. Surface aliquots were collected and then composited, sieved, thoroughly homogenized, and screened using the XRF to pinpoint contaminated cells. Additionally, four subsurface aliquots were collected at the same locations as the surface aliquots. They were also composited, sieved, thoroughly homogenized, and screened using the XRF. Figure 9 illustrates a Phase 2 sampling grid cell diagram. Based on the XRF data, each adjoining cell was either identified as clean (below action level), or designated for excavation (at or above action level).

For Phase 3 sampling, cleanup was confirmed by collecting and compositing four aliquots from the surface of each grid cell excavated during Phase 2. The surface composites were then screened (as in Phase 2), using the transportable XRF. Ten percent of the screened samples were also sent to an off-site laboratory for confirmatory sampling. Based on the Phase 3 screening and sampling results, each cell was documented as clean, or, excavated to additional depth, as necessary.

During Phase 2, the OSC conducted ground penetrating radar (GPR) and electromagnetic conductivity (EM) geophysical surveys to help delineate the buried trench and lagoon areas along with any other waste burial areas. The GPR survey was run along the north-south grid axis across the suspected locations of the trench and lagoons. Several structural discontinuities, defining possible disturbed areas, were detected. One anomaly corresponded with the suspected location and orientation of the feeder trench. Several discontinuities were identified in the suspected lagoon areas; however, the data did not conclusively pinpoint precise locations. This could be due to a disturbance of that area during the backfilling process by the PRP. The GPR survey is illustrated in figure 10.

For the comprehensive EM survey, the original 50 foot grid spacing was decreased to 25 feet along the north-south grid axis. The EM survey was run along the north-south axes and readings were obtained at the established grid nodes. The EM survey was utilized throughout the site to detect the presence of buried metal objects (e.g., buried pipe leading to the lagoons), and potential subsurface contaminant plumes. The EM survey identified several high conductivity anomalies: the suspected feeder trench location, part of the lagoon area, and

Figure 8: Phase 2 Soil Sampling and XRF Screening Locations
ABC Plating Site

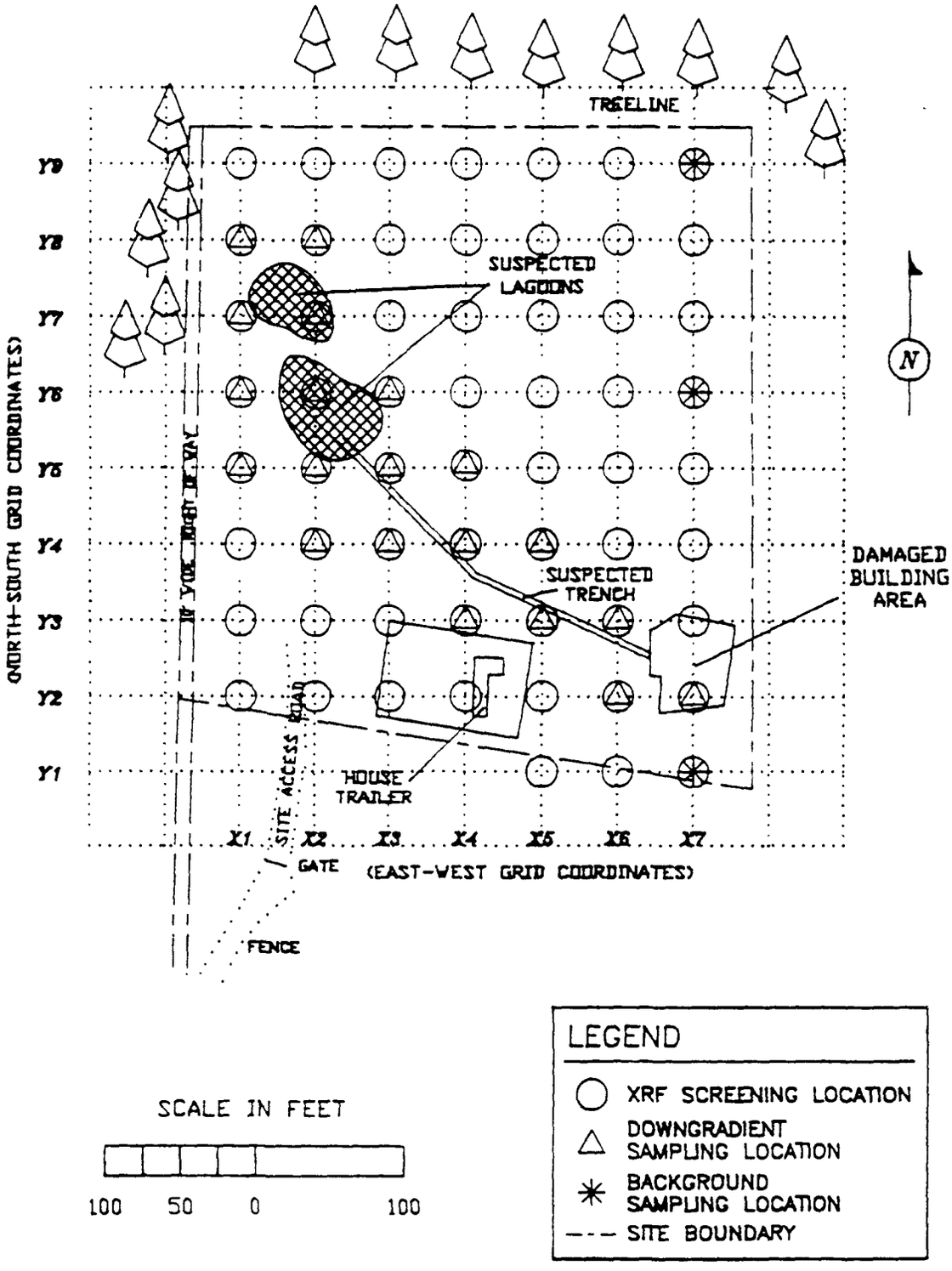
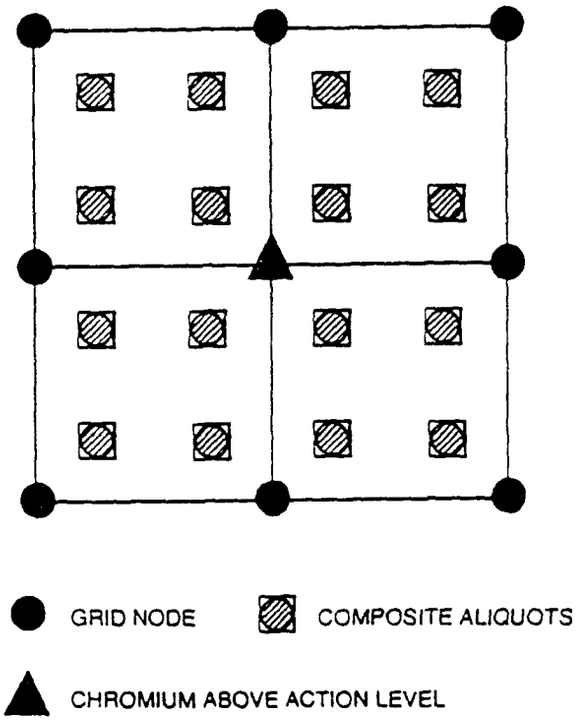


Figure 9: Phase 2 Sampling Grid Cell Diagram*



* Surface samples should be taken over a minimum area of one square foot. Sampling areas for depth sampling are limited by the diameter of the sampling equipment (e.g., auger, split spoon, or coring devices).

a small area west of the process building (figure 11), which could have been an illegal waste dumping area. Several areas of interference were encountered due to the presence of large metal objects at the surface (a dumpster, surface vats and a junk car).

2.11.7 Parameters for Analysis

During Phase 1 sampling activities, full priority pollutant metals and total cyanide analyses were conducted on all samples. Since Phase 1 samples were collected from the areas of highest suspected contaminant concentration (i.e., sources and drainage pathways), Phase 2 samples were run for total chromium and cyanide, the only analytes detected during the Phase 1 analyses. During Phase 3, the samples sent to the laboratory for screening confirmation were analyzed for total chromium and cyanide. Throughout the removal, it was not possible to screen soils on site for cyanide, therefore the OSC requested laboratory cyanide analysis on the 10% confirmatory samples.

Figure 10: GPR Survey Results
ABC Plating Site

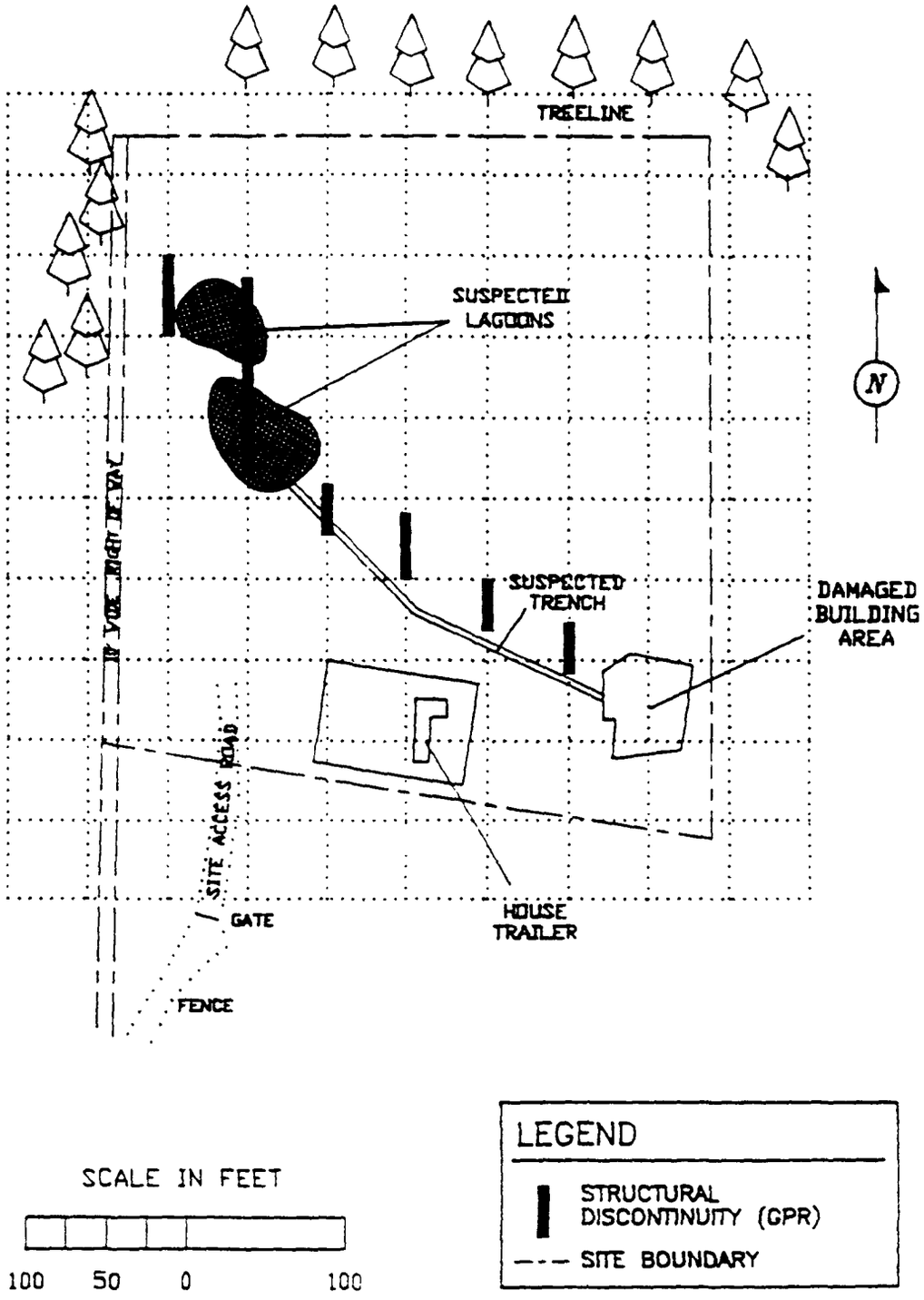
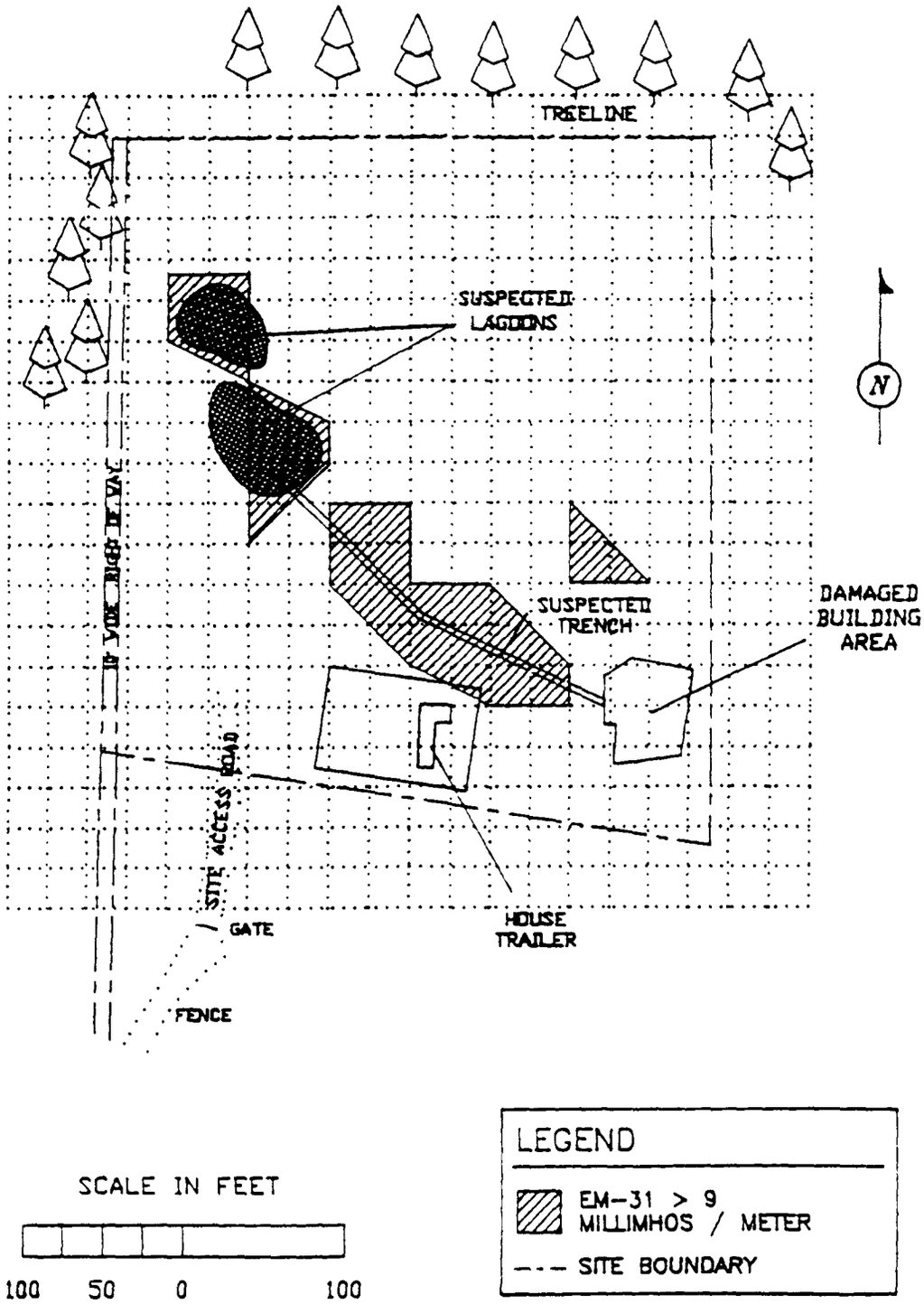


Figure 11: EM-31 Survey Results
ABC Plating Site



3.0 EQUIPMENT

3.1 INTRODUCTION

Sample collection requires an understanding of the capabilities of the sampling equipment, since using inappropriate equipment may result in biased samples. This chapter provides information for selecting field sampling and screening equipment.

3.2 FIELD ANALYTICAL SCREENING EQUIPMENT

Field analytical screening methods provide on-site measurements of contaminants of concern, limiting the number of samples which need to be sent to an off-site laboratory for time-consuming and often costly analysis. Field screening techniques can also evaluate soil samples for indications that soil contamination exists (e.g., X-ray fluorescence (XRF) for target metals or soil gas survey for identification of buried wastes or other subsurface contamination). All field screening equipment and methods described in this section are **portable** (the equipment is hand-held, and generally no external power is necessary). Examples are photoionization detectors (PID), flame ionization detectors (FID), and some XRF devices.

Field screening generally provides analytical data of suitable quality for site characterization, monitoring during removal activities, and on-site health and safety decisions. The methods presented here can provide rapid, cost-effective, real-time data; however, results are often not compound-specific and not quantitative.

When selecting one field screening method over another, consider relative cost, sample analysis time, potential interferences or instrument limitations, detection limit, QA/QC requirements, level of training required for operation, equipment availability, and data bias. Also consider which elements, compounds, or classes of compounds the field screening instrument is designed to analyze. As discussed in section 2.7, the screening method selected should be sensitive enough to minimize the potential for false negatives. When collecting samples for on-site analysis (e.g., XRF), evaluate the detection limits and bias of the screening method by sending a minimum of 10% of the samples to an off-site laboratory for confirmation.

Table 3 summarizes the advantages and disadvantages of selected portable field screening equipment.

3.3 GEOPHYSICAL EQUIPMENT

Geophysical techniques can be used in conjunction with field analytical screening to help delineate areas of subsurface contamination, including buried drums and tanks. Geophysical data can be obtained relatively rapidly, often without disturbing the site. Geophysical techniques suitable for removal activities include: ground penetrating radar (GPR), magnetometry, electromagnetic conductivity (EM) and resistivity. Specific advantages and disadvantages associated with geophysical equipment are summarized in table 4. See also EPA ERT Standard Operating Procedure (SOP) #2159, General Surface Geophysics (U.S. EPA, January 1991).

3.4 SELECTING SAMPLING EQUIPMENT

The mechanical method by which a sampling tool collects the sample may impact representativeness. For example, if the sampling objective is to determine the concentrations of contaminants at each soil horizon interface, using a hand auger would be inappropriate: the augering technique would disrupt and mix soil horizons, making the precise horizon interface difficult to determine. Depth of sampling is another factor to consider in the proper selection of sampling equipment. A trowel, for example, is suitable for unconsolidated surface soils, but may be a poor choice for sampling at 12 inches, due to changes in soil consistency with depth.

All sampling devices should be of sufficient quality not to contribute contamination to samples (e.g., painted surfaces which could chip off into the sample). In addition, the sampling equipment should be either easily decontaminated, or cost-effective if considered to be expendable. Consider ease of use when selecting sampling equipment.

Complicated sampling procedures usually require increased training and introduce a greater likelihood

Table 3: Portable Field Analytical Screening Equipment

Equipment	Application to Sampling Design	Advantages and Disadvantages
X-ray fluorescence (portable)	Detects heavy metals in soils.	Rapid sample analysis; may be used in situ; requires trained operator; potential matrix interferences; may be used with a generic or site-specific calibration model; detection limit may exceed action level; detects to ppm level; detection limit should be calculated on a site-specific basis.
Flame ionization detector (FID)	Semi-quantitatively detects VOCs in soils.	Immediate results; can be used in GC mode to identify specific organic compounds; detects VOCs only; detects to ppm level.
Photoionization detector (PID)	Detects total concentration of VOCs and some non-volatile organics and inorganics in soils.	Immediate results; easy to use; non-compound specific; results affected by high ambient humidity and electrical sources such as radios; does not respond to methane; detects to ppm level.
Field test kits	Detects specific elements, compounds, or compound classes in soils.	Rapid results; easy to use; low cost; limited number of kit types available; kits may be customized to user needs; semi-quantitative; interferences by other analytes is common; colorimetric interpretation is needed; detection level dependent upon type of kit used; can be prone to error.
Radiation detector	Detects the presence of selected forms of radiation in soils or other waste materials.	Easy to use; low cost; probes for one or a combination of alpha, beta or gamma forms of radiation; unit and detection limits vary greatly; detailed site surveys are time intensive and require experienced personnel to interpret results.

Sources : U.S. EPA, September 1988a; U.S. EPA, December 1987; U.S. EPA, 1987.

Table 4: Geophysical Equipment

Equipment	Application to Sampling Design	Advantages and Disadvantages
Ground penetrating radar (GPR)	Detects reflection anomalies caused by lithology changes or buried objects; varying depths of investigation, 15 to 30 feet, are possible.	Capable of high resolution; generates continuous measurement profile; can survey large area quickly; site specific: best results are achieved in dry, sandy soils; clay-rich and water saturated soils produce poor reflections and limit depth of penetration; data interpretation requires a trained geophysicist.
Magnetometer	Detects presence and areal extent of ferromagnetic material in subsurface soils, including buried metal containers. Single 55-gallon drums can be identified at depths up to 10 feet and large masses of drums up to 30 feet or more.	Quick and easy to operate; good initial survey instrument; readings are often affected by nearby man-made steel structures (including above-ground fences, buildings, and vehicles); data interpretation may require geophysicist.
Electromagnetic conductivity meter (EM)	Detects electrical conductivity changes in subsurface geologic lithology, pore fluids, and buried objects. Depth of investigation varies from 9 feet to 180 feet depending on instrument used, coil spacing, and coil configuration.	Rapid data collection; can delineate inorganic and large-scale organic contamination in subsurface fluids; sensitive to man-made structures (including buried cables, above-ground steel structures and electrical power lines); survey planning and data interpretation may require geophysicist.
Wadi	Detects electrical conductivity changes in surface and sub-surface materials utilizing existing very low frequency (VLF) radio waves.	Utilizes existing long-distance communication VLF radio waves (10-30 Khz range): no need to induce electrical field; directional problems can be overcome with portable transmitters.
Resistivity meter	Detects electrical resistivity variations in subsurface materials (e.g., lithology, pore fluids, buried pipelines and drums). Vertical resolution to depths of 100 feet are possible.	Detects lateral and vertical variations; instrument requires direct ground contact, making it relatively labor intensive; sensitive to outside interference; data interpretation requires a trained geophysicist.

Sources : Benson, et. al. 1988; NJDEP, 1988.

of procedural errors. Standard operating procedures help to avoid such errors. Sample volume is another selection concern. Specific advantages and disadvantages of soil sampling equipment are given in table 5. Refer also to EPA ERT SOP #2012, Soil Sampling (in U.S. EPA, January 1991) for guidance on using various types of soil sampling equipment.

3.5 EXAMPLE SITE

3.5.1 Selection of Sampling Equipment

Dedicated plastic scoops were used for Phase 1 soil sampling. For Phase 2, the OSC used bucket augers for both surface and subsurface soil sampling because of their ease of use, good vertical depth range, and uniform surface sampling volume. Standard operating procedures were followed to promote proper sample collection, handling, and decontamination. From the bucket auger, each sample was placed into a dedicated plastic pan and mixed using a dedicated plastic scoop. Samples were further prepared for XRF screening and laboratory analysis (section 4.8).

3.5.2 Selection of Field Analytical Screening Equipment

Phase 1 sampling identified the sources and types of on-site contaminants in order to establish a threat. Hazard categorization techniques, organic vapor detecting instruments, and radiation and cyanide monitors were utilized to tentatively identify containerized liquid wastestreams in order to select initial judgmental soil sampling locations. During Phase 2 sampling, a portable XRF unit was used to determine the extent of contamination and to identify additional hot spots. Samples to be sent for laboratory analysis were then placed into sampling jars (as discussed in section 4.8). Samples collected from upgradient grid nodes for XRF screening only were stored on site for later treatment/disposal. For Phase 3, the XRF was used to confirm whether contaminated areas identified during Phase 2 were sufficiently excavated.

3.5.3 Selection of Geophysical Equipment

The GPR instrument delineated buried trench and lagoon boundaries. The EM meter detected subsurface conductivity changes due to buried metal containers and contaminants. The EM-31 (a shallower-surveying instrument than the EM-34) was selected because expected contaminant depth was less than 10 feet and because of the instrument's maneuverability and ease of use.

Table 5: Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stony, dry, or sandy soil.
Scoop or trowel	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Tulip bulb planter	Soft soil, 0-6 in.	Easy to use and decontaminate; uniform diameter and sample volume; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; not useful for hard soils.
Soil coring device	Soft soil, 0-24 in.	Relatively easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; can be difficult to decontaminate.
Thin-wall tube sampler	Soft soil, 0-10 ft	Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); may be used in conjunction with bucket auger; acetate sleeve may be used to help maintain integrity of VOA samples; easy to decontaminate; can be difficult to remove cores from sampler.
Split spoon sampler	Soil, 0 in.-bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); acetate sleeve may be used to help maintain integrity of VOA samples; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.
Shelby tube sampler	Soft soil, 0 in.-bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); tube may be used to ship sample to lab undisturbed; may be used in conjunction with drill rig for obtaining deep cores and for permeability testing; not durable in rocky soils.
Bucket auger	Soft soil, 3 in.-10 ft	Easy to use; good depth range; uniform diameter and sample volume; acetate sleeve may be used to help maintain integrity of VOA samples; may disrupt and mix soil horizons greater than 6 inches in thickness.
Hand-operated power auger	Soil, 6 in.-15 ft	Good depth range; generally used in conjunction with bucket auger for sample collection; destroys soil core (unsuitable for VOA and undisturbed sample collection); requires 2 or more equipment operators; can be difficult to decontaminate; requires gasoline-powered engine (potential for cross-contamination).

Sources: NJDEP, 1988; U.S. EPA, January 1991.

4.0 FIELD SAMPLE COLLECTION AND PREPARATION

4.1 INTRODUCTION

In addition to sampling equipment, field sample collection includes sample quantity and sample volume. Field sample preparation refers to all aspects of sample handling after collection, until the sample is received by the laboratory. Sample preparation for soils may include, but is not limited to:

- removing extraneous material;
- sieving samples;
- homogenizing samples;
- splitting samples;
- compositing samples; and
- final preparation.

Sample preparation depends on the sampling objectives and analyses to be performed. Proper sample preparation and handling help to maintain sample integrity. Improper handling can result in a sample becoming unsuitable for the type of analysis required. For example, homogenizing, sieving, and compositing samples all result in a loss of volatile constituents and are therefore inappropriate when volatile contaminants are the concern.

4.2 SAMPLE COLLECTION

How a sample is collected can affect its representativeness. The greater the number of samples collected from a site and the larger the volume of each sample, the more representative the analytical results will be. However, sampling activities are often limited by sampling budgets and project schedules. The following sections provide guidelines on appropriate sample numbers and volumes.

4.2.1 SAMPLE NUMBER

The number of samples needed will vary according to the particular sampling approach that is being used. For example, in grid sampling, one sample is generally collected at each grid node, regardless of grid size. As discussed in section 2.11.6, once contaminated grid node samples are located, adjoining grid cells can be sampled more thoroughly to define areas of contamination. Four aliquots from each grid cell, situated equidistant from the sides of each cell and each other (as illustrated in figure 9), are recommended for grid cells measuring up to 100 x 100 feet. One additional aliquot may be collected from the center of each cell, making a total of five aliquots per cell. For grid sizes greater than 100 feet x 100 feet, nine aliquots, situated equidistant from the sides of each cell and each other (as illustrated in figure 12), are recommended. Depending on budget and other considerations, grid cell aliquots can be analyzed as separate samples or composited into one or more samples per cell.

4.2.2 Sample Volume

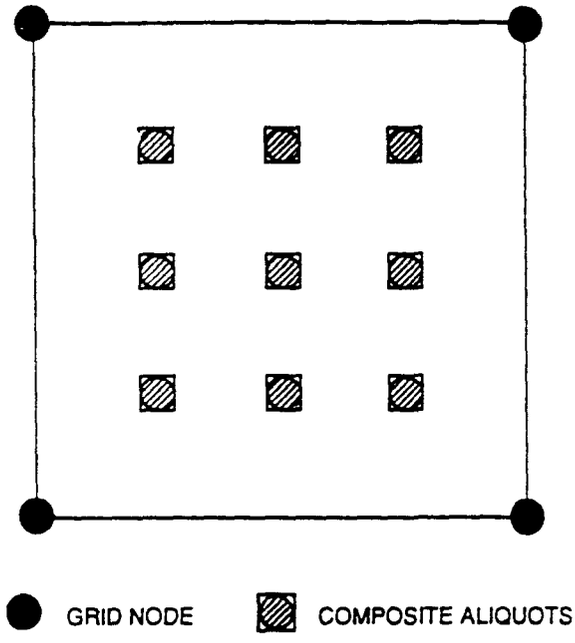
Both sample depth and area are considerations in determining appropriate sample volume. Depending on the analytes being investigated, samples are collected at the surface (0-3 in.), extended surface (0-6 in.), and/or at one-foot depth intervals. Non-water soluble contaminants such as dioxin and PCBs are often encountered within the first six inches of soil. Water-soluble contaminants such as metals, acids, ketones, and alcohols will be encountered at deeper depths in most soils except clays. Contaminants in solution, such as PCPs in diesel fuel and pesticides in solvents, can penetrate to great depths (e.g., down to bedrock), depending on soil type.

For surface samples, collect soil over a surface area of one square foot per sample. A square cardboard template measuring 12 in. x 12 in., or a round template with a 12 in. diameter can be used to mark sampling areas. For subsurface samples, one of several coring devices may be used (see table 5). Using a coring device results in a smaller diameter sampling area than a surface template, and therefore somewhat lessens the representativeness of the sample.

4.3 REMOVING EXTRANEOUS MATERIAL

Identify and discard materials in a field sample which are not relevant or vital for characterizing the sample or the site, since their presence may introduce an error in the sampling or analytical procedures. Examples of extraneous material in soil samples include pieces of glass, twigs or leaves. However, not all non-soil material is extraneous.

Figure 12: Phase 2 Sampling Grid Cell Diagram (Grid Sizes > 100 × 100 ft.)



For example, when sampling at a junkyard, lead-contaminated battery casing pieces should not be removed from a sample if the casing composes more than 10% of the sample composition. For a sample to be representative, it must also incorporate the lead from the casing. Collect samples of any material thought to be a potential source of contamination for a laboratory extraction procedure. Discuss any special analytical requirements for extraneous materials with project management, geologists, and chemists and notify the laboratory of any special sample handling requirements.

4.4 SIEVING SAMPLES

Sieving is the process of physically sorting a sample to obtain uniform particle sizes, using sieve screens of predetermined size. For example, the sampler may wish to sieve a certain number of samples to determine if particle size is related to contaminant distribution. In the Removal Program, sieving is generally only conducted when preparing soil samples for XRF screening. For this purpose, a 20-mesh screen size is recommended.

Be aware of the intent of the sampling episode, when deciding whether to sieve a sample prior to analysis. Prior to sieving, samples may need to be oven-dried. Discarding non-soil or non-sieved materials, as well as the sieving process itself, can result in physical and chemical losses. Sieving is not recommended where volatile compounds are of concern. Analyze the discarded materials, or a fraction thereof, to determine their contribution to the contamination of the site being investigated.

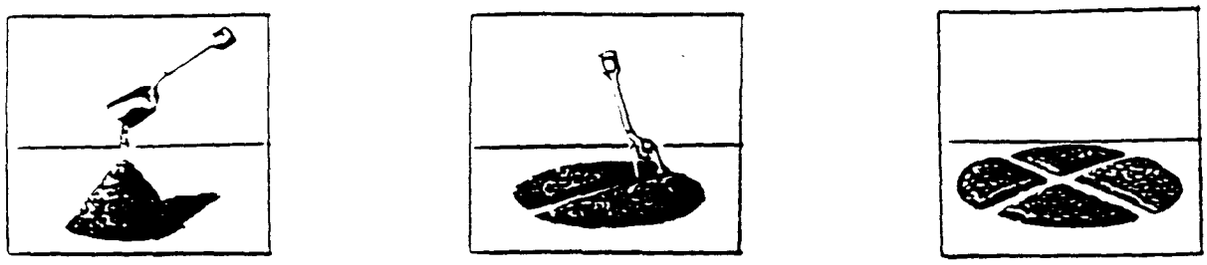
4.5 HOMOGENIZING SAMPLES

Homogenization is the mixing or blending of a soil sample in an attempt to provide uniform distribution of contaminants. (Do not homogenize samples for volatile compound analysis). Ideally, proper homogenization ensures that portions of the containerized samples are equal or identical in composition and are representative of the total soil sample collected. Incomplete homogenization will increase sampling error. All samples to be composited or split should be homogenized after all aliquots have been combined. Manually homogenize samples using a stainless steel spoon or scoop and a stainless steel bucket, or use a disposable scoop and pan. Quarter and split the sample as illustrated in figure 12, repeating each step a minimum of 5 times until the sample is visually homogenized. Samples can also be homogenized using a mechanically-operated stirring device as depicted in ASTM standard D422-63.

4.6 SPLITTING SAMPLES

Splitting samples after collection and field preparation into two or more equivalent parts is performed when two or more portions of the same sample need to be analyzed separately. Split samples are most often collected in enforcement actions to compare sample results obtained by EPA with those obtained by the potentially responsible party (PRP). Split samples also provide a measure of the sample variability, and a measure of the analytical and extraction errors. Before splitting, follow homogenization techniques outlined above. Fill two sample collection jars simultaneously with alternate spoonfuls (or scoopfuls) of homogenized sample. To simultaneously homogenize and split a sample, **quarter** (as illustrated in figure 13) or **mechanically** split the sample using a riffle sample splitter. The latter two techniques are described in detail in ASTM Standard C702-87.

Figure 13: Quartering to Homogenize and Split Samples



Step 1:

- Cone Sample on Hard Clean Surface
- Mix by Forming New Cone

Step 2:

- Quarter After Flattening Cone

Step 3:

- Divide Sample into Quarters

Step 4:

- Remix Opposite Quarters
- Reform Cone
- Repeat a Minimum of 5 Times

After: ASTM Standard C702-87

4.7 COMPOSITING SAMPLES

Compositing is the process of physically combining and homogenizing several individual soil aliquots. Compositing samples provides an average concentration of contaminants over a certain number of sampling points, which reduces both the number of required lab analyses and the sample variability. Compositing can be a useful technique, but must always be implemented with caution. Compositing is not recommended where volatile compounds are of concern.

Specify the method of selecting the aliquots that are composited and the compositing factor in the sampling plan. The compositing factor is the number of aliquots to be composited into one sample (e.g., 3 to 1; 10 to 1). Determine this factor by evaluating detection limits for parameters of interest and comparing them with the selected action level for that parameter. Compositing also requires that each discrete aliquot be the same in terms of volume or weight, and that the aliquots be thoroughly homogenized. Since compositing dilutes high concentration aliquots, the applicable detection limits should be reduced accordingly. If the composite value is to be compared to a selected action level, then the action level must be divided by the number of aliquots that make up the composite in order to determine the appropriate detection limit (e.g., if the action level for a particular substance is 50 ppb, an action level of 10 ppb should be used when analyzing a 5-aliquot composite). The detection level need not be reduced if the composite area is assumed to be homogeneous in concentration (for example, stack emission plume deposits of particulate contamination across an area, or roadside spraying of waste oils).

4.8 FINAL PREPARATION

Select sample containers on the basis of compatibility with the material being sampled, resistance to breakage, and volume. For soil sampling, use wide-mouth glass containers with Teflon-lined lids. Appropriate sample volumes and containers will vary according to the parameter being analyzed. Keep low and medium concentration soil samples to be analyzed for organic constituents at 4°C. Actual sample volumes, appropriate containers, and holding times are specified in the *QA/QC Guidance for Removal Activities* (U.S. EPA, April 1990), in 40 CFR 136, and in the Compendium of ERT Soil Sampling and Surface Geophysics (U.S. EPA, January 1991). Package all samples in compliance with Department of Transportation (DOT) or International Air Transport Association (IATA) requirements.

It is sometimes possible to ship samples to the laboratory directly in the sampling equipment. For example, the ends of a Shelby tube can be sealed with caps, taped, and sent to the laboratory for analysis. To help maintain the integrity of VOA samples, collect soil cores using acetate sleeves and send the sleeves to the laboratory. To ensure the integrity of the sample after delivery to the laboratory, make laboratory sample preparation procedures part of all laboratory bid contracts.

4.9 EXAMPLE SITE

After placing each sample in a dedicated pan and mixing (as discussed in section 3.5.1), plant matter, stones, and broken glass were removed. Soil samples were oven-dried (at 104° C) and sieved using a 20-mesh screen in preparation for XRF analysis. Samples were then homogenized and split using the quartering technique. Opposite quarters were remixed and quartering was repeated five times to ensure thorough homogenization. A portion of each sample was placed into XRF analysis cups for screening. The remainder of each sample was placed into 8-ounce, wide-mouth glass jars with Teflon-lined lids and sent to a laboratory for inorganic analysis. The samples were packaged in compliance with IATA requirements. Chain-of-custody paperwork was prepared for the samples. Laboratory paperwork was completed as appropriate and the samples were shipped to the predesignated laboratories for analysis.

5.0 QUALITY ASSURANCE/QUALITY CONTROL EVALUATION

5.1 INTRODUCTION

The goal of representative sampling is to collect samples which yield analytical results that accurately depict site conditions during a given time frame. The goal of quality assurance/quality control (QA/QC) is to identify and implement correct methodologies which limit the introduction of error into the sampling and analytical procedures, ultimately affecting the analytical data.

QA/QC samples evaluate the degree of site variation, whether samples were cross-contaminated during sampling and sample handling procedures, or if a discrepancy in sample results is due to laboratory handling and analysis procedures.
The QA/QC sample results are used to assess the quality of the analytical results of waste and environmental samples collected from a site.

5.2 QA/QC OBJECTIVES

Three QA/QC objectives (QA1, QA2, and QA3) have been defined by the Removal Program, based on the EPA QA requirements for precision, accuracy (bias), representativeness, completeness, comparability, and detection level. The QA1 objective applies when a large amount of data are needed quickly and relatively inexpensively, or when preliminary screening data, which do not need to be analyte or concentration specific, are useful. QA1 requirements are used with data from field analytical screening methods, for a quick, preliminary assessment of site contamination. Examples of QA1 activities include: determining physical and/or chemical properties of samples; assessing preliminary on-site health and safety; determining the extent and degree of contamination; assessing waste compatibility; and characterizing hazardous wastes.

QA2 verifies analytical results. The QA2 objective intends to provide a certain level of confidence for a select portion (10% or more) of the preliminary data. This objective allows the OSC to use field screening methods to quickly focus on specific pollutants and concentration levels, while at the same time requiring laboratory verification and quality assurance for at least 10% of the samples. QA2 verification methods are analyte specific. Examples of QA2 activities include: defining the extent and degree of contamination; verifying site cleanup; and verifying screening objectives obtainable with QA1, such as pollutant identification.

QA3 assesses the analytical error of the concentration level, as well as the identity of the analyte(s) of interest. QA3 data provide the highest degree of qualitative and quantitative accuracy and confidence of all QA objectives by using rigorous methods of laboratory analysis and quality assurance. Examples of QA3 activities include: selecting treatment and disposal options; evaluating health risk or environmental impact; verifying cleanup; and identifying pollutant source. The QA3 objective should be used only when determination of analytical precision in a certain concentration range is crucial for decision-making.

5.3 SOURCES OF ERROR

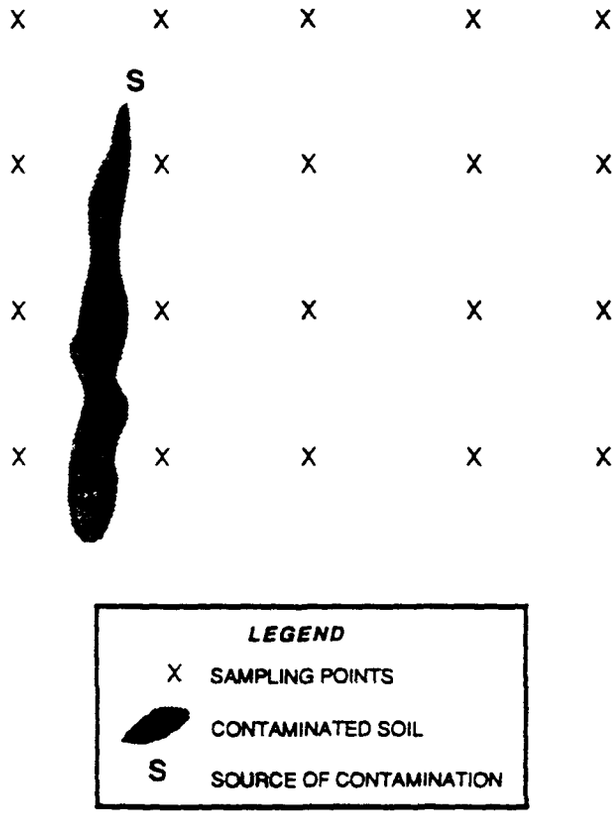
Identifying and quantifying the error or variation in sampling and laboratory analysis can be difficult. However, it is important to limit their effect(s) on the data. Four potential sources of error are:

- sampling design;
- sampling methodology;
- sample heterogeneity; and
- analytical procedures.

5.3.1 Sampling Design

Site variation includes the variation both in the types and in the concentration levels of contaminants throughout a site. Representative sampling should accurately identify and define this variation. However, error can be introduced by the selection of a sampling design which "misses" site variation. For example, a sampling grid with relatively large distances between sampling points or a biased sampling approach (i.e., judgmental sampling) may allow significant contaminant trends to go unidentified, as illustrated in figure 14.

Figure 14: Sampling Error Due to Sampling Design



5.3.2 Sampling Methodology

Error can be introduced by the sampling methodology and sample handling procedures, as in cross-contamination from inappropriate use of sample collection equipment, unclean sample containers, improper sampling equipment decontamination and shipment procedures, and other factors. Standardized procedures for collecting, handling, and shipping samples allow for easier identification of the source(s) of error, and can limit error associated with sampling methodology. The use of standard operating procedures ensures that all sampling tasks for a given matrix and analyte will be performed in the same manner, regardless of the individual sampling team, date, or location of sampling activity. Trip blanks, field blanks, replicate samples, and rinsate blanks are used to identify error due to sampling methodology and sample handling procedures.

5.3.3 Sample Heterogeneity

Sample heterogeneity is a potential source of error. Unlike water, soil is rarely a homogeneous medium and it exhibits variable properties with lateral distance and with depth. This heterogeneity may also be present in the sample container unless the sample was homogenized in the field or in the laboratory. The laboratory uses only a small aliquot of the sample for analysis; if the sample is not properly homogenized, the analysis may not be truly representative of the sample and of the corresponding site. Thoroughly homogenizing samples, therefore, can limit error associated with sample heterogeneity.

5.3.4 Analytical Procedures

Error which may originate in analytical procedures includes cross-contamination, inefficient extraction, and inappropriate methodology. Matrix spike samples, replicate samples, performance evaluation samples, and associated quality assurance evaluation of recovery, precision, and bias, can be used to distinguish analytical error from error introduced during sampling activities.

5.4 QA/QC SAMPLES

This section briefly describes the types and uses of QA/QC samples that are collected in the field, or prepared for or by the laboratory. QA/QC samples are analyzed in addition to field samples and provide information on the variability and usability of environmental sample results. They assist in identifying the origin of analytical discrepancies to help determine how the analytical results should be used. They are used mostly to validate analytical results. Field replicate, collocated, background, and rinsate blank samples are the most commonly collected field QA/QC samples. Performance evaluation, matrix spike, and matrix spike duplicate samples, either prepared for or by the laboratory, provide additional measures of control for the data generated. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific quality assurance objectives. Refer to data validation procedures in U.S. EPA, April 1990, for guidelines on utilizing QA/QC analytical results. The following paragraphs briefly describe each type of QA/QC sample.

5.4.1 Field Replicates

Field replicates are field samples obtained from one location, homogenized, divided into separate containers and treated as separate samples throughout the remaining sample handling and analytical processes. These samples are used to assess error associated with sample heterogeneity, sample methodology and analytical procedures. Use field replicates when determining total error for critical samples with contamination concentrations near the action level. For statistical analysis to be valid in such a case, a minimum of eight replicate samples would be required.

5.4.2 Collocated Samples

Collocated samples are collected adjacent to the routine field sample to determine local variability of the soil and contamination at the site. Typically, collocated samples are collected about one-half to three feet away from the selected sample location. Analytical results from collocated samples can be used to assess site variation, but only in the immediate sampling area. Due to the non-homogeneous nature of soil at sites, collocated samples should not be used to assess variability across a site and are not recommended for assessing error. Determine the applicability of collocated samples on a site-by-site basis. Collecting many samples (more than 50 samples/acre), is sufficient to demonstrate site variation.

5.4.3 Background Samples

Background samples are collected upgradient of the area(s) of contamination (either on or off site) where there is little or no chance of migration of the contaminants of concern. Background samples determine the natural composition of the soil (especially important in areas with high concentrations of naturally-occurring metals) and are considered "clean" samples. They provide a basis for comparison of contaminant concentration levels with samples collected on site. At least one background soil sample should be collected; however, more are warranted when site-specific factors such as natural variability of local soil, multiple on-site contaminant source areas, and presence of off-site facilities potentially contributing to soil contamination exist. Background samples may be collected for all QA objectives, in order to evaluate potential error associated with sampling design, sampling methodology, and analytical procedures.

5.4.4 Rinsate Blanks

Rinsate blanks are samples obtained by running analyte-free water over decontaminated sampling equipment to test for residual contamination. The blank is placed in sample containers for handling, shipment, and analysis identical to the samples collected that day. A rinsate blank is used to assess cross-contamination brought about by improper decontamination procedures. Where dedicated sampling equipment is not utilized, collect one rinsate blank, per type of sampling device, per day to meet QA2 and QA3 objectives.

5.4.5 Performance Evaluation Samples

Performance evaluation (PE) samples evaluate the overall bias of the analytical laboratory and detect any error in the analytical method used. These samples are usually prepared by a third party, using a quantity of analyte(s) which is known to the preparer but unknown to the laboratory, and always undergo certification analysis. The analyte(s) used to prepare the PE sample is the same as the analyte(s) of concern. Laboratory procedural error is evaluated by the percentage of analyte identified in the PE sample (percent recovery). Even though they are not available for all analytes, PE samples are required to achieve QA3 objectives. Where PE samples are unavailable for an analyte of interest, QA2 is the highest QA standard achievable.

5.4.6 Matrix Spike Samples

Matrix spike and matrix spike duplicate samples (MS/MSDs) are environmental samples that are spiked in the laboratory with a known concentration of a target analyte(s) to verify percent recoveries. MS/MSDs are primarily used to check sample matrix interferences. They can also be used to monitor laboratory performance. However, a dataset of at least three or more results is necessary to distinguish between laboratory performance and matrix interference.

MS/MSDs can also monitor method performance. Again, a dataset is helpful to assess whether a method is performing properly. Generally,

interference and poor method performance go together.

MS/MSDs can also evaluate error due to laboratory bias and precision (when four or more pairs are analyzed). Analyze one MS/MSD pair to assess bias for every 20 soil samples. Use the average percent recovery for the pair. To assess precision, analyze at least 8 matrix spike replicates from the same sample, determine the standard deviation and the coefficient of variation. See pages 9 - 10 of the *QA/QC Guidance for Removal Activities* (U.S. EPA, April 1990) for procedures on calculating analytical error. MS/MSDs are optional for QA2 and required to meet QA3 objectives as one of several methods to determine analytical error.

5.4.7 Field Blanks

Field blanks are samples prepared in the field using certified clean sand or soil and are then submitted to the laboratory for analysis. A field blank is used to evaluate contamination error associated with sampling methodology and laboratory procedures. If available, submit field blanks at a rate of one per day.

5.4.8 Trip Blanks

Trip blanks are samples prepared prior to going into the field. Trip blanks consist of certified clean sand or soil and are handled, transported, and analyzed in the same manner as the other volatile organic samples acquired that day. Trip blanks are used to evaluate error associated with sampling methodology and analytical procedures by determining if any contamination was introduced into samples during sampling, sample handling and shipment, and/or during laboratory handling and analysis. If available, utilize trip blanks to meet QA2 and QA3 objectives for volatile organic analyses only.

5.5 EVALUATION OF ANALYTICAL ERROR

The percentage and types of QA/QC samples needed to help identify the error and confidence in the data is based on the sampling objectives and the corresponding QA/QC objectives. The acceptable level of error is determined by the intended use of the data and the sampling objectives, including such factors as: the degree of threat to public health, welfare, or the environment; selected action levels; litigation concerns; and budgetary constraints.

The use of replicate samples is one method to evaluate error. To evaluate the total error of samples with contaminant concentrations near the selected action level, prepare and analyze a minimum of eight replicates of the same sample. Analytical data from replicate samples can also be used for a quick check on errors associated with sample heterogeneity, sample methodology and analytical procedures. Differing analytical results from two or more replicate samples could indicate improper sample preparation (e.g., incomplete homogenization), or that contamination was introduced during sample collection, preparation, handling, shipment, or analysis.

It may be desirable to try to quantify confidence; however, quantification or analytical data correction is not always possible. A 95% confidence level (i.e., 5% acceptable error) should be adequate for most Removal Program sampling activities. Experience will provide the best determination of whether to use a higher (e.g., 99%) or lower (e.g., 90%) level of confidence. It must be recognized that the use of confidence levels is based on the assumption that a sample is homogeneous. See also section 6.8 for information on total error.

5.6 CORRELATION BETWEEN FIELD SCREENING RESULTS AND CONFIRMATION RESULTS

One cost-effective approach for delineating the extent of site contamination is to correlate inexpensive field screening data and other field measurements (e.g., XRF, soil-gas measurements) with laboratory results. The relationship between the two methods can then be described by a regression analysis and used to predict laboratory results based on field screening measurements. In this manner, cost-effective field screening results may be used in addition to, or in lieu of, off-site laboratory sample analysis.

Statistical regression involves developing a model (equation) that relates two or more variables at an acceptable level of correlation. When field screening techniques, such as XRF, are used along with laboratory methods (e.g., atomic absorption (AA)), a regression equation can be used to predict a laboratory value based on the results of the

screening device. The model can also be used to place confidence limits around predictions. Additional discussion of correlation and regression can be found in most introductory statistics textbooks. A simple regression equation (e.g., linear) can be developed on many calculators or computer databases; however, a statistician should be consulted to check the accuracy of more complex models.

Evaluation of the accuracy of a model in part relies on statistical correlation. Statistical correlation involves computing an index called the correlation coefficient (r) that indicates the degree and nature of the relationship between two or more sets of values. The correlation coefficient ranges from −1.0 (a perfect inverse or negative relationship), through 0 (no relationship), to +1.0 (a perfect direct, or positive, relationship). The square of the correlation coefficient, called the coefficient of determination, or simply R^2, is an estimate of the proportion of variance in one variable (the dependent variable) that can be accounted for by the independent variables. The R^2 value that is acceptable depends on the sampling objectives and intended data uses. As a rule of thumb, statistical relationships should have an R^2 value of at least 0.6 to determine a reliable model; however, for health or risk assessment purposes, the acceptable R^2 value may be made more stringent (e.g., 0.8). Analytical calibration regressions have an R^2 value of 0.98 or better.

Once a reliable regression equation has been derived, the field screening data can be used to predict laboratory results. These predicted values can then be located on a base map and contoured (mapping methods are described in chapter 6). These maps can be examined to evaluate the estimated extent of contamination and the adequacy of the sampling program.

5.7 EXAMPLE SITE

The field screening of containerized liquid wastes performed during Phase 1 utilized the QA1 objective. The purpose of this screening was to quickly obtain data indicating general chemical class. The screening did not need to be analyte or concentration specific nor was confirmation of the results needed. The Phase 1 sampling was performed according to the QA2 objective. The analyses were analyte and concentration specific. Confirmational analysis was run on 10% of the samples in order to verify screening results. Recoveries of matrix spike and matrix spike duplicate samples indicated no matrix interferences. Dedicated equipment was used during Phase 1 sampling, making rinsate blanks unnecessary. Phase 2 field screening (XRF) was performed according to the QA2 objective. During Phase 2, samples were collected at 30% of the nodes screened with the XRF. These samples were sent for laboratory AA analysis. A correlation was established by plotting the Phase 2 AA and XRF data. This allowed the XRF data from the other 70% of the nodes to be used to evaluate the chromium levels across the site.

For Phase 2 and 3 sampling, 10% of the data were confirmed by running replicate analyses to obtain an estimate of precision. The results indicated good correlation. Matrix spikes and matrix spike duplicate samples indicated no matrix interferences. During Phase 2, the OSC opted to include performance evaluation (PE) samples for metals to evaluate the overall laboratory bias (although not required for QA2 data quality). The laboratory achieved 92% recovery, which was within the acceptable control limits.

During Phases 2 and 3, a rinsate blank was collected each day. Following the decontamination of the bucket augers, analyte-free water was poured over the augers and the rinsate was placed into 1-liter polyethylene bottles and preserved. The rinsate blanks were analyzed for total metals and cyanide to determine the effectiveness of the decontamination procedures and the potential for cross-contamination. All rinsate blank samples were "clean", indicating sufficient decontamination procedures.

The correlation analysis run on Phase 2 laboratory (AA) data and corresponding XRF values resulted in r values of 0.97 for both surface and subsurface data, which indicated a strong relationship between the AA and XRF data. Following the correlation analyses, regression analyses were run and equations to predict laboratory values based on the XRF data were developed. The resulting equation for the surface data was: AA = 0.87 (XRF) + 10.16. The resulting regression equation for the subsurface data was: AA = 0.94 (XRF) + 0.30.

6.1 INTRODUCTION

Data presentation and analysis techniques are performed with analytical, geophysical, or field screening results. The techniques discussed below can be used to compare analytical values, to evaluate numerical distribution of data, to determine and illustrate the location of hot spots and the extent of contamination across a site, and to assess the need for removal of contaminated soil with concentrations at or near the action level. The appropriate methods to present and analyze sample data depend on the sampling objectives, the number of samples collected, the sampling approaches used, and a variety of other considerations.

6.2 DATA POSTING

Data posting involves placement of sample values on a site basemap. Data posting is useful for displaying the spatial distribution of sample values to visually depict extent of contamination and to locate hot spots. Data posting requires each sample to have a specific location (e.g., X and Y coordinates). Ideally, the sample coordinates would be surveyed values to facilitate placement on a scaled map.

6.3 GEOLOGIC GRAPHICS

Geologic graphics include cross-sections and fence diagrams, which are two- and three-dimensional depictions, respectively, of soils and strata to a given depth beneath the site. These types of graphics are useful for posting subsurface analytical data as well as for interpreting subsurface geology and contaminant migration.

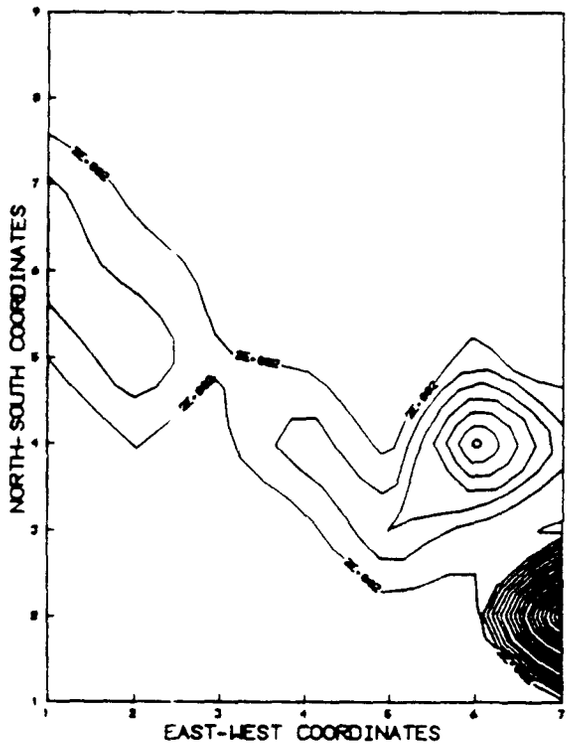
6.4 CONTOUR MAPPING

Contour maps are useful for depicting contaminant concentration values throughout a site. Contour mapping requires an accurate, to-scale basemap of the site. After data posting sample values on the basemap, insert contour lines (or isopleths) at a specified contour interval, interpolating values between sample points. Contour lines can be drawn manually or be generated by computer using contouring software. Although the software makes the contouring process easier, computer programs have a limitation: they may interpolate between all data points, attempting to fit a contour interval to the full range of data values. This can result in a contour map that does not accurately represent general site contaminant trends. Typical removal sites have low concentration/non-detect areas and hot spots. Computer contouring programs may represent these features as in figure 15 which illustrates a site that has a 4000 mg/kg hot spot. Because there is a large difference in concentration between the hot spot and the surrounding area, the computer contouring program used a contour interval that eliminated most of the subtle site features and general trends. However, if that same hot spot concentration value is posted at a reduced value, then the contouring program can select a more appropriate contour interval to better illustrate the general site trends. Figure 16 depicts the same site as in figure 15 but the hot spot concentration value has been arbitrarily posted at 1400 mg/kg. The map was recontoured and the contouring program selected a contour interval that resulted in a map which enhanced the subtle detail and general site contaminant trends.

6.5 STATISTICAL GRAPHICS

The distribution or spread of the data set is important in determining which statistical techniques to use. Common statistical analyses such as the t-test relies on normally distributed data. The histogram is a statistical bar graph which displays the distribution of a data set. A normally distributed data set takes the shape of a bell curve, with the mean and median close together about halfway between the maximum and minimum values. A probability plot depicts cumulative percent against the concentration of the contaminant of concern. A normally distributed data set, when plotted as a probability plot, would appear as a straight line. Use a histogram or probability plot to see trends and anomalies in the data prior to conducting more rigorous forms of statistical analysis.

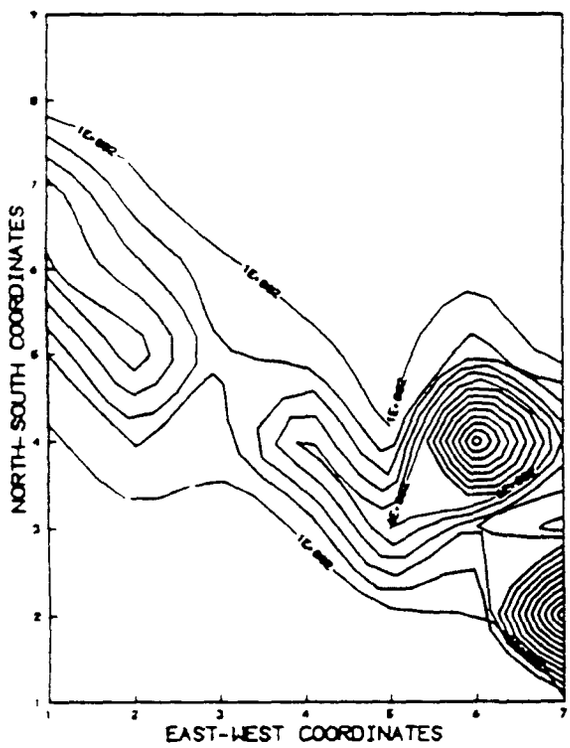
Figure 15: Computer Generated Contour Map (4000 mg/kg Hot Spot)
ABC Plating Site



Total Chromium Concentration
Units = mg/kg
Contour Interval = 100 mg/kg

Includes 4000 mg/kg Hot Spot

Figure 16: Computer Generated Contour Map (1400 mg/kg Hot Spot)
ABC Plating Site



Total Chromium Concentration
Units = mg/kg
Contour Interval = 100 mg/kg

Includes 1400 mg/kg Hot Spot*

1400 mg/kg hot spot is substituted for 4000 mg/kg hot spot (see section 6.4 – Contour Mapping)

6.6 GEOSTATISTICS

Geostatistical methods are useful for data analysis and presentation. The characteristic feature of geostatistics is the use of variograms to quantify and model the spatial relationship between values at different sampling locations and for interpolating (e.g., kriging) estimated values across a site. The geostatistical analysis can be broken down into two phases. First, a model is developed that describes the spatial relationship between sample locations on the basis of a plot of spatial variance versus the distance between pairs of samples. This plot is called a variogram. Second, the spatial relationship modeled by the variogram is used to compute a weighted-average interpolation of the data. The result of geostatistical mapping by data interpolation is a contour map that represents estimates of values across a site, and maps depicting potential error in the estimates. The error maps are useful for deciding if additional samples are needed and for calculating best or worst-case scenarios for site cleanup. More information on geostatistics can be found in U.S. EPA, September 1988b and U.S. EPA, 1990. Geo-EAS and GEOPACK, geostatistical environmental assessment software packages developed by U.S. EPA, can greatly assist with geostatistical analysis methods.

6.7 RECOMMENDED DATA INTERPRETATION METHODS

The data interpretation method chosen depends on project-specific considerations, such as the number of sampling locations and their associated range in values. A site depicting extremely low data values (e.g., non-detects) with significantly higher values (e.g., 5,000 ppm) from neighboring hot spots, with little or no concentration gradient in-between, does not lend itself to contouring and geostatistics, specifically the development of variograms. However, data posting would be useful at such a site to illustrate hot spot and clean areas. Conversely, geostatistics and contour mapping, as well as data posting, can be applied to site data with a wide distribution of values (i.e., depicting a "bell shaped" curve) with beneficial results.

6.8 UTILIZATION OF DATA

When conducting search sampling to determine the locations of hot spots (as discussed in section 2.9), analyze the data using one of the methods discussed in this chapter. For each node that is determined to be close to or above the action level, the following procedure is recommended.

Investigate all neighboring grid cells to determine which areas must be excavated and/or treated. From each grid cell, take a composite sample consisting of four or more aliquots, using the procedure described in section 2.11.6. Grid cells with contaminant concentrations significantly above the action level (e.g., 20%) should be marked for removal. Grid cells with contaminant concentrations significantly less than the action level should be designated as clean. For grid cells with contaminant concentrations close to the action level, it is recommended that additional sampling be done within that grid cell to determine whether it is truly a hot spot, or whether the analytical result is due to sampling and/or analytical procedural error. If additional sampling is to be performed, one of the following methods should be considered:

- Collect a minimum of four grab samples within the grid cell in question. Use these samples to develop a 95% confidence interval around the mean concentration. If the action level falls within or below this confidence interval, then consider removal/treatment of the soil within that grid cell. More information on confidence intervals and standard deviation can be found in Gilbert, 1987.

- Collect additional composite samples from the grid cells in question using the technique discussed in section 2.11.6. From these additional samples, determine the need for removal/treatment.

These two practical approaches help to determine the total error associated with collecting a sample from a non-homogeneous site. Total error includes design error, sampling error, non-homogeneous sampling error, and analytical error.

If additional sampling is being considered, weigh the cost-effectiveness of collecting the additional samples versus removing the soil from the areas in question. This decision must be made on a site-by-site basis.

After removal/treatment of the contaminated soil, re-investigate the grid cells to verify cleanup below the action level. Each grid cell that had soil removed must either be composite sampled again, or have multiple grab samples collected with a 95% confidence interval set up again. Again, this decision must be made on a site-by-site basis. The methodology should be repeated until all grid cells are determined to have soil concentrations below the action level.

6.9 EXAMPLE SITE

The Phase 2 XRF/atomic absorption (AA) data were examined to determine the appropriate data interpretation method to use. A histogram was generated to illustrate the distribution of the data as depicted in figure 17. The histogram showed an uneven distribution of the data with most values less than 50 (approximately 4 on the LN scale of the histogram). Also, the presence of a single data point of 4000 (8 on the LN scale) was shown on the histogram. The data were initially posted as illustrated in figures 18 and 19. Data posting was performed manually to give the OSC a quick depiction of the general site contamination trends. A contour mapping program was used to generate contours based on the posted data. Figure 15 illustrates the results of contouring with the 4000 mg/kg hot spot included. This contour map exaggerated the hot spot while eliminating the subtle site features and contaminant trends. Figure 16 depicts the same site data with the hot spot arbitrarily reduced to 1400 mg/kg. The resulting contour map enhanced more of the subtle site features and trends while reducing the effects of the hot spot.

AA concentrations predicted by the regression equations were kriged and contoured using Geo-EAS (figures 20 and 21). Both the kriged contours and the data posting showed the same general site contaminant trends. However, data posting gave a more representative depiction of actual levels of contamination and the OSC used data posting for decision-making.

For each node with chromium concentrations close to or above the 100 ppm action level, the adjacent grid cells were further investigated. Composite samples consisting of four aliquots of soil were taken from within each grid cell in question and analyzed. If the soil concentration level was significantly below 100 ppm of chromium, the cell was designated as clean. Each cell that had a soil concentration level well above the action level was marked for treatment/removal. Any cells having soil concentrations close to the action level were sampled further using the compositing method to better quantify the actual contaminant concentration. Since the surrounding area is residential, on-site landfilling was not considered a viable treatment option. To expedite treatment/disposal, all excavated soil from contaminated cells was stockpiled on site until treatment/disposal could be accomplished under a fixed-price contract. The stockpile, placed in the area of the most highly contaminated grid cells (where the lagoons were located), was covered until treatment/disposal could be arranged. Cleanup was verified with composite sampling in the excavated cells. Results of the composite sampling were compared with the action level to verify cleanup. All action levels were met. The excavation pits were filled with stone and clean soil, covered with topsoil, graded and seeded.

Figure 17: Histogram of Surface Chromium Concentrations
ABC Plating Site

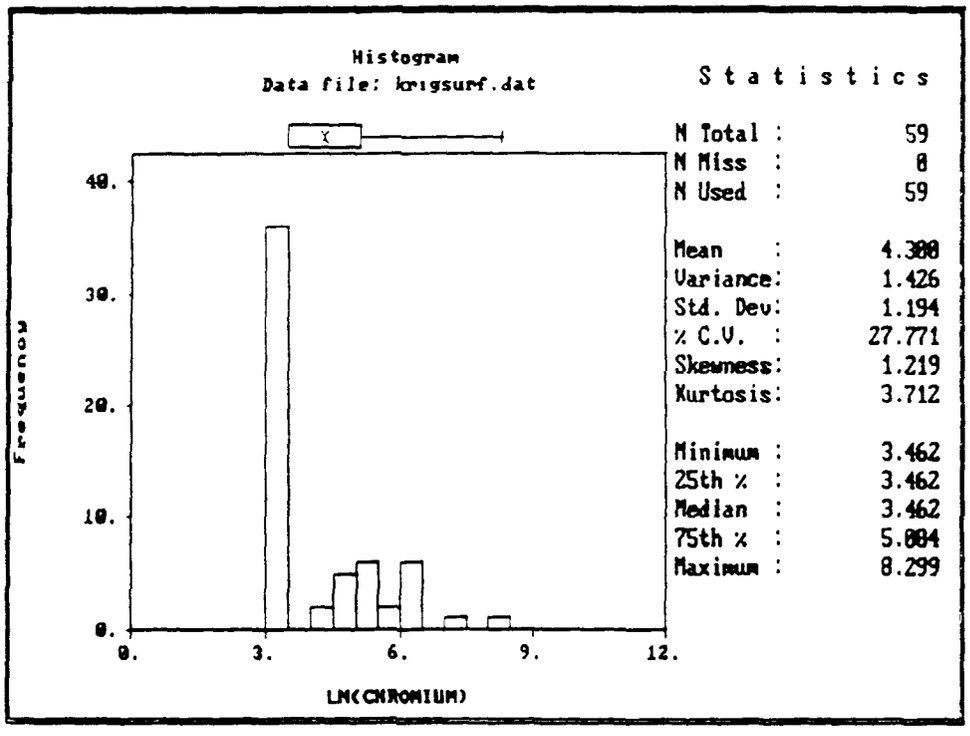


Figure 18: Phase 2 Surface Data Posting for Chromium
ABC Plating Site

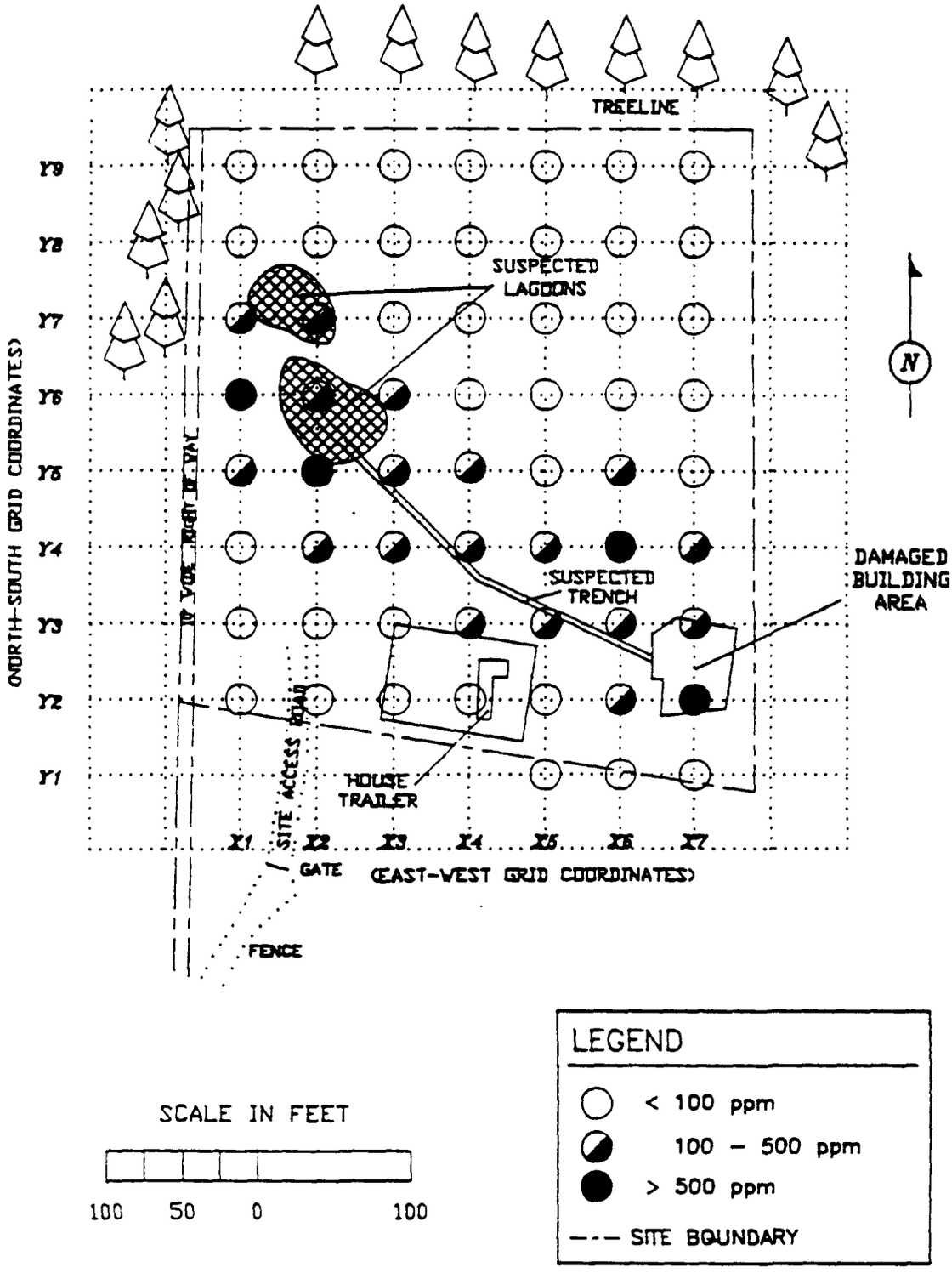


Figure 19: Phase 2 Subsurface Data Posting for Chromium ABC Plating Site

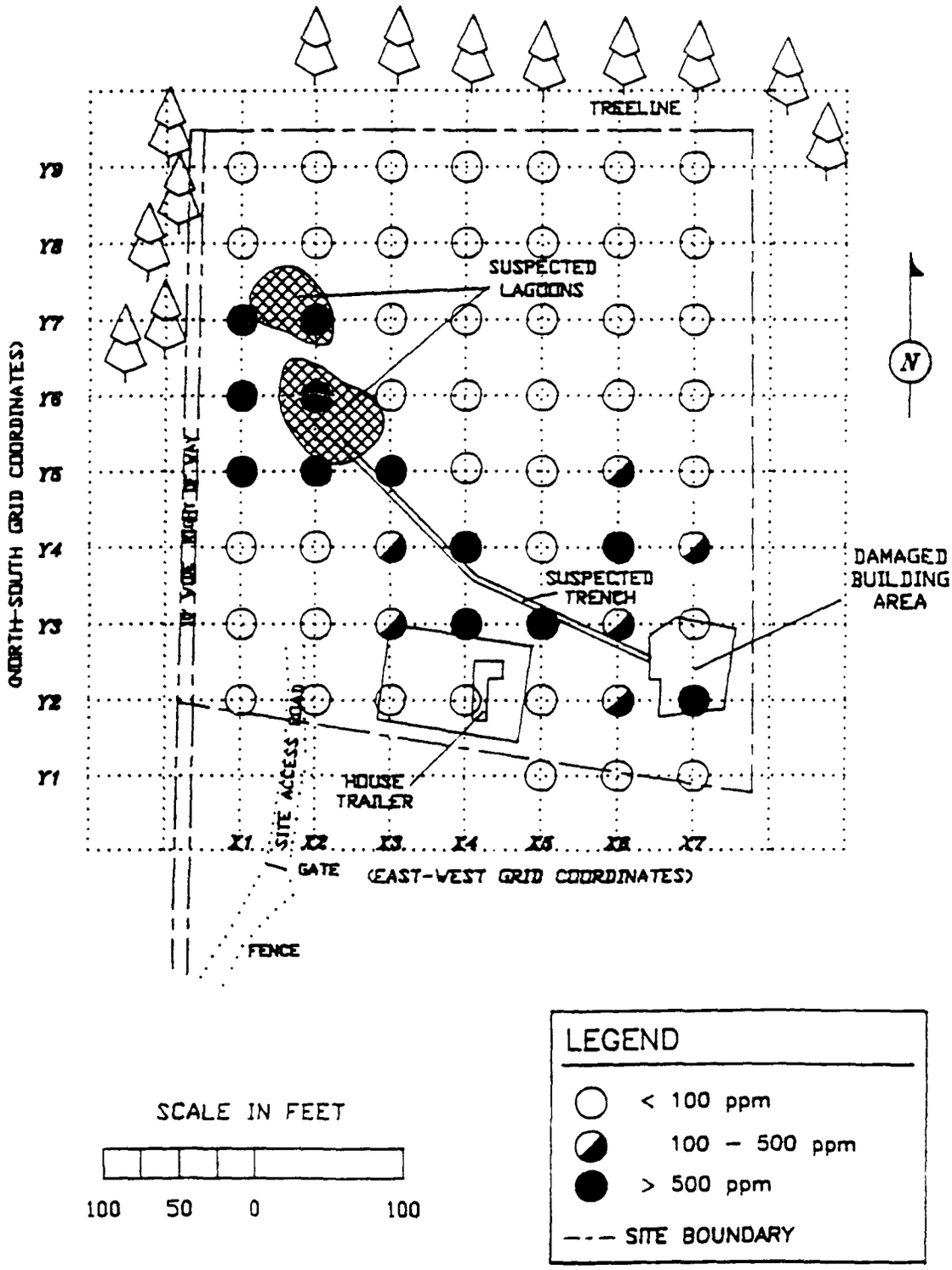


Figure 20: Contour Map of Surface Chromium Data (ppm)
ABC Plating Site

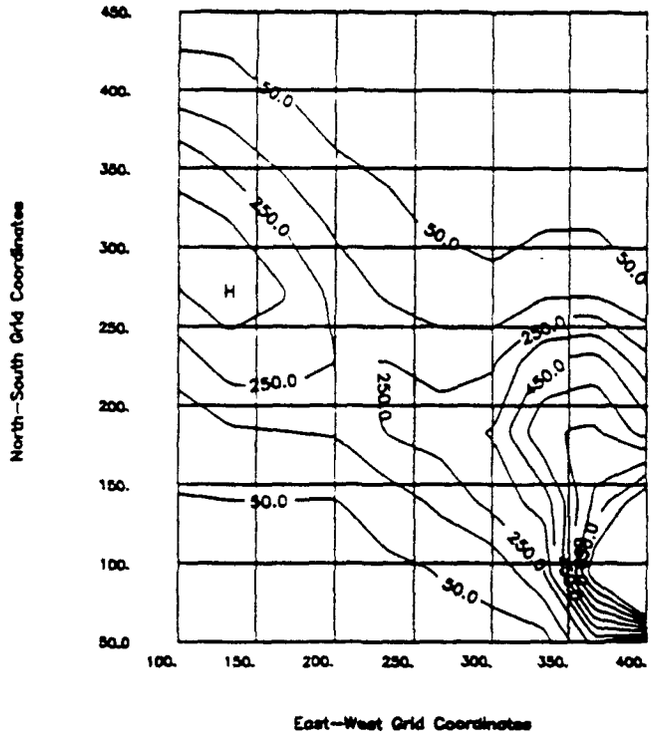
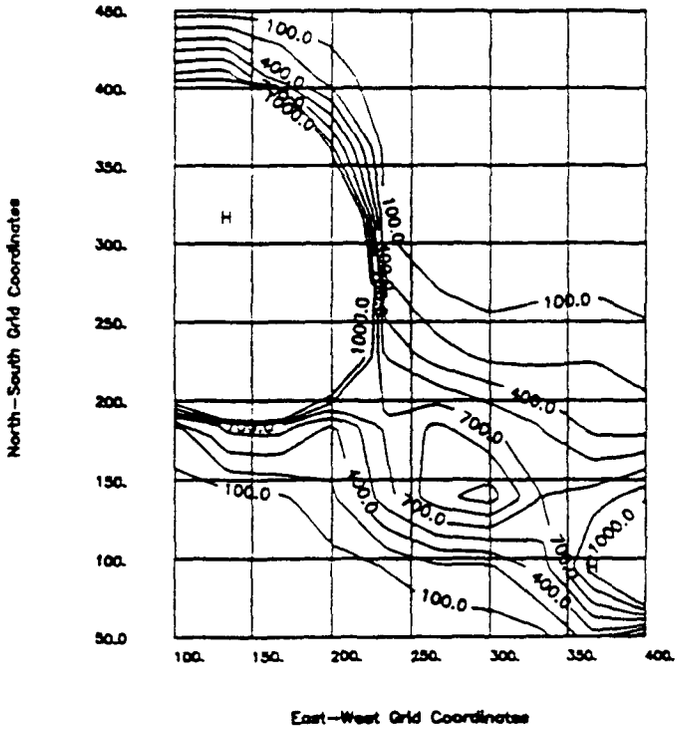


Figure 21: Contour Map of Subsurface Chromium Data (ppm)
ABC Plating Site



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APPENDIX B

Compendium of ERT Waste Sampling Procedures

EPA/540/P-91/008
OSWER Directive 9360.4-07
January 1991

COMPENDIUM OF ERT WASTE SAMPLING PROCEDURES

Sampling Equipment Decontamination

Drum Sampling

Tank Sampling

Chip, Wipe, and Sweep Sampling

Waste Pile Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities,* OSWER directive 9360.4-01, EPA/540/G-90/004.

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1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 on page 4 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

2.0 DRUM SAMPLING: SOP #2009

2.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide technical guidance on safe and cost-effective response actions at hazardous waste sites containing drums with unknown contents. Container contents are sampled and characterized for disposal, bulking, recycling, grouping, and/or classification purposes.

2.2 METHOD SUMMARY

Prior to sampling, drums must be inventoried, staged, and opened. An inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation of drums which have similar wastes or characteristics. Opening of closed drums can be performed manually or remotely. Remote drum opening is recommended for worker safety. The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from drums are considered waste samples. No preservatives should be added since there is a potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Follow these waste sample handling procedures:

1. Place sample container in two Ziploc plastic bags.
2. Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
3. Mark the sample identification number on the outside of the can.
4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.
5. Fill out chain of custody form for each cooler, place in plastic, and affix to inside lid of cooler.
6. Secure and custody seal the lid of cooler.
7. Arrange for the appropriate transportation mode consistent with the type of hazardous waste involved.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized or if shock-sensitive materials are suspected. A laser thermometer may be used instead.

Drums that have been overpressurized, to the extent that the head is swollen several inches above the level of the chime, should not be moved. A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The venting should be done from behind a wall or barricade. This device can be cheaply and easily designed and constructed where needed. Once the pressure has been relieved, the bung can be removed and the drum sampled.

2.5 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- personal protection equipment
- wide-mouth glass jars with Teflon cap liner, approximately 500 mL volume
- uniquely numbered sample identification labels with corresponding data sheets
- 1-gallon covered cans half-filled with absorbent (vermiculite)
- chain of custody forms
- decontamination materials
- glass thief tubes or Composite Liquid Waste Samplers (COLIWASA)
- laser thermometer
- drum opening devices

Drum opening devices include the following:

2.5.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy formulated to reduce the likelihood of sparks. The use of a non-sparking bung wrench does not completely eliminate the possibility of a spark being produced. (See Figure 1, Appendix B.)

2.5.2 Drum Deheader

When a bung is not removable with a bung wrench, a drum can be opened manually by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads must be opened by other means. (See Figure 2, Appendix B.)

2.5.3 Hand Pick, Pickaxe, and Hand Spike

These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available; whereas the spikes are generally uniquely fabricated 4-foot long poles with a pointed end. (See Figure 3, Appendix B.)

2.5.4 Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personal exposure. (See Figure 4, Appendix B.)

2.5.5 Hydraulic Drum Opener

Another remote method for opening drums is with remotely operated hydraulic devices. One such device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump which pressurizes soil through a length of hydraulic line. (See Figure 5, Appendix B.)

2.5.6 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device. (See Figure 6, Appendix B.)

2.6 REAGENTS

Reagents are not typically required for preserving drum samples. However, reagents are used for decontaminating sampling equipment. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

2.7.2 Drum Inspection

Appropriate procedures for handling drums depend on the contents. Thus, prior to any handling, drums should be visually inspected to gain as much information as possible about their contents. Those in charge of inspections should be on the look-out for:

- drum condition, corrosion, rust, and leaking contents

- symbols, words, or other markings on the drum indicating hazards (i.e., explosive, radioactive, toxic, flammable)

- signs that the drum is under pressure

- shock sensitivity

Monitor around the drums with radiation instruments, organic vapor monitors (OVA) and combustible gas indicators (CGI).

Classify the drums into categories, for instance:

- radioactive
- leaking/deteriorating
- bulging
- drums containing lab packs
- explosive/shock sensitive

All personnel should assume that unmarked drums contain hazardous materials until their contents have been categorized, and that labels on drums may not accurately describe their contents.

If it is presumed that there are buried drums on-site, geophysical investigation techniques such as magnetometry, ground penetrating radar, and metal detection can be employed in an attempt to determine depth and location of the drums. See ERT SOP #2159, General Surface Geophysics.

2.7.3 Drum Staging

Prior to sampling, the drums should be staged to allow easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum should explode or catch fire when opened.

While staging, physically separate the drums into the following categories: those containing liquids, those containing solids, lab packs, or gas cylinders, and those which are empty. This is done because the strategy for sampling and handling drums/containers in each of these categories will be different. This may be achieved by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open-top drums. Closed-head drums with a bung opening generally contain liquid.

- Visual inspection of the contents of the drum during sampling followed by restaging, if needed.

Once a drum has been excavated and any immediate hazard has been eliminated by overpacking or transferring the drum's contents, affix a numbered tag to the drum and transfer it to a staging area. Color-coded tags, labels, or bands should be used to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored, on a drum data sheet (Appendix A). This data sheet becomes the principal

recordkeeping tool for tracking the drum onsite.

Where there is good reason to suspect that some drums contain radioactive, explosive, and shock-sensitive materials, these drums should be staged in a separate, isolated area. Placement of explosives and shock-sensitive materials in diked and fenced areas will minimize the hazard and the adverse effects of any premature detonation of explosives.

Where space allows, the drum opening area should be physically separated from the drum removal and drum staging operations. Drums are moved from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

2.7.4 Drum Opening

There are three basic techniques available for opening drums at hazardous waste sites:

- Manual opening with non-sparking bung wrenches,
- Drum deheading, and
- Remote drum puncturing or bung removal.

The choice of drum opening techniques and accessories depends on the number of drums to be opened, their waste contents, and physical condition. Remote drum opening equipment should always be considered in order to protect worker safety. Under OSHA 1910.120, manual drum opening with bung wrenches or deheaders should be performed only with structurally sound drums having contents that are known to be (1) not shock sensitive, (2) non-reactive, (3) non-explosive, and (4) non-flammable.

Manual Drum Opening with a Bung Wrench

Manual drum opening with bung wrenches (Figure 1, Appendix B) should not be performed unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then follow these procedures to minimize the hazard:

1. Fully outfit field personnel with protective gear.
2. Position drum upright with the bung up, or, for drums with bungs on the side, lay the drum on its side with the bung plug up.
3. Wrench the bung with a slow, steady pulling motion across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a "cheater bar" to the handle to improve leverage.

Manual Drum Opening with a Drum Deheader

Drums are opened with a drum deheader (Figure 2, Appendix B) by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will cut off the entire top. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut off the entire top. Since there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to use a remote method to puncture the drum prior to using the deheader.

Self-propelled drum openers which are either electrically or pneumatically driven can be used for quicker and more efficient deheading.

Manual Drum Opening with a Hand Pick, Pickaxe, or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, the drum can be opened for sampling by using a hand pick, pickaxe, or spike (Figure 3, Appendix B). Often the drum lid or head must be hit with a great deal of force in order to penetrate it. The potential for splash or spraying is greater than with other opening methods and, therefore, this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums cannot be opened slowly with these tools, spray from drums is common requiring appropriate safety measures. Decontaminate the pick or spike after each drum is opened to avoid cross-contamination and/or adverse chemical reaction from incompatible materials.

Remote Drum Opening with a Backhoe Spike

Remotely operated drum opening tools are the safest available means of drum opening. Remote drum opening is slow, but is much safer compared to manual methods of opening.

Drums should be "staged" or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike (Figure 4, Appendix B) should be decontaminated after each drum is opened to prevent cross-contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the required level of personal protection gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system.

Remote Drum Opening with Hydraulic Devices

A piercing device with a metal point is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure (Figure 5, Appendix B). The piercing device can be attached so that the sampling hole can be made on either the side or the head of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place if desired and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

Remote Drum Opening with Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely (Figure 6, Appendix B).

2.7.5 Drum Sampling

After the drum has been opened, monitor headspace gases using an explosimeter and organic vapor analyzer. In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel.

When sampling a previously sealed vessel, check for the presence of a bottom sludge. This is easily accomplished by measuring the depth to the apparent bottom, then comparing it to the known interior depth.

Glass Thief Sampler

The most widely used implement for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Appendix B). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

Procedures for using a glass thief are as follows:

1. Remove cover from sample container.

2. Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum.

3. Allow the waste in the drum to reach its natural level in the tube.

4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.

5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.

6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.

7. Remove tube from the sample container, break it into pieces and place the pieces in the drum.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the drum.

10. Log all samples in the site logbook and on field data sheets.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

It should be noted that in some instances disposal of the tube by breaking it into the drum may interfere with eventual plans for the removal of its contents. This practice should be cleared with the project officer or other disposal techniques evaluated.

COLIWASA Sampler

Some equipment is designed to collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) and modifications thereof. The COLIWASA (Figure 8, Appendix B) is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end.

Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. One model of the COLIWASA is shown in Appendix B; however, the design can be modified and/or adapted somewhat to meet the needs of the sampler.

The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult, if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Follow these procedures for using the COLIWASA:

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the drum.

8. Log all samples in the site logbook and on field data sheets.

9. Package samples and complete necessary paperwork.

10. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- Document all data on standard chain of custody forms, field data sheets, or within site logbooks.

- Operate all instrumentation in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

The opening of closed containers is one of the most hazardous site activities. Maximum efforts should be made to ensure the safety of the sampling team. Proper protective equipment and a general awareness of the possible dangers will minimize the risk inherent in sampling operations. Employing proper drum-opening techniques and equipment will also safeguard personnel. Use remote sampling equipment whenever feasible.

3.0 TANK SAMPLING: SOP #2010

3.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide protocols for sampling tanks and other confined spaces from outside the vessel.

3.2 METHOD SUMMARY

The safe collection of a representative sample should be the criterion for selecting sample locations. A representative sample can be collected using techniques or equipment that are designed for obtaining liquids or sludges from various depths. The structure and characteristics of storage tanks present problems with collection of samples from more than one location; therefore, the selection of sampling devices is an important consideration.

Depending on the type of vessel and characteristics of the material to be sampled, one can choose a bailer, glass thief, bacon bomb sampler, sludge judge, COLIWASA, or subsurface grab sampler to collect the sample. For depths of less than 5-feet, a bailer, COLIWASA, or sludge judge can be used. A sludge judge, subsurface grab sampler, bailer, or bacon bomb sampler can be used for depths greater than 5-feet. A sludge judge or bacon bomb can be used to determine if the tank consists of various strata.

All sample locations should be surveyed for air quality prior to sampling. At no time should sampling continue with an LEL reading greater than 25%.

All personnel involved in tank sampling should be advised as to the hazards associated with working in unfavorable conditions.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from tanks are considered waste samples and, as such, addition of preservatives is not required due to the potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Waste sample handling procedures should be as follows:

1. Place sample container in two Ziploc plastic bags.
2. Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
3. Mark the sample identification number on the outside of the can.
4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.
5. Fill out a chain of custody form for each cooler, place it in plastic, and affix it to the inside lid of the cooler.
6. Secure and custody seal the lid of cooler.
7. Arrange for the transportation appropriate for the type of hazardous waste involved.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

Sampling a storage tank requires a great deal of manual dexterity, often requiring the sampler to climb to the top of the tank upon a narrow vertical or spiral stairway or ladder while wearing protective clothing and carrying sampling equipment.

Before climbing onto the vessel, perform a structural survey of the tank to ensure the sampler's

safety and accessibility prior to initiating field activities.

As in all opening of containers, take extreme caution to avoid ignition or combustion of volatile contents. All tools used must be constructed of a non-sparking material and electronic instruments must be intrinsically safe.

All sample locations should be surveyed for air quality prior to sampling. At no time should sampling continue with an LEL reading greater than 25%.

3.5 EQUIPMENT/APPARATUS

Storage tank materials include liquids, sludges, still bottoms, and solids of various structures. The type of sampling equipment chosen should be compatible with the waste. Samplers commonly used for tanks include: the bacon bomb sampler, the sludge judge, glass thief, bailer, COLIWASA, and subsurface grab sampler.

- sampling plan
- safety equipment
- tape measure
- weighted tape line or equivalent
- camera/film
- stainless steel bucket or bowl
- sample containers
- Ziploc plastic bags
- logbook
- labels
- field data sheets
- chain of custody forms
- flashlight (explosion proof)
- coolers
- ice
- decontamination supplies
- bacon bomb sampler
- sludge judge
- glass thief
- bailer
- COLIWASA
- subsurface grab sampler
- water/oil level indicator
- OVA (organic vapor analyzer or equivalent)
- explosimeter/oxygen meter
- high volume blower

3.6 REAGENTS

Reagents are not typically required for the preservation of waste samples. However, reagents will be utilized for decontamination of equipment. Decontamination solutions required are specified in ERT SOP #2006, Sampling Equipment Decontamination.

3.7 PROCEDURES

3.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Identify and mark all sampling locations.

3.7.2 Preliminary Inspection

1. Inspect the external structural characteristics of each tank and record in the site logbook. Potential sampling points should be evaluated for safety, accessibility, and sample quality.

2. Prior to opening a tank for internal inspection, the tank sampling team should:

   - Review safety procedures and emergency contingency plans with the Safety Officer,

   - Ensure that the tank is properly grounded,

   - Remove all sources of ignition from the immediate area.

3. Each tank should be mounted using appropriate means. Remove manway covers using non-sparking tools.

4. Collect air quality measurements for each potential sample location using an explosimeter/oxygen meter for a lower explosive limit (LEL/O_2) reading and an OVA/HNU for an organic vapor concentration. Both readings should be taken from the tank headspace, above the sampling port, and in the breathing zone.

5. Prior to sampling, the tank headspace should be cleared of any toxic or explosive vapor concentration using a high volume blower. No work should start if LEL readings exceed 25%. At 10% LEL, work can continue but with extreme caution.

3.7.3 Sampling Procedures

1. Determine the depth of any and all liquid-solid interface, and depth of sludge using a weighted tape measure, probe line, sludge judge, or equivalent.

2. Collect liquid samples from 1-foot below the surface, from mid-depth of liquid, and from 1-foot above the bottom sludge layer. This can be accomplished with a subsurface grab sampler or bacon bomb. For liquids less than 5-feet in depth, use a glass thief or COLIWASA to collect the sample.

   If sampling storage tanks, vacuum trucks, or process vessels, collect at least one sample from each compartment in the tank. Samples should always be collected through an opened hatch at the top of the tank. Valves near the bottom should not be used, because of their questionable or unknown integrity. If such a valve cannot be closed once opened, the entire tank contents may be lost to the ground surface. Also, individual strata cannot be sampled separately through a valve near the bottom.

3. Compare the three samples for visual phase differences. If phase differences appear, systematic iterative sampling should be performed. By halving the distance between two discrete sampling points, one can determine the depth of the phase change.

4. If another sampling port is available, sample as above to verify the phase information.

5. Measure the outside diameter of the tank and determine the volume of wastes using the depth measurements. (See Appendix C for calculations.)

6. Sludges can be collected using a bacon bomb sampler, glass thief, or sludge judge.

7. Record all information on the sample data sheet or site logbook. Label the container with the appropriate sample tag.

8. Decontaminate sampling equipment as per ERT SOP #2006, Sampling Equipment Decontamination.

3.7.4 Sampling Devices

Bacon Bomb Sampler

The bacon bomb sampler (Figure 9, Appendix B) is designed to collect material from various levels within a storage tank. It consists of a cylindrical body, usually made of chrome-plated brass and bronze with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger opens and closes the valve. A line is attached to the removable top cover which has a locking mechanism to keep the plunger closed after sampling.

1. Attach the sample line and the plunger line to the sampler.

2. Measure and then mark the sampling line at the desired depth.

3. Gradually lower the bacon bomb sampler by the sample line until the desired level is reached.

4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill before releasing the plunger line to seal off the sampler.

5. Retrieve the sampler by the sample line. Be careful not to pull up on the plunger line and thereby prevent accidental opening of the bottom valve.

6. Rinse or wipe off the exterior of the sampler body.

7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the tank.

10. Log all samples in the site logbook and on field data sheets and label all samples.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Sludge Judge

A sludge judge (Figure 10, Appendix B) is used for obtaining an accurate reading of solids which can settle, in any liquid, to any depth. The sampler consists of 3/4-inch plastic pipe in 5-foot sections, marked at 1-foot increments, with screw-style fittings. The top section includes a nylon line for raising the sampler.

1. Lower the sludge judge to the bottom of the tank.

2. When the bottom has been reached, and the pipe has filled to surface level, tug slightly on the rope as you begin to raise the unit. This will seat the check valve, trapping the column of material.

3. When the unit has been raised clear of the tank liquid, the amount of sludge in the sample can be read using the 1-foot increments marked on the pipe sections.

4. By touching the pin extending from the bottom section against a hard surface, the material is released from the unit.

5. Cap the sample container tightly and place prelabeled sample container in a carrier.

6. Replace the bung or place plastic over the tank.

7. Log all samples in the site logbook and on field data sheets and label all samples.

8. Package samples and complete necessary paperwork.

9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Subsurface Grab Sampler

Subsurface grab samplers (Figure 11, Appendix B) are designed to collect samples of liquids at various depths. The sampler is usually constructed of aluminum or stainless steel tubing with a polypropylene or Teflon head that attaches to a 1-liter sample container.

1. Screw the sample bottle onto the sampling head.

2. Lower the sampler to the desired depth.

3. Pull the ring at the top which opens the spring-loaded plunger in the head assembly.

4. When the bottle is full, release the ring, lift sampler, and remove sample bottle.

5. Cap the sample container tightly and place prelabeled sample container in a carrier.

6. Replace the bung or place plastic over the tank.

7. Log all samples in the site logbook and on field data sheets and label all samples.

8. Package samples and complete necessary paperwork.

9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Glass Thief

The most widely used implement for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Appendix B). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

1. Remove cover from sample container.

2. Insert glass tubing almost to the bottom of the

tank or until a solid layer is encountered. About 1 foot of tubing should extend above the tank.

3. Allow the waste in the tank to reach its natural level in the tube.

4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does *not come into contact with stopper.*

5. Carefully remove the capped tube from the tank and insert the uncapped end in the sample container. Do not spill liquid on the outside of the sample container.

6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.

7. Remove tube from the sample container, break it into pieces and place the pieces in the tank.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the tank.

10. Log all samples in the site logbook and on field data sheets and label all samples.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a tank containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

Bailer

The positive-displacement volatile sampling bailer (manufactured by GPI or equivalent) (Figure 12, Appendix B) is perhaps the most appropriate for collecting water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions. Generally, bailers can provide an acceptable sample, providing that the sampling personnel use extra care in the collection process.

1. Make sure clean plastic sheeting surrounds the tank.

2. Attach a line to the bailer.

3. Lower the bailer slowly and gently into the tank so as not to splash the bailer into the tank contents.

4. Allow the bailer to fill completely and retrieve the bailer from the tank.

5. Begin slowly pouring from the bailer.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the tank.

8. Log all samples in the site logbook and on field data sheets and label all samples.

9. Package samples and complete necessary paperwork.

10. Transport sample to decontamination zone to prepare it for transport to an analytical laboratory.

COLIWASA

Some equipment is designed to collect a sample from the full depth of a tank and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) (Figure 8, Appendix B) and modifications thereof. The COLIWASA is a much cited sampler designed to permit representative sampling of multiphase wastes from tanks and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the tank.

8. Log all samples in the site logbook and on field data sheets and label all samples.

9. Package samples and complete necessary paperwork.

10. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

3.8 CALCULATIONS

Refer to Appendix C for calculations to determine tank volumes.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

3.10 DATA VALIDATION

This section is not applicable to this SOP.

3.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures. More specifically, the hazards associated with tank sampling may cause bodily injury, illness, or death to the worker. Failure to recognize potential hazards of waste containers is the cause of most accidents. It should be assumed that the most unfavorable conditions exist, and that the danger of explosion and poisoning will be present. Hazards specific to tank sampling are:

- Hazardous atmospheres can be flammable, toxic, asphyxiating, or corrosive.

- If activating electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated

to prevent inadvertent activation while workers are occupied.

- Communication is of utmost importance between the sampling worker and the standby person to prevent distress or injury going unnoticed. The Illuminating Engineers Society Lighting Handbook requires suitable illumination to provide sufficient visibility for work.

- Noise reverberation may disrupt verbal communication with standby personnel.

- Tank vibration may affect multiple body parts and organs of the sampler depending on vibration characteristics.

- General hazards include falling scaffolding, surface residues (which could cause electrical shock, incompatible material reactions, slips, or falls), and structural objects (including baffles/trays in horizontal/vertical tanks, and overhead structures).

4.0 CHIP, WIPE, AND SWEEP SAMPLING: SOP #2011

4.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) outlines the recommended protocol and equipment for collection of representative chip, wipe, and sweep samples to monitor potential surficial contamination.

This method of sampling is appropriate for surfaces contaminated with non-volatile species of analytes (i.e., PCB, PCDD, PCDF, metals, cyanide, etc.) Detection limits are analyte specific. Sample size should be determined based upon the detection limit desired and the amount of sample requested by the analytical laboratory. Typical sample area is 1 square foot. However, based upon sampling location, the area may need modification due to area configuration.

4.2 METHOD SUMMARY

Since surface situations vary widely, no universal sampling method can be recommended. Rather, the method and implements used must be tailored to suit a specific sampling site. The sampling location should be selected based upon the potential for contamination as a result of manufacturing processes or personnel practices.

Chip sampling is appropriate for porous surfaces and is generally accomplished with either a hammer and chisel, or an electric hammer. The sampling device should be laboratory cleaned and wrapped in clean, autoclaved aluminum foil until ready for use. To collect the sample, a measured and marked off area is chipped both horizontally and vertically to an even depth of 1/8 inch. The sample is then transferred to the proper sample container.

Wipe samples are collected from smooth surfaces to indicate surficial contamination; a sample location is measured and marked off. Sampling personnel wear a new pair of surgical gloves to open a sterile gauze pad, and then soak it with solvent. The solvent used is dependent on the surface being sampled. This pad is then stroked firmly over the sample surface, first vertically, then horizontally, to ensure complete coverage. The pad is then transferred to the sample container.

Sweep sampling is an effective method for the collection of dust or residue on porous or non-porous surfaces. To collect such a sample, an appropriate area is measured off. Then, while wearing a new pair of disposable surgical gloves, sampling personnel use a dedicated brush to sweep material into a dedicated dust pan. The sample is then transferred to the proper sample container.

Samples collected by all three methods are sent to the laboratory for analysis.

4.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples should be stored out of direct sunlight to reduce photodegredation and shipped on ice (4°C) to the laboratory performing the analysis. Appropriately-sized, laboratory-cleaned, glass sample jars should be used for sample collection. The amount of sample required is determined in concert with the analytical laboratory.

4.4 INTERFERENCES AND POTENTIAL PROBLEMS

This method has few significant interferences or problems. Typical problems result from rough porous surfaces which may be difficult to wipe, chip, or sweep.

4.5 EQUIPMENT/APPARATUS

- lab-clean sample containers of proper size and composition
- field and travel blanks
- site logbook
- sample analysis request forms
- chain of custody forms
- custody seals
- sample labels
- disposable surgical gloves
- sterile wrapped gauze pad (3 in. x 3 in.)
- appropriate pesticide (HPLC) grade solvent

- medium-sized, laboratory-cleaned paint brush
- medium-sized, laboratory-cleaned chisel
- autoclaved aluminum foil
- camera
- hexane (pesticide/HPLC grade)
- iso-octane
- distilled/deionized water

4.6 REAGENTS

Reagents are not required for preservation of chip, wipe or sweep samples. However, reagents will be utilized for decontamination of sampling equipment. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

4.7 PROCEDURES

4.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

4.7.2 Chip Sample Collection

Sampling of porous surfaces is generally accomplished by using a chisel and hammer or electric hammer. The sampling device should be laboratory cleaned or field decontaminated as per ERT SOP# 2006, Sampling Equipment Decontamination. It is then wrapped in cleaned, autoclaved aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampling device should be used for only one sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record surface area to be chipped.

3. Don a new pair of disposable surgical gloves.

4. Open a laboratory-cleaned chisel or equivalent sampling device.

5. Chip the sample area horizontally, then vertically to an even depth of approximately 1/8 inch.

6. Place the sample in an appropriately-prepared sample container with a Teflon-lined cap.

7. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

8. Store samples out of direct sunlight and cool to 4°C.

9. Leave contaminated sampling device in the sampled material, unless decontamination is practical.

10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.7.3 Wipe Sample Collection

Wipe sampling is accomplished by using a sterile gauze pad, adding a solvent in which the contaminant is most soluble, then wiping a pre-determined, pre-measured area. The sample is packaged in an amber jar to prevent photodegradation and packed in coolers for shipment to the lab. Each gauze pad is used for only one wipe sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record surface area to be wiped.

3. Don a new pair of disposable surgical gloves.

4. Open new sterile package of gauze pad.

5. Soak the pad with the appropriate solvent.

6. Wipe the marked surface area using firm strokes. Wipe vertically, then horizontally to ensure complete surface coverage.

7. Place the gauze pad in an appropriately prepared sample container with a Teflon-lined cap.

8. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

9. Store samples out of direct sunlight and cool to 4°C.

10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.7.4 Sweep Sample Collection

Sweep sampling is appropriate for bulk contamination. This procedure utilizes a dedicated, hand-held sweeper brush to acquire a sample from a pre-measured area.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record the surface area to be swept.

3. Don a new pair of disposable surgical gloves.

4. Sweep the measured area using a dedicated brush; collect the sample in a dedicated dust pan.

5. Transfer sample from dust pan to sample container.

6. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

7. Store samples out of direct sunlight and cool to 4°C.

8. Leave contaminated sampling device in the sample material, unless decontamination is practical.

9. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.8 CALCULATIONS

Results are usually provided in mg/g, μg/g or another appropriate weight per unit weight measurement. Results may also be given in a mass per unit area.

4.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or within the site logbook.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activities apply to wipe samples:

- A blank should be collected for each sampling event. This consists of a sterile gauze pad, wet with the appropriate solvent, and placed in a prepared sample container. The blank will help identify potential introduction of contaminants via

the sampling methods, the pad, solvent or sample container.

- Spiked wipe samples can also be collected to better assess the data being generated. These are prepared by spiking a piece of foil of known area with a standard of the analyte of choice. The solvent containing the standard is allowed to evaporate, and the foil is wiped in a manner identical to the other wipe samples.

Specific quality assurance activities for chip and sweep samples should be determined on a site-specific basis.

4.10 DATA VALIDATION

Review the quality control samples and use the data to qualify the environmental results.

4.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

5.0 WASTE PILE SAMPLING: SOP #2017

5.1 SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to outline the equipment and methods used in collecting representative samples from waste piles, sludges or other solid or liquid waste mixed with soil.

5.2 METHOD SUMMARY

Stainless steel shovels or scoops should be used to clear away surface material before samples are collected. For samples at depth, a decontaminated auger may be required to advance the hole, then another decontaminated auger used for sample collection. For a sample core, thin-wall tube samplers or grain samplers may be used. Near surfaces samples can be collected with a clean stainless steel spoon or trowel.

All samples collected, except those for volatile organic analysis, should be placed into a Teflon-lined or stainless steel pail and mixed thoroughly before being transferred to an appropriate sample container.

5.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is generally not recommended. Refrigeration to 4°C is usually the best approach, supplemented by a minimal holding time.

Wide mouth glass containers with Teflon-lined caps are typically used for waste pile samples. Sample volume required is a function of the analytical requirements and should be specified in the work plan.

5.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are several variables involved in waste sampling, including shape and size of piles, compactness, and structure of the waste material. Shape and size of waste material or waste piles vary greatly in areal extent and height. Since state and federal regulations often require a specified number of samples per volume of waste, size and shape must be used to calculate volume and to plan for the correct number of samples. Shape must also be accounted for when planning physical access to the sampling point and when selecting the appropriate equipment to successfully collect the sample at that location.

Material to be sampled may be homogeneous or heterogeneous. Homogeneous material resulting from known situations may not require an extensive sampling protocol. Heterogeneous and unknown wastes require more extensive sampling and analysis to ensure the different components are being represented.

The term "representative sample" is commonly used to denote a sample that has the properties and composition of the population from which it was collected, in the same proportions as found in the population. This can be misleading unless one is dealing with a homogenous waste from which one sample can represent the whole population.

The usual options for obtaining the most "representative sample" from waste piles are simple or stratified random sampling. Simple random sampling is the method of choice unless (1) there are known distinct strata; (2) one wants to prove or disprove that there are distinct strata; or (3) one is limited in the number of samples and desires to minimize the size of a "hot spot" that could go unsampled. If any of these conditions exist, stratified random sampling would be the better strategy.

This strategy, however, can be employed only if all points within the pile can be accessed. In such cases, the pile should be divided into a three-dimensional grid system; the grid sections assigned numbers; and the sampling points chosen using random-number tables or random-number generators. The only exceptions to this are situations in which representative samples cannot be collected safely or where the investigative team is trying to determine worst-case conditions.

If sampling is limited to certain portions of the pile, a statistically based sample will be representative only of that portion, unless the waste is homogenous.

5.5 EQUIPMENT/APPARATUS

Waste pile solids include powdered, granular, or block materials of various sizes, shapes, structure, and compactness. The type of sampler chosen should be compatible with the waste. Samplers commonly used for waste piles include: stainless steel scoops, shovels, trowels, spoons, and stainless steel hand augers, sampling triers, and grain samplers.

Waste pile sampling equipment check list:

- sampling plan
- maps/plot plan
- safety equipment, as specified in the health and safety plan
- compass
- tape measure
- survey stakes or flags
- camera and film
- stainless steel, plastic, or other appropriate homogenization bucket or bowl
- 1-quart mason jars w/Teflon liners
- Ziploc plastic bags
- logbook
- labels
- chain of custody forms and seals
- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- canvas or plastic sheet
- spade or shovel
- spatula
- scoop
- plastic or stainless steel spoons
- trowel
- continuous flight (screw) auger
- bucket auger
- post hole auger
- extension rods
- T-handle
- thin-wall tube sampler
- sampling trier
- grain sampler

5.6 REAGENTS

No chemical reagents are used for the preservation of waste pile samples; however, decontamination solutions may be required. If decontamination of equipment is required, refer to ERT Standard Operating Procedure (SOP) #2006, Sampling Equipment Decontamination, and the site-specific work plan.

5.7 PROCEDURES

5.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes or flagging to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

5.7.2 Sample Collection

SAMPLING WITH SHOVELS AND SCOOPS

Collection of samples from surface portions of the pile can be accomplished with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

Accurate, representative samples can be collected with this procedure depending on the care and

precision demonstrated by sample team members. Use of a flat, pointed mason trowel to cut a block of the desired material can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with implements such as garden trowels.

Use the following procedure to collect surface samples:

1. Carefully remove the top layer of material to the desired sample depth with a precleaned spade.

2. Using a precleaned stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of material from the area which came in contact with the spade.

3. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH AUGERS AND THIN-WALL TUBE SAMPLERS

This system consists of an auger, a series of extensions, a "T" handle, and a thin-wall tube sampler (Figure 13, Appendix B). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the pile at the completion depth. The system is withdrawn and the core collected from the thin-wall tube sampler.

Several augers are available. These include: bucket, continuous flight (screw), and post hole augers. Bucket augers are better for direct sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-foot intervals. The continuous flight augers are satisfactory for use when a composite of the complete waste pile column is desired. Post hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy areas.

Use the following procedure for collecting waste pile samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris. It may be advisable to remove the first 3 to 6 inches of surface material for an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated materials onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the pile. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from device.

9. Discard the top of the core (approximately 1-inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

SAMPLING WITH A TRIER

This system consists of a trier and a "T" handle. The auger is driven into the waste pile and used to extract a core sample from the appropriate depth.

Use the following procedure to collect waste pile samples with a sampling trier:

1. Insert the trier (Figure 14, Appendix B) into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes spillage of the sample. Extraction of the samples might require tilting of the sample containers.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are being collected, place samples from the other sampling intervals into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH A GRAIN SAMPLER

The grain sampler (Figure 15, Appendix B) is used for sampling powdered or granular wastes or materials in bags, fiberdrums, sacks, similar containers or piles. This sampler is most useful when the solids are no greater than 0.6 cm (1/4 inch) in diameter.

This sampler consists of two slotted telescoping brass or stainless steel tubes. The outer tube has a conical, pointed tip at one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain samplers are generally 61 to 100 cm (24 to 40 inch) long by 1.27 to 2.54 cm (1/2 to 1 inch) in diameter and are commercially available at laboratory supply houses.

Use the following procedures to collect waste pile samples with a grain sampler:

1. With the sampler in the closed position, insert it into the granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.

2. Rotate the sampler inner tube into the open position.

3. Wiggle the sampler a few times to allow material to enter the open slots.

4. With the sampler in the closed position, withdraw it from the material being sampled.

5. Place the sampler in a horizontal position with the slots facing upward.

6. Rotate the outer tube and slide it away from the inner tube.

7. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

5.8 CALCULATIONS

This section is not applicable to this SOP.

5.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

5.10 DATA VALIDATION

This section is not applicable to this SOP.

5.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

APPENDIX A

Drum Data Sheet Form

Drum Data Sheet Form

SOP #2009

Drum ID#: _____ Date Sampled: _____

Estimated Liquid Quantity: _____ Time: _____

Grid Location:* _____

Staging Location: _____

Sampler's Name: _____

Drum Condition: _____

Sampling Device: _____

Physical Appearance of the Drum/Bulk Contents: _____

Odor: _____

Color: _____

pH: _____ % Liquid: _____

Laboratory Analytical Data: _____ Date of Analysis: _____

Compatibility: _____

Hazard: _____

Waste ID: _____

Treatment Disposal Recommendations: _____

Approval

Lab: _____ Date: _____

Site Manager: _____ Date: _____

* Area of site where drum was originally located.

Based on di Napoli, 1982. Table originally printed in the Proceedings of the National Conference on Management of Uncontrolled Hazardous Waste Sites, 1982. Available from Hazardous Materials Control Research Institute, 9300 Columbia Blvd., Silver Spring, MD 20910.

APPENDIX B

Figures

Figure 1: Universal Bung Wrench

SOP #2009

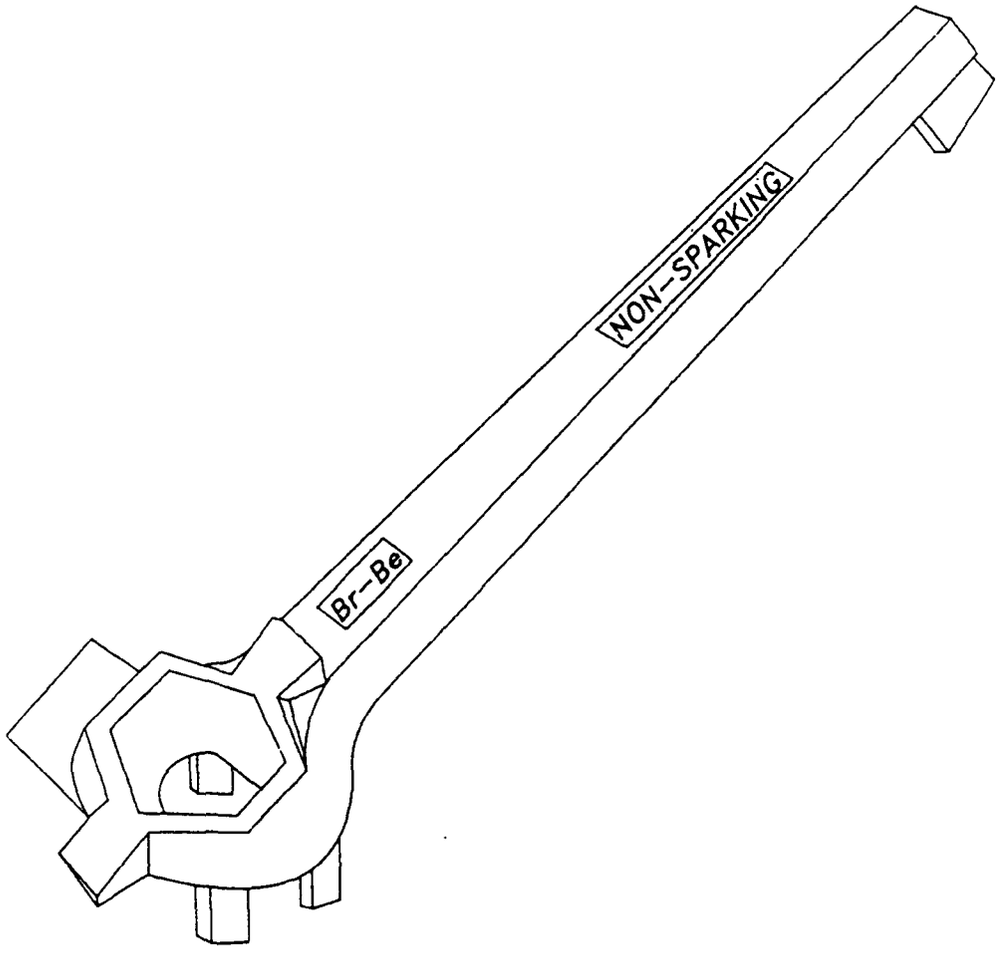


Figure 2: Drum Deheader

SOP #2009

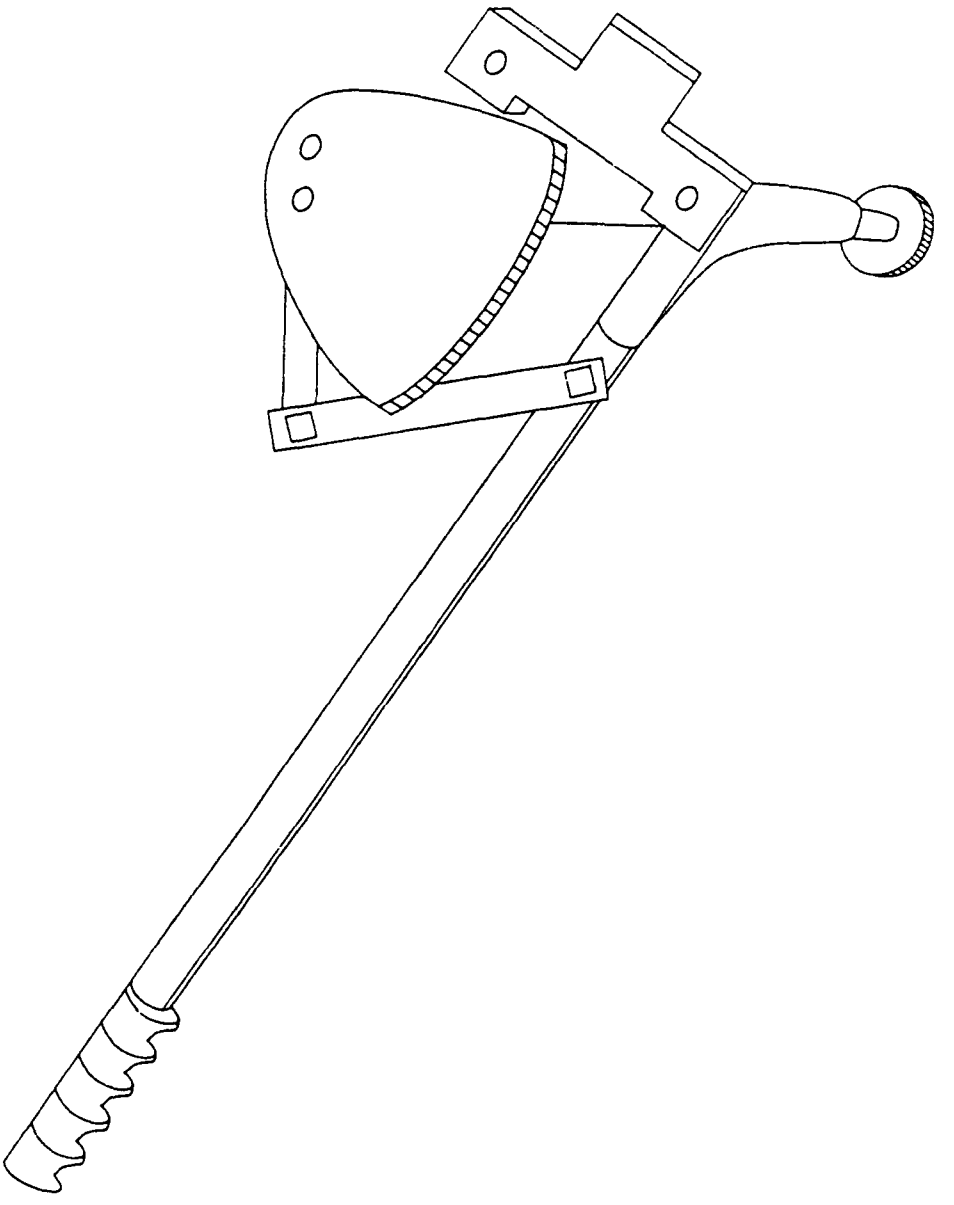


Figure 3: Hand Pick, Pickaxe, and Hand Spike

SOP #2009

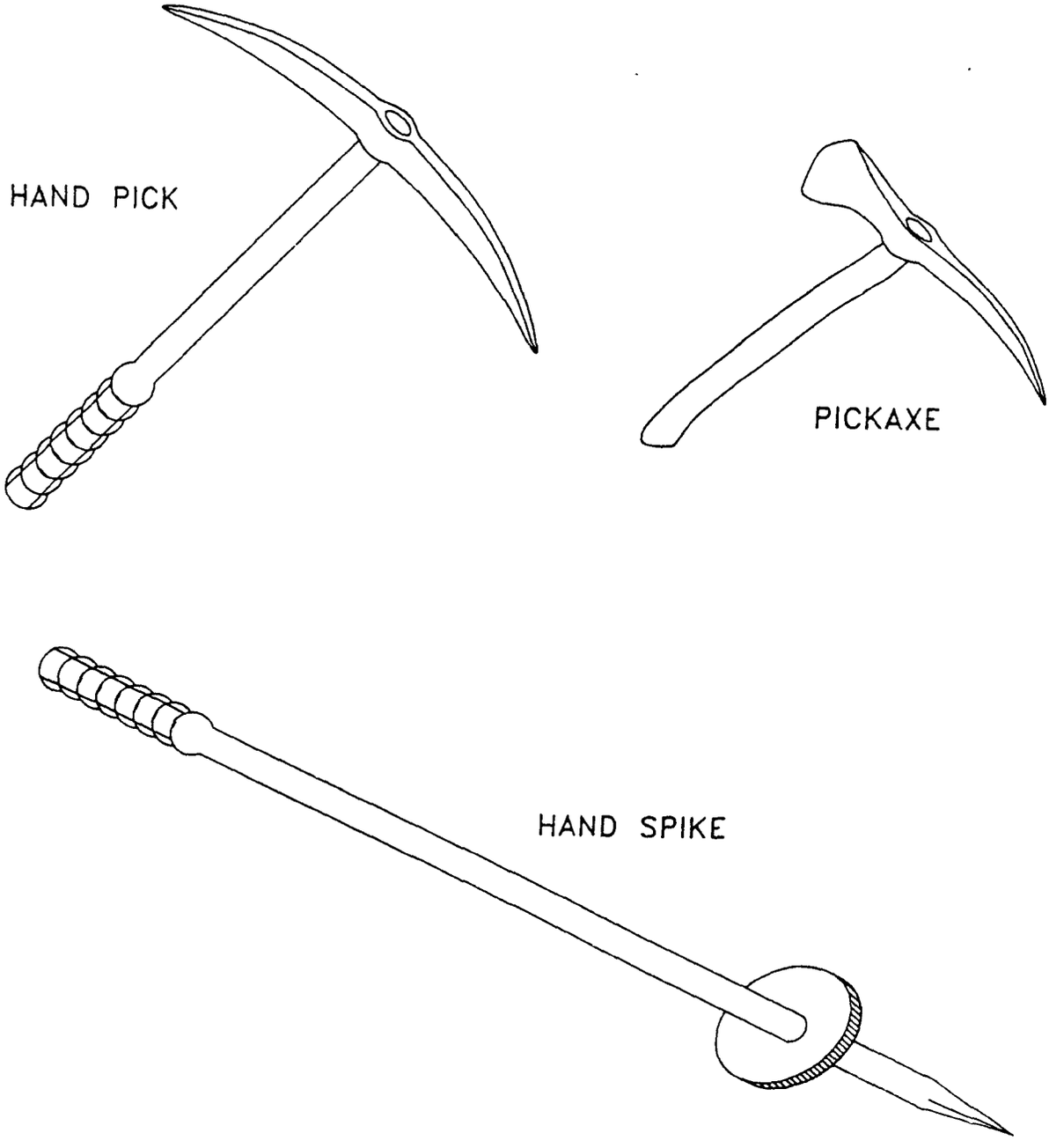


Figure 4: Backhoe Spike

SOP #2009

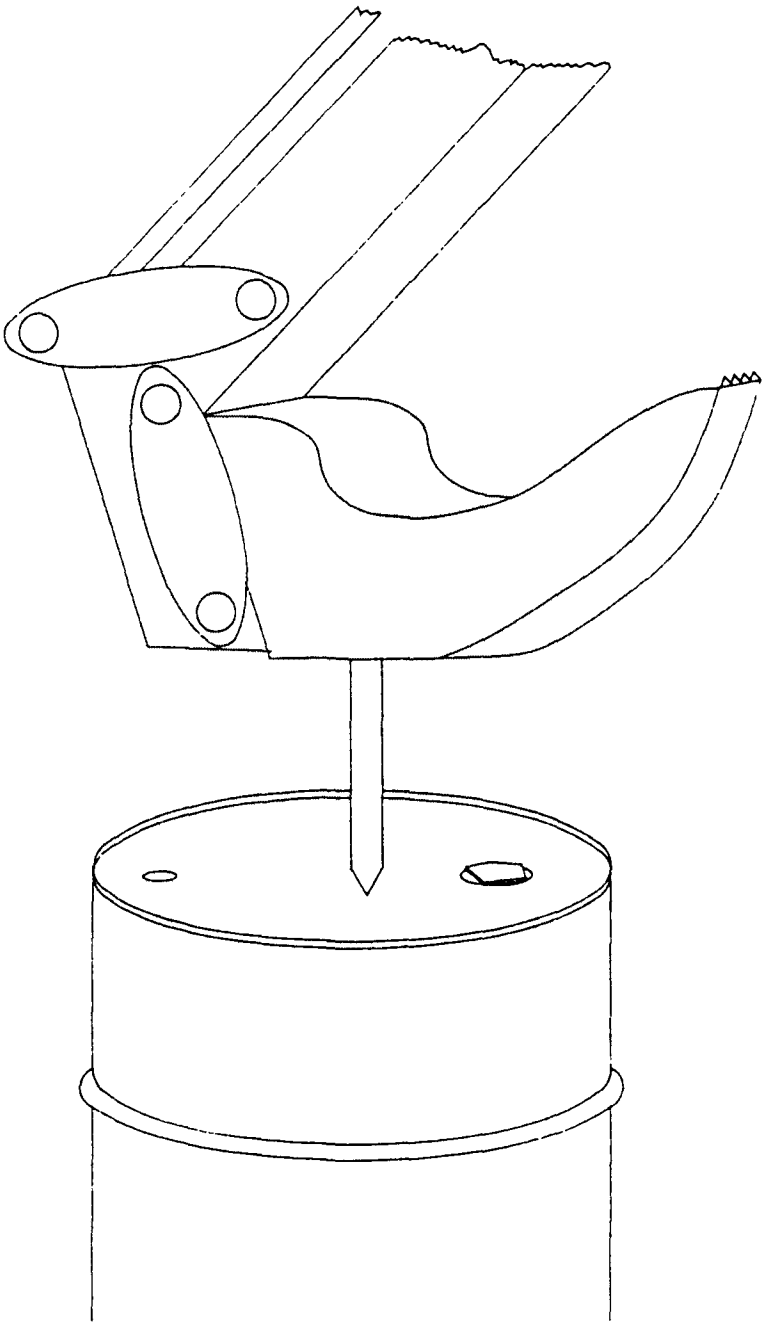


Figure 5: Hydraulic Drum Opener

SOP #2009

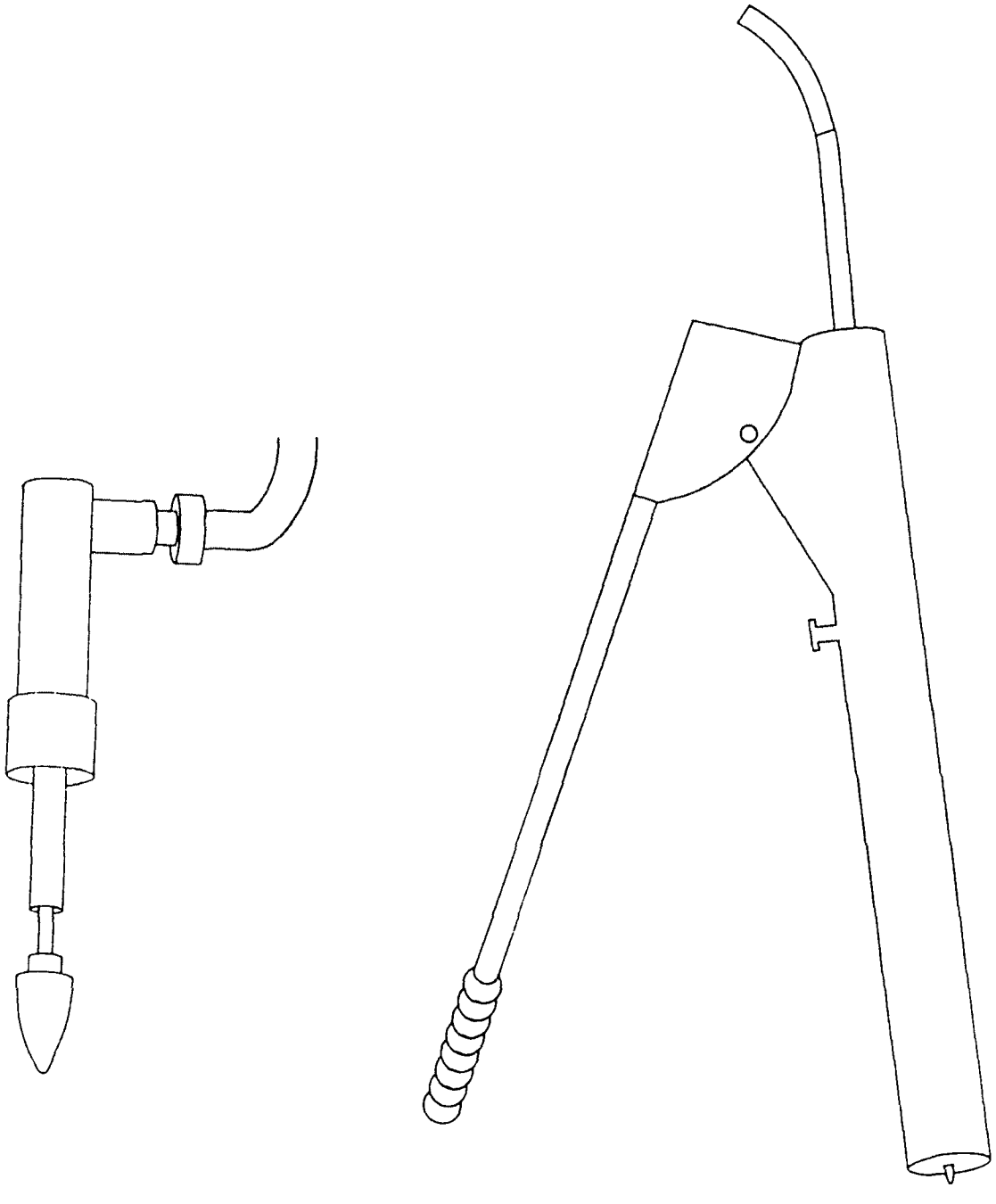


Figure 6: Pneumatic Bung Remover

SOP #2009

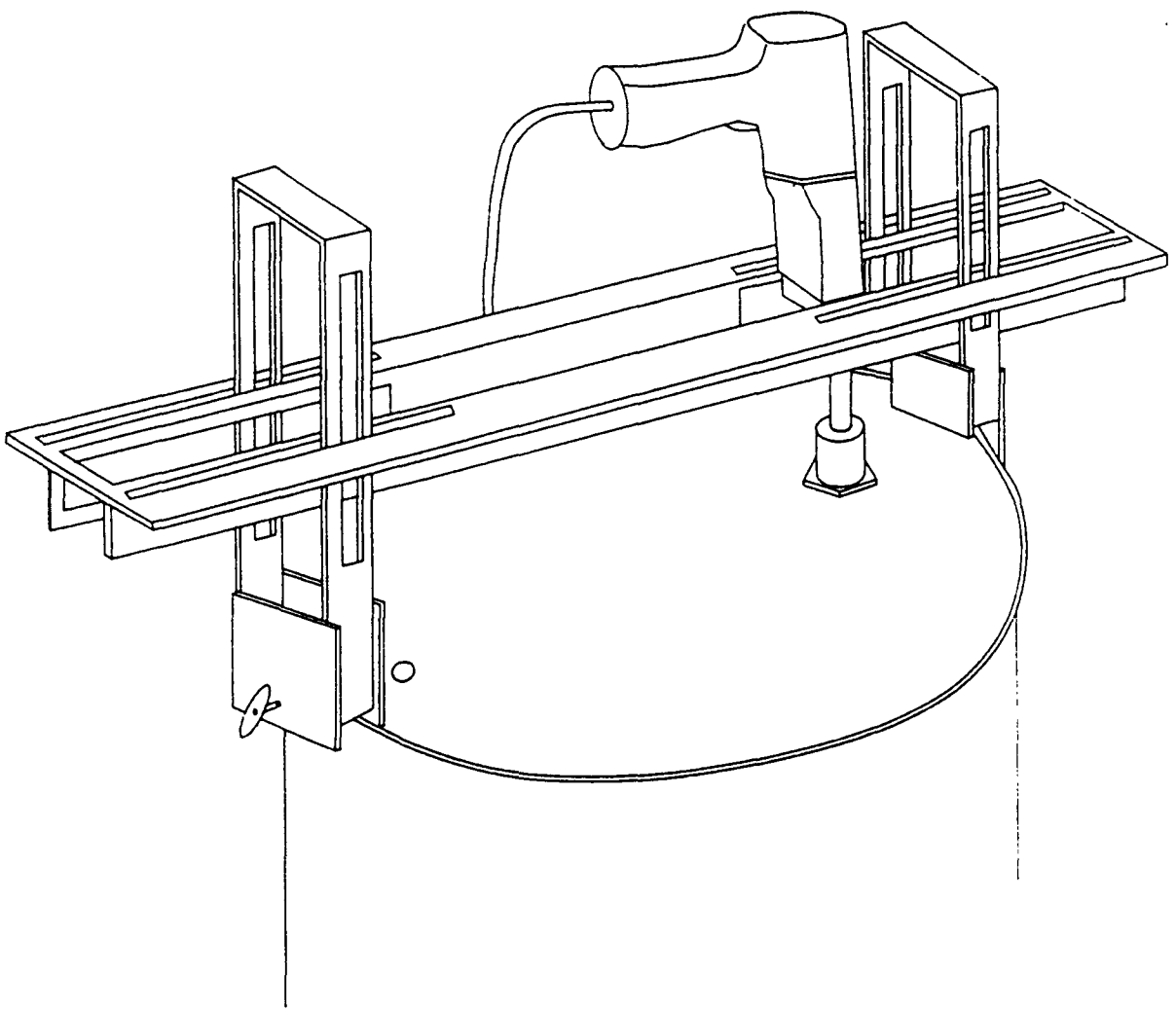
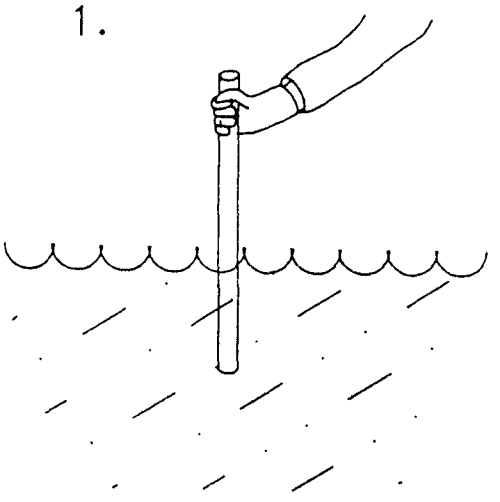


Figure 7: Glass Thief

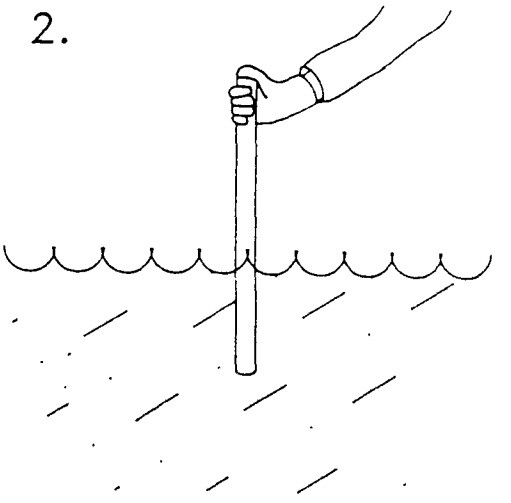
SOP# 2009

1.



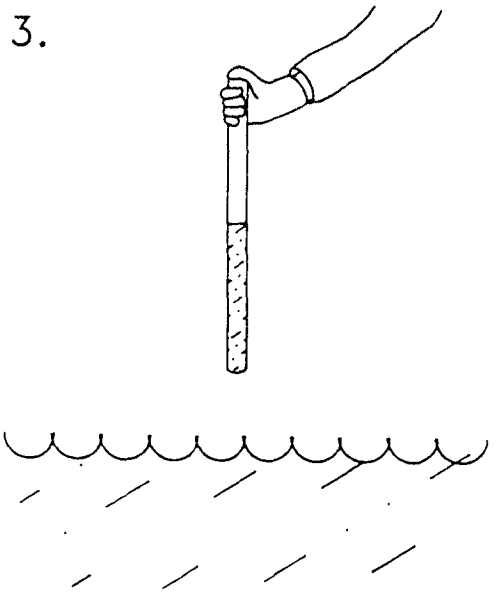
Insert open tube (thief) sampler in containerized liquid.

2.



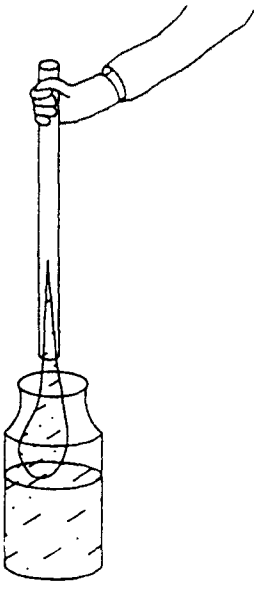
Cover top of sampler with gloved thumb.

3.



Remove open tube (thief) sampler from containerized liquid.

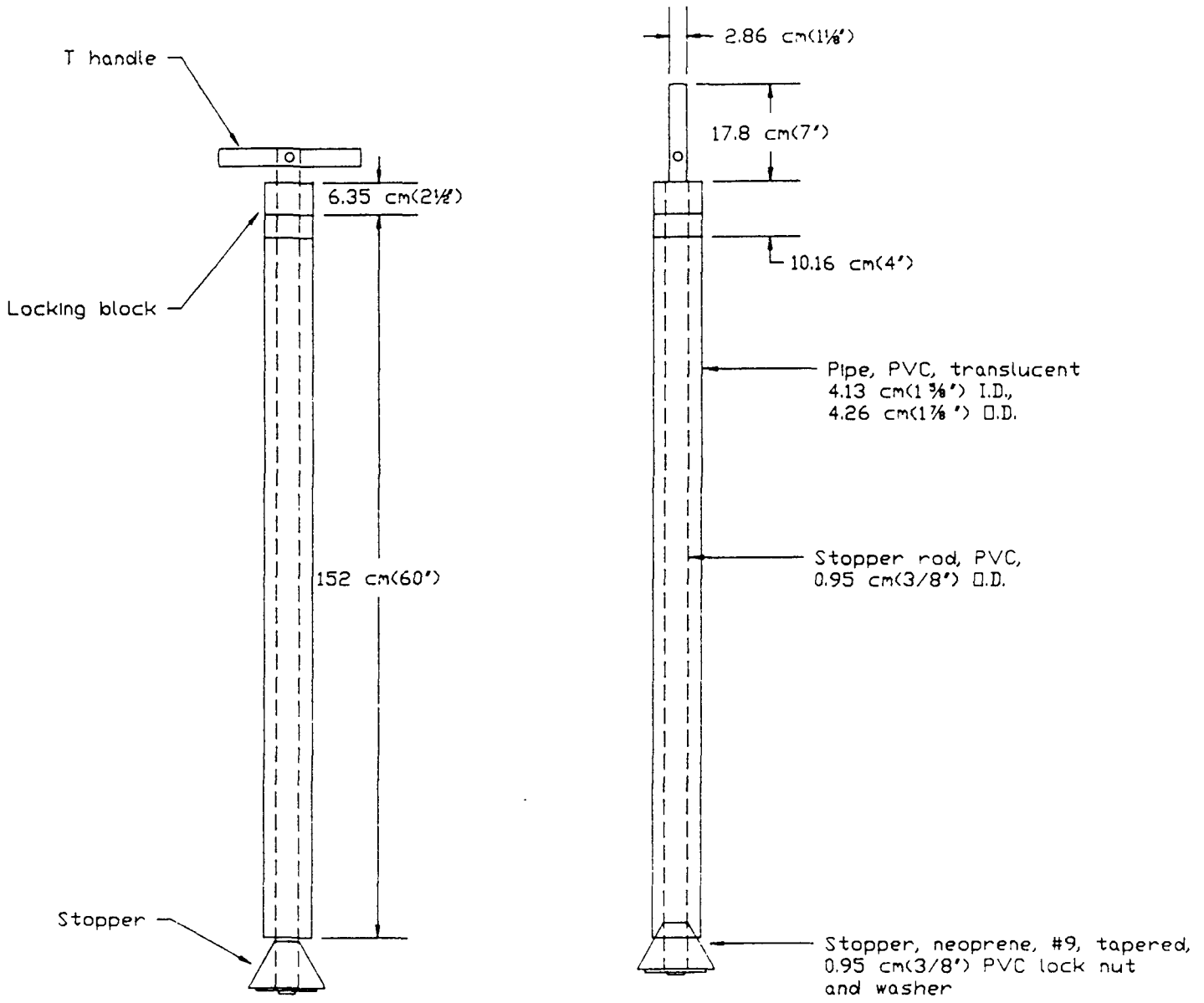
4.



Place open tube sampler over appropriate sample bottle and remove gloved thumb.

Figure 8: COLIWASA

SOP #2009



SAMPLING POSITION CLOSED POSITION

Figure 9: Bacon Bomb Sampler

SOP #2010

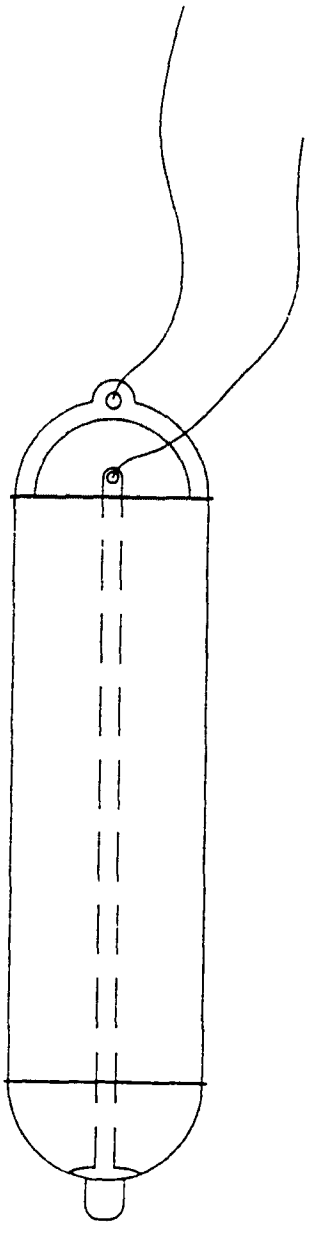


Figure 10: Sludge Judge

SOP #2010

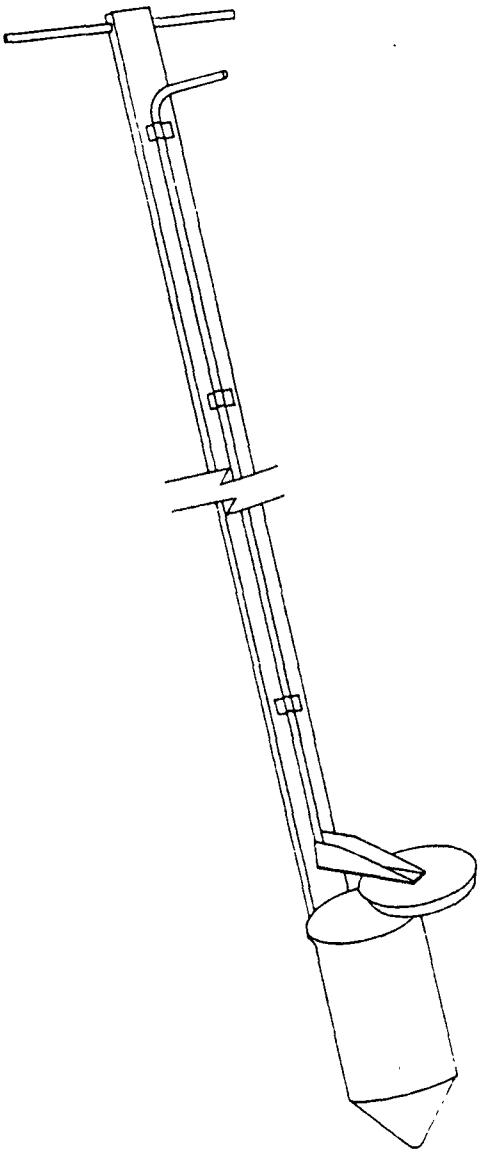


Figure 11: Subsurface Grab Sampler

SOP #2010

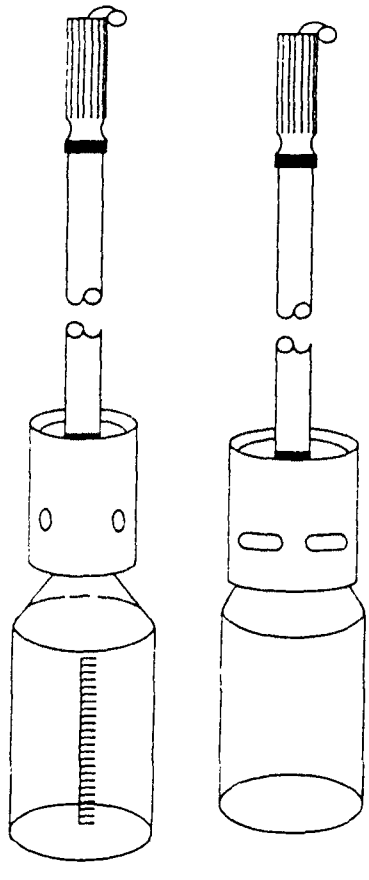


Figure 12: Bailer

SOP #2010

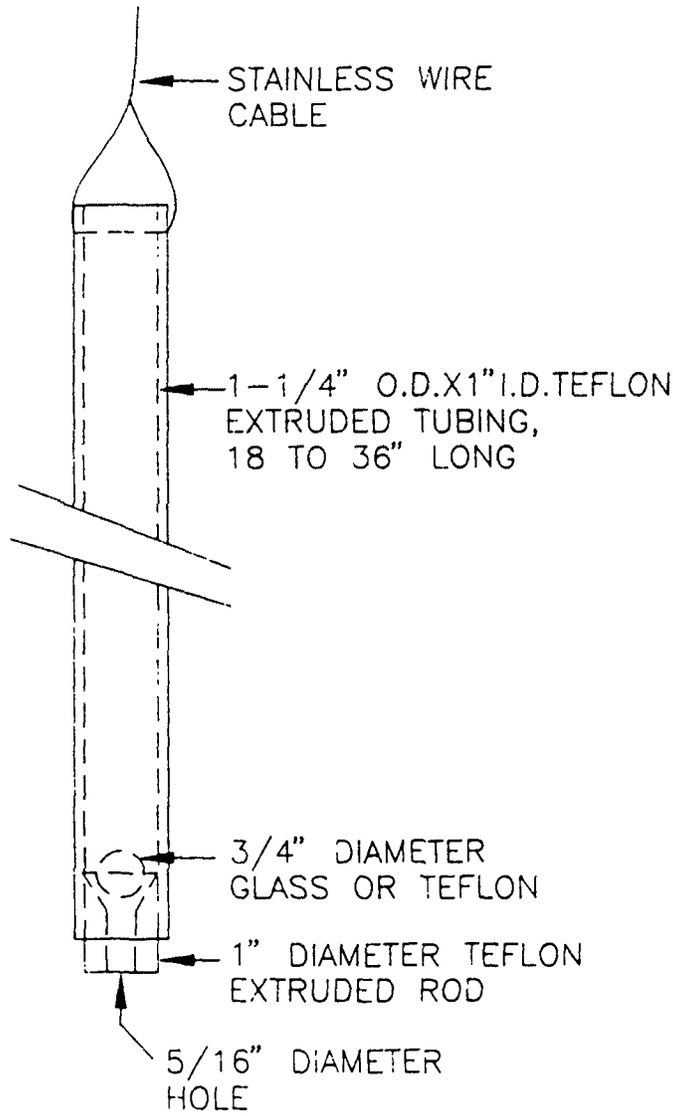
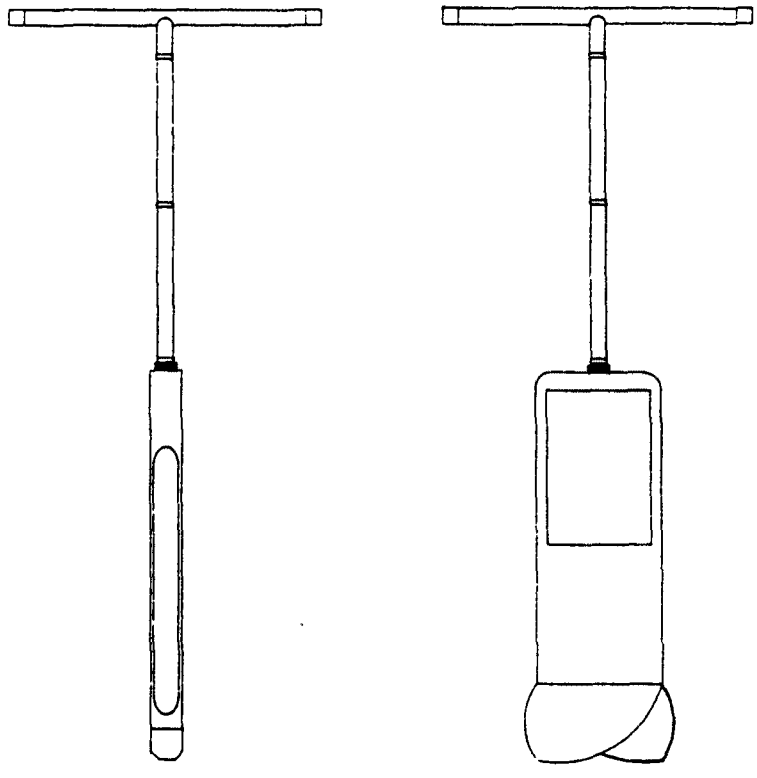


Figure 13: Sampling Augers

SOP #2017



TUBE AUGER

BUCKET AUGER

Figure 14: Sampling Trier

SOP #2017

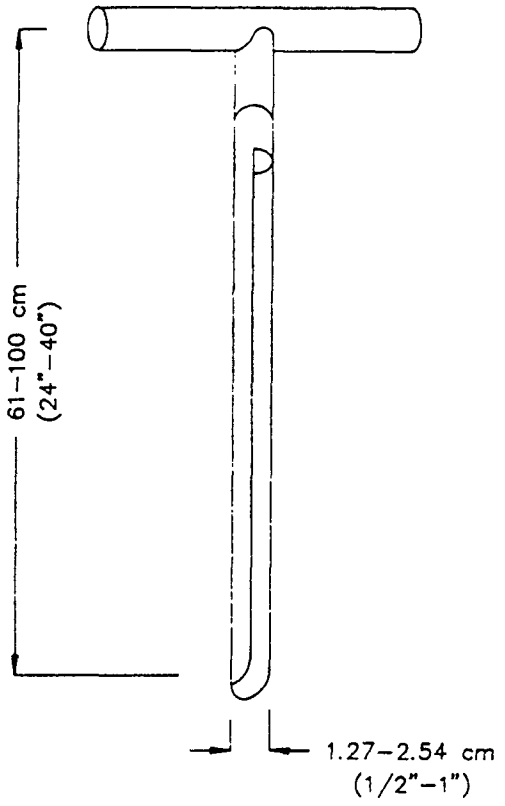
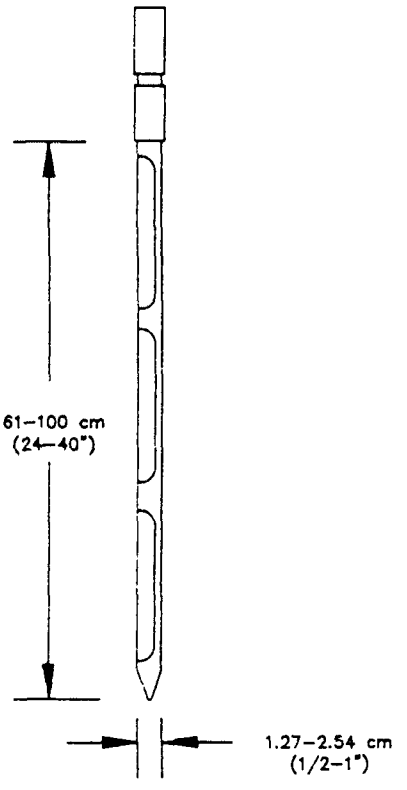


Figure 15: Grain Sampler

SOP #2017



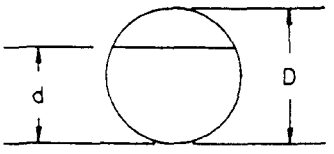
APPENDIX C

Calculations

Various Volume Calculations

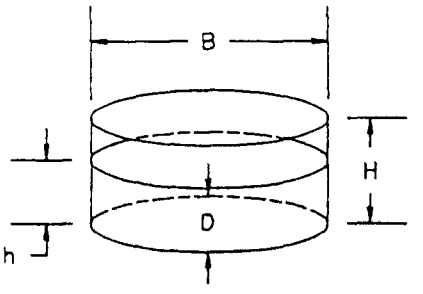
SOP #2010

SPHERE



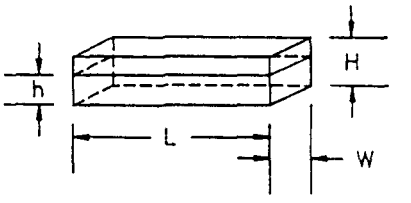
Total Volume
$V=1/6\ \pi D^3 = 0.523498D^3$
Partial Volume
$V=1/3\ \pi d^2\ (3/2\ D-d)$

ELLIPTICAL CONTAINER



Total Volume
$V=\pi BDH$
Partial Volume
$V=\pi BDh$

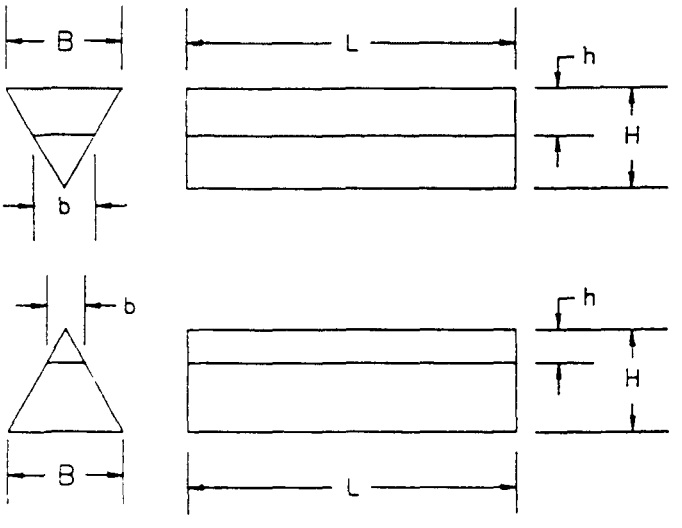
ANY RECTANGULAR CONTAINER



Total Volume
V=HLW
Partial Volume
V=hLW

TRIANGULAR CONTAINER

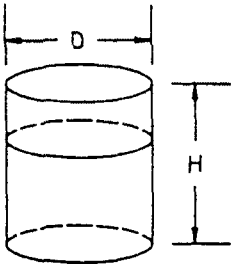
Total Volume
V=1/2 HBL



Case 1
Partial Volume
V=1/2 hBL

Case 2
Partial Volume
V=1/2 L(HB−hB)

RIGHT CYLINDER

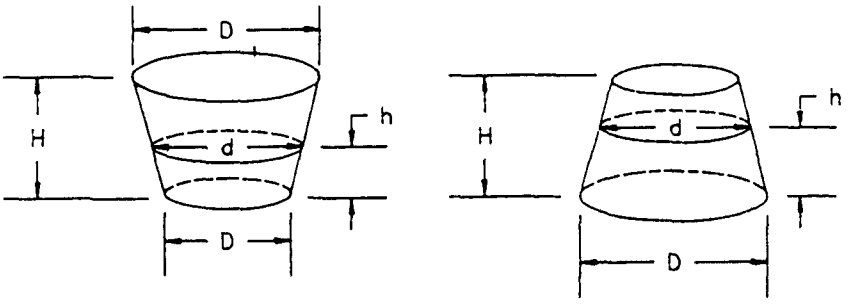


Total Volume
$V=1/4\ \pi D^2\ H$

Partial Volume
$V=1/4\ \pi D^2\ h$

FRUSTUM OF A CONE

Case 1 Case 2



Total Volume

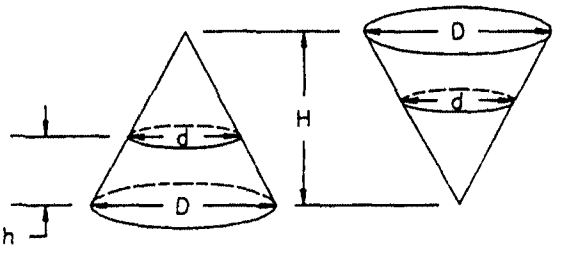
$V = \pi/12\ H(D_1^2 + D_1 D_2 + D_2^2)$

Partial Volume

$V = \pi/12\ h(D_1^2 + D_1\ d + d^2)$

CONE

Case 1 Case 2



Total Volume

$V = \pi/12 \cdot D^2 H$

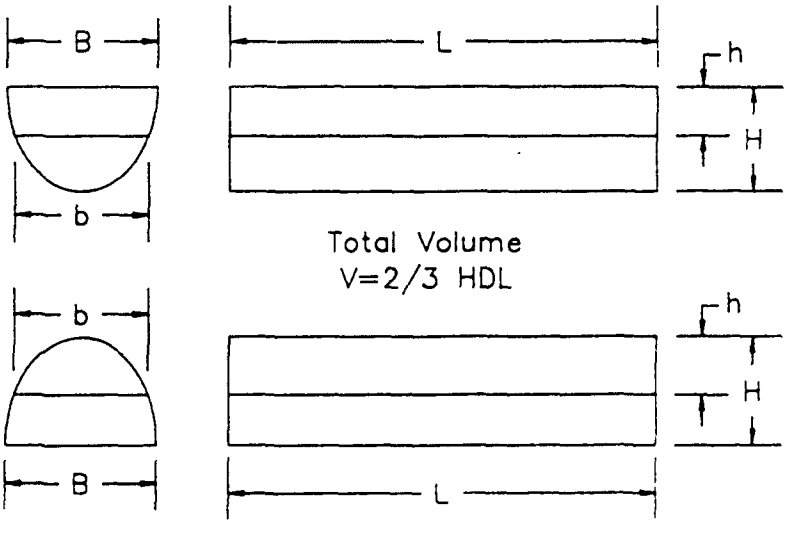
Partial Volume Case 1

$V = \pi/12 \cdot d^2 h$

Partial Volume Case 2

$V = \pi/12 \cdot (D^2 H - d^2 h)$

PARABOLIC CONTAINER



Case 1

Partial Volume

$V = 2/3\ hdL$

Total Volume

$V = 2/3\ HDL$

Case 2

Partial Volume

$V = 2/3\ (HD - hd) \cdot L$

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*U.S. Government Printing Office: 1991 — 548-187/40582

APPENDIX C

Compendium of ERT Soil Sampling and Surface Geophysics Procedures

EPA/540/P-91/006
OSWER Directive 9360.4-02
January 1991

COMPENDIUM OF ERT SOIL SAMPLING AND SURFACE GEOPHYSICS PROCEDURES

Sampling Equipment Decontamination

Soil Sampling

Soil Gas Sampling

General Surface Geophysics

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

Printed on Recycled Paper

Notice

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The policies and procedures established in this document are intended solely for the guidance of government personnel for use in the Superfund Removal Program. They are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States. The Agency reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Soil Sampling and Surface Geophysics Procedures. Send remarks to:

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1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes.

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film.[1] The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

2.0 SOIL SAMPLING: SOP #2012

2.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for collecting representative soil samples. Analysis of soil samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

2.2 METHOD SUMMARY

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, a trier, a split-spoon, or, if required, a backhoe.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is not generally recommended. Refrigeration to 4°C, supplemented by a minimal holding time, is usually the best approach.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems associated with soil sampling. These include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

2.5 EQUIPMENT/APPARATUS

- sampling plan
- maps/plot plan
- safety equipment, as specified in the health and safety plan
- compass
- tape measure
- survey stakes or flags
- camera and film
- stainless steel, plastic, or other appropriate homogenization bucket or bowl
- 1-quart mason jars w/Teflon liners
- Ziploc plastic bags
- logbook
- labels
- chain of custody forms and seals
- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- canvas or plastic sheet
- spade or shovel
- spatula
- scoop
- plastic or stainless steel spoons
- trowel
- continuous flight (screw) auger
- bucket auger
- post hole auger
- extension rods
- T-handle
- sampling trier
- thin-wall tube sampler
- Vehimeyer soil sampler outfit
  - tubes
  - points
  - drive head
  - drop hammer
  - puller jack and grip
- backhoe

2.6 REAGENTS

Reagents are not used for the preservation of soil samples. Decontamination solutions are specified in

ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner prior to soil sampling.

2.7.2 Sample Collection

Surface Soil Samples

Collect samples from near-surface soil with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

This method can be used in most soil types but is limited to sampling near surface areas. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sampling team member. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Follow these procedures to collect surface soil samples.

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.

2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.

3. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.

Sampling at Depth with Augers and Thin-Wall Tube Samplers

This system consists of an auger, a series of extensions, a "T" handle, and a thin-wall tube sampler (Appendix A, Figure 1). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the soil at the completion depth. The system is withdrawn and the core collected from the thin-wall tube sampler.

Several types of augers are available. These include: bucket, continuous flight (screw), and posthole augers. Bucket augers are better for direct

sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-feet intervals. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil.

Follow these procedures for collecting soil samples with the auger and a thin-wall tube sampler.

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first 3 to 6 inches of surface soil for an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.

5. Remove auger tip from drill rods and replace with a pre-cleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from the device.

9. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container(s). Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into the appropriate, labeled container(s) and secure the cap(s) tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

Sampling at Depth with a Trier

The system consists of a trier, and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

Follow these procedures to collect soil samples with a sampling trier.

1. Insert the trier (Appendix A, Figure 2) into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

Sampling at Depth with a Split Spoon (Barrel) Sampler

The procedure for split spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted

When split tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved 1974).

Follow these procedures for collecting soil samples with a split spoon.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit onto the bottom and the heavier head piece onto the top.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.

5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in diameters of 2 and 3 1/2 inches. However, in order to obtain the required sample volume, use of a larger barrel may be required.

6. Without disturbing the core, transfer it to an appropriate labeled sample container(s) and seal tightly.

Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soil, when detailed examination of soil characteristics (horizontal structure, color, etc.) are required. It is the least cost effective sampling method due to the relatively high cost of backhoe operation.

Follow these procedures for collecting soil samples from test pit/trench excavations.

1. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).

2. Using the backhoe, dig a trench to approximately 3 feet in width and approximately 1 foot below the cleared sampling location. Place removed or excavated soils on plastic sheets. Trenches greater than 5 feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.

3. Use a shovel to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.

4. Take samples using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling

to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.

5. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.

6. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

3.0 SOIL GAS SAMPLING: SOP #2149

3.1 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of waste site evaluation. Using this method, underground contamination can be identified, and the source, extent, and movement of the pollutants can be traced.

This Standard Operating Procedure (SOP) outlines the methods used by EPA/ERT in installing soil gas wells; measuring organic levels in the soil gas using an HNU PI 101 Portable Photoionization Analyzer and/or other air monitoring devices; and sampling the soil gas using Tedlar bags, Tenax sorbent tubes, and SUMMA canisters.

3.2 METHOD SUMMARY

A 3/8-inch diameter hole is driven into the ground to a depth of 4 to 5 feet using a commercially available "slam bar". (Soil gas can also be sampled at other depths by the use of a longer bar or bar attachments.) A 1/4-inch O.D. stainless steel probe is inserted into the hole. The hole is then sealed at the top around the probe using modeling clay. The gas contained in the interstitial spaces of the soil is sampled by pulling the sample through the probe using an air sampling pump. The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a direct reading instrument.

The air sampling pump is not used for SUMMA canister sampling of soil gas. Sampling is achieved by soil gas equilibration with the evacuated SUMMA canister. Other field air monitoring devices, such as the combustible gas indicator (MSA CGI/02 Meter, Model 260) and the organic vapor analyzer (Foxboro OVA, Model 128), can also be used depending on specific site conditions. Measurement of soil temperature using a temperature probe may also be desirable. Bagged samples are usually analyzed in a field laboratory using a portable Photovac GC.

Power driven sampling probes may be utilized when soil conditions make sampling by hand unfeasible (i.e., frozen ground, very dense clays, pavement, etc.). Commercially available soil gas sampling probes (hollow, 1/2-inch O.D. steel probes) can be driven to the desired depth using a power hammer (e.g., Bosch Demolition Hammer). Samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe and attached to the probe point. Samples are collected and analyzed as described above.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.3.1 Tedlar Bag

Soil gas samples are generally contained in 1-L Tedlar bags. Bagged samples are best stored in coolers to protect the bags from any damage that may occur in the field or in transit. In addition, coolers ensure the integrity of the samples by keeping them at a cool temperature and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours.

3.3.2 Tenax Tube

Bagged samples can also be drawn into Tenax or other sorbent tubes to undergo lab GC/MS analysis If Tenax tubes are to be utilized, special care must be taken to avoid contamination. Handling of the tubes should be kept to a minimum, and samplers must wear nylon or other lint-free gloves. After sampling, each tube should be stored in a clean, sealed culture tube; the ends packed with clean glass wool to protect the sorbent tube from breakage. The culture tubes should be kept cool and wrapped in aluminum foil to prevent any photodegradation of samples (see Section 3.7.4.).

3.3.3 SUMMA Canister

The SUMMA canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being utilized in the field. After sampling is completed, they are stored and shipped in travel cases.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

3.4.1 HNU Measurements

A number of factors can affect the response of the HNU PI 101. High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when a soil gas well is actually in groundwater. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response.

Other field screening instruments can be affected by interferences. Consult the manufacturers' manuals.

3.4.2 Factors Affecting Organic Concentrations in Soil Gas

Concentrations in soil gas are affected by dissolution, adsorption, and partitioning. Partitioning refers to the ratio of component found in a saturated vapor above an aqueous solution to the amount in the solution; this can, in theory, be calculated using the Henry's Law constants. Contaminants can also be adsorbed onto inorganic soil components or "dissolved" in organic components. These factors can result in a lowering of the partitioning coefficient.

Soil "tightness" or amount of void space in the soil matrix, will affect the rate of recharging of gas into the soil gas well.

Existence of a high, or perched, water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with sampling of the soil gas. Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling.

3.4.3 Soil Probe Clogging

A common problem with this sampling method is soil probe clogging. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see procedure #3 in Section 3.7.1).

3.4.4 Underground Utilities

Prior to selecting sample locations, an underground utility search is recommended. The local utility companies can be contacted and requested to mark the locations of their underground lines. Sampling plans can then be drawn up accordingly. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground pipes or drums exist.

3.5 EQUIPMENT/APPARATUS

3.5.1 Slam Bar Method

- slam bar (one per sampling team)
- soil gas probes, stainless steel tubing, 1/4-inch O.D., 5 foot length
- flexible wire or cable used for clearing the tubing during insertion into the well
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4-inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection of samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample, storage and transportation

3.5.2 Power Hammer Method

- Bosch demolition hammer
- 1/2-inch O.D. steel probes, extensions, and points
- dedicated aluminum sampling points
- Teflon tubing, 1/4-inch O.D.
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4-inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection of samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample, storage and transportation
- generator with extension cords
- high lift jack assembly for removing probes

3.6 REAGENTS

- HNU Systems Inc. Calibration Gas for HNU Model PI 101, and/or calibration gas for other field air monitoring devices
- deionized organic-free water, for decontamination
- methanol, HPLC grade, for decontamination
- ultra-zero grade compressed air, for field blanks
- standard gas preparations for Photovac GC calibration and Tedlar bag spikes

3.7 PROCEDURES

3.7.1 Soil Gas Well Installation

1. Initially, make a hole slightly deeper than the desired depth. For sampling up to 5 feet, use a 5-foot single piston slam bar. For deeper depths, use a piston slam bar with threaded 4-foot-long extensions. Other techniques can be used, so long as holes are of narrow diameter and no contamination is introduced.

2. After the hole is made, carefully withdraw the slam bar to prevent collapse of the walls of the hole. Then insert the soil gas probe.

3. It is necessary to prevent plugging of the probe, especially for deeper holes. Place a metal wire or cable, slightly longer than the probe, into the probe prior to inserting into the hole. Insert the probe to full depth, then pull it up 3 to 6 inches, then clear it by moving the cable up and down. The cable is removed before sampling.

4. Seal the top of the sample hole at the surface against ambient air infiltration by using modeling clay molded around the probe at the surface of the hole.

5. If conditions preclude hand installation of the soil gas wells, the power driven system may be employed. Use the generator-powered demolition hammer to drive the probe to the desired depth (up to 12 feet may be attained with extensions). Pull the probe up 1 to 3 inches if the retractable point is used. No clay is needed to seal the hole. After sampling, retrieve the probe using the high lift jack assembly.

6. If semi-permanent soil gas wells are required, use the dedicated aluminum probe points. Insert these points into the bottom of the power-driven probe and attach it to the Teflon tubing. Insert the probe as in step 5. When the probe is removed, the point and Teflon tube remain in the hole, which may be sealed by backfilling with sand, bentonite, or soil.

3.7.2 Screening with Field instruments

1. The well volume must be evacuated prior to sampling. Connect the Gilian pump, adjusted to 3.0 L/min, to the sample probe using a section of Teflon tubing as a connector. Turn the pump on, and a vacuum is pulled through the probe for approximately 15 seconds. A longer time is required for sample wells of greater depths.

2. After evacuation, connect the monitoring instrument(s) to the probe using a Teflon connector. When the reading is stable, or peaks, record the reading. For detailed procedures on HNU field protocol, see appendix B, and refer to the manufacturer's instructions.

3. Some readings may be above or below the range set on the field instruments. The range may be reset, or the response recorded as a figure greater than or less than the range. Consider the recharge rate of the well with soil gas when sampling at a different range setting.

3.7.3 Tedlar Bag Sampling

1. Follow step 1 in section 3.7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sampling, evacuation is not necessary.

2. Use the vacuum box and sampling train (Figure 3 in Appendix A) to take the sample. The sampling train is designed to minimize the introduction of contaminants and losses due to adsorption. All wetted parts are either Teflon or stainless steel. The vacuum is drawn indirectly to avoid contamination from sample pumps.

3. Place the Tedlar bag inside the vacuum box, and attach it to the sampling port. Attach the sample probe to the sampling port via Teflon tubing and a "quick connect" fitting.

4. Draw a vacuum around the outside of the bag, using a Gilian pump connected to the vacuum box evacuation port, via Tygon tubing and a "quick connect" fitting. The vacuum causes the bag to inflate, drawing the sample.

5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close valve. Label bag, record data on data sheets or in logbooks. Record the date, time, sample location ID, and the HNU, or other instrument reading(s) on sample bag label.

CAUTION: Labels should not be pasted directly onto the bags, nor should bags be labeled directly using a marker or pen. Inks and adhesive may diffuse through the bag material, contaminating the sample. Place labels on the edge of the bags, or tie the labels to the metal eyelets provided on the bags. Markers with inks containing volatile organics (i.e., permanent ink markers) should not be used.

3.7.4 Tenax Tube Sampling

Samples collected in Tedlar bags may be sorbed onto Tenax tubes for further analysis by GC/MS.

Additional Apparatus

- Syringe with a luer-lock tip capable of drawing a soil gas or air sample from a Tedlar bag onto a Tenax/CMS sorbent tube. The syringe capacity is dependent upon the volume of sample being drawn onto the sorbent tube.

- Adapters for fitting the sorbent tube between the Tedlar bag and the sampling syringe. The adapter attaching the Tedlar bag to the sorbent tube consists of a reducing union (1/4-inch to 1/16-inch O.D. -- Swagelok cat. # SS-400-6-ILV or equivalent) with a length of 1/4-inch O.D. Teflon tubing replacing the nut on the 1/6-inch (Tedlar bag) side. A 1/4-inch I.D. silicone O-ring replaces the ferrules in the nut on the 1/4-inch (sorbent tube) side of the union.

  The adapter attaching the sampling syringe to the sorbent tube consists of a reducing union (1/4-inch to 1/16-inch O.D. -- Swagelok Cat. # SS-400-6-ILV or equivalent) with a 1/4-inch I.D. silicone O-ring replacing the ferrules in the nut on the 1/4-inch (sorbent tube) side and the needle of a luer-lock syringe needle inserted into the 1/16-inch side (held in place with a 1/16-inch ferrule). The

luer-lock end of the needle can be attached to the sampling syringe. It is useful to have a luer-lock on/off valve situated between the syringe and the needle.

- Two-stage glass sampling cartridge (1/4-inch O.D. x 1/8-inch I.D. x 5 1/8 inch) contained in a flame-sealed tube (manufactured by Supelco Custom Tenax/Spherocarb Tubes or equivalent) containing two sorbent sections retained by glass wool:

  Front section: 150 mg of Tenax-GC
  Back section: 150 mg of CMS (Carbonized Molecular Sieve)

  Sorbent tubes may also be prepared in the lab and stored in either Teflon-capped culture tubes or stainless steel tube containers. Sorbent tubes stored in this manner should not be kept more than 2 weeks without reconditioning. (See SOP #2052 for Tenax/CMS sorbent tube preparation).

- Teflon-capped culture tubes or stainless steel tube containers for sorbent tube storage. These containers should be conditioned by baking at 120°C for at least 2 hours. The culture tubes should contain a glass wool plug to prevent sorbent tube breakage during transport. Reconditioning of the containers should occur between usage or after extended periods of disuse (i.e., 2 weeks or more).

- Nylon gloves or lint-free cloth. (Hewlett Packard Part # 8650-0030 or equivalent.)

Sample Collection

1. Handle sorbent tubes with care, using nylon gloves (or other lint-free material) to avoid contamination.

2. Immediately before sampling, break one end of the sealed tube and remove the Tenax cartridge. For in-house prepared tubes, remove cartridge from its container.

3. Connect the valve on the Tedlar bag to the sorbent tube adapter. Connect the sorbent tube to the sorbent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag.

4. Connect the sampling syringe assembly to the CMS (black) side of the sorbent tube. Fittings on the adapters should be very tight.

5. Open the valve on the Tedlar bag.

6. Open the on/off valve of the sampling syringe.

7. Draw a predetermined volume of sample onto the sorbent tube. (This may require closing the syringe valve, emptying the syringe and then repeating the procedure, depending upon the syringe capacity and volume of sample required.)

8. After sampling, remove the tube from the sampling train with gloves or a clean cloth. Do **not label or write on the Tenax/CMS tube.**

9. Place the sorbent tube in a conditioned stainless steel tube holder or culture tube Culture tube caps should be sealed with Teflon tape.

Sample Labeling

Each sample tube container (not tube) must be labeled with the site name, sample station number, sample date, and sample volume.

Chain of custody forms must accompany all samples to the laboratory.

Quality Assurance

Before field use, a QA check should be performed on each batch of sorbent tubes by analyzing a tube with thermal desorption/cryogenic trapping GC/MS.

At least one blank sample must be submitted with each set of samples collected at a site. This trip blank must be treated the same as the sample tubes except no sample will be drawn through the tube.

Sample tubes should be stored out of UV light (i.e., sunlight) and kept on ice until analysis.

Samples should be taken in duplicate, when possible.

3.7.5 SUMMA Canister Sampling

1. Follow item 1 in step 3.7.2 to evacuate well volume. If HNU analysis was performed prior to taking a sample, evacuation is not necessary.

2. Attach a certified clean, evacuated 6-L SUMMA canister via the 1/4-inch Teflon tubing.

3. Open the valve on SUMMA canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is 20 minutes.

4. Site name, sample location, number, and date must be recorded on a chain of custody form and on a blank tag attached to the canister.

3.8 CALCULATIONS

3.8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas station may be subtracted:

Final Reading = Sample Reading - Background

3.8.2 Photovac GC Analysis

Calculations used to determine concentrations of individual components by Photovac GC analysis are beyond the scope of this SOP and are covered in ERT SOP #2109, Photovac GC Analysis for Soil, Water and Air/Soil Gas.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

3.9.1 Field Instrument Calibration

Consult the manufacturers' manuals for correct use and calibration of all instrumentation. The HNU should be calibrated at least once a day.

3.9.2 Gilian Model HFS113A Air Sampling Pump Calibration

Flow should be set at approximately 3.0 L/min; accurate flow adjustment is not necessary. Pumps should be calibrated prior to bringing into the field.

3.9.3 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe via a Gilian pump and checking the response of the HNU PI 101. If HNU readings are higher than background, replacement or decontamination is necessary.

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNU reading is at background. More persistent contamination can be washed out using methanol and water, then air drying. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

3.9.4 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it should be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a Gilian pump, for approximately 30 seconds between each sample. After purging, the sampling train can be checked using an HNU, or other field monitoring device, to establish the cleanliness of the Teflon line.

3.9.5 Field Blank

Each cooler containing samples should also contain one Tedlar bag of ultra-zero grade air, acting as a field blank. The field blank should accompany the samples in the field (while being collected) and when they are delivered for analysis. A fresh blank must be provided to be placed in the empty cooler pending additional sample collection. One new field blank per cooler of samples is required. A chain of custody form must accompany each cooler of samples and should include the blank that is dedicated to that group of samples.

3.9.6 Trip Standard

Each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the

analytical instruments (Photovac GC, etc.). This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. A chain of custody form should accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples.

3.9.7 Tedlar Bag Check

Prior to use, one bag should be removed from each lot (case of 100) of Tedlar bags to be used for sampling and checked for possible contamination as follows: the test bag should be filled with ultra-zero grade air; a sample should be drawn from the bag and analyzed via Photovac GC or whatever method is to be used for sample analysis. This procedure will ensure sample container cleanliness prior to the start of the sampling effort.

3.9.8 SUMMA Canister Check

From each lot of four cleaned SUMMA canisters, one is to be removed for a GC/MS certification check. If the canister passes certification, then it is re-evacuated and all four canisters from that lot are available for sampling.

If the chosen canister is contaminated, then the entire lot of four SUMMA canisters must be recleaned, and a single canister is re-analyzed by GC/MS for certification.

3.9.9 Options

Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i.e., if a total of 100 samples are to be collected, five samples should be duplicated). In choosing which samples to duplicate, the following criterion applies. if, after filling the first Tedlar bag, and, evacuating the well for 15 seconds, the second HNU (or other field monitoring device being used) reading matches or is close to (within 50%) the first reading, a duplicate sample may be taken.

Spikes

A Tedlar bag spike and Tenax tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc.). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. SUMMA canisters containing samples are not spiked.

3.10 DATA VALIDATION

For each target compound, the level of concentration found in the sample must be greater than three times the level (for that compound) found in the field blank which accompanied that sample to be considered valid. The same criteria apply to target compounds detected in the Tedlar bag pre-sampling contamination check.

3.11 HEALTH AND SAFETY

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D, unless the sampling location is within the hot zone of a site, which requires Level B or Level C protection. However, to ensure that the proper level of protection is utilized, constantly monitor the ambient air using the HNU PI 101 to obtain background readings during the sampling procedure. As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed

Also, perform an underground utility search prior to sampling (see section 3.4.4). When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

4.0 General Surface Geophysics: SOP #2159

4.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the general procedures used to acquire surface geophysical data. This data is used for delineating subsurface waste, and for interpreting geologic, hydrogeologic or other data related to hazardous waste site characterization.

The media pertinent to these surface geophysical methods are soil/rock and groundwater. The sensitivity or minimum response of a given method depends on the comparison of the object or area of study to that of its background (i.e., what the media's response would be like without the object of study). Therefore, the suitability of surface geophysical methods for a given investigation must be judged on the object's ability to be measured and the extent to which the specific setting of the study interferes with the measurement.

The surface geophysical method(s) selected for application at a site are dependent on site conditions, such as depth to bedrock, depth to target, urban disturbances (fences, power lines, surface debris, etc.) and atmospheric conditions. Detectability of the target is dependent on the sensitivity of the instrument and the variation of the field measurement from the ambient noise. Ambient noise is the pervasive noise associated with an environment. Therefore, the applicability of geophysical methods at a given site is dependent on the specific setting at that site.

Five geophysical methods may be utilized in hazardous waste site characterization: magnetometry, electromagnetics, resistivity, seismology and ground penetrating radar (GPR). Magnetometers may be used to locate buried ferrous metallic objects and geologic information. Electromagnetic methods can be used to determine the presence of metals, electrical conductivity of the terrain, and geologic information. Resistivity methods are used to determine the electrical resistivity of the terrain and geologic information. Seismic methods are useful in determining geologic stratigraphy and structure. GPR may be used to locate disturbance in the soil (i.e., trenches, buried utilities and fill boundaries) and some near-surface geologic information.

These procedures may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the procedures employed should be documented and associated with the final report.

4.2 METHOD SUMMARY

4.2.1 Magnetics

A magnetometer is an instrument which measures magnetic field strength in units of gammas (nanoteslas). Local variations, or anomalies, in the earth's magnetic field are the result of disturbances caused mostly by variations in concentrations of ferromagnetic material in the vicinity of the magnetometer's sensor. A buried ferrous object, such as a steel drum or tank, locally distorts the earth's magnetic field and results in a magnetic anomaly. The objective of conducting a magnetic survey at a hazardous waste or groundwater pollution site is to map these anomalies and delineate the area containing buried sources of the anomalies.

Analysis of magnetic data can allow an experienced geophysicist to estimate the areal extent of buried ferrous targets, such as a steel tank or drum. Often, areas of burial can be prioritized upon examination of the data, with high priority areas indicating a near certainty of buried ferrous material. In some instances, estimates of depth of burial can be made from the data. Most of these depth estimates are graphical methods of interpretation, such as slope techniques and half-width rules, as described by Nettleton (1976). The accuracy of these methods is dependent upon the quality of the data and the skill of the interpreting geophysicist. An accuracy of 10 to 20 percent is considered acceptable. The magnetic method may also be used to map certain geologic features, such as igneous intrusions, which may play an important role in the hydrogeology of a groundwater pollution site.

Advantages

Advantages of using the magnetic method for the initial assessment of hazardous waste sites are the

relatively low cost of conducting the survey and the relative ease of completing a survey in a short amount of time. Little, if any, site preparation is necessary. Surveying requirements are not as stringent as for other methods and may be completed with a transit or Brunton-type pocket transit and a non-metallic measuring tape. Often, a magnetic investigation is a very cost-effective method for initial assessment of a hazardous waste site where buried steel drums or tanks are a concern.

Disadvantages

"Cultural noise" is a limitation of the magnetic method in certain areas. Man-made structures that are constructed with ferrous material, such as steel, have a detrimental effect on the quality of the data. Avoid features such as steel structures, power lines, metal fences, steel reinforced concrete, pipelines and underground utilities. When these features are unavoidable, note their locations in a field notebook and on the site map.

Another limitation of the magnetic method is the inability of the interpretation methods to differentiate between various steel objects. For instance, it is not possible to determine if an anomaly is the result of a steel tank, or a group of steel drums, or old washing machines. Also, the magnetic method does not allow the interpreter to determine the contents of a buried tank or drum.

4.2.2 Electromagnetics

The electromagnetic method is a geophysical technique based on the physical principles of inducing and detecting electrical current flow within geologic strata. A receiver detects these induced currents by measuring the resulting time-varying magnetic field. The electromagnetic method measures bulk conductivity (the inverse of resistivity) of geologic materials beneath the transmitter and receiver coils. Electromagnetics should not be confused with the electrical resistivity method. The difference between the two techniques is in the method which the electrical currents are forced to flow in the earth. In the electromagnetic method, currents are induced by the application of time-varying magnetic fields, whereas in the electrical resistivity method, current is injected into the ground through surface electrodes.

Electromagnetics can be used to locate pipes, utility lines, cables, buried steel drums, trenches, buried waste, and concentrated contaminant plumes. The method can also be used to map shallow geologic features, such as lithologic changes and fault zones.

Advantages

Electromagnetic measurements can be collected rapidly and with a minimum number of field personnel. Most electromagnetic equipment used in groundwater pollution investigations is lightweight and easily portable. The electromagnetic method is one of the more commonly used geophysical techniques applied to groundwater pollution investigations.

Disadvantages

The main limitation of the electromagnetic method is "cultural noise". Sources of "cultural noise" can include: large metal objects, buried cables, pipes, buildings, and metal fences.

The electromagnetic method has limitations in areas where the geology varies laterally. These can cause conductivity anomalies or lineations, which might be misinterpreted as contaminant plumes.

4.2.3 Electrical Resistivity

The electrical resistivity method is used to map subsurface electrical resistivity structure, which is in turn interpreted by the geophysicist to determine the geologic structure and/or physical properties of the geologic materials. Electrical resistivities of geologic materials are measured in ohm-meters, and are functions of porosity, permeability, water saturation and the concentration of dissolved solids in the pore fluids.

Resistivity methods measure the bulk resistivity of the subsurface, as do the electromagnetic methods. The difference between the two methods is in the way that electrical currents are forced to flow in the earth. In the electrical resistivity method, current is injected into the ground through surface electrodes, whereas in electromagnetic methods currents are induced by application of time-varying magnetic fields.

Advantages

The principal advantage of the electrical resistivity method is that quantitative modeling is possible

using either computer software or published master curves. The resulting models can provide accurate estimates of depths, thicknesses and resistivities of subsurface layers. The layer resistivities can then be used to estimate the resistivity of the saturating fluid, which is related to the total concentration of dissolved solids in the fluid.

Disadvantages

The limitations of using the resistivity method in groundwater pollution site investigations are largely due to site characteristics, rather than in any inherent limitations of the method. Typically, polluted sites are located in industrial areas that contain an abundance of broad spectrum electrical noise. In conducting a resistivity survey, the voltages are relayed to the receiver over long wires that are grounded at each end. These wires act as antennae receiving the radiated electrical noise that in turn degrades the quality of the measured voltages.

Resistivity surveys require a fairly large area, far removed from pipelines and grounded metallic structures such as metal fences, pipelines and railroad tracks. This requirement precludes using resistivity on many polluted sites. However, the resistivity method can often be used successfully off-site to map the stratigraphy of the area surrounding the site. A general "rule of thumb" for resistivity surveying is that grounded structures be at least half of the maximum electrode spacing distance away from the axis of the survey line.

Another consideration in the resistivity method is that the fieldwork tends to be more labor intensive than some other geophysical techniques A minimum of two to three crew members are required for the fieldwork.

4.2.4 Seismic

Surface seismic techniques used in groundwater pollution site investigations are largely restricted to seismic refraction and seismic reflection methods. The equipment used for both methods is fundamentally the same and both methods measure the travel-time of acoustic waves propagating through the subsurface. In the refraction method, the travel-time of waves refracted along an acoustic interface is measured, and in the reflection method, the travel-time of a wave which reflects or echoes off an interface is measured.

The interpretation of seismic data will yield subsurface velocity information, which is dependent upon the acoustic properties of the subsurface material. Various geologic materials can be categorized by their acoustic properties or velocities. Depth to geologic interfaces are calculated using the velocities obtained from a seismic investigation. The geologic information gained from a seismic investigation is then used in the hydrogeologic assessment of a groundwater pollution site and the surrounding area. The interpretation of seismic data indicates changes in lithology or stratigraphy, geologic structure, or water saturation (water table). Seismic methods are commonly used to determine the depth and structure of geologic and hydrogeologic units, to estimate hydraulic conductivity, to detect cavities or voids, to determine structure stability, to detect fractures and fault zones, and to estimate ripability. The choice of method depends upon the information needed and the nature of the study area. This decision must be made by a geophysicist who is experienced in both methods, is aware of the geologic information needed by the hydrogeologist, and is also aware of the environment of the study area. The refraction technique has been used more often than the reflection technique for hazardous waste site investigations.

Seismic Refraction Method

Seismic refraction is most commonly used at sites where bedrock is less than 500 feet below the ground surface. Seismic refraction is simply the travel path of a sound wave through an upper medium and along an interface and then back to the surface. A detailed discussion of the seismic refraction technique can be found in Dobrin (1976), Telford, et. al. (1985), and Musgrave (1967).

Advantages: Seismic refraction surveys are more common than reflection surveys for site investigations. The velocities of each layer can be determined from refraction data, and a relatively precise estimate of the depth to different interfaces can be calculated.

Refraction surveys add to depth information in-between boreholes. Subsurface information can be obtained between boreholes at a fraction of the cost of drilling. Refraction data can be used to determine the depth to the water table or bedrock. In buried valley areas, refraction surveys map the depth to bedrock. The velocity information

obtained from a refraction survey can be related to various physical properties of the bedrock. Rock types have certain ranges of velocities and these velocities are not always unique to a particular rock type. However, they can allow a geophysicist to differentiate between certain units, such as shales and granites.

Disadvantages: The seismic refraction method is based on several assumptions. To successfully resolve the subsurface using the refraction method, the conditions of the geologic environment must approximate these assumptions:

- the velocities of the layers increase with depth,
- the velocity contrast between layers is sufficient to resolve the interface, and
- the geometry of the geophones in relation to the refracting layers will permit the detection of thin layers.

These conditions must be met for accurate depth information.

Collecting and interpreting seismic refraction data has several disadvantages. Data collection can be labor intensive. Also, large line lengths are needed; therefore, as a general rule, the distance from the shot, or seismic source, to the first geophone station must be at least three times the desired depth of exploration.

Seismic Reflection Method

The seismic reflection method is not as commonly used on groundwater pollution site investigations as seismic refraction. In the seismic reflection method, a sound wave travels down to a geologic interface and reflects back to the surface. Reflections occur at an interface where there is a change in the acoustic properties of the subsurface material.

Advantages: The seismic reflection method yields information that allows the interpreter to discern between fairly discrete layers, so it is useful for mapping stratigraphy. Reflection data is usually presented in profile form, and depths to interfaces are represented as a function of time. Depth information can be obtained by converting time sections into depth measurements using velocities obtained from seismic refraction data, sonic logs, or velocity logs. The reflection technique requires much less space than refraction surveys. The long offsets of the seismic source from the geophones, common in refraction surveys, are not required in the reflection method. In some geologic environments, reflection data can yield acceptable depth estimates.

Disadvantages: The major disadvantage to using reflection data is that a precise depth determination cannot be made. Velocities obtained from most reflection data are at least 10% and can be 20% of the true velocities. The interpretation of reflection data requires a qualitative approach. In addition to being more labor intensive, the acquisition of reflection data is more complex than refraction data.

The reflection method places higher requirements on the capabilities of the seismic equipment. Reflection data is commonly used in the petroleum exploration industry and requires a large amount of data processing time and lengthy data collection procedures. Although mainframe computers are often used in the reduction and analysis of large amounts of reflection data, recent advances have allowed for the use of personal computers on small reflection surveys for engineering purposes. In most cases, the data must be recorded digitally or converted to a digital format, to employ various numerical processing operations. The use of high resolution reflection seismic methods relies heavily on the geophysicist, the computer capacity, the data reduction and processing programs, resolution capabilities of the seismograph and geophones, and the ingenuity of the interpreter. Without these capabilities, reflection surveys are not recommended.

4.2.5 Ground Penetrating Radar

The ground penetrating radar (GPR) method is used for a variety of civil engineering, groundwater evaluation and hazardous waste site applications. This geophysical method is the most site-specific of all geophysical techniques, providing subsurface information ranging in depth from several tens of meters to only a fraction of a meter. A basic understanding of the function of the GPR instrument, together with a knowledge of the geology and mineralogy of the site, can help determine if GPR will be successful in the site assessment. When possible, the GPR technique should be integrated with other geophysical and

geologic data to provide the most comprehensive site assessment.

The GPR method uses a transmitter that emits pulses of high-frequency electromagnetic waves into the subsurface. The transmitter is either moved slowly across the ground surface or moved at fixed station intervals. The penetrating electromagnetic waves are scattered at points of change in the complex dielectric permittivity, which is a property of the subsurface material dependent primarily upon the bulk density, clay content and water content of the subsurface (Olhoeft, 1984). The electromagnetic energy which is scattered back to the receiving antenna on the surface is recorded as a function of time.

Depth penetration is severely limited by attenuation of the transmitted electromagnetic waves into the ground. Attenuation is caused by the sum of electrical conductivity, dielectric relaxation, and geometric scattering losses in the subsurface. Generally, penetration of radar frequencies is minimized by a shallow water table, an increase in the clay content of the subsurface, and in environments where the electrical resistivity of the subsurface is less than 30 ohm-meters (Olhoeft, 1986). Ground penetrating radar works best in dry sandy soil above the water table. At applicable sites, depth resolution should be between 1 and 10 meters (Benson, 1982).

The analog plot produced by a continuously recording GPR system is analogous to a seismic reflection profile; that is, data is represented as a function of horizontal distance versus time. This representation should not be confused with a geologic cross section which represents data as a function of horizontal distance versus depth. Because very high-frequency electromagnetic waves in the megahertz range are used by radar systems, and time delays are measured in nanoseconds (10^{-9} seconds), very high resolution of the subsurface is possible using GPR. This resolution can be as high as 0.1 meter. For depth determinations, it is necessary to correlate the recorded features with actual depth measurements from boreholes or from the results of other geophysical investigations. When properly interpreted, GPR data can optimally resolve changes in soil horizons, fractures, water insoluble contaminants, geological features, man-made buried objects, and hydrologic features such as water table depth and wetting fronts.

Advantages

Most GPR systems can provide a continuous display of data along a traverse which can often be interpreted qualitatively in the field. GPR is capable of providing high resolution data under favorable site conditions. The real-time capability of GPR results in a rapid turnaround, and allows the geophysicist to quickly evaluate subsurface site conditions.

Disadvantages

One of the major limitations of GPR is the site-specific nature of the technique. Another limitation is the cost of site preparation which is necessary prior to the survey. Most GPR units are towed across the ground surface. Ideally, the ground surface should be flat, dry, and clear of any brush or debris. The quality of the data can be degraded by a variety of factors, such as an uneven ground surface or various cultural noise sources. For these reasons, it is mandatory that the site be visited by the project geophysicist before a GPR investigation is proposed. The geophysicist should also evaluate all stratigraphic information available, such as borehole data and information on the depth to water table in the survey area.

4.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this SOP.

4.4 INTERFERENCES AND POTENTIAL PROBLEMS

See section 4.2.1 for a discussion of limitations of the magnetic method.

See section 4.2.2 for a discussion of limitations of the electromagnetic method.

See section 4.2.3 for a discussion of limitations of the electrical resistivity method.

See section 4.2.4 for a discussion of limitations of the seismic refraction method and the seismic reflection method.

See section 4.2.5 for a discussion of limitations of the ground penetrating radar (GPR) method.

4.5 EQUIPMENT/APPARATUS

4.5.1 Magnetics

- GEM GSM-19G magnetometer/gradiometer, EDA OMNI IV magnetometer/gradiometer, Geonics 856AGX (with built-in datalogger) or equivalent
- magnetometer base station
- 300-foot tape measure
- non-ferrous survey stakes (wooden or plastic)

4.5.2 Electromagnetics

- Geonics EM-31, EM-34 or equivalent
- Polycorder datalogger
- Dat 31Q software (data dump software)
- 300-foot tape measure
- survey stakes

4.5.3 Electrical Resistivity

- DC resistivity unit (non-specific)
- 4 electrodes and appropriate cables (length dependent on depth of survey)
- 1 or 2 12-volt car batteries
- 300-foot tape measure

4.5.4 Seismic

- 12- or 24-channel seismograph (Geometrics 2401 or equivalent)
- 30 10Hz to 14Hz geophones (for refraction)
- 30 50Hz or greater geophones (for reflection)
- 300-foot tape measure
- survey stakes
- sledge hammer and metal plate or explosives

4.5.5 Ground Penetrating Radar

- GSSI SIR-8 or equivalent
- 80 Mhz, 100 Mhz or 300 Mhz antenna/receiver pit
- 200-foot cable
- 300-foot tape measure

4.6 REAGENTS

This section is not applicable to this SOP.

4.7 PROCEDURES

Refer to the manufacturer's operating manual for specific procedures relating to operation of the equipment.

4.8 CALCULATIONS

Calculations vary based on the geophysical method employed. Refer to the instrument-specific users manual for specific formulae.

4.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance activities apply to the implementation of these procedures.

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

Method-specific quality assurance procedures may be found in the user's manual.

4.10 DATA VALIDATION

Evaluate data as per the criteria established in section 4.9 above.

4.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

APPENDIX A

Figures

Figure 1: Sampling Augers

SOP #2012

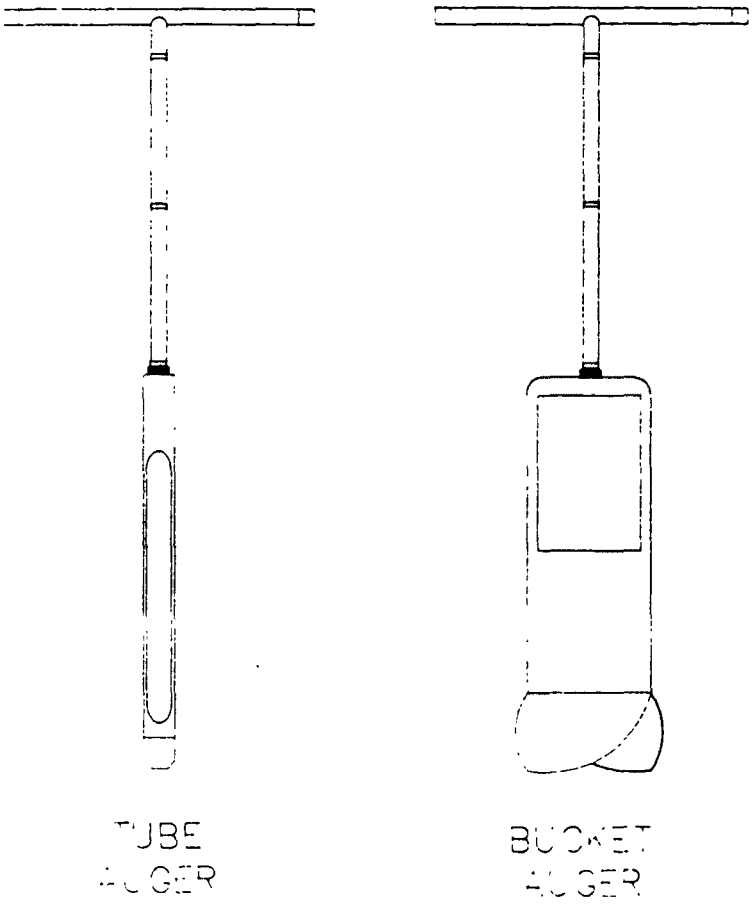


Figure 2: Sampling Trier

SOP #2012

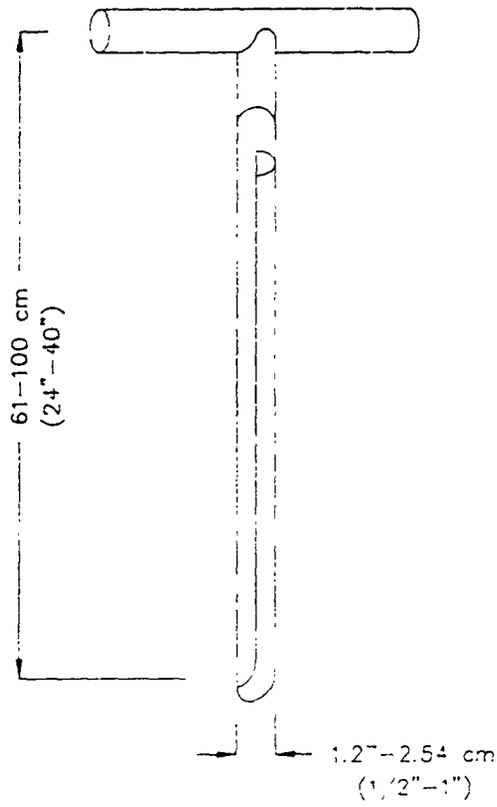
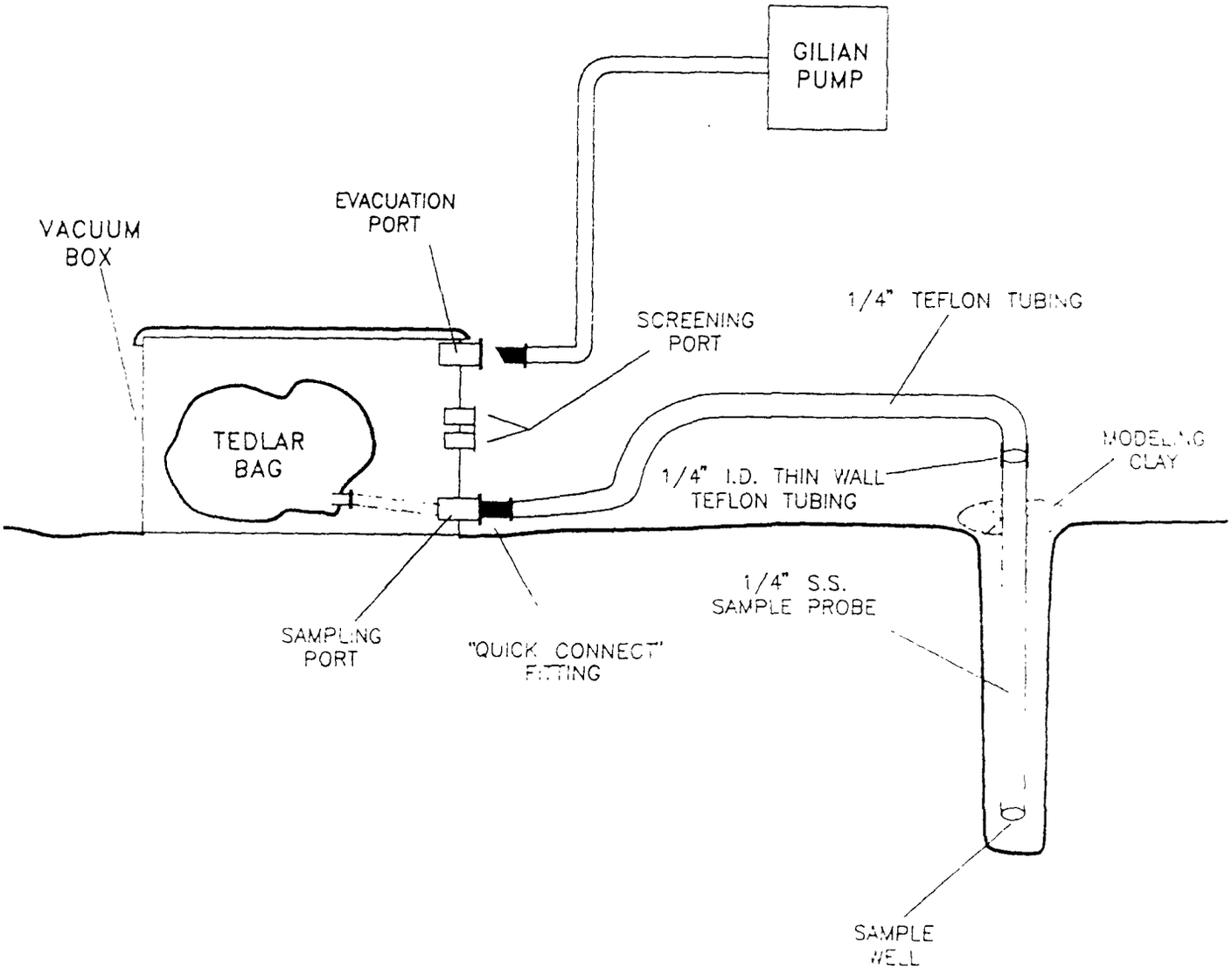


Figure 3: Sampling Train Schematic

SOP #2149



APPENDIX B

HNU Field Protocol

Startup Procedure

1. Before attaching the probe, check the function switch on the control panel to ensure that it is in the "off" position. Attach the probe by plugging it into the interface on the top of the readout module. Use care in aligning the prongs in the probe cord with the socket: do not force it.

2. Turn the function switch to the battery check position. The needle on the meter should read within or above the green area on the scale. If not, recharge the battery. If the red indicator light comes on, the battery needs recharging.

3. Turn the function switch to any range setting. For no more than 2 to 3 seconds, look into the end of the probe to see if the lamp is on. If it is on, you will see a purple glow. Do not stare into the probe any longer than three seconds. Long term exposure to UV light can damage the eyes. Also, listen for the hum of the fan motor.

4. To zero the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 to 20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

Operational Check

1. Follow the startup procedure.

2 With the instrument set on the 0-20 range, hold a solvent-based Magic Marker near the probe tip. If the meter deflects upscale, the instrument is working.

Field Calibration Procedure

1 Follow the startup procedure and the operational check.

2. Set the function switch to the range setting for the concentration of the calibration gas.

3. Attach a regulator (HNU 101-351) to a disposable cylinder of isobutylene gas. Connect the regulator to the probe of the HNU with a piece of clean Tygon tubing. Turn the valve on the regulator to the "on" position.

4. After 15 seconds, adjust the span dial until the meter reading equals the concentration of the calibration gas used. The calibration gas is usually 100 ppm of isobutylene in zero air. The cylinders are marked in benzene equivalents for the 10.2 eV probe (approximately 55 ppm benzene equivalent) and for the 11.7 eV probe (approximately 65 ppm benzene equivalent). Be careful to unlock the span dial before adjusting it. If the span has to be set below 3.0 calibration, the lamp and ion chamber should be inspected and cleaned as appropriate. For cleaning of the 11.7 eV probe, only use an electronic-grade, oil-free freon or similar water-free, grease-free solvent.

5. Record in the field log: the instrument ID # (EPA decal or serial number if the instrument is a rental); the initial and final span settings; the date and time; concentration and type of calibration used; and the name of the person who calibrated the instrument.

Operation

1. Follow the startup procedure, operational check, and calibration check.

2. Set the function switch to the appropriate range. If the concentration of gases or vapors is unknown, set the function switch to the 0-20 ppm range. Adjust it as necessary.

3. While taking care not to permit the HNU to be exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site health and safety plan.

4. When the activity is completed or at the end of the day, carefully clean the outside of the HNU with a damp disposable towel to remove any

visible dirt. Return the HNU to a secure area and place on charge.

5. With the exception of the probe's inlet and exhaust, the HNU can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.

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SOPs #2006, 2012, 2149

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APPENDIX D

Compendium of ERT Surface Water and Sediment Sampling Procedures

EPA/540/P-91/005
OSWER Directive 9360 4-03
January 1991

COMPENDIUM OF ERT SURFACE WATER AND SEDIMENT SAMPLING PROCEDURES

Sampling Equipment Decontamination

Surface Water Sampling

Sediment Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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The policies and procedures established in this document are intended solely for the guidance of government personnel, for use in the Superfund Removal Program. They are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States. The Agency reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Surface Water and Sediment Sampling Procedures. Send remarks to:

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1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

2.0 SURFACE WATER SAMPLING: SOP #2013

2.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and nonaqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

2.2 METHOD SUMMARY

Sampling situations vary widely and therefore no universal sampling procedure can be recommended.

However, sampling of both aqueous and non-aqueous liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- bacon bomb sampler
- dip sampler
- direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, follow these procedures:

1. Transfer the sample(s) into suitable labeled sample containers.

2. Preserve the sample if appropriate, or use pre-preserved sample bottles.

3. Cap the container, put it in a Ziploc plastic bag and place it on ice in a cooler.

4. Record all pertinent data in the site logbook and on a field data sheet.

5. Complete the chain of custody form.

6. Attach custody seals to the cooler prior to shipment.

7. Decontaminate all sampling equipment prior to the collection of additional samples.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross-contamination of samples and improper sample collection.

- Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to ERT SOP #2006, Sampling Equipment Decontamination.

- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

2.5 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples includes:

- Kemmerer bottles
- bacon bomb sampler
- dip sampler
- line and messengers
- sample bottle preservatives
- Ziploc bags
- ice
- cooler(s)
- chain of custody forms, field data sheets

- decontamination equipment
- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- logbook/waterproof pen
- sample bottle labels

2.6 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

2.7.2 Sampling Considerations

Representative Samples

In order to collect a representative sample, the hydrology and morphometrics (e.g., measurements of volume, depth, etc.) of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist which would effect analytical results. Measurements should be collected at 1-meter intervals from the substrate to the surface using an appropriate instrument, such as a Hydrolab (or equivalent).

Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths anytime surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Will the sample be collected from the shore or from a boat on the impoundment?

- What is the desired depth at which the sample is to be collected?

- What is the overall depth and flow direction of river or stream?

Sampler Composition

The appropriate sampling device must be of a proper composition. Samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be used based upon the analyses to be performed.

2.7.3 Sample Collection

Kemmerer Bottle

Kemmerer bottle (Figure 1, Appendix A) may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

Bacon Bomb Sampler

A bacon bomb sampler (Figure 2, Appendix A) may be used in similar situations to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.

2. Release the trigger line and retrieve the sampler.

3. Transfer the sample to the appropriate sample container by pulling the trigger.

Dip Sampler

A dip sampler (Figure 3, Appendix A) is useful for situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Extend the device to the sample location and collect the sample.

3. Retrieve the sampler and transfer the sample to the appropriate sample container.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants are a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA/QC procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, take adequate precautions. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him or her to lose their balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, follow appropriate boating safety procedures.

3.0 SEDIMENT SAMPLING: SOP #2016

3.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative sediment samples. Analysis of sediment may determine whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations present a risk to public health, welfare, or the environment.

The methodologies discussed in this procedure are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by the sampling area. However, if modifications occur, they should be documented in the site logbook or report summarizing field activities.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static, as in lakes, ponds, or other impoundments or flowing, as in rivers and streams.

3.2 METHOD SUMMARY

Sediment samples may be recovered using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface versus subsurface), the type of sample required (disturbed versus undisturbed) and the sediment type.

Sediment is collected from beneath an aqueous layer either directly, using a hand-held device such as a shovel, trowel, or auger, or indirectly using a remotely activated device such as an Ekman or Ponar dredge. Following collection, the sediment is placed into a container constructed of inert material, homogenized, and transferred to the appropriate sample containers. The homogenization procedure should not be used if sample analysis includes volatile organics.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

- Chemical preservation of solids is generally not recommended. Cooling is usually the best approach, supplemented by the appropriate holding time.

- Wide-mouth glass containers with Teflon-lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the work plan.

- Transfer sediment from the sample collection device to an appropriate sample container using a stainless steel or plastic lab spoon or equivalent. If composite samples are collected, place the sediment sample in a stainless steel, plastic or other appropriate composition (e.g.: Teflon) bucket, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then place the sediment sample into labeled containers.

- Samples for volatile organic analysis must be collected directly from the bucket, before mixing the sample, to minimize loss due to volatilization of contaminants.

- All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampler should be used for only one sample. Dedicated samplers for sediment samples may be impractical due to the large number of sediment samples which may be required and the cost of the sampler. In this case, samplers should be cleaned in the field using the decontamination procedure described in ERT SOP# 2006, Sampling Equipment Decontamination.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

Substrate particle size and organic content are directly related to water velocity and flow characteristics of a body of water. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic content do not typically concentrate pollutants and are found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results.

3.5 EQUIPMENT/APPARATUS

Equipment needed for collection of sediment samples includes:

- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- stainless steel, plastic, or other appropriate composition bucket
- 4-oz., 8-oz., and one-quart, wide-mouth jars w/Teflon-lined lids
- Ziploc plastic bags
- logbook
- sample jar labels
- chain of custody forms, field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- spade or shovel
- spatula
- scoop
- trowel
- bucket auger
- thin-walled auger
- extension rods
- T-handle
- sampling trier
- sediment coring device (tubes, points, drive head, drop hammer, "eggshell" check valve devices, acetate cores)
- Ponar dredge
- Ekman dredge
- nylon rope

3.6 REAGENTS

Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

3.7 PROCEDURES

3.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. Specific site characteristics, including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, and extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

3.7.2 Sample Collection

Selection of a sampling device is most often contingent upon: (1) the depth of water at the sampling location, and (2) the physical characteristics of the medium to be sampled.

Sampling Surface Sediments with a Trowel or Scoop From Beneath a Shallow Aqueous Layer

Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with

tools such as spades, shovels, and scoops. Surface material can be removed to the required depth; then a stainless steel or plastic scoop should be used to collect the sample.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect sediment samples with a scoop or trowel:

1. Using a precleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.

2. Transfer the sample into an appropriate sample or homogenization container.

Sampling Surface Sediments with a Thin-Wall Tube Auger From Beneath a Shallow Aqueous Layer

This system consists of an auger, a series of extension rods, and a "T" handle (see Figure 4, Appendix A). The auger is driven into the sediment and used to extract a core. A sample of the core is taken from the appropriate depth.

Use the following procedure to collect sediment samples with a thin-walled auger:

1. Insert the auger into the material to be sampled at a 0° to 45° angle from vertical. This orientation minimizes spillage of the sample from the sampler. Extraction of samples may require tilting of the sampler.

2. Rotate the auger once or twice to cut a core of material.

3. Slowly withdraw the auger, making sure that the slot is facing upward.

4. An acetate core may be inserted into the auger prior to sampling, if characteristics of the sediments or body of water warrant. By using this technique, an intact core can be extracted.

5. Transfer the sample into an appropriate sample or homogenization container.

Sampling Deep Sediments with Augers and Thin-Wall Tube Samplers From Beneath a Shallow Aqueous Layer

This system uses an auger, a series of extension rods, a "T" handle, and a thin-wall tube sampler (Figure 4, Appendix A). The auger bores a hole to a desired sampling depth and then is withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the sediment at the completion depth. The core is then withdrawn and the sample collected. This method can be used to collect consolidated sediments, but is somewhat limited by the depth of the aqueous layer.

Several augers are available which include bucket and posthole augers. Bucket augers are better for direct sample recovery, are fast, and provide a large volume of sample. Posthole augers have limited utility for sample collection as they are designed more for their ability to cut through fibrous, rooted, swampy areas.

Follow these procedures to collect sediment samples with a hand auger:

1. Attach the auger bit to a drill extension rod, then attach the "T" handle to the drill extension rod.

2. Clear the area to be sampled of any surface debris.

3. Begin augering, periodically removing any accumulated sediment from the auger bucket.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. (When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.)

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower tube sampler down borehole. Gradually force tube sampler into sediment.

Care should be taken to avoid scraping the borehole sides. Also, avoid hammering of the drill rods to facilitate coring, since the vibrations may cause the boring walls to collapse.

7. Remove tube sampler and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 1 inch), as this represents material collected by the tube sampler before penetration of the layer of concern.

10. Transfer sample into an appropriate sample or homogenization container.

Sampling Surface Sediments From Beneath a Deep Aqueous Layer with an Ekman or Ponar Dredge

This technique consists of lowering a sampling device to the sediment by use of a rope, cable, or extended handle. The mechanism is triggered, and the device entraps sediment in spring-loaded jaws, or within lever-operated jaws.

Follow these procedures for collecting sediment with an Ekman dredge (Figure 5, Appendix A):

1. Thread a sturdy nylon or stainless steel cable through the bracket, or secure the extended handle to the bracket with machine bolts.

2. Attach springs to both sides. Arrange the Ekman dredge sampler so that the jaws are in the open position and trip cables are positioned over the release studs.

3. Lower the sampler to a point just above the sediment surface.

4. Drop the sampler sharply onto the sediment.

5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extended handle.

6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Be careful to retain fine sediments.

7. Open the dredge and transfer the sediment into a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been secured. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

8. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Follow these procedures for collecting sediment with a Ponar dredge (Figure 6, Appendix A):

1. Attach a sturdy nylon or steel cable to the hook provided on top of the dredge.

2. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.

3. Slowly lower the sampler to a point just above the sediment.

4. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.

5. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.

6. Open the dredge and transfer the sediment to a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been gained. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

7. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Sampling Subsurface Sediments From Beneath a Deep Aqueous Layer with a Sample Coring Device

Follow these procedures when using a sample coring device (Figure 7, Appendix A) to collect

subsurface sediments. It consists of a coring device, handle, and acetate core utilized in the following procedure:

1. Assemble the coring device by inserting the acetate core into the sampling tube.

2. Insert the "eggshell" check valve mechanisms into the tip of the sampling tube with the convex surface positioned inside the acetate core.

3. Screw the coring point onto the tip of the sampling tube.

4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.

5. Place the sampler in a perpendicular position on the material to be sampled.

6. This sampler may be used with either a drive hammer for firm consolidated sediments, or a "T" handle for soft sediments. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. Rotate the sampler to shear off the core of the bottom, retrieve the device and proceed to Step 15.

7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.

8. With left hand holding the tube, drive the sampler into the material to the desired depth. Do not drive the tube further than the tip of the hammer's guide.

9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.

10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.

11. Rotate the sampler at least two revolutions to shear off the sample at the bottom.

12. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90°.

13. Withdraw the sampler by pulling the handle (hammer) upwards and dislodging the hammer from the sampler.

14. Unscrew the coring point and remove the "eggshell" check valve.

15. Slide the acetate core out of the sampler tube. The acetate core may be capped at both ends. The sample may be used in this fashion, or the contents transferred to a stainless steel or plastic bucket and mixed thoroughly to obtain a homogeneous sample representative of the entire sampling interval.

16. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

3.8 CALCULATIONS

This section is not applicable to this SOP.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA/QC procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

3.10 DATA VALIDATION

This section is not applicable to this SOP.

3.11 HEALTH AND SAFETY

When working with potentially hazardous materials follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling sediment from bodies of water containing known or suspected hazardous substances, adequate precautions must be taken to ensure the sampler's safety. The team member collecting the sample should not get too close to the edge of the water, where bank failure may cause him or her to lose their balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is necessary, implement appropriate protective measures.

APPENDIX A

Figures

Figure 1: Kemmerer Bottle

SOP #2013

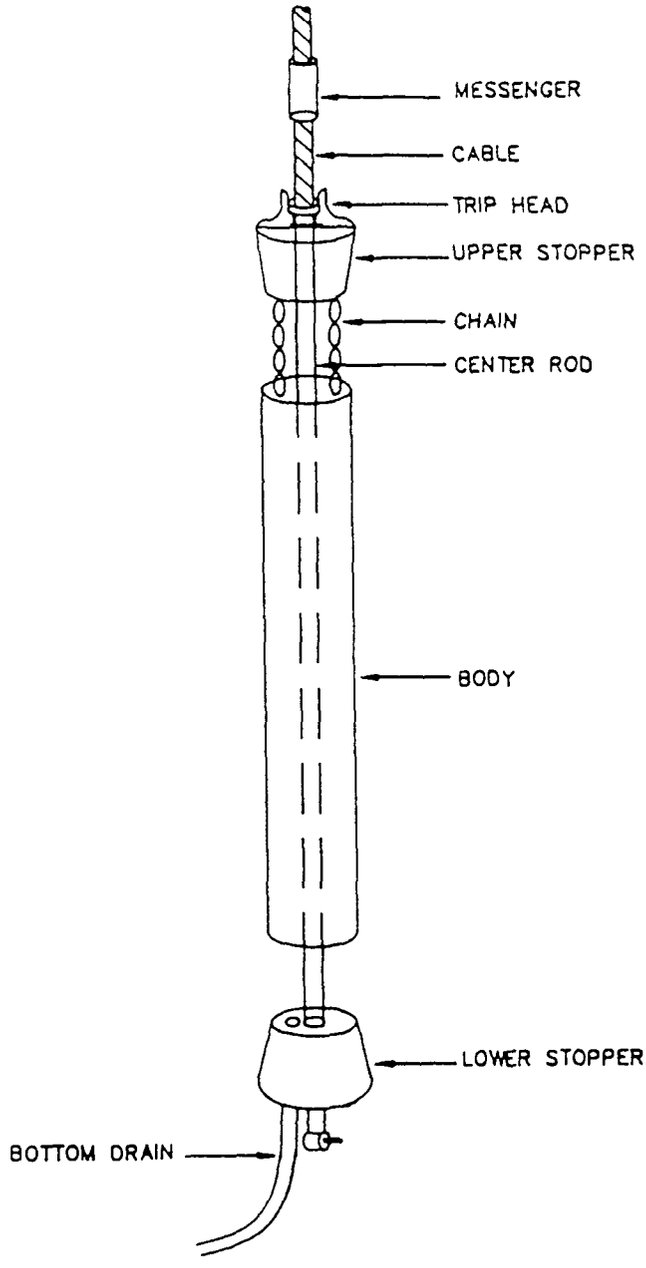


Figure 2: Bacon Bomb Sampler

SOP #2013

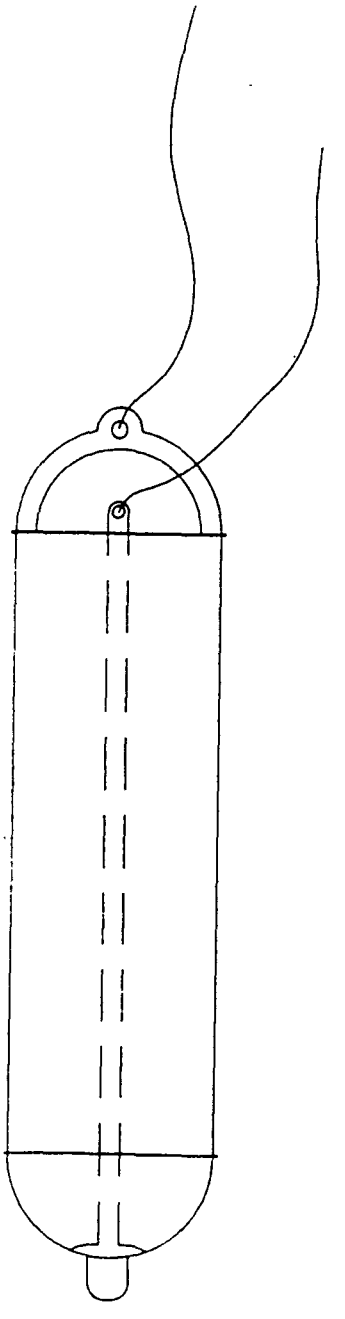


Figure 3: Dip Sampler

SOP #2013

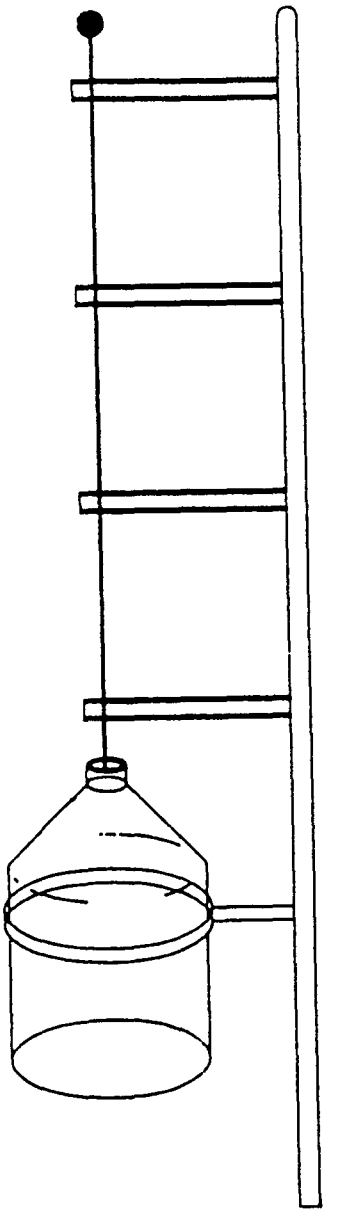


Figure 4: Sampling Auger

SOP #2016

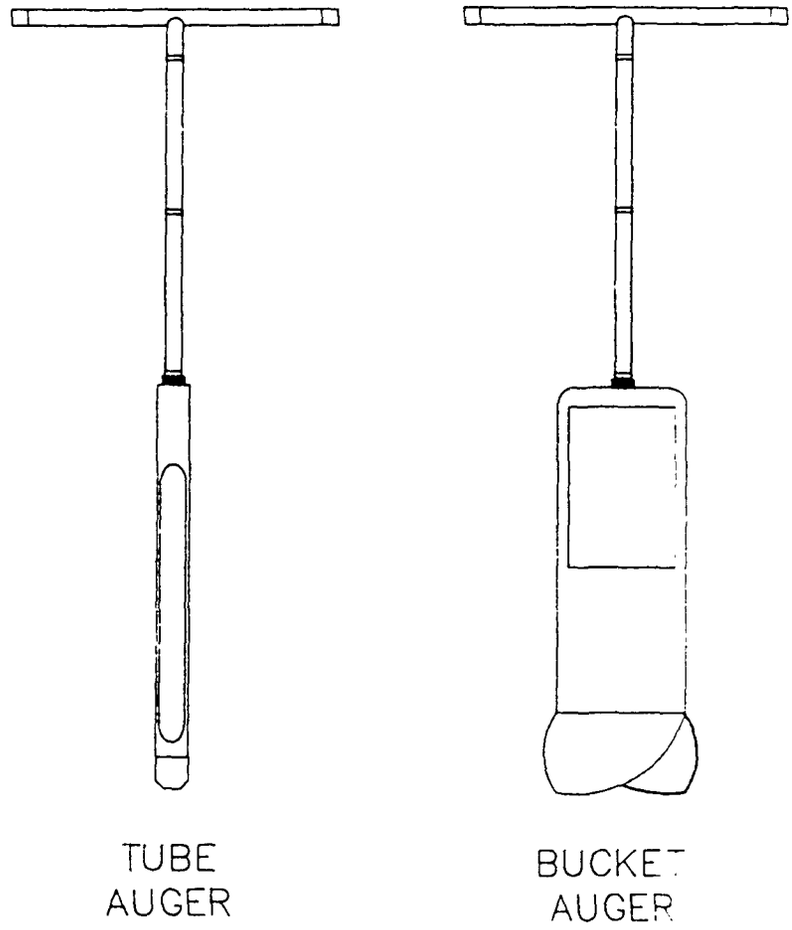


Figure 5: Ekman Dredge

SOP #2016

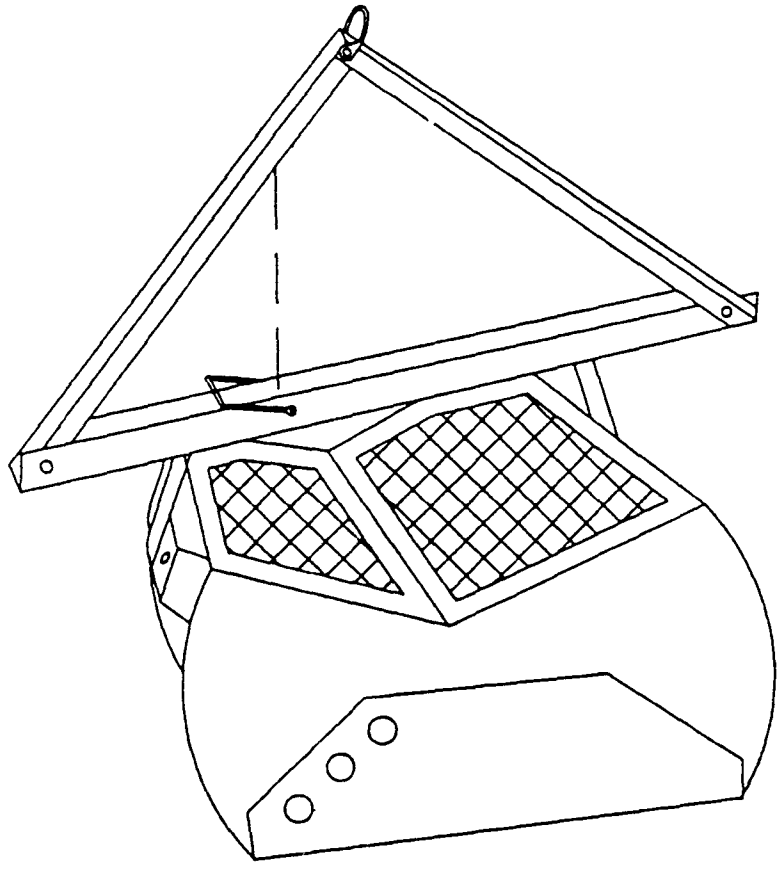


Figure 6: Ponar Dredge

SOP #2016

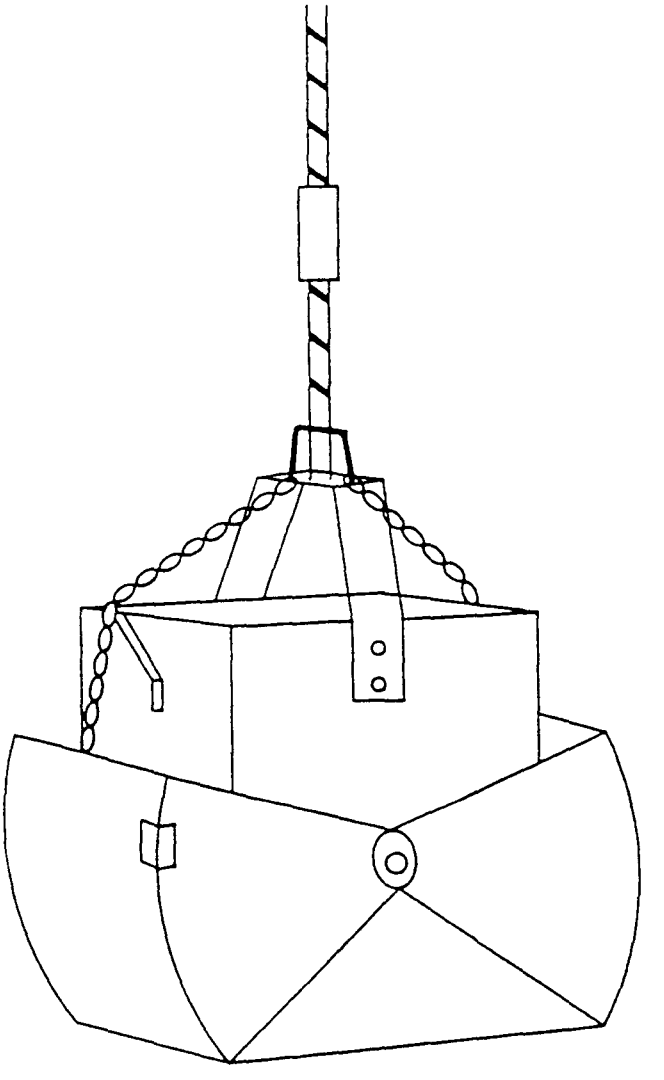
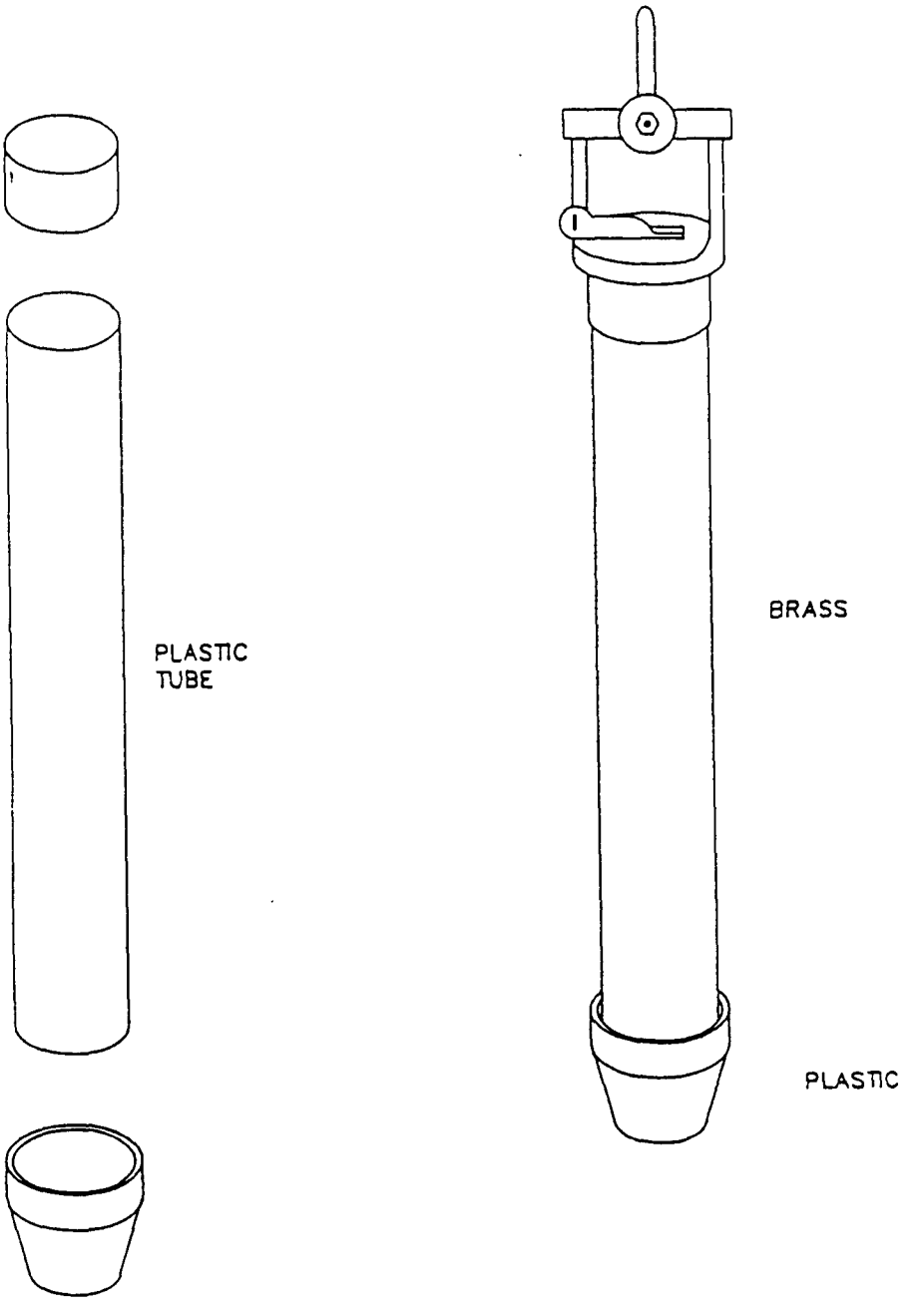


Figure 7: Sample Coring Device

SOP #2016



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APPENDIX E

Compendium of ERT Groundwater Sampling Procedures

EPA/540/P-91/007
OSWER Directive 9360.4-06
January 1991

COMPENDIUM OF ERT GROUNDWATER SAMPLING PROCEDURES

Sampling Equipment Decontamination

Groundwater Well Sampling

Soil Gas Sampling

Monitoring Well Installation

Water Level Measurement

Well Development

Controlled Pumping Test

Slug Test

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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Notice

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The policies and procedures established in this document are intended solely for the guidance of government personnel, for use in the Superfund Removal Program. They are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States. The Agency reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Groundwater Sampling Procedures. Send remarks to:

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National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

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1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

2.0 GROUNDWATER WELL SAMPLING: SOP #2007

2.1 SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to provide general reference information on sampling of groundwater wells. This guideline is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of groundwater contaminants (e.g., volatile and semi-volatile organic compounds, pesticides, metals, biological parameters).

2.2 METHOD SUMMARY

Prior to sampling a monitoring well, the well must be purged. This may be done with a number of instruments. The most common of these are the bailer, submersible pump, non-gas contact bladder pump and inertia pump. At a minimum, three well volumes should be purged, if possible. Equipment must be decontaminated prior to use and between wells. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments, and need not be the same as the device used for purging. Care should be taken when choosing the sampling device as some will affect the integrity of the sample. Sampling equipment must also be decontaminated. Sampling should occur in a progression from the least to most contaminated well, if this information is known.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements. Samples should be collected directly from the sampling device into appropriate laboratory-cleaned containers. Check that a Teflon liner is present in the cap, if required. Attach a sample identification label. Complete a field data sheet, a chain of custody form and record all pertinent data in the site logbook.

Samples shall be appropriately preserved, labelled, logged, and placed in a cooler to be maintained at 4°C. Samples must be shipped well before the holding time is over and ideally should be shipped within 24 hours of sample collection. It is imperative that these samples be shipped or delivered daily to the analytical laboratory in order to maximize the time available for the laboratory to perform the analysis. The bottles should be shipped with adequate packing and cooling to ensure that they arrive intact.

Certain conditions may require special handling techniques. For example, treatment of a sample for volatile organic (VOA) analysis with sodium thiosulfate preservative is required if there is residual chlorine in the water (such as public water supply) that could cause free radical chlorination and change the identity of the original contaminants. However, sodium thiosulfate should not be used if chlorine is not present in the water. Special requirements must be determined prior to conducting fieldwork.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

2.4.1 General

The primary goal of groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and only utilizing trained field personnel.

2.4.2 Purging

In a non-pumping well, there will be little or no vertical mixing of the water, 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, become stagnant and lack the VOAs representative of the groundwater. Sampling personnel should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in an unrepresentative sample. To safeguard against collecting nonrepresentative stagnant water, follow these guidelines during sampling:

- As a general rule, all monitoring wells should be pumped or bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site-specific project plan. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding ground water formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical. However, in all cases where the monitoring data is to be used for enforcement actions, evacuation is recommended.

- For wells that can be pumped or bailed to dryness with the equipment being used, the well should be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and the schedule allows, evacuation of more than one volume of water is preferred. If recovery is slow, sample the well upon recovery after one evacuation.

- A nonrepresentative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

2.4.3 Materials

Samplers and evacuation equipment (bladders, pumps, bailers, tubing, etc.) should be limited to those made with stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample.

Table 2 on page 7 discusses the advantages and disadvantages of certain equipment.

2.5 EQUIPMENT/APPARATUS

2.5.1 General

- water level indicator
  - electric sounder
  - steel tape
  - transducer
  - reflection sounder
  - airline
- depth sounder
- appropriate keys for well cap locks
- steel brush
- HNU or OVA (whichever is most appropriate)
- logbook
- calculator
- field data sheets
- chain of custody forms
- forms and seals
- sample containers
- Engineer's rule
- sharp knife (locking blade)
- tool box (to include at least: screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench)
- leather work gloves
- appropriate health and safety gear
- 5-gallon pail
- plastic sheeting
- shipping containers
- packing materials
- bolt cutters
- Ziploc plastic bags
- containers for evacuation of liquids
- decontamination solutions
- tap water
- non-phosphate soap
- several brushes

Table 2: Advantages and Disadvantages of Various Groundwater Sampling Devices

Device	Advantages	Disadvantages
Bailer	• The only practical limitations are size and materials • No power source needed • Portable • Inexpensive; it can be dedicated and hung in a well reducing the chances of cross-contamination • Minimal outgassing of volatile organics while sample is in bailer • Readily available • Removes stagnant water first • Rapid, simple method for removing small volumes of purge water	• Time consuming, especially for large wells • Transfer of sample may cause aeration
Submersible Pump	• Portable; can be used on an unlimited number of wells • Relatively high pumping rate (dependent on depth and size of pump) • Generally very reliable; does not require priming	• Potential for effects on analysis of trace organics • Heavy and cumbersome, particularly in deeper wells • Expensive • Power source needed • Susceptible to damage from silt or sediment • Impractical in low yielding or shallow wells
Non-Gas Contact Bladder Pump	• Maintains integrity of sample • Easy to use	• Difficult to clean although dedicated tubing and bladder may be used • Only useful to approximately 100 feet in depth • Supply of gas for operation (bottled gas and/or compressor) is difficult to obtain and is cumbersome
Suction Pump	• Portable, inexpensive, and readily available	• Only useful to approximately 25 feet or less in depth • Vacuum can cause loss of dissolved gases and volatile organics • Pump must be primed and vacuum is often difficult to maintain • May cause pH modification
Inertia Pump	• Portable, inexpensive, and readily available • Rapid method for purging relatively shallow wells	• Only useful to approximately 70 feet or less in depth • May be time consuming to use • Labor intensive • WaTerra pump is only effective in 2-inch diameter wells

- pails or tubs
- aluminum foil
- garden sprayer
- preservatives
- distilled or deionized water

2.5.2 Bailer

- clean, decontaminated bailer(s) of appropriate size and construction material
- nylon line, enough to dedicate to each well
- Teflon-coated bailer wire
- sharp knife
- aluminum foil (to wrap clean bailers)
- 5-gallon bucket

2.5.3 Submersible Pump

- pump(s)
- generator (110, 120, or 240 volt) or 12-volt battery if inaccessible to field vehicle
- 1-inch black PVC coil pipe -- enough to dedicate to each well
- hose clamps
- safety cable
- tool box supplement
  - pipe wrenches, 2
  - wire strippers
  - electrical tape
  - heat shrink
  - hose connectors
  - Teflon tape
- winch or pulley
- gasoline for generator
- flow meter with gate valve
- 1-inch nipples and various plumbing (i.e., pipe connectors)

2.5.4 Non-Gas Contact Bladder Pump

- non-gas contact bladder pump
- compressor or nitrogen gas tank
- batteries and charger
- Teflon tubing -- enough to dedicate to each well
- Swagelock fitting
- toolbox supplements -- same as submersible pump

2.5.5 Suction Pump

- pump
- black coil tubing -- enough to dedicate to each well
- gasoline -- if required
- toolbox
- plumbing fittings
- flow meter with gate valve

2.5.6 Inertia Pump

- pump assembly (WaTerra pump, piston pump)
- 5-gallon bucket

2.6 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservation required is specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Identify and mark all sampling locations.

2.7.2 Field Preparation

1. Start at the least contaminated well, if known.

2. Lay plastic sheeting around the well to minimize likelihood of contamination of equipment from soil adjacent to the well.

3. Remove locking well cap, note location, time of day, and date in field notebook or an appropriate log form.

4. Remove well casing cap.

5. Screen headspace of well with an appropriate monitoring instrument to determine the presence of volatile organic compounds and record in site logbook.

6. Lower water level measuring device or equivalent (i.e. permanently installed transducers or airline) into well until water surface is encountered.

7. Measure distance from water surface to reference measuring point on well casing or protective barrier post and record in site logbook. Alternatively, if there is no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the well head.

8. Measure total depth of well (do this at least twice to confirm measurement) and record in site logbook or on log form.

9. Calculate the volume of water in the well and the volume to be purged using the calculations in Section 2.8.

10. Select the appropriate purging and sampling equipment.

2.7.3 Evacuation of Static Water (Purging)

The amount of flushing a well receives prior to sample collection depends on the intent of the monitoring program as well as the hydrogeologic conditions. Programs where overall quality determination of water resources are involved may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume can be determined prior to sampling so that the sample is a composite of known volume of the aquifer, or the well can be pumped until the stabilization of parameters such as temperature, electrical conductance, or pH has occurred.

However, monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce flow from other areas. Generally, three well volumes are considered effective, or calculations can be made to determine, on the basis of the aquifer parameters and well dimensions, the appropriate volume to remove prior to sampling.

During purging, water level measurements may be taken regularly at 15- to 30-second intervals. This data may be used to compute aquifer transmissivity and other hydraulic characteristics.

The following well evacuation devices are most commonly used. Other evacuation devices are available, but have been omitted in this discussion due to their limited use.

Bailer

Bailers are the simplest purging device used and have many advantages. They generally consist of a rigid length of tube, usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well and retrieve a volume of water. The three most common types of bailer are PVC, Teflon, and stainless steel.

This manual method of purging is best suited to shallow or narrow diameter wells. For deep, larger diameter wells which require evacuation of large volumes of water, other mechanical devices may be more appropriate.

Bailing equipment includes a clean decontaminated bailer, Teflon or nylon line, a sharp knife, and plastic sheeting.

1. Determine the volume of water to be purged as described in Section 2.7.2, Field Preparation.

2. Lay plastic sheeting around the well to prevent contamination of the bailer line with foreign materials.

3. Attach the line to the bailer and lower until the bailer is completely submerged.

4. Pull bailer out ensuring that the line either falls onto a clean area of plastic sheeting or never touches the ground.

5. Empty the bailer into a pail until full to determine the number of bails necessary to achieve the required purge volume.

6. Thereafter, pour the water into a container and dispose of purge waters as specified in the site-specific project plan.

Submersible Pump

Submersible pumps are generally constructed of plastic, rubber, and metal parts which may affect the analysis of samples for certain trace organics and inorganics. As a consequence, submersible pumps may not be appropriate for investigations requiring analyses of samples for trace contaminants. However, they are still useful for pre-sample purging. However, the pump must have a check valve to prevent water in the pump and the pipe from rushing back into the well.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110- or 220-volt AC power supply. Those units powered by compressed gas normally use a small electric compressor which also needs 12-volt DC or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells.

1. Determine the volume of water to be purged as described in section 2.7.2, Field Preparation.

2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with foreign materials.

3. Assemble pump, hoses and safety cable, and lower the pump into the well. Make sure the pump is deep enough so that purging does not evacuate all the water. (Running the pump without water may cause damage.)

4. Attach flow meter to the outlet hose to measure the volume of water purged.

5. Attach power supply, and purge well until specified volume of water has been evacuated (or until field parameters, such as temperature, pH, conductivity, etc. have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, lower the pump further into the well, and continue pumping.

6. Collect and dispose of purge waters as specified in the site-specific project plan.

Non-Contact Gas Bladder Pump

For this procedure, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used to provide the least amount of material interference to the sample (Barcelona, 1985). Water comes into contact with the inside of the bladder (Teflon) and the sample tubing, also Teflon, that may be dedicated to each well. Some wells may have permanently installed bladder pumps (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

1. Assemble Teflon tubing, pump and charged control box.

2. Use the same procedure for purging with a bladder pump as for a submersible pump.

3. Be sure to adjust flow rate to prevent violent jolting of the hose as sample is drawn in.

Suction Pump

There are many different types of suction pumps. They include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze the flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross-contamination. Peristaltic pumps, however, require a power source.

1. Assemble the pump, tubing, and power source if necessary.

2. To purge with a suction pump, follow the exact procedures outlined for the submersible pump.

Inertia Pump

Inertia pumps, such as the WaTerra pump and piston pump, are manually operated. They are appropriate to use when wells are too deep to bail by hand, but are not inaccessible enough to warrant an automatic (submersible, etc.) pump. These

pumps are made of plastic and may be either decontaminated or discarded, after use.

1. Determine the volume of water to be purged as described in Section 2.7.2, Field Preparation.

2. Lay plastic sheeting around the well to prevent contamination of pumps or hoses with foreign materials.

3. Assemble pump, and lower to the appropriate depth in the well.

4. Begin pumping manually, discharging water into a 5-gallon bucket (or other graduated vessel). Purge until specified volume of water has been evacuated (or until field parameters such as temperature, pH, conductivity, etc. have stabilized).

5. Collect and dispose of purge waters as specified in the site-specific project plan.

2.7.4 Sampling

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, purging and sample withdrawal equipment should be completely inert, economical to use, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power resources, and capable of delivering variable rates for sample collection.

There are several factors to take into consideration when choosing a sampling device. Care should be taken when reviewing the advantages or disadvantages of any one device. It may be appropriate to use a different device to sample than that which was used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample.

Bailer

The positive-displacement volatile sampling bailer (by GPI) is perhaps the most appropriate for collection of water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions. Generally, bailers can provide an acceptable sample, providing that sampling personnel use extra care in the collection process.

1. Surround the monitoring well with clean plastic sheeting.

2. Attach a line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling.

3. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.

4. Allow bailer to fill and then slowly and gently retrieve the bailer from the well, avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer.

5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it will not become contaminated. See Section 2.7.7 for special considerations on VOA samples.

6. Begin pouring slowly from the bailer.

7. Filter and preserve samples as required by sampling plan.

8. Cap the sample container tightly and place pre-labeled sample container in a carrier.

9. Replace the well cap.

10. Log all samples in the site logbook and on field data sheets and label all samples.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to analytical laboratory.

Submersible Pump

Although it is recommended that samples not be collected with a submersible pump due to the reasons stated in Section 2.4, there are some situations where they may be used.

1. Allow the monitoring well to recharge after purging, keeping the pump just above the screened section.

2. Attach gate valve to hose (if not already fitted), and reduce flow of water to a manageable sampling rate.

3. Assemble the appropriate bottles.

4. If no gate valve is available, run the water down the side of a clean jar and fill the sample bottles from the jar.

5. Cap the sample container tightly and place pre-labeled sample container in a carrier.

6. Replace the well cap.

7. Log all samples in the site logbook and on the field data sheets and label all samples.

8. Package samples and complete necessary paperwork.

9. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

10. Upon completion, remove pump and assembly and fully decontaminate prior to setting into the next sample well. Dedicate the tubing to the hole.

Non-Gas Contact Bladder Pump

The use of a non-gas contact positive displacement bladder pump is often mandated by the use of dedicated pumps installed in wells. These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Barcelona (1984) and Nielsen (1985) report that the non-gas contact positive displacement pumps cause the least amount of alteration in sample integrity as compared to other sample retrieval methods.

1. Allow well to recharge after purging.

2. Assemble the appropriate bottles.

3. Turn pump on, increase the cycle time and reduce the pressure to the minimum that will allow the sample to come to the surface.

4. Cap the sample container tightly and place pre-labeled sample container in a carrier.

5. Replace the well cap.

6. Log all samples in the site logbook and on field data sheets and label all samples.

7. Package samples and complete necessary paperwork.

8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

9. On completion, remove the tubing from the well and either replace the Teflon tubing and bladder with new dedicated tubing and bladder or rigorously decontaminate the existing materials.

10. Collect non-filtered samples directly from the outlet tubing into the sample bottle.

11. For filtered samples, connect the pump outlet tubing directly to the filter unit. The pump pressure should remain decreased so that the pressure build-up on the filter does not blow out the pump bladder or displace the filter. For the Geotech barrel filter, no actual connections are necessary so this is not a concern.

Suction Pump

In view of the limitations of suction pumps, they are not recommended for sampling purposes.

Inertia Pump

Inertia pumps may be used to collect samples. It is more common, however, to purge with these pumps and sample with a bailer.

1. Following well evacuation, allow the well to recharge.

2. Assemble the appropriate bottles.

3. Since these pumps are manually operated, the flow rate may be regulated by the sampler. The sample may be discharged from the pump outlet directly into the appropriate sample container.

4. Cap the sample container tightly and place pre-labeled sample container in a carrier.

5. Replace the well cap.

6. Log all samples in the site logbook and on field data sheets and label all samples.

7. Package samples and complete necessary paperwork.

8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

9. Upon completion, remove pump and decontaminate or discard, as appropriate.

2.7.5 Filtering

For samples that require filtering, such as samples which will be analyzed for total metals, the filter must be decontaminated prior to use and between uses. Filters work by two methods. A barrel filter such as the "Geotech" filter works with a bicycle pump, which is used to build up positive pressure in the chamber containing the sample. The sample is then forced through the filter paper (minimum size 0.45 μm) into a jar placed underneath. The barrel itself is filled manually from the bailer or directly via the hose of the sampling pump. The pressure must be maintained up to 30 psi by periodic pumping.

A vacuum type filter involves two chambers, the upper chamber contains the sample and a filter (minimum size 0.45 μm) divides the chambers. Using a hand pump or a Gilian type pump, air is withdrawn from the lower chamber, creating a vacuum and thus causing the sample to move through the filter into the lower chamber where it is drained into a sample jar, repeated pumping may be required to drain all the sample into the lower chamber. If preservation of the sample is necessary, this should be done after filtering.

2.7.6 Post Operation

After all samples are collected and preserved, the sampling equipment should be decontaminated prior to sampling another well. This will prevent cross-contamination of equipment and monitoring wells between locations.

1. Decontaminate all equipment.

2. Replace sampling equipment in storage containers.

3. Prepare and transport water samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment.

2.7.7 Special Considerations for VOA Sampling

The proper collection of a sample for volatile organics requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona, 1984; Nielsen, 1985). Field conditions and other constraints will limit the choice of appropriate systems. The focus of concern must be to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible.

The following procedures should be followed:

1. Open the vial, set cap in a clean place, and collect the sample during the middle of the cycle. When collecting duplicates, collect both samples at the same time.

2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overfill it. There should be a convex meniscus on the top of the vial.

3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap.

4. Invert the vial and tap gently. Observe vial for at least 10 seconds. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air is in the sample vial.

5. Immediately place the vial in the protective foam sleeve and place into the cooler, oriented so that it is lying on its side, not straight up.

6. The holding time for VOAs is 7 days. Samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4°C, but do not allow them to freeze.

2.8 CALCULATIONS

There are no calculations necessary to implement this procedure. However, if it is necessary to calculate the volume of the well, utilize the following equation:

$$\text{Well volume} = nr^2h\ (cf) \qquad \text{[Equation 1]}$$

where:

- n = pi
- r = radius of monitoring well (feet)
- h = height of the water column (feet) [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
- cf = conversion factor (gal/ft^3) = 7.48 gal/ft^3 [In this equation, 7.48 gal/ft^3 is the necessary conversion factor.]

Monitoring wells are typically 2, 3, 4, or 6 inches in diameter. If you know the diameter of the monitoring well, there are a number of standard conversion factors which can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitoring well diameters can be calculated as follows:

$$v = nr^2\ (cf) \qquad \text{[Equation 2]}$$

where:

- v = volume in gallons per linear foot
- n = pi
- r = radius of monitoring well (feet)
- cf = conversion factor (7.48 gal/ft^3)

For a 2-inch diameter well, the volume in gallons per linear foot can be calculated as follows:

$$\begin{aligned} v &= nr^2\ (cf) \qquad \text{[Equation 2]} \\ &= 3.14\ (1/12\ ft)^2\ \ 7.48\ gal/ft^3 \\ &= 0.1632\ gal/ft \end{aligned}$$

Remember that if you have a 2-inch diameter, well you must convert this to the radius in feet to be able to use the equation.

The volume in gallons per linear foot for the common size monitoring wells are as follows:

Well Diameter	v (volume in gal/ft.)
2 inches	0.1632
3 inches	0.3672
4 inches	0.6528
6 inches	1.4688

If you utilize the conversion factors above, Equation 1 should be modified as follows:

$$\text{Well volume} = (h)(v) \qquad \text{[Equation 3]}$$

where:

- h = height of water column (feet)
- v = volume in gallons per linear foot as calculated from Equation 2

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless

otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures. More specifically, depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

For volatile organic contaminants:

- Avoid breathing constituents venting from the well.
- Pre-survey the well head-space with an FID/PID prior to sampling.
- If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling are:

- Lifting injuries associated with pump and bailer retrieval; moving equipment.
- Use of pocket knives for cutting discharge hose.
- Heat/cold stress as a result of exposure to extreme temperatures (may be heightened by protective clothing).
- Slip, trip, fall conditions as a result of pump discharge.
- Restricted mobility due to the wearing of protective clothing.

3.0 SOIL GAS SAMPLING: SOP #2149

3.1 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of waste site evaluation. Using this method, underground contamination can be identified, and the source, extent, and movement of the pollutants can be traced.

This Standard Operating Procedure (SOP) outlines the methods used by EPA/ERT in installing soil gas wells; measuring organic levels in the soil gas using an HNU PI 101 Portable Photoionization Analyzer and/or other air monitoring devices; and sampling the soil gas using Tedlar bags, Tenax sorbent tubes, and SUMMA canisters.

3.2 METHOD SUMMARY

A 3/8-inch diameter hole is driven into the ground to a depth of 4 to 5 feet using a commercially available "slam bar". (Soil gas can also be sampled at other depths by the use of a longer bar or bar attachments.) A 1/4-inch O.D. stainless steel probe is inserted into the hole. The hole is then sealed at the top around the probe using modeling clay. The gas contained in the interstitial spaces of the soil is sampled by pulling the sample through the probe using an air sampling pump. The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a direct reading instrument.

The air sampling pump is not used for SUMMA canister sampling of soil gas. Sampling is achieved by soil gas equilibration with the evacuated SUMMA canister. Other field air monitoring devices, such as the combustible gas indicator (MSA CGI/02 Meter, Model 260) and the organic vapor analyzer (Foxboro OVA, Model 128), can also be used depending on specific site conditions. Measurement of soil temperature using a temperature probe may also be desirable. Bagged samples are usually analyzed in a field laboratory using a portable Photovac GC.

Power driven sampling probes may be utilized when soil conditions make sampling by hand unfeasible (i.e., frozen ground, very dense clays, pavement, etc.). Commercially available soil gas sampling probes (hollow, 1/2-inch O.D. steel probes) can be driven to the desired depth using a power hammer (e.g., Bosch Demolition Hammer). Samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe and attached to the probe point. Samples are collected and analyzed as described above.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.3.1 Tedlar Bag

Soil gas samples are generally contained in 1-L Tedlar bags. Bagged samples are best stored in coolers to protect the bags from any damage that may occur in the field or in transit. In addition, coolers ensure the integrity of the samples by keeping them at a cool temperature and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours.

3.3.2 Tenax Tube

Bagged samples can also be drawn into Tenax or other sorbent tubes to undergo lab GC/MS analysis. If Tenax tubes are to be utilized, special care must be taken to avoid contamination. Handling of the tubes should be kept to a minimum, and samplers must wear nylon or other lint-free gloves. After sampling, each tube should be stored in a clean, sealed culture tube; the ends packed with clean glass wool to protect the sorbent tube from breakage. The culture tubes should be kept cool and wrapped in aluminum foil to prevent any photodegradation of samples (see Section 3.7.4.).

3.3.3 SUMMA Canister

The SUMMA canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being utilized in the field. After sampling is completed, they are stored and shipped in travel cases.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

3.4.1 HNU Measurements

A number of factors can affect the response of the HNU PI 101. High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when a soil gas well is actually in groundwater. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response.

Other field screening instruments can be affected by interferences. Consult the manufacturers' manuals.

3.4.2 Factors Affecting Organic Concentrations in Soil Gas

Concentrations in soil gas are affected by dissolution, adsorption, and partitioning. Partitioning refers to the ratio of component found in a saturated vapor above an aqueous solution to the amount in the solution; this can, in theory, be calculated using the Henry's Law constants. Contaminants can also be adsorbed onto inorganic soil components or "dissolved" in organic components. These factors can result in a lowering of the partitioning coefficient.

Soil "tightness" or amount of void space in the soil matrix, will affect the rate of recharging of gas into the soil gas well.

Existence of a high, or perched, water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with sampling of the soil gas. Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling.

3.4.3 Soil Probe Clogging

A common problem with this sampling method is soil probe clogging. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see procedure #3 in Section 3.7.1).

3.4.4 Underground Utilities

Prior to selecting sample locations, an underground utility search is recommended. The local utility companies can be contacted and requested to mark the locations of their underground lines. Sampling plans can then be drawn up accordingly. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground pipes or drums exist.

3.5 EQUIPMENT/APPARATUS

3.5.1 Slam Bar Method

- slam bar (one per sampling team)
- soil gas probes, stainless steel tubing, 1/4-inch O.D., 5 foot length
- flexible wire or cable used for clearing the tubing during insertion into the well
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4-inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection of samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample, storage and transportation

3.5.2 Power Hammer Method

- Bosch demolition hammer
- 1/2-inch O.D. steel probes, extensions, and points
- dedicated aluminum sampling points
- Teflon tubing, 1/4-inch O.D.
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4-inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection of samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample, storage and transportation
- generator with extension cords
- high lift jack assembly for removing probes

3.6 REAGENTS

- HNU Systems Inc. Calibration Gas for HNU Model PI 101, and/or calibration gas for other field air monitoring devices
- deionized organic-free water, for decontamination
- methanol, HPLC grade, for decontamination
- ultra-zero grade compressed air, for field blanks
- standard gas preparations for Photovac GC calibration and Tedlar bag spikes

3.7 PROCEDURES

3.7.1 Soil Gas Well Installation

1. Initially, make a hole slightly deeper than the desired depth. For sampling up to 5 feet, use a 5-foot single piston slam bar. For deeper depths, use a piston slam bar with threaded 4-foot-long extensions. Other techniques can be used, so long as holes are of narrow diameter and no contamination is introduced.

2. After the hole is made, carefully withdraw the slam bar to prevent collapse of the walls of the hole. Then insert the soil gas probe.

3. It is necessary to prevent plugging of the probe, especially for deeper holes. Place a metal wire or cable, slightly longer than the probe, into the probe prior to inserting into the hole. Insert the probe to full depth, then pull it up 3 to 6 inches, then clear it by moving the cable up and down. The cable is removed before sampling.

4. Seal the top of the sample hole at the surface against ambient air infiltration by using modeling clay molded around the probe at the surface of the hole.

5. If conditions preclude hand installation of the soil gas wells, the power driven system may be employed. Use the generator-powered demolition hammer to drive the probe to the desired depth (up to 12 feet may be attained with extensions). Pull the probe up 1 to 3 inches if the retractable point is used. No clay is needed to seal the hole. After sampling, retrieve the probe using the high lift jack assembly.

6. If semi-permanent soil gas wells are required, use the dedicated aluminum probe points. Insert these points into the bottom of the power-driven probe and attach it to the Teflon tubing. Insert the probe as in step 5. When the probe is removed, the point and Teflon tube remain in the hole, which may be sealed by backfilling with sand, bentonite, or soil.

3.7.2 Screening with Field Instruments

1. The well volume **must** be evacuated prior to sampling. Connect the Gilian pump, adjusted to 3.0 L/min, to the sample probe using a section of Teflon tubing as a connector. Turn the pump on, and a vacuum is pulled through the probe for approximately 15 seconds. A longer time is required for sample wells of greater depths.

2. After evacuation, connect the monitoring instrument(s) to the probe using a Teflon connector. When the reading is stable, or peaks, record the reading. For detailed procedures on HNU field protocol, see appendix B, and refer to the manufacturer's instructions.

3. Some readings may be above or below the range set on the field instruments. The range may be reset, or the response recorded as a figure greater than or less than the range. Consider the recharge rate of the well with soil gas when sampling at a different range setting.

3.7.3 Tedlar Bag Sampling

1. Follow step 1 in section 3.7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sampling, evacuation is not necessary.

2. Use the vacuum box and sampling train (Figure 3 in Appendix A) to take the sample. The sampling train is designed to minimize the introduction of contaminants and losses due to adsorption. All wetted parts are either Teflon or stainless steel. The vacuum is drawn indirectly to avoid contamination from sample pumps.

3. Place the Tedlar bag inside the vacuum box, and attach it to the sampling port. Attach the sample probe to the sampling port via Teflon tubing and a "quick connect" fitting.

4. Draw a vacuum around the outside of the bag, using a Gilian pump connected to the vacuum box evacuation port, via Tygon tubing and a "quick connect" fitting. The vacuum causes the bag to inflate, drawing the sample.

5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close valve. Label bag, record data on data sheets or in logbooks. Record the date, time, sample location ID, and the HNU, or other instrument reading(s) on sample bag label.

CAUTION: Labels should not be pasted directly onto the bags, nor should bags be labeled directly using a marker or pen. Inks and adhesive may diffuse through the bag material, contaminating the sample. Place labels on the edge of the bags, or tie the labels to the metal eyelets provided on the bags. Markers with inks containing volatile organics (i.e., permanent ink markers) should not be used.

3.7.4 Tenax Tube Sampling

Samples collected in Tedlar bags may be sorbed onto Tenax tubes for further analysis by GC/MS.

Additional Apparatus

- Syringe with a luer-lock tip capable of drawing a soil gas or air sample from a Tedlar bag onto a Tenax/CMS sorbent tube. The syringe capacity is dependent upon the volume of sample being drawn onto the sorbent tube.

- Adapters for fitting the sorbent tube between the Tedlar bag and the sampling syringe. The adapter attaching the Tedlar bag to the sorbent tube consists of a reducing union (1/4-inch to 1/16-inch O.D. -- Swagelok cat. # SS-400-6-ILV or equivalent) with a length of 1/4-inch O.D. Teflon tubing replacing the nut on the 1/6-inch (Tedlar bag) side. A 1/4-inch I.D. silicone O-ring replaces the ferrules in the nut on the 1/4-inch (sorbent tube) side of the union.

  The adapter attaching the sampling syringe to the sorbent tube consists of a reducing union (1/4-inch to 1/16-inch O.D. -- Swagelok Cat. # SS-400-6-ILV or equivalent) with a 1/4-inch I.D. silicone O-ring replacing the ferrules in the nut on the 1/4-inch (sorbent tube) side and the needle of a luer-lock syringe needle inserted into the 1/16-inch side (held in place with a 1/16-inch ferrule). The

luer-lock end of the needle can be attached to the sampling syringe. It is useful to have a luer-lock on/off valve situated between the syringe and the needle.

- Two-stage glass sampling cartridge (1/4-inch O.D. x 1/8-inch I.D. x 5 1/8 inch) contained in a flame-sealed tube (manufactured by Supelco Custom Tenax/Spherocarb Tubes or equivalent) containing two sorbent sections retained by glass wool:

  Front section: 150 mg of Tenax-GC
  Back section: 150 mg of CMS (Carbonized Molecular Sieve)

  Sorbent tubes may also be prepared in the lab and stored in either Teflon-capped culture tubes or stainless steel tube containers. Sorbent tubes stored in this manner should not be kept more than 2 weeks without reconditioning. (See SOP #2052 for Tenax/CMS sorbent tube preparation).

- Teflon-capped culture tubes or stainless steel tube containers for sorbent tube storage. These containers should be conditioned by baking at 120°C for at least 2 hours. The culture tubes should contain a glass wool plug to prevent sorbent tube breakage during transport. Reconditioning of the containers should occur between usage or after extended periods of disuse (i.e., 2 weeks or more).

- Nylon gloves or lint-free cloth. (Hewlett Packard Part # 8650-0030 or equivalent.)

Sample Collection

1. Handle sorbent tubes with care, using nylon gloves (or other lint-free material) to avoid contamination.

2. Immediately before sampling, break one end of the sealed tube and remove the Tenax cartridge. For in-house prepared tubes, remove cartridge from its container

3. Connect the valve on the Tedlar bag to the sorbent tube adapter. Connect the sorbent tube to the sorbent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag.

4. Connect the sampling syringe assembly to the CMS (black) side of the sorbent tube. Fittings on the adapters should be very tight.

5. Open the valve on the Tedlar bag.

6. Open the on/off valve of the sampling syringe.

7. Draw a predetermined volume of sample onto the sorbent tube. (This may require closing the syringe valve, emptying the syringe and then repeating the procedure, depending upon the syringe capacity and volume of sample required.)

8. After sampling, remove the tube from the sampling train with gloves or a clean cloth. **Do not label or write on the Tenax/CMS tube.**

9. Place the sorbent tube in a conditioned stainless steel tube holder or culture tube. Culture tube caps should be sealed with Teflon tape.

Sample Labeling

Each sample tube container (not tube) must be labeled with the site name, sample station number, sample date, and sample volume.

Chain of custody forms must accompany all samples to the laboratory.

Quality Assurance

Before field use, a QA check should be performed on each batch of sorbent tubes by analyzing a tube with thermal desorption/cryogenic trapping GC/MS.

At least one blank sample must be submitted with each set of samples collected at a site. This trip blank must be treated the same as the sample tubes except no sample will be drawn through the tube.

Sample tubes should be stored out of UV light (i.e., sunlight) and kept on ice until analysis.

Samples should be taken in duplicate, when possible.

3.7.5 SUMMA Canister Sampling

1. Follow item 1 in step 3.7.2 to evacuate well volume. If HNU analysis was performed prior to taking a sample, evacuation is not necessary.

2. Attach a certified clean, evacuated 6-L SUMMA canister via the 1/4-inch Teflon tubing.

3. Open the valve on SUMMA canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is 20 minutes.

4. Site name, sample location, number, and date must be recorded on a chain of custody form and on a blank tag attached to the canister.

3.8 CALCULATIONS

3.8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas station may be subtracted:

Final Reading = Sample Reading - Background

3.8.2 Photovac GC Analysis

Calculations used to determine concentrations of individual components by Photovac GC analysis are beyond the scope of this SOP and are covered in ERT SOP #2109, Photovac GC Analysis for Soil, Water and Air/Soil Gas.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

3.9.1 Field Instrument Calibration

Consult the manufacturers' manuals for correct use and calibration of all instrumentation. The HNU should be calibrated at least once a day.

3.9.2 Gilian Model HFS113A Air Sampling Pump Calibration

Flow should be set at approximately 3.0 L/min; accurate flow adjustment is not necessary. Pumps should be calibrated prior to bringing into the field.

3.9.3 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe via a Gilian pump and checking the response of the HNU PI 101. If HNU readings are higher than background, replacement or decontamination is necessary.

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNU reading is at background. More persistent contamination can be washed out using methanol and water, then air drying. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

3.9.4 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it should be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a Gilian pump, for approximately 30 seconds between each sample. After purging, the sampling train can be checked using an HNU, or other field monitoring device, to establish the cleanliness of the Teflon line.

3.9.5 Field Blank

Each cooler containing samples should also contain one Tedlar bag of ultra-zero grade air, acting as a field blank. The field blank should accompany the samples in the field (while being collected) and when they are delivered for analysis. A fresh blank must be provided to be placed in the empty cooler pending additional sample collection. One new field blank per cooler of samples is required. A chain of custody form must accompany each cooler of samples and should include the blank that is dedicated to that group of samples.

3.9.6 Trip Standard

Each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the

analytical instruments (Photovac GC, etc.). This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. A chain of custody form should accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples.

3.9.7 Tedlar Bag Check

Prior to use, one bag should be removed from each lot (case of 100) of Tedlar bags to be used for sampling and checked for possible contamination as follows: the test bag should be filled with ultra-zero grade air; a sample should be drawn from the bag and analyzed via Photovac GC or whatever method is to be used for sample analysis. This procedure will ensure sample container cleanliness prior to the start of the sampling effort.

3.9.8 SUMMA Canister Check

From each lot of four cleaned SUMMA canisters, one is to be removed for a GC/MS certification check. If the canister passes certification, then it is re-evacuated and all four canisters from that lot are available for sampling.

If the chosen canister is contaminated, then the entire lot of four SUMMA canisters must be recleaned, and a single canister is re-analyzed by GC/MS for certification.

3.9.9 Options

Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i.e., if a total of 100 samples are to be collected, five samples should be duplicated). In choosing which samples to duplicate, the following criterion applies: if, after filling the first Tedlar bag, and, evacuating the well for 15 seconds, the second HNU (or other field monitoring device being used) reading matches or is close to (within 50%) the first reading, a duplicate sample may be taken.

Spikes

A Tedlar bag spike and Tenax tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc.). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. SUMMA canisters containing samples are not spiked.

3.10 DATA VALIDATION

For each target compound, the level of concentration found in the sample must be greater than three times the level (for that compound) found in the field blank which accompanied that sample to be considered valid. The same criteria apply to target compounds detected in the Tedlar bag pre-sampling contamination check.

3.11 HEALTH AND SAFETY

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D, unless the sampling location is within the hot zone of a site, which requires Level B or Level C protection. However, to ensure that the proper level of protection is utilized, constantly monitor the ambient air using the HNU PI 101 to obtain background readings during the sampling procedure. As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed.

Also, perform an underground utility search prior to sampling (see section 3.4.4). When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures

4.0 MONITORING WELL INSTALLATION: SOP #2150

4.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide an overview of the methods used for monitoring well installation. Monitoring well installation creates a permanent access for the collection of samples to determine groundwater quality and the hydrogeologic properties of the aquifer in which the contaminants exist. Such wells should not alter the medium which is being monitored.

The most commonly used drilling methods are: (1) hollow-stem augers, (2) cable tool drills, and (3) rotary drills. Rotary drilling can be divided into a mud rotary or air rotary method.

4.2 METHOD SUMMARY

There is no ideal monitoring well installation method for all conditions; therefore, hydrogeologic conditions at the site and project objectives must be considered before deciding which drilling method to use.

4.2.1 Hollow-Stem Augering

Hollow-stem augering is fast and relatively less expensive than cable tool or rotary drilling methods. It is possible to drill several hundred feet of borehole per day in unconsolidated formations.

4.2.2 Cable Tool Drilling

Cable tool drilling method involves lifting and dropping a heavy, solid chisel-shaped bit, suspended on a steel cable. This bit pounds a hole through soil and rock. Temporary steel casing is used while drilling to keep the hole open and to isolate strata. The temporary casing is equipped with a drive shoe, which is attached to the lower end, and which aids the advancement of the casing by drilling out a slightly larger diameter borehole than the hole made by the drill bit alone.

Water is sometimes used when drilling above the saturated zone to reduce dust and to form a slurry with the loosened material. This facilitates removal of cuttings using a bailer or a sand pump. Potable water or distilled/deionized water should be used to prevent the introduction of contamination into the borehole.

4.2.3 Rotary Drilling

Mud Rotary Method

In the mud rotary method, the borehole is advanced by rapid rotation of the drill bit, which cuts and breaks the material at the bottom of the hole into smaller pieces. Cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite) down through the drill rods and bit, and up the annulus between the borehole and the drill rods. The drilling fluid also serves to cool the drill bit and prevent the borehole from collapsing in unconsolidated formations.

Air Rotary Method

The air rotary method is the same as the mud rotary except that compressed air is pumped down the drill rods and returns with the drill cuttings up through the annulus. Air rotary method is generally limited to consolidated and semi-consolidated formations. Casing is sometimes used to prevent cavings in semi-consolidated formations. The air must be filtered to prevent introduction of contamination into the borehole.

4.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Often, a primary object of the drilling program is to obtain representative lithologic or environmental samples. Lithologic samples are taken in order to determine the geologic or hydrogeologic regime at a site. The most common techniques for retrieving lithologic samples in unconsolidated formations are described below.

- Split spoon sampling, carried out continuously or at discrete intervals during drilling, is used to make a field description of the sample and create a log of each boring.

- Shelby tube sampling, is used when an undisturbed sample is required from clayey or silty soils, especially for geotechnical evaluation or chemical analysis.

- Cuttings description is used when a general lithologic description and approximate depths are sufficient.

The most common techniques for retrieving lithologic sampling in consolidated formations are described below.

- Rock coring is carried out continuously or at discrete intervals during drilling and enables the geologist to write a field description of the sample, create a log of each boring, and map occurrences and orientation of fractures.

- Cuttings description is used when a general lithologic description and approximate depths are sufficient.

4.4 INTERFERENCES AND POTENTIAL PROBLEMS

Table 3 on page 27 displays the advantages and disadvantages of the various drilling techniques.

4.5 EQUIPMENT/APPARATUS

The drilling contractor will provide all operational equipment for the drilling program which is outlined. The geologist should bring:

- well log sheets
- metal case (container for well logs)
- ruler
- depth sounder
- water level indicator
- all required health and safety gear
- sample collection jars
- trowels
- description aids (Munsell, grain size charts, etc.)

4.6 REAGENTS

No chemical reagents are used in this procedure. Decontamination of drilling equipment should follow ERT SOP #2006, Sampling Equipment Decontamination and the site-specific work plan.

4.7 PROCEDURES

4.7.1 Preparation

The planning, selection and implementation of any monitoring well installation program should include the following steps.

1. Review existing data on site geology and hydrogeology including publications, air photos, water quality data, and existing maps. These may be obtained from local, state, or federal agencies.

2. Visit the site to observe field geology and potential access problems for drill rig, to establish water supply, and drill equipment and materials storage area.

3. Prepare site safety plan.

4. Define project objectives; select drilling, well development, and sampling methods.

5. Select well construction materials including well construction specifications (i.e., casing and screen materials, casing and screen diameter, screen length and screen interval, filter pack and screen size).

6. Determine need for containing drill cuttings/fluids and their disposal.

7. Prepare work plan including all of the above.

8. Prepare and execute the drilling contract.

9. Implement the drilling program.

10. Prepare the final report, including background data, project objective, field procedure, well construction data including well logs and well construction.

All drilling and well installation programs must be planned and supervised by a professional geologist/hydrogeologist.

4.7.2 Field Preparation

1. Prior to the mobilization of the drill rig,

Table 3: Advantages and Disadvantages of Various Drilling Techniques

Drilling Type	Advantages	Disadvantages
Auger	• Allows sampling from different strata during drilling. • Less potential for cross-contamination between strata than in other techniques. • Large diameter borehole may be drilled for multiple-well completion. • Less well development is generally needed than in mud rotary because of the relatively large diameter borehole, the ability to emplace a large and effective gravel pack, and because no drilling fluids are introduced into the borehole.	• Very slow or impossible in coarse materials such as cobbles and boulders. • Cannot drill hard rock formations and is generally not suited for wells deeper than 100 feet. • Not good in caving formations. • Potential for disturbing large volume of subsurface materials around the borehole; therefore affecting local permeabilities and creating annular channels for contaminant movement between different strata.
Cable Tool	• Allows for easy and accurate detection of the water table. • Driven casing seals off formation, minimizing the threat of cross-contamination in pollution investigation. • Especially successful for drilling in glacial till.	• Extremely slow rate of drilling. • Can lose casing in deep wells.
Mud Rotary	• Quite fast, more than 100 feet of borehole advancement per day is possible. • Geophysical logs such as resistivity (which must be run in an uncased borehole) can be run before well construction.	• Potential cross-contamination of strata exposed to the circulating drilling fluid during drilling. • Difficulty in removing mud residues during well development. • Drilling mud may alter the groundwater chemistry by binding metals, sorbing organic compounds and by altering pH, cation exchange capacity and chemical oxidation demand of native fluids. • Drilling mud may change local permeability of the formation.
Air Rotary	• Like mud rotary method, more than 100 feet of borehole advancement a day is possible. • Sampling different strata during drilling is possible if temporary casing is advanced.	• In contaminated formations, the use of high pressure air may pose a significant hazard to the drill crew due to rapid transport of contaminated material up the borehole during drilling. • Introduction of air to ground water could reduce concentration of volatile organic compounds locally.

thoroughly decontaminate the rig and all associated equipment to remove all oil, grease, mud, etc.

2. Before drilling each boring, steam-clean and rinse all the "down-the-hole" drill equipment with potable water to minimize cross-contamination. Special attention should be given to the thread section of the casings, and to the drill rods. All drilling equipment should be steam-cleaned at completion of the project to ensure that no contamination is transported to or from the sampling site.

3. Record lithologic descriptions and all field measurements and comments on the well log form (Appendix C). Include well construction diagrams on the well log form for each well installed. At a minimum, the well construction information should show depth from surface grade, the bottom of the boring, the screened interval, casing material, casing diameter, gravel pack location, grout seal and height of riser pipe above the ground. Also record the actual compositions of the grout and seal on the well log form.

4.7.3 Well Construction

The most commonly used casing materials include stainless steel, polyvinyl chloride (PVC) and Teflon. Monitoring wells are constructed with casings and materials that are resistant to the subsurface environment. The selection of well construction material is based on the material's long-term interaction with the contaminated groundwater. Construction materials should not cause an analytical bias in the interpretation of the chemical analysis of the water samples.

Well casing material should also be judged from a structural standpoint. Material should be rigid and nonporous, with a low surface-area-to-water ratio in the wellbore relative to the formation materials (U.S. EPA, 1987).

1. Fill the annular space between the well screen and the boring with a uniform gravel/sand pack to serve as a filter media. For wells deeper than approximately 50 feet, or when recommended by the site geologist, emplace the sand pack using a tremie pipe (normally consisting of a 1.25-inch PVC or steel pipe). Pump sand slurry composed of sand and potable water through the tremie pipe into the annulus throughout the entire screened interval, and over the top of the screen. It is necessary to pump sufficient sand/gravel slurry to cover the screen after the sand/gravel pack has settled and become dense.

2. Determine the depth of the top of the sand using the tremie pipe, thus verifying the thickness of the sand pack. Add more sand to bring the top of the sand pack to approximately 2-3 feet above the top of the well screen. Under no circumstances should the sand pack extend into any aquifer other than the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of crossflow between producing zones through the sand pack.

3. In materials that will not maintain an open hole, withdraw the temporary or outer casing gradually during placement of sand pack/grout to the extent practical.

   For example, after filling 2 feet with sand pack, the outer casing should be withdrawn 2 feet. This step of placing more gravel and withdrawing the outer casing should be repeated until the level of the sand pack is approximately 3 feet above the top of the well screen. This ensures that there is no locking of the permanent (inner) casing in the outer casing.

4. Emplace a bentonite seal, composed of pellets, between the sand pack and grout to prevent infiltration of cement into the filter pack and the well screen.

   These pellets should have a minimum purity of 90% montmorillonite clay, and a minimum dry bulk density of 75 lb/ft^3 for 1/2-inch pellets, as provided by American Colloid, or equivalent. Bentonite pellets shall be poured directly down the annulus.

   Care must be taken to avoid introducing pellets into the well bore. A cap placed over the top of the well casing before pouring the bentonite pellets from the bucket will prevent this. To ensure even application, pour the pellets from different points around the casing. To avoid bridging of pellets, they should not be introduced at a rate faster than they can settle. A tremie pipe may be used to redistribute and

level out the top of the seal.

5. If using a slurry of bentonite as an annular seal, prepare it by mixing powdered or granular bentonite with potable water. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout to be emplaced above it. As a precaution, regardless of depth, and depending on fluid viscosity, add a few handfuls of bentonite pellets to solidify the bentonite slurry surface.

6. Place a mixture of cement and bentonite grout from the top of the bentonite seal to the ground surface.

   Only Type I or II cement without accelerator additives may be used. An approved source of potable water must be used for mixing grouting materials. The following mixes are acceptable:

   - Neat cement, a maximum of 6 gallons of water per 94-pound bag of cement
   - Granular bentonite, 1.5 pounds of bentonite per 1 gallon of water
   - Cement-bentonite, 5 pounds of pure bentonite per 94-pound bag of cement with 7-8 gallons of water; 13-14 pounds weight, if dry mixed
   - Cement-bentonite, 6 to 8 pounds of pure bentonite per 94-pound bag of cement with 8-10 gallons of water, if water mixed
   - Non-expandable cement, mixed at 7.5 gallons of water to 1/2 teaspoon of aluminum hydroxide, 94 pounds of neat cement (Type I) and 4 pounds of bentonite
   - Non-expandable cement, mixed at 7 gallons of water to 1/2 teaspoon of aluminum hydroxide, 94 pounds of neat cement (Type I and Type II)

7. Pump grout through a tremie pipe to the bottom of the open annulus until undiluted grout flows from the annulus at the ground surface.

8. In materials that will not maintain an open hole, the temporary steel casing should be withdrawn in a manner that prevents the level of grout from d[illegible] low the bottom of the casing.

9. Additional gro[illegible] 'ed to compensate for the remov[illegible] porary casing and the tremie pip[illegible] hat the top of the grout is at or a[illegible] surface.

10. Place the prote[illegible] Protective casings should be instal[illegible] ll monitoring wells. Exceptions are [illegible] by-case basis. The minimum eleme[illegible] protection design include:

    - A protective steel cap to keep precipitation out of the protective casing, secured to the casing by padlocks.
    - A 5-foot-minimum length of black iron or galvanized pipe, e tending about 1.5 to 3 feet above the gr ind surface, and set in cement grout. Th pipe diameter should be 8 inches for 4-inch wells, and 6 inches for 2-inch wells (pending on approved borehole size). A 0.5-inch drain hole near ground level is permitted.
    - The installation of guard posts in addition to the protective asing, in areas where vehicular traffic m pose a hazard. These guard posts consis f 3-inch diameter steel posts or tee-bar dr en steel posts. Groups of three are radially located 4 feet around each well 2 feet below and 4 feet above ground surface, with flagging in areas of high vegetation. Each post is cemented in-place.
    - A flush mount of protective casing may also be used in areas of high traffic or where access to other areas would be limited by a well with stickup.

After the grout sets (about 48 hours), fill any depression due to settlement with a grout mix similar to that described above.

4.8 CALCULATIONS

To maintain an open borehole using sand or water rotary drilling, the drilling fluid must exert a pressure greater than the formation pore pressure. Typical pore pressure for ar unconfined aquifer is

0.433 psi/ft and for a confined aquifer is 0.465 psi/ft.

The calculation for determining the hydrostatic pressure of the drilling fluid is:

Hydrostatic Pressure (psi) = Fluid Density (lb/gal) x Height of Fluid Column (ft) x 0.052

The minimum grout volume necessary to grout a well can be calculated using:

$$\text{Grout Vol } (ft^3) = \text{Vol of Borehole } (ft^3) - \text{Vol of Casing } (ft^3)$$

$$= L\,(r_B^2 - r_C^2)$$

where:

r_B = radius of boring (ft)
r_C = radius of casing (ft)
L = length of borehole to be grouted (ft)

4.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures.

However, the following general QA procedures apply:

- All data must be documented on standard well completion forms, field data sheets or within field/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

4.10 DATA VALIDATION

This section is not applicable to this SOP.

4.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

5.0 WATER LEVEL MEASUREMENT: SOP #2151

5.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water in an open borehole, cased borehole, monitoring well or piezometer.

Generally, water level measurements from boreholes, piezometers, or monitoring wells are used to construct water table or potentiometric surface maps. Therefore, all water level measurements at a given site should be collected within a 24-hour period. Certain situations may necessitate that all water level measurements be taken within a shorter time interval. These situations may include:

- the magnitude of the observed changes between wells appears too large
- atmospheric pressure changes
- aquifers which are tidally influenced
- aquifers affected by river stage, impoundments, and/or unlined ditches
- aquifers stressed by intermittent pumping of production wells
- aquifers being actively recharged due to precipitation events

5.2 METHOD SUMMARY

A survey mark should be placed on the casing for use as a reference point for measurement. Many times the lip of the riser pipe is not flat. Another measuring reference should be located on the grout apron. The measuring point should be documented in the site logbook and on the groundwater level data form (see Appendix C).

Water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development, prior to measurement. In low yield situations, recovery may take longer.

Working with decontaminated equipment, proceed from the least to the most contaminated wells. Open the well and monitor headspace with the appropriate monitoring instrument to determine the presence of volatile organic compounds. Lower the water level measurement device into the well until water surface or bottom of casing is encountered. Measure distance from water surface to the reference point on the well casing and record in the site logbook and/or groundwater level data form. Remove all downhole equipment, decontaminate as necessary, and replace well casing cap.

5.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this SOP.

5.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The chalk used on steel tape may contaminate the well.
- Cascading water may obscure the water mark or cause it to be inaccurate.
- Many types of electric sounders use metal indicators at 5-foot intervals around a conducting wire. These intervals should be checked with a surveyor's tape to ensure accuracy.
- If there is oil present on the water, it can insulate the contacts of the probe on an electric sounder or give false readings due to thickness of the oil. Determining the thickness and density of the oil layer may be warranted, in order to determine the correct water level.
- Turbulence in the well and/or cascading water can make water level determination difficult with either an electric sounder or steel tape.

- An airline measures drawdown during pumping. It is only accurate to 0.5 foot unless it is calibrated for various "drawdowns".

5.5 EQUIPMENT/APPARATUS

There are a number of devices which can be used to measure water levels, such as steel tape or airlines. The device should be adequate to attain an accuracy of 0.01 feet.

The following equipment is needed to measure water levels:

- air monitoring equipment
- water level measurement device
- electronic water level indicator
- metal tape measure
- airline
- steel tape
- chalk
- ruler
- notebook
- paper towels
- decontamination solution and equipment
- groundwater level data forms

5.6 REAGENTS

No chemical reagents are used in this procedure, with the exception of decontamination solutions. Where decontamination of equipment is required, refer to ERT SOP #2006, Sampling Equipment Decontamination and the site-specific work plan.

5.7 PROCEDURES

5.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4 Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Identify and mark all sampling locations.

5.7.2 Procedures

1. Make sure water level measuring equipment is in good operating condition.

2. If possible and where applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated.

3. Clean all equipment entering the well by the following decontamination procedure:

   - Triple rinse equipment with deionized water.

   - Wash equipment with an Alconox solution followed by a deionized water rinse.

   - Rinse with an approved solvent (e.g., methanol, isopropyl alcohol, acetone) as per the work plan, if organic contamination is suspected.

   - Place equipment on clean surface such as a Teflon or polyethylene sheet.

4. Remove locking well cap, note location, time of day, and date in site notebook or an appropriate groundwater level data form.

5. Remove well casing cap.

6. If required by site-specific condition, monitor headspace of well with PID or FID to determine presence of volatile organic compounds and record in site logbook.

7. Lower electric water level measuring device or equivalent (i.e., permanently installed tranducers or airline) into the well until water surface is encountered.

8. Measure the distance from the water surface to the reference measuring point on the well casing or protective barrier post and record in the field logbook. In addition, note that the

water level measurement was from the top of the steel casing, top of the PVC riser pipe, from the ground surface, or from some other position on the well head.

9. The groundwater level data form in Appendix C should be completed as follows:

   - site name
   - logger name: person taking field notes
   - date: the date when the water levels are being measured
   - location: monitor well number and physical location
   - time: the military time at which the water level measurement was recorded
   - depth to water: the water level measurement in feet, or in tenths or hundreds of feet, depending on the equipment used
   - comments: any information the field personnel feels to be applicable
   - measuring point: marked measuring point on PVC riser pipe, protective steel casing or concrete pad surrounding well casing from which all water level measurements for individual wells should be measured. This provides consistency in future water level measurements.

10. Measure total depth of well (at least twice to confirm measurement) and record in site notebook or on log form.

11. Remove all downhole equipment, replace well casing cap and lock steel caps.

12. Rinse all downhole equipment and store for transport to next well.

13. Note any physical changes such as erosion or cracks in protective concrete pad or variation in total depth of well in field notebook and on field data sheets.

14. Decontaminate all equipment as outlined in Step 3 above.

5.8 CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation:

$$Ew = E-D$$

where:

Ew = Elevation of water above mean sea level
E = Elevation above sea level at point of measurement
D = Depth to water

5.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or within personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.
- Each well should be tested at least twice in order to compare results.

5.10 DATA VALIDATION

This section is not applicable to this SOP.

5.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

6.0 WELL DEVELOPMENT: SOP #2156

6.1 SCOPE AND APPLICATION

The purpose of monitoring well development is to ensure removal of fines from the vicinity of the well screen. This allows free flow of water from the formation into the well and also reduces the turbidity of the water during sampling events. The most common well development methods are: surging, jetting, and overpumping.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting motion surges water into the formation and loosens sediment to be pulled from the formation into the well. Occasionally, sediment must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. For example, channels or voids may form near the screen if the filter pack sloughs away during surging (Keely and Boateng, 1987).

Jetting involves lowering a small diameter pipe into the well to a few feet above the well screen, and injecting water or air through the pipe under pressure so that sediments at the bottom are geysered out the top of the well. It is important not to jet air or water directly across the screen. This may cause fines in the well to be driven into the entrance of the screen openings thereby causing blockages.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and allowing it to recharge. This process is repeated until sediment-free water is produced. Overpumping is not as vigorous as surging and jetting and is probably the most desirable for monitoring well development.

6.2 METHOD SUMMARY

Development of a well should occur as soon as practical after installation, but not sooner than 48 hours after grouting is completed, if a rigorous well development is being used. If a less rigorous method, such as bailing, is used for development, it may be initiated shortly after installation. The main concern is that the method being used for development does not interfere with allowing the grout to set.

Open the monitoring well, take initial measurements (e.g. head space air monitoring readings, water level, well depth, pH, temperature, and specific conductivity) and record results in the site logbook. Develop the well by the appropriate method (i.e., overpumping, jetting, or surging) to accommodate site conditions and project requirements. Continue until the developed water is clear and free of sediment. Containerize all discharge water from known or suspected contaminated areas. Record final measurements in the logbook. Decontaminate equipment as appropriate prior to use in the next well.

6.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this Standard Operating Procedure (SOP).

6.4 INTERFERENCES AND POTENTIAL PROBLEMS

The following interferences or problems may occur during well development:

- The possibility of disturbing the filter pack increases with surging and jetting well development methods.
- The introduction of external water or air by jetting may alter the hydrochemistry of the aquifer.

6.5 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well. For example, submersible pumps cannot be used for well development unless the wells are 4 inches or greater in diameter, because the smallest

submersible pump has a 3 1/4 inch O.D.

In general, the well should be developed shortly after it is drilled. Most drilling rigs have air compressors or pumps that may be used for the development process.

6.6 REAGENTS

No chemical reagents are used in this procedure except for decontamination solutions. For guidelines on equipment decontamination, refer to ERT SOP #2006, Sampling Equipment Decontamination and the site-specific work plan.

6.7 PROCEDURES

6.7.1 Preparation

1. Coordinate site access and obtain keys to the monitoring well security cap locks.

2. Obtain information on each well to be developed (i.e., drilling, method, well diameter, depth, screened interval, anticipated contaminants, etc.).

3. Obtain a water level meter, air monitoring equipment, materials for decontamination, pH and electrical conductivity meters, a thermometer, and a stopwatch.

4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted tanks may be necessary in some cases; alternately, a portable water treatment unit (e.g. activated carbon) may be used to decontaminate the purge water.

6.7.2 Operation

The development should be performed as soon as practical after the well is installed, but no sooner than 48 hours after grouting is completed. Dispersing agents, acids, or disinfectants should not be used to enhance development of the well.

1. Assemble necessary equipment on a plastic sheet around the well.

2. Record pertinent information in field logbook (personnel, time, location ID, etc.).

3. Open monitoring well, and take air monitoring readings at the top of casing and in the breathing zone as appropriate.

4. Measure depth to water and the total depth of the monitoring well from the same datum point.

5. Measure the initial pH, temperature, and specific conductivity of the water and record in the logbook.

6. Develop the well until the water is clear and appears to be free of sediment. Note the initial color, clarity and odor of the water.

7. All water produced by development in contaminated or suspected contaminated areas must be containerized or treated. Clearly label each container with the location ID. Determination of the appropriate disposal method will be based on the first round of analytical results from each well.

8. No water should be added to the well to assist development without prior approval by the site geologist. If a well cannot be cleaned of mud to produce formation water because the aquifer yields insufficient water, small amounts of potable water may be injected to clean up this poorly yielding well. This may be done by dumping in buckets of water. When most of the mud is out, continue development with formation water only. It is essential that at least five times the amount of water injected must be produced back from the well in order to ensure that all injected water is removed from the formation.

9. Note the final color, clarity and odor of the water.

10. Measure the final pH, temperature and specific conductance of the water and record in the field logbook.

11. Record the following data in the field logbook:

    - well designation (location ID)
    - date(s) of well installation
    - date(s) and time of well development
    - static water level before and after

development
- quantity of water removed and time of removal
- type and size/capacity of pump and/or bailer used
- description of well development techniques used

6.7.3 Post Operation

1. Decontaminate all equipment.

2. Store containers of purge water produced during development in a safe and secure area.

3. After the first round of analytical results have been received, determine and implement the appropriate purge water disposal method.

6.8 CALCULATIONS

There are no calculations necessary to implement this procedure. However, if it is necessary to calculate the volume of the well, utilize the following equation:

$$\text{Well volume} = nr^2h(cf) \quad \text{[Equation 1]}$$

where:

n	=	pi
r	=	radius of monitoring well (feet)
h	=	height of the water column (feet) [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf	=	conversion factor (gal/ft^3) = 7.48 gal/ft^3 [In this equation, 7.48 gal/ft^3 is the necessary conversion factor, because 7.48 gallons of water occupy 1 ft^3]

Monitoring wells are typically 2 inches, 3 inches, 4 inches, or 6 inches in diameter. If the diameter of the monitoring well is known, a number of standard conversion factors can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitoring well diameters can be calculated as follows:

$$v = nr^2(cf) \quad \text{[Equation 2]}$$

where:

v	=	volume in gallons per linear foot
n	=	pi
r	=	radius of monitoring well (feet)
cf	=	conversion factor (7.48 gal/ft^3)

For a 2-inch diameter well, the volume per linear foot can be calculated as follows:

$$\begin{aligned} v &= nr^2(cf) \quad \text{[Equation 2]} \\ &= 3.14\ (1/12\ \text{ft})^2\ \ 7.48\ \text{gal/ft}^3 \\ &= 0.1632\ \text{gal/ft} \end{aligned}$$

Remember that if you have a 2-inch diameter well, you must convert this to the radius in feet to be able to use the equation.

The volume per linear foot for monitoring wells of common size are as follows:

Well diameter	v (volume in gal/ft.)
2-inch	0.1632
3-inch	0.3672
4-inch	0.6528
6-inch	1.4688

If you utilize the factors above, Equation 1 should be modified as follows:

$$\text{Well volume} = h(v) \quad \text{[Equation 3]}$$

where:

h	=	height of water column (feet)
v	=	volume in gallons per linear foot from Equation 2

6.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or personal/site logbooks.

- All instrumentation must be operated in accordance with operating instructions as

supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

6.10 DATA VALIDATION

This section is not applicable to this SOP.

6.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

7.0 CONTROLLED PUMPING TEST: SOP #2157

7.1 SCOPE AND APPLICATION

The most reliable and commonly used method of determining aquifer characteristics is by controlled aquifer pumping tests. Groundwater flow varies in space and time and depends on the hydraulic properties of the rocks and the boundary conditions imposed on the groundwater system. Pumping tests provide results that are more representative of aquifer characteristics than those predicted by slug or bailer tests. Pumping tests require a greater degree of activity and expense, however, and are not always justified for all levels of investigation. For example, slug tests may be acceptable at the reconnaissance level whereas pumping tests are usually performed as part of a feasibility study in support of designs for aquifer remediation.

Aquifer characteristics which may be learned using pumping tests include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers. These parameters can be determined by graphical solutions and computerized programs. This Standard Operating Procedure (SOP) outlines the protocol for conducting controlled pumping tests.

7.2 METHOD SUMMARY

It is desirable to monitor pre-test water levels at the test site for about 1 week prior to performance of the pump test. This information allows for the determination of the barometric efficiency of the aquifer, as well as noting changes in head, due to recharging or pumping in the area adjacent to the well. Prior to initiating the long term pump test, a step test is conducted to estimate the greatest flow rate that may be sustained by the pump well.

After the pumping well has recovered from the step test, the long term pumping test begins. At the beginning of the test, the discharge rate is set as quickly and accurately as possible. The water levels in the pumping well and observation wells are recorded accordingly with a set schedule. Data is entered on the Pump/Recovery Test Data Sheet (Appendix C). The duration of the test is determinated by project needs and aquifer properties, but rarely goes beyond 3 days or until water levels become constant.

7.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

7.4 INTERFERENCES AND POTENTIAL PROBLEMS

Interferences and potential problems include:

- atmospheric conditions
- impact of local potable wells
- compression of the aquifer due to trains, heavy traffic, etc.

7.5 EQUIPMENT/APPARATUS

- tape measure (subdivided into tenths of feet)
- submersible pump
- water pressure transducer
- electric water level indicator
- weighted tapes
- steel tape (subdivided into tenths of feet)
- generator
- electronic data-logger (if transducer method is used)
- watch or stopwatch with second hand
- semilogarithmic graph paper (if required)
- water proof ink pen and logbook
- thermometer
- appropriate references and calculator
- a barometer or recording barograph (for tests conducted in confined aquifers)
- heat shrinks
- electrical tape
- flashlights and lanterns
- pH meter
- conductivity meter
- discharge pipe
- flow meter

7.6 REAGENTS

No chemical reagents are used for this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required, refer to ERT SOP #2006, Sampling Equipment Decontamination and the site-specific work plan.

7.7 PROCEDURES

7.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Identify and mark all sampling locations.

7.7.2 Field Preparation

1. Review the site work plan and become familiar with information on the wells to be tested.

2. Check and ensure the proper operation of all field equipment. Ensure that the electronic data-logger is fully charged, if appropriate. Test the electronic data-logger using a container of water. Always bring additional transducers in case of malfunctions.

3. Assemble a sufficient number of field data forms to complete the field assignment.

4. Develop the pumping well prior to testing, per ERT SOP #2156, Well Development.

5. Provide an orifice, weir, flow meter, container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well.

6. Provide sufficient pipe to transport the discharge from the pumping well to an area beyond the expected cone of depression. Conducting a pumping test in contaminated groundwater may require treatment, special handling, or a discharge permit before the water can be discharged.

7. The discharge pipe must have a gate valve to control the pumping rate.

8. Determine if there is an outlet near the well head for water quality determination and sampling.

7.7.3 Pre-Test Monitoring

It is desirable to monitor pretest water levels at the test site for about 1 week prior to performance of the test. This can be accomplished by using a continuous-recording device such as a Stevens recorder. This information allows the determination of the barometric efficiency of the aquifer when barometric records are available. It also helps determine if the aquifer is experiencing an increase or decrease in head with time due to recharge or pumping in the nearby area, or diurnal effects of evapotranspiration. Changes in barometric pressure are recorded during the test (preferably with an on-site barograph) in order to correct water levels for any possible fluctuations which may occur due to changing atmospheric conditions. Pretest water level trends are projected for the duration of the test. These trends and/or barometric changes are used to "correct" water levels during the test so they are representative of the hydraulic response of the aquifer due to pumping of the test well.

7.7.4 Step Test

Conduct a step test prior to initiating a long term pumping test. The purpose of a step test is to estimate the greatest flow rate that may be sustained during a long term test. The test is performed by progressively increasing the flow rate at 1 hour intervals. The generated drawdown versus time data is plotted on semilogarithmic graph paper, and the discharge rate is determined from this graph.

7.7.5 Pump Test

Time Intervals

After the pumping well has fully recovered from the step test, the long term pumping test may start. At the beginning of the test, the discharge rate should be set as quickly and accurately as possible. The water levels in the pumping well and observation wells will be recorded according to Tables 4 and 5 below.

Water Level Measurements

Water levels will be measured as specified in ERT SOP #2151, Well Level Measurement. During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well. After the first 2 hours, two people are usually sufficient to continue the test. It is not necessary that readings at the wells be taken simultaneously. It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured. Alternately, individual pressure transducers and electronic data-loggers may be used to reduce the number of field personnel hours required to complete the pumping test. A typical aquifer pump test form is shown in Appendix C.

During a pumping test, the following data must be recorded accurately on the aquifer test data form.

1. Site ID -- A number assigned to identify a specific site.

Table 4: Time Intervals for Measuring Drawdown in the Pumped Well

Elapsed Time From Start of Test (Minutes)	Interval Between Measurements (Minutes)
0 - 10	0.5 - 1
10 - 15	1
15 - 60	5
60 - 300	30
300 - 1440	60
1440 - termination	480

Table 5: Time Intervals for Measuring Drawdown in an Observation Well

Elapsed Time From Start of Test (Minutes)	Interval Between Measurements (Minutes)
0 - 60	2
60 - 120	5
120 - 240	10
240 - 360	30
360 - 1440	60
1440 - termination	480

2. Location -- The location of the well in which water level measurements are being taken.

3. Distance from Pumped Well -- Distance between the observation well and the pumping well, in feet.

4. Logging Company -- The company conducting the pumping test.

5. Test Start Date -- The date when the pumping test began.

6. Test Start Time -- Start time, using a 24-hour clock.

7. Static Water Level (Test Start) -- Depth to water, in feet and tenths of feet, in the observation well at the beginning of the pumping test.

8. Test End Date -- The date when the pumping test was completed.

9. Test End Time -- End time, using a 24-hour clock.

10. Static Water Level (Test End) -- Depth to water, in feet and tenths of feet, in the observation well at the end of the pumping test.

11. Average Pumping Rate -- Summation of all entries recorded in the Pumping Rate (gal/min) column divided by the total number of Pumping Rate (gal/min) readings.

12. Measurement Methods -- Type of instrument used to measure depth-to-water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers).

13. Comments -- Appropriate observations or information which have not been recorded elsewhere, including notes on sampling.

14. Elapsed Time (min) -- Time of measurement recorded continuously from start of test (time 00.00).

15. Depth to Water (ft) -- Depth to water, in feet and tenths of feet, in the observation well at the time of the water level measurement.

16. Pumping Rate (gal/min) -- Flow rate of pump measured from an orifice, weir, flow meter, container or other type of water-measuring device.

Test Duration

The duration of the test is determined by the needs of the project and properties of the aquifer. One simple test for determining adequacy of data is when the log-time versus drawdown for the most distant observation well begins to plot as a straight line on the semilogarithmic graph paper. There are several exceptions to this simple rule of thumb; therefore, it should be considered a minimum criterion. Different hydrogeologic conditions can produce straight line trends on log-time versus drawdown plots. In general, longer tests produce more definitive results. A duration of 1 to 3 days is desirable, followed by a similar period of monitoring the recovery of the water level. Unconfined aquifers and partially penetrating wells may have shorter test durations. Knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives, is necessary in interpreting just how long the test should be conducted. There is no need to continue the test if the water level becomes constant with time. This normally indicates that a hydrogeologic source has been intercepted and that additional useful information will not be collected by continued pumping.

7.7.6 Post Operation

1. After completion of water level recovery measurements, decontaminate and/or dispose of equipment as per ERT SOP #2006, Sampling Equipment Decontamination.

2. When using an electronic data-logger, use the following procedures.

   - Stop logging sequence.
   - Print data, or save memory and disconnect battery at the end of the day's activities.

3. Replace testing equipment in storage containers.

4. Check sampling equipment and supplies. Repair or replace all broken or damaged equipment.

5. Review field forms for completeness.

6. Interpret pumping/recovery test field results.

7.8 CALCULATIONS

There are several accepted methods for determining aquifer properties such as transmissivity, storativity, and conductivity. However, the method to use is dependent on the characteristics of the aquifer being tested (confined, unconfined, leaky confining layer, etc.). When reviewing pump test data, texts by Fetter, or Driscoll or Freeze and Cherry may be used to determine the method most appropriate to your case. See the reference section on page 69.

7.9 QUALITY ASSURANCE/ QUALITY CONTROL

Calibrate all gauges, transducers, flow meters, and other equipment used in conducting pumping tests before use at the site.

Obtain records of the instrument calibration and file with the test data records. The calibration records will consist of laboratory measurements. If necessary, perform any on-site zero adjustment and/or calibration. Where possible, check all flow and measurement meters on-site using a container of measured volume and stopwatch; the accuracy of the meters must be verified before testing proceeds.

7.10 DATA VALIDATION

This section is not applicable to this SOP.

7.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

8.0 SLUG TEST: SOP #2158

8.1 SCOPE AND APPLICATION

This procedure can determine the horizontal hydraulic conductivity of distinct geologic horizons under in situ conditions. The hydraulic conductivity (K) is an important parameter for modeling the flow of groundwater in an aquifer.

8.2 METHOD SUMMARY

A slug test involves the instantaneous injection of a slug (a solid cylinder of known volume) or withdrawal of a volume of water. A slug displaces a known volume of water from a well and measures the artificial fluctuation of the groundwater level.

There are several advantages to using slug tests to estimate hydraulic conductivities. First, estimates can be made in situ, thereby avoiding errors incurred in laboratory testing of disturbed soil samples. Second, compared with pump tests, slug tests can be performed quickly and at relatively low cost, because pumping and observation wells are not required. And last, the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay).

8.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this Standard Operating Procedure (SOP).

8.4 INTERFERENCES AND POTENTIAL PROBLEMS

- Only the hydraulic conductivity of the area immediately surrounding the well is estimated, which may not be representative of the average hydraulic conductivity of the area.
- The storage coefficient, S, usually cannot be determined by this method.

8.5 EQUIPMENT/APPARATUS

The following equipment is needed to perform slug tests. All equipment which comes in contact with the well should be decontaminated and tested prior to commencing field activities.

- tape measure (subdivided into tenths of feet)
- water pressure transducer
- electric water level indicator
- weighted tapes
- steel tape (subdivided into tenths of feet)
- electronic data-logger (if transducer method is used)
- stainless steel slug of a known volume
- watch or stopwatch with second hand
- semilogarithmic graph paper (if required)
- waterproof ink pen and logbook
- thermometer
- appropriate references and calculator
- electrical tape
- 21X micrologger
- Compaq portable computer or equivalent with Grapher installed on the hard disk

8.6 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solvents may be necessary. When decontaminating the slug or equipment, refer to ERT SOP #2006, Sampling Equipment Decontamination, and the site-specific work plan.

8.7 PROCEDURES

8.7.1 Field Procedures

When the slug test is performed using an electronic data-logger and pressure transducer, all data will be stored internally or on computer diskettes or tape. The information will be transferred directly to the main computer and analyzed. Keep a computer printout of the data in the files as documentation.

If the slug test data is collected and recorded manually, the slug test data form (Appendix C) will

be used to record observations. The slug test data form should include the following information:

- site ID -- identification number assigned to the site
- location ID -- identification of location being tested
- date -- the date when the test data were collected in this order: year, month, day (e.g., 900131 for January 31, 1990)
- slug volume (ft^3) -- manufacturer's specification for the known volume or displacement of the slug device
- logger -- identifies the company or person responsible for performing the field measurements
- test method -- the slug device either is injected or lowered into the well, or is withdrawn or pulled-out from the monitor well. Check the method that is applicable to the test situation being run.
- comments -- appropriate observations or information for which no other blanks are provided.
- elapsed time (minutes) -- cumulative time readings from beginning of test to end of test, in minutes
- depth to water (feet) -- depth to water recorded in tenths of feet

The following general procedures may be used to collect and report slug test data. These procedures may be modified to reflect site-specific conditions:

1. Decontaminate the transducer and cable.

2. Make initial water level measurements on monitoring wells in an upgradient-to-downgradient sequence, if possible, to minimize the potential for cross-contamination.

3. Before beginning the slug test, record information into the electronic data-logger. The type of information may vary depending on the model used. When using different models, consult the operator's manual for the proper data entry sequence to be used.

4. Test wells from least contaminated to most contaminated, if possible.

5. Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings, (see SOP #2151, Water Level Measurement).

6. Cover sharp edges of the well casing with duct tape to protect the transducer cables.

7. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test but at least 2 feet from the bottom of the well. Be sure the depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at a constant depth.

8. Connect the transducer cable to the electronic data-logger.

9. Enter the initial water level and transducer design range into the recording device according to the manufacturer's instructions. The transducer design range will be stamped on the side of the transducer. Record the initial water level on the recording device.

10. "Instantaneously" introduce or remove a known volume or slug of water to the well. Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.

11. Consider the moment of volume addition or removal as time zero. Measure and record the depth to water and the time at each reading. Depths should be measured to the nearest 0.01 foot. The number of depth-time measurements necessary to complete the test is variable. It is critical to make as many measurements as possible in the early part of the test. The number and intervals between measurements will be determined from previous aquifer tests or evaluations.

12. Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semilogarithmic plot of time versus depth.

13. Retrieve slug (if applicable).

Note: The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours. If the well is to be used as a monitoring well, precautions against contaminating it should be taken. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers or measuring devices should be decontaminated prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross-contamination of the wells.

Slug tests should be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the static water level prior to sampling. At least 1 week should elapse between the drilling of a well and the performance of a slug test.

8.7.2 Post Operation

When using an electronic data-logger, use the following procedure:

1. Stop logging sequence.
2. Print data.
3. Send data to computer by telephone.
4. Save memory and disconnect battery at the end of the day's activities.
5. Review field forms for completeness.

8.8 CALCULATIONS

The simplest interpretation of piezometer recovery is that of Hvorslev (1951). The analysis assumes a homogenous, isotropic medium in which soil and water are incompressible. Hvorslev's expression for hydraulic conductivity (K) is:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

for $L/R > 8$

where:

K = hydraulic conductivity [feet/second]
r = casing radius [feet]
L = length of open screen (or open borehole) [feet]
R = filter pack (borehole) radius [feet]
T_o = Basic Time Lag [seconds]; value of t on semilogarithmic plot of $(H-h)/(H-H_o)$ vs. t, when $(H-h)/(H-H_o) = 0.37$

where:

H = initial water level prior to removal of slug
H_o = water level at $t = 0$
h = recorded water level at $t > 0$

(Hvorslev, 1951; Freeze and Cherry, 1979)

The Bower and Rice method is also commonly used for K calculations. However, it is much more time consuming than the Hvorslev method. Refer to Freeze and Cherry or Fetter for a discussion of these methods.

8.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets, or within personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activity will apply:

- Each well should be tested at least twice in order to compare results.

8.10 DATA VALIDATION

This section is not applicable to this SOP.

8.11 HEALTH AND SAFETY

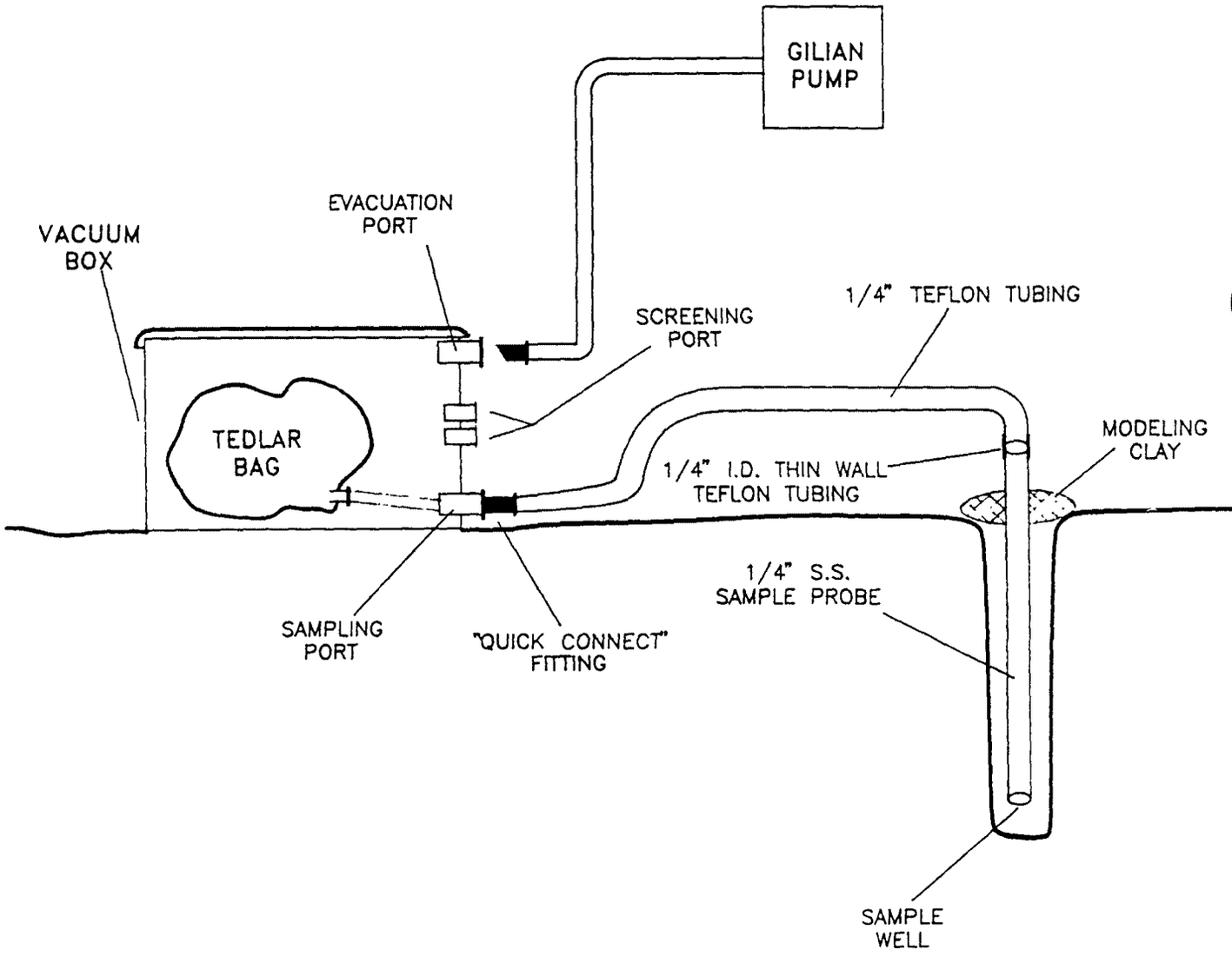
When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

APPENDIX A

Sampling Train Schematic

Figure 1: Sampling Train Schematic

SOP #2149



APPENDIX B

HNU Field Protocol

Startup Procedure

1. Before attaching the probe, check the function switch on the control panel to ensure that it is in the 'off' position. Attach the probe by plugging it into the interface on the top of the readout module. Use care in aligning the prongs in the probe cord with the plug in; do not force.

2. Turn the function switch to the battery check position. The needle on the meter should read within or above the green area on the scale. If not, recharge the battery. If the red indicator light comes on, the battery needs recharging.

3. Turn the function switch to any range setting. For no more than 2 to 3 seconds look into the end of the probe to see if the lamp is on. If it is on, you will see a purple glow. Do not stare into the probe any longer than three seconds. Long term exposure to UV light can damage eyes. Also, listen for the hum of the fan motor.

4. To zero the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 to 20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

Operational Check

1. Follow the startup procedure.

2. With the instrument set on the 0-20 range, hold a solvent-based Magic Marker near the probe tip. If the meter deflects upscale, the instrument is working.

Field Calibration Procedure

1. Follow the startup procedure and the operational check.

2. Set the function switch to the range setting for the concentration of the calibration gas.

3. Attach a regulator (HNU 101-351) to a disposable cylinder of isobutylene gas. Connect the regulator to the probe of the HNU with a piece of clean Tygon tubing. Turn the valve on the regulator to the 'on' position.

4. After 15 seconds, adjust the span dial until the meter reading equals the concentration of the calibration gas used. The calibration gas is usually 100 ppm of isobutylene in zero air. The cylinders are marked in benzene equivalents for the 10.2 eV probe (approximately 55 ppm benzene equivalent) and for the 11.7 eV probe (approximately 65 ppm benzene equivalent). Be careful to unlock the span dial before adjusting it. If the span has to be set below 3.0 calibration, the lamp and ion chamber should be inspected and cleaned as appropriate. For cleaning of the 11.7 eV probe, only use an electronic-grade, oil-free freon or similar water-free, grease-free solvent.

5. Record in the field log: the instrument ID # (EPA decal or serial number if the instrument is a rental); the initial and final span settings; the date and time; concentration and type of calibration used; and the name of the person who calibrated the instrument.

Operation

1. Follow the startup procedure, operational check, and calibration check.

2. Set the function switch to the appropriate range. If the concentration of gases or vapors is unknown, set the function switch to the 0-20 ppm range. Adjust it if necessary.

3. While taking care not to permit the HNU to be exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site health and safety plan.

4. When the activity is completed or at the end of the day, carefully clean the outside of the HNU with a damp disposable towel to remove any

visible dirt. Return the HNU to a secure area and place on charge.

5. With the exception of the probe's inlet and exhaust, the HNU can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.

APPENDIX C

Forms

Well Completion Form

SOP #2150

PAGE__OF__

MONITOR WELL INSTALLATION

Client: _____ Job No.: _____ Date Drilled: _____ Well No.: _____

Site: _____ Elevation: Pad _____ Top of Steel Casing: _____

Total Depth: _____ Casing Size & Type: _____ Screen Size: _____

Comments: _____

Depth	Symbol Stratigraphy	Sample Description	Completion Data

Groundwater Level Data Form

SOP #2151 PAGE__OF__

SITE NAME:			
LOG DATE:		LOGGER NAME:	
MEASUREMENT REFERENCE POINT: __TOP OF GROUND __TOP OF CASING			
LOCATION	TIME	DEPTH TO WATER (FT)	COMMENTS

Pump/Recovery Test Data Sheet

SOP #2157 PAGE__OF__

SITE ID:	DISTANCE FROM PUMPED WELL (FT):
LOCATION:	LOGGER:
TEST START	TEST END
DATE:	DATE:
TIME:	TIME:
STATIC WATER LEVEL (FT):	STATIC WATER LEVEL (FT):
AVERAGE PUMPING RATE (GAL/MIN):	
MEASUREMENT METHODS:	
COMMENTS:	

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)
0.00			0.00	

Pump/Recovery Test Data Sheet (Continued)

SOP #2157 PAGE__OF__

SITE ID:	DATE:
LOCATION:	LOGGER:

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)

Slug Test Data Form

SOP #2158 PAGE__OF__

DATE:	
SITE ID:	SLUG VOLUME (FT^3):
LOCATION ID:	LOGGER:
TEST METHOD: __ SLUG INJECTION __ SLUG WITHDRAWAL	
COMMENTS:	
TIME (Begin Test #1):	TIME (Begin Test #2):
TIME (End Test #1):	TIME (End Test #2):

ELAPSED TIME (MIN)	DEPTH TO WATER (FT)	ELAPSED TIME (MIN)	DEPTH TO WATER (FT)

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