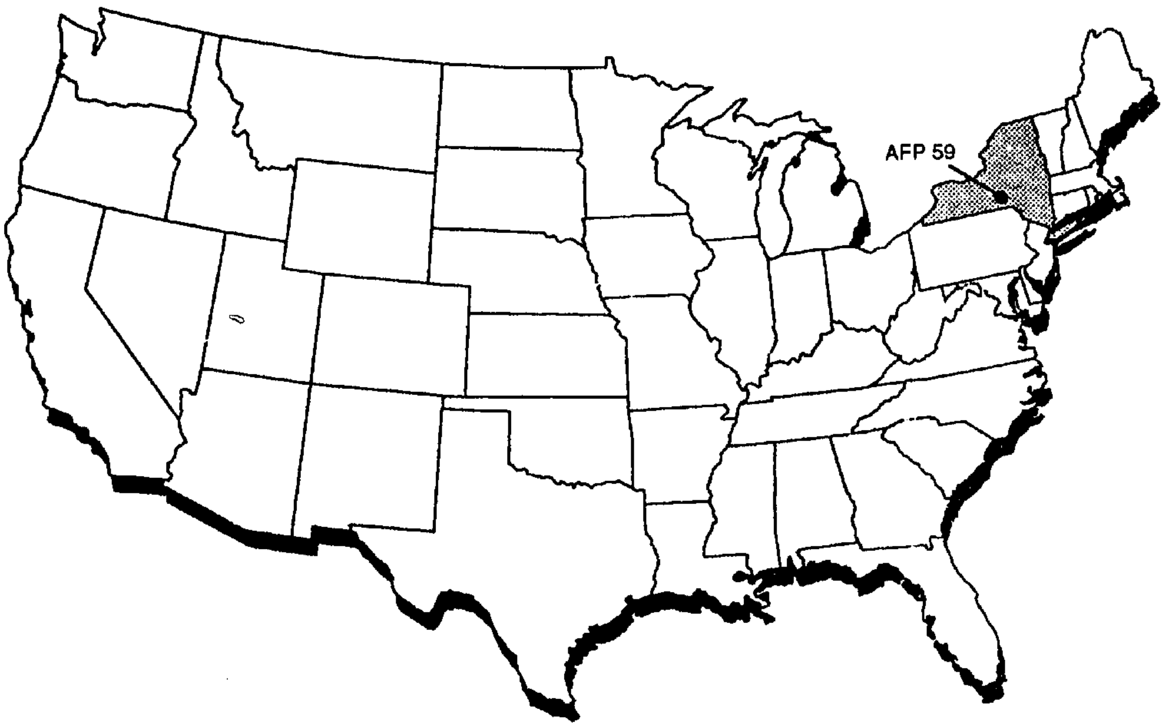
INSTALLATION RESTORATION PR
REMEDIAL INVESTIGATION
FINAL SAMPLING AND ANALYSIS PLAN

AIR FORCE PLANT 59
JOHNSON CITY, NEW YORK

NOVEMBER 1994



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Remedial Investigation Final Sampling and Analysis Plan

Air Force Plant 59

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November 1994

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An Installation Restoration Program (IRP) Remedial Investigation (RI) is being conducted at Air Force Plant (AFP) 59 in Johnson City, New York. A field program consisting of geophysical utility clearance surveys, direct push soil and groundwater sampling, subsurface soil sampling, monitoring well installation, groundwater sampling, sediment and surface water sampling, and aquifer testing has been developed to meet the project objectives of the RI. The procedures to complete these field tasks are described in detail in this report. The details of the Quality Assurance program for the entire RI are also contained in this report.

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PREFACE

This Sampling and Analysis Plan (SAP) prescribes the Quality Assurance and Quality Control requirements for the expected tasks and activities needed to complete the remedial investigation (RI) at Air Force Plant 59 according to the requirements of Contract No. F41624-94-D-8055, Delivery Order 0004, between the U.S. Air Force and EARTH TECH. It was developed to assure that all environmental data generated for the project are scientifically valid, defensible, comparable and of known and acceptable precision and accuracy. The SAP has been prepared in accordance with format and content requirements of the "Handbook to Support the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)", September 1993.

The Air Force Center for Environmental Excellence (AFCEE) Restoration Team Chief (RTC) is Mr. John McCown. The EARTH TECH Project Manager for this contract is Ms. Reid Wellensiek. The activities covered by this Sampling and Analysis Plan began in July 1994 and are anticipated to be completed by September 1995.

Approved:

Robert A. Colonna, Program Manager

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LIST OF ACRONYMS

AFCEE	Air Force Center for Environmental Excellence
AFP 59	Air Force Plant 59
ARAR	Applicable or Relevant and Appropriate Requirement
ASC	Aeronautical Systems Center
ASTM	American Society of Testing and Material
bgs	Below Ground Surface
CCN	CompuChem Number
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COC	Chain-of-Custody
DTW	Depth to Water
EMI	Electromagnetic Imaging
FID	Flame Ionization Detector
FSP	Field Sampling Plan
GC	Gas Chromatograph
GC/MS	Gas Chromatography/Mass Spectrometry
GE	General Electric
GPR	Ground Penetrating Radar
HSA	Hollow Stem Auger
ICP	Inductively Coupled Plasma
I.D.	Inner Diameter
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management System
MDL	Method Detection Limit
mg/kg	Milligrams per Kilogram
mL/L	Milliliters per Liter
MS	Matrix Spike
MSL	Mean Sea Level
MSD	Matrix Spike Duplicate
NIST	National Institute for Standards and Technology
NTU	Nephelometric Turbidity Unit
NYSDEC	New York State Department of Environmental Conservation
O.D.	Outside Diameter
PCB	Polychlorinated Biphenyl
PE	Performance Evaluation
PID	Photoionization Detector
POC	Point-of-Contact
PQL	Practical Quantitation Limit
PVC	Polyvinyl chloride
QA	Quality Assurance

LIST OF ACRONYMS

Continued

QAPP	Quality Assurance Project Plan
QC	Quality Control
QCTOOL	Quality Control Tool
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RPD	Relative Percent Difference
RPM	Remedial Program Manager
RSD	Relative Standard Deviation
RTC	Restoration Team Chief
SCG	Standards Criteria and Guidance
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOC	Semi-volatile Organic Compound
TBC	To Be Considered
TD	Total Depth
TOC	Total Organic Carbon
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
USCS	Unified Soil Classification System
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WBV	Well Bore Volume

SECTION 1.0

QUALITY ASSURANCE PROJECT PLAN

This document describes the Quality Assurance (QA) and Quality Control (QC) procedures to be used to accomplish the Installation Restoration Program (IRP) Remedial Investigation (RI) of Air Force Plant 59 (AFP 59). This investigation is part of a larger program, the IRP, which is designed to evaluate potential hazardous waste contamination at U.S. Air Force (USAF) facilities. This Quality Assurance Project Plan (QAPP) was prepared in accordance with the "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans" (USEPA, 1983) and with guidelines provided in the "Handbook for the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)" (USAF, 1993).

1.1 Introduction

The QAPP outlines the procedures, protocols, QC criteria, and overall investigation strategy to be used by Earth Tech and its subcontractors during the RI of AFP 59 in Johnson City, New York. Laboratory methodologies, instrument calibration, and chain-of-custody (COC) procedures are discussed in Section 1.0, while Section 2.0, Field Sampling Plan (FSP), describes the field program.

1.1.1 The U.S. Air Force Installation Restoration Program

The USAF is conducting the activities described in this QAPP and the associated Work Plan as part of the larger IRP. The history of the IRP is discussed in detail in Section 1.1 of the Work Plan.

1.1.2 Purpose and Scope

The QAPP for the investigation of AFP 59 identifies the policies, organization, objectives, functional activities, and specific QA and QC activities undertaken by Earth Tech (The Earth Technology Corporation) and its subcontractors to ensure the validity of analytical data generated during the course of the investigation. The purpose of the program is to ensure that all technical data generated for AFP 59 are accurate, representative, and will withstand judicial scrutiny.

The QAPP also contains specific guidelines for the acquisition and documentation of laboratory data generated as a result of field work performed and described more completely in the FSP. The QAPP supplements the Work Plan to produce an effective control program that provides adequate confidence that collected data are valid, have integrity, and are preserved and retrievable. Data are valid when they conform to the basic requirements of a study; they have integrity when they are obtained correctly by using technically sound methods and practices; they are preserved when they are protected against loss and physical damage or destruction; and they are retrievable when they can be readily obtained as needed from where they are located.

Throughout this project, QC will involve a system of checks on field and laboratory procedures (through the use of data collection, documentation, field blanks, duplicates, documentation of all sample movement, COC records, etc.) to provide supporting information on the quality of the methods employed and the analytical data. QA will provide supervisory checking to certify that the QC procedures have been properly implemented to produce accurate data. All QA/QC procedures will be in accordance with applicable professional technical standards, U.S. Environmental Protection Agency (USEPA) requirements, government regulations and guidelines, and specific USAF project goals and requirements outlined in the "Handbook for the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)," (The Handbook) (USAF, 1993). This QAPP has been prepared in accordance with all USEPA and Air Force Center for Environmental Excellence (AFCEE) QAPP guidelines.

1.2 Project Description

The site history and previous IRP investigations are summarized below. Additionally, the project scope and objectives are discussed, and subcontractors to be used to meet the objectives are identified.

1.2.1 Project Background

AFP 59 is located in the Village of Johnson City, Broome County, New York, about 3 miles west of the Central Business District of the City of Binghamton and about 4 miles east of the center of the Village of Endicott (see Figure 1-1). The plant was designed and built in 1942 by PLANCOR, the (former) Defense Plant Corporation. The original building occupied 621,500 square feet of floor space and has remained essentially unchanged. The total land area of AFP 59 is 29.6 acres.

AFP 59 is a government-owned, contractor-operated facility. Remington Rand, Inc. was the first manufacturer to occupy the plant. Remington Rand manufactured aluminum aircraft propellers at the plant from 1942 to 1945. The plant closed at the end of World War II and remained idle until April 1949, when it was reopened as an aircraft controls manufacturing facility. General Electric (GE) Aerospace was contracted to operate the facility and the manufacturing process. The major process at that time was the manufacture of parts for electro-mechanical aircraft control systems. Plant activity peaked in 1967 at the height of the Vietnam War. During the 1970s, technological advances in electronic control systems caused a decreasing demand for electro-mechanical control systems, resulting in a decline in machine shop activity.

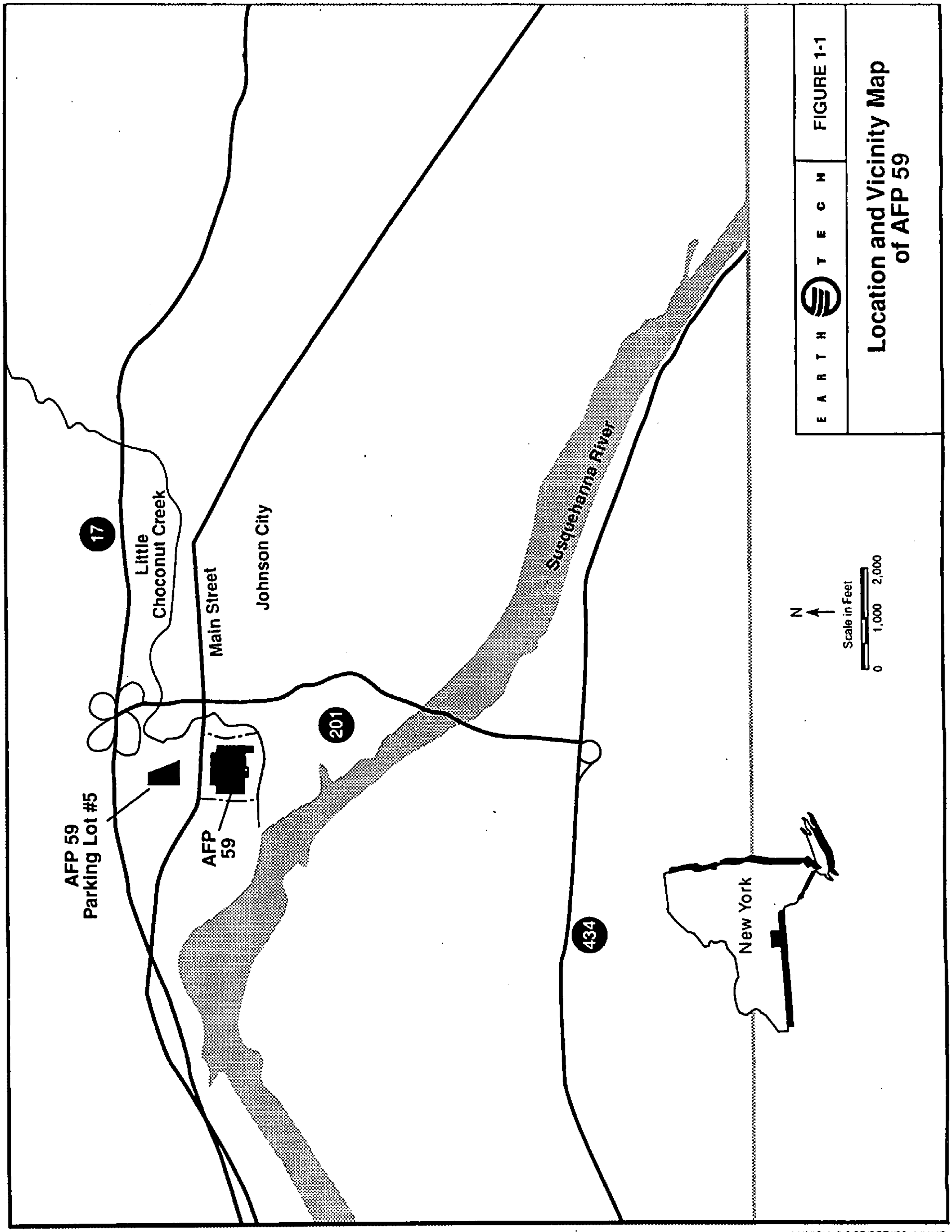


FIGURE 1-1

Location and Vicinity Map of AFP 59

GF/AFP 59/EBS/LOC & VICINITY

In April 1993, Martin Marietta Aircraft Controls acquired GE Aerospace and took over the operation of the facility and the manufacturing activities. Martin Marietta currently manufactures flight control, laser, weapons control, internal navigation, and guidance systems at AFP 59. These systems are used in various military aircraft including the F-18, F-15, F-111, and B-1. Control systems for Boeing 757 and 767 commercial jets also are manufactured at the plant. Currently, manufacturing at AFP 59 operates on a two-shift schedule, employing approximately 1,100 people.

The USAF initiated an IRP investigation at AFP 59 in March 1984. Phase I (Records Search) and Phase II (Confirmation/Quantification) studies have been conducted. Studies of areas of concern have also been conducted in coordination with the New York State Department of Environmental Conservation (NYSDEC) to achieve closure of these areas. Locations of the areas of concern as well as specific sites identified in the AFP 59 Management Action Plan are shown in Figure 1-2. Additionally, offsite investigations of potential sources of contamination contributing to the municipal water supply contamination have been conducted by the NYSDEC. A summary of the activities completed during these studies is provided in Table 1-1 and in Sections 1.2.2.1 and 1.2.2.2 of the Work Plan.

1.2.2 Project Scope and Objectives

Project objectives for the AFP 59 RI have been identified and are presented below.

- Identify potential onsite sources of soil and/or groundwater contamination.
- Define the nature and extent of onsite groundwater contamination in the shallow and deep zones of the aquifer.
- Define the nature and extent of soil contamination.
- Define background concentrations of both metals and organics in soil, sediment, surface water, and groundwater to determine potential contributions of upgradient sources of contamination.
- Identify migration pathways, including the degree of interconnection between the shallow and deep zones of the aquifer.
- Determine the relationship of any identified contamination at AFP 59 to contamination at municipal wells.
- Refine the conceptual site model, including source identification, contaminant migration, and evaluation of remedial alternatives.
- Complete a baseline risk assessment.

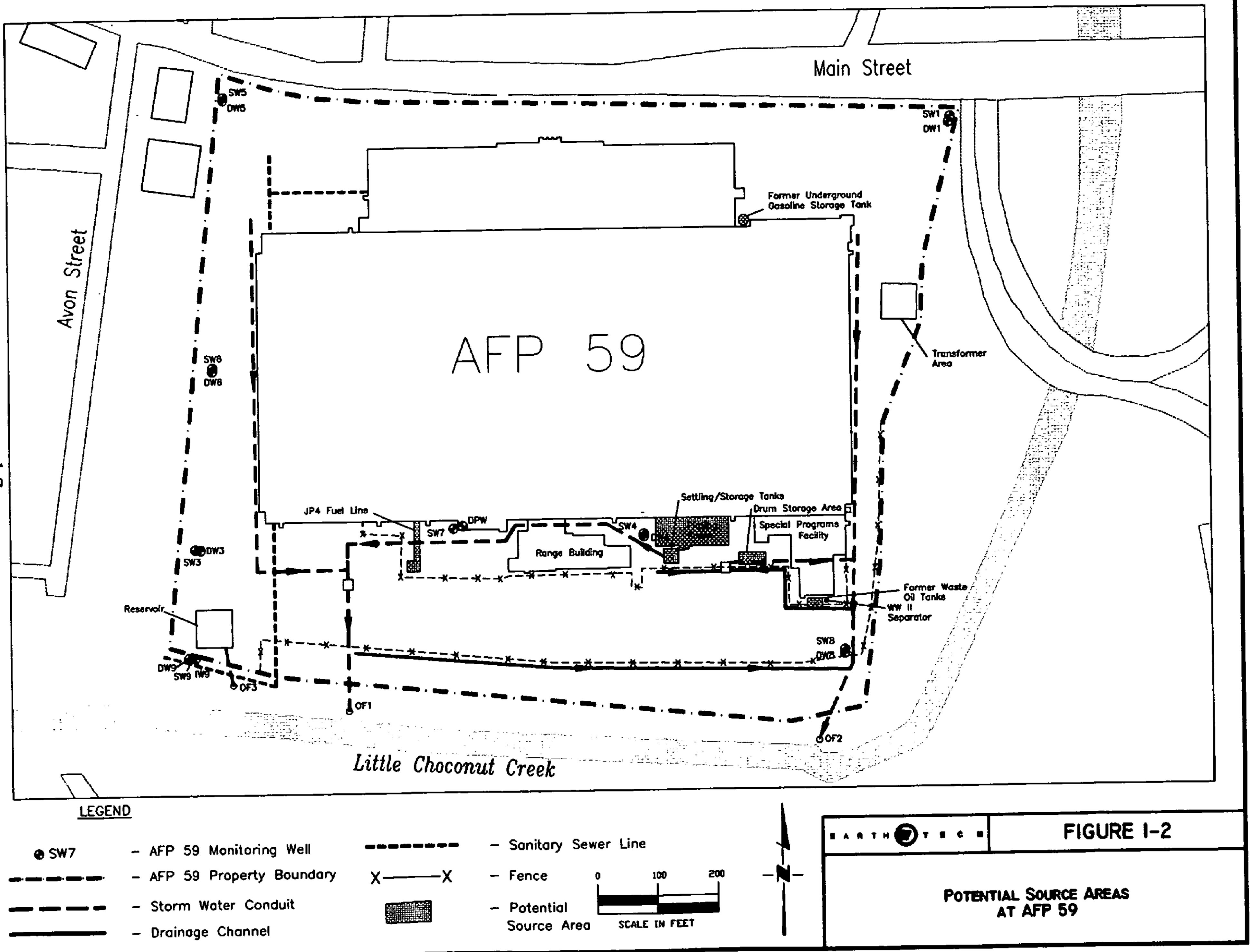


FIGURE I-2

POTENTIAL SOURCE AREAS AT AFP 59

TABLE 1-1
SUMMARY OF ACTIVITIES AND FINDINGS OF PREVIOUS INVESTIGATIONS AT AFP 59

Investigation	Activities	Findings
IRP Phase I Records Search (CH2M Hill, 1984)	Compilation of information on hazardous materials use and disposal practices. Identification of problems associated with these practices.	Two sites were identified: (1) the underground waste oil tanks (Site 1) and (2) the drum storage area (Site 2).
IRP Phase II, Stage 1 Confirmation/Quantification Study (Fred C. Hart Associates, Inc., 1988)	Drilling and sampling of three shallow borings south of the plating room. Installation of three shallow monitoring wells.	(1) Detection of chlorinated compounds in groundwater from the onsite production well and SW3. (2) Total chromium was detected in all soil samples, ranging in concentration from 5.43 mg/kg to 67.4 mg/kg. (3) Recommended additional studies.
IRP Phase II, Stage 2 Confirmation/Quantification Study Supplemental Site Inspection (Argonne National Laboratory, 1994)	Drilling and sampling of an additional 14 monitoring wells. Groundwater sampling of existing monitoring wells SW1 and SW3 as well as Johnson City municipal well #7 and the onsite production well. Drilling and sampling of six soil borings and collection of 18 hand auger samples. Three surface water and sediment samples collected from Little Choconut Creek and water samples from outfalls 001 and 002.	(1) Identification of six sites containing possible contamination including former waste oil tanks, the plating building, a WWII oil/water separator location, a settling pond area, a JP-4 fluid storage and piping area, and the location of a former gasoline storage tank. (2) Detection of chlorinated compounds in groundwater, surface water, and soil samples. (3) Elevated concentrations of metals near the plating building. Chromium was detected at 446 mg/kg in a hand auger soil sample located directly south of the plating building.
Settling Tank/Spent Plating Storage Tank Soil Study (Marcor, 1991)	Two soil borings were drilled and sampled adjacent to the settling tank and spent plating storage tank.	Results indicated the presence of metals and tetrachloroethene below TCLP regulatory levels.
Settling Tank/Spent Plating Storage Tank Soil Study (OHM Remediation Services Corp., 1992)	Three soil samples were collected in Pits #1, 2, and 3 to the west, south, and east of the spent plating storage tank. Chip samples were also collected in both settling/spent plating storage tanks.	Metals which were above New York State recommended soil cleanup levels in the three soil samples were chromium, lead, manganese, nickel, and zinc. Chromium had a maximum detection of 265 mg/kg in the soil sample south of the storage tank; lead, nickel, and zinc also had the maximum detections at this location with concentrations of 99.0, 68.8 and 53.8 mg/kg, respectively. No metals were found above the TCLP limit.
Plating Room Soil Investigation (OHM Remediation Services Corp., 1993b)	Twenty-two soil samples were collected and analyzed from beneath the plating room floor.	The presence of several metals, TCE, and acetone were detected in soil samples from the plating room. The highest metals concentrations were detected on the east side of the middle section of the plating room. Additional sampling was recommended.

TABLE 1-1
SUMMARY OF ACTIVITIES AND FINDINGS OF PREVIOUS INVESTIGATIONS AT AFP 59

Continued

Investigation	Activities	Findings
Settling Tank/Spent Plating Storage Tank Soil Study (OHM Remediation Services Corp., 1993a)	Four soil samples were collected and analyzed adjacent to the east and west sides of the settling/spent plating storage tanks.	Acetone, methylene chloride, and TCE were detected in the soil; all detections were below NYSDEC cleanup levels.
Plating Room and Settling Tank/Spent Plating Storage Tank Study (OHM Remediation Services Corp., 1994)	Three chip samples from the settling tank and three soil samples from the plating room were collected. The soil samples were collected from points to the north, east, and west of location 007 that previously had high detections of metals.	Acetone, methylene chloride, and/or TCE were detected in all three soil samples; all detections were below NYSDEC cleanup levels. Barium, cadmium, and chromium were also detected in the three soil samples, with the highest detections at concentrations of 0.684, 0.015, and 1.30 mg/L, respectively. TCE was detected in all three chip samples from the settling tank at 1.27, 8.38, and 0.137 mg/L.

- Meet the requirements of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120(h) to allow transfer of the property.

Data gaps have been identified based on a review of the existing conceptual site model and are summarized in Section 2.6 of the Work Plan. In order to fill these data gaps and meet the project objectives, the planned field activities employ a variety of techniques and methods, as shown in Table 1-2.

Earth Tech will conduct the field investigation using a phased approach in order to efficiently characterize the site. The first phase of the investigation, a reconnaissance survey of AFP 59, will consist of: a geophysical clearance survey; soil and groundwater sampling; onsite analyses for screening; offsite analyses for site characterization; water level measurements in existing monitoring wells; and groundwater quality screening at selected existing monitoring wells. A geophysical survey will be conducted to locate subsurface utilities prior to sampling. Soil and groundwater samples will be collected using a direct push sampling technique and analyzed at an onsite mobile laboratory for volatile organic compounds (VOCs). The screening data will be used to locate potential source areas and delineate areas of contamination. The grid spacing for sampling can be modified as the field program progresses to provide more detailed information in any areas where contamination is identified. Selected soil samples will also be sent offsite for analysis at a fixed laboratory to provide data for site characterization, including definition of background. Groundwater samples from existing monitoring wells will also be analyzed onsite during the first phase to obtain screening data on the existing nature of contamination. A synoptic round of water level measurements will be obtained to generate a potentiometric map and determine groundwater flow directions.

The data collected during the reconnaissance survey will be analyzed to determine optimal locations to install monitoring wells and obtain additional soil and groundwater samples. Groundwater monitoring wells will be installed during the second phase of the field program to define the extent of contamination, provide reproducible sampling locations, and define the subsurface hydrogeology. Monitoring well clusters consisting of a shallow well screened in the outwash deposits and a deep well screened in the ice-contact deposits will be installed. Additionally, where fine-grained lakebed deposits separate the two units an intermediate depth well will be installed. Soil samples will be collected during drilling to observe the subsurface lithology and for chemical analysis. Soil samples will be analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), metals, and percent total organic carbon (TOC). Existing wells and all newly installed monitoring wells will be sampled and analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and hardness. A synoptic round of water level measurements will be obtained from all onsite wells. An aquifer pump test will be conducted to determine the degree of interconnection between the upper and lower zones of the aquifer.

Sediment and surface water samples will be collected from Little Choconut Creek to determine the impact of installation activities on the creek. Samples will be analyzed for VOCs, SVOCs, pesticides/PCBs, and metals. Additionally, surface water samples will be analyzed for hardness,

TABLE 1-2
SUMMARY OF REMEDIAL INVESTIGATION FIELD WORK AT AFP 59

Environmental Matrix	Field Activities	
	Reconnaissance Survey - Phase I	Phase II
Groundwater	Collect 33 direct push groundwater samples for onsite VOC analysis.	Drill and install 4 monitoring well clusters (1 deep, 1 shallow, and potentially 1 intermediate at each location).
	Collect groundwater samples from select existing monitoring wells and screen for VOCs.	Collect groundwater samples from all new and existing monitoring wells. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, and hardness.
	Obtain a synoptic round of water level measurements.	Obtain a synoptic round of water level measurements. Conduct an aquifer pump test.
Soil	Collect soil samples from approximately 32 direct push sample locations for onsite VOC analysis.	Collect 3 soil samples from each monitoring well location and 12 soil borings and send to a fixed laboratory to be analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and percent TOC.
	Analyze select soil samples from the direct push sampling at an offsite laboratory for metals and VOCs.	
Surface Water	None.	Collect 5 surface water samples from Little Choconut Creek. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, and hardness.
Sediment	None.	Collect 5 sediment samples from Little Choconut Creek. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, and percent TOC.

and sediment samples will be analyzed for percent TOC. A Fish and Wildlife Impact Analysis (NYSDEC, 1991) will be conducted through at least Step IIB.

1.2.3 Subcontractors

The services of four subcontractors will be retained to complete the tasks required for the investigation. The subcontractors and their respective responsibilities are provided below.

1. Direct Push Soil and Groundwater Sampling:

   Target Environmental Services Inc.
   9180 Rumsey Road
   Columbia, MD 21045
   Telephone: (410) 992-6622
   Fax: (410) 992-0347

   Target Environmental Services Inc. will collect all direct push soil and groundwater samples, and will perform all onsite analytical services. Target will provide necessary sample containers, including prepreserved VOA vials and non-reactive plastic (acetate) soil liners for the onsite laboratory.

2. Laboratory:

   CompuChem Environmental Corporation
   3306 Chapel Hill/Nelson Hwy.
   Research Triangle Park, NC 27709
   Telephone: (800) 833-5097
   Fax: (919) 406-1686

   CompuChem will provide sample bottles, trip blanks, COC forms and seals, preservatives, American Society of Testing and Materials (ASTM) Type II water, analytical services, laboratory QA reports, and IRPIMS deliverables.

3. Driller:

   Parratt-Wolff
   Fisher Road
   East Syracuse, NY 13057
   Telephone: (800) 782-7260

   The driller will provide all necessary equipment and personnel to collect subsurface soil samples, and install and develop monitoring wells.

4. Surveyor:

Purdy Surveying
317 Front Street
Vestal, NY 13850
Telephone: (607) 748-7379

A certified land surveyor will survey all soil boring, surface water, sediment, and newly installed monitoring well locations.

5. Investigation-Derived Waste Disposal:

Northeast Environmental Services, Inc.
RR3, Box 8B, Marguerite Drive
Canastota, NY 13032
Telephone: (315) 697-3979

Northeast Environmental Services will characterize and dispose of all investigation-derived waste in accordance with all applicable regulations.

1.3 Project Organization and Responsibility

An interdisciplinary project team has been selected to provide the specific technical management capabilities and qualifications required by the RI. The following is a list of key personnel by title.

Program Manager	Robert A. Colonna	(703) 549-8728
Program Health and Safety Manager	Glen Barrett	(703) 549-8728
Program QA Manager	Doug Hazelwood	(703) 549-8728
Project Manager	Reid Wellensiek	(703) 549-8728
Laboratory Quality Assurance Officer	Linda Fowler	(919) 406-1600
Laboratory Project Manager	Stephanie Winfield	(919) 406-2456

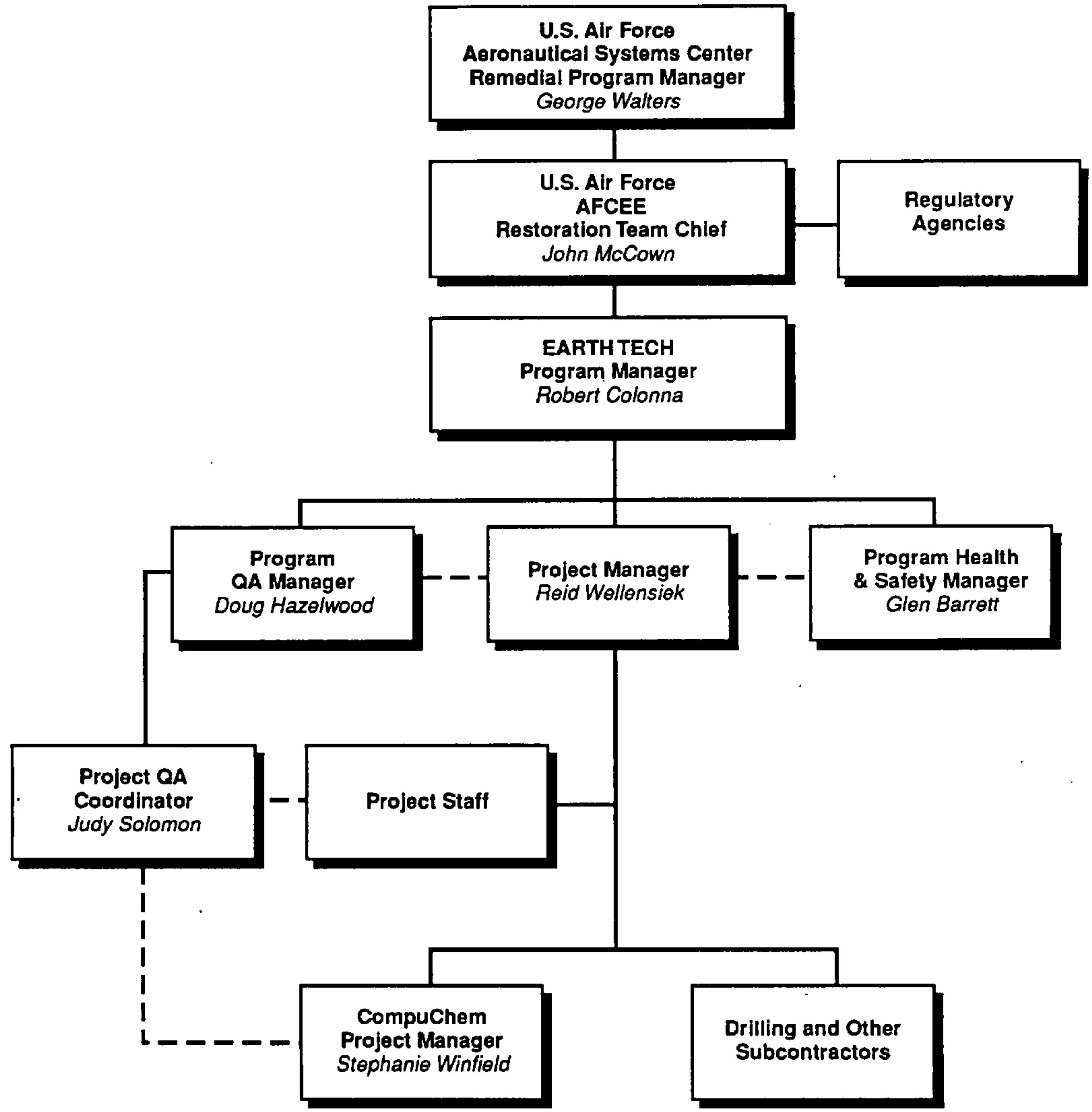
1.3.1 Project Responsibility

The responsibilities and authorities of key Earth Tech and CompuChem project personnel are discussed in the following sections and are identified in Figures 1-3 and 1-4, respectively..

1.3.1.1 Earth Tech Project Personnel

Program Manager. The Program Manager is Robert A. Colonna, who is responsible for overall direction, coordination, technical consistency, and review of the entire contract. His responsibilities include:

1. Final approval and review of work plans, all project deliverables, schedules, contract changes, and personnel allocations for each task;



EARTH TECH | FIGURE 1-3

EARTH TECH Quality Assurance Program Organization

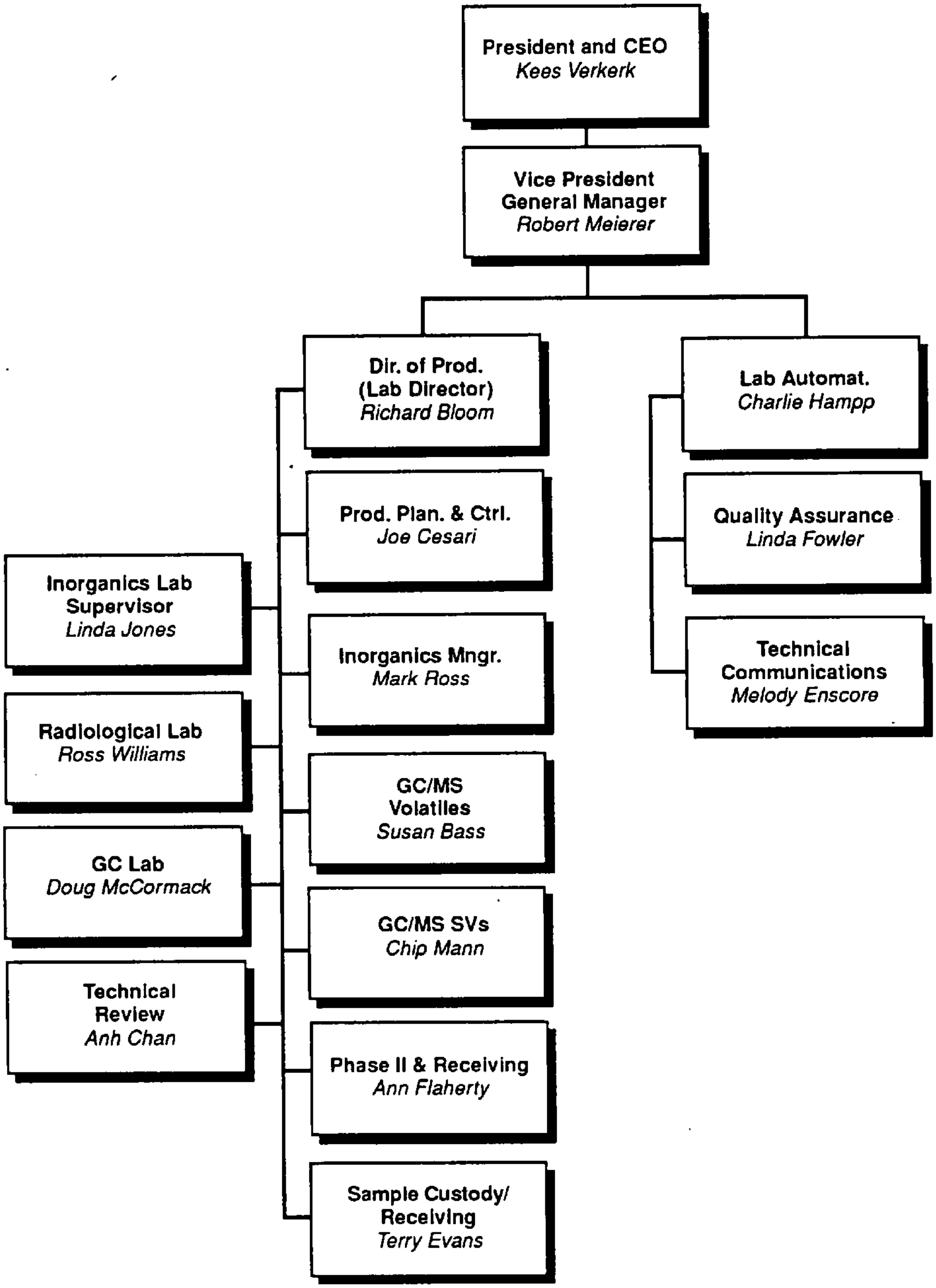


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FIGURE 1-4

CompuChem Organizational Chart

2. Guiding the resolution of problems of particular difficulty that may arise on each task;

3. Approving project deliverables, budgets, and tasks; and

4. Facilitating coordination among management, field teams, and support personnel to ensure consistent performance.

In order to fulfill his specified responsibilities, the Program Manager has the authority to:

1. Select project personnel and guarantee their availability for the duration of the project;

2. Alter personnel assignments if necessary to meet project objectives;

3. Require interactions (e.g., peer review of technical deliverables) among work element supervisors to ensure consistency of work products; and

4. Communicate, as necessary, with the USAF/AFCEE Restoration Team Chief (RTC) and/or ASC Remedial Program Manager (RPM) to evaluate the progress of the program and to ensure the early resolution of any potential problems.

Program Health and Safety Manager. Glen Barrett is designated as the Program Health and Safety Manager. He will be responsible for the personal safety of all site personnel through the preparation of a Project Health and Safety Plan detailing required safety standard operating procedures (SOPs). A Site Health and Safety Officer will monitor the labeling, shipping, and control of hazardous or potentially hazardous samples, brief field personnel on health and safety requirements, and ensure that all personnel and subcontractors adhere to the contents of the Health and Safety Plan.

Program Quality Assurance Manager. Doug Hazelwood is designated as the Program QA Manager. His responsibilities include providing unbiased monitoring of the QC procedures of the project team, ensuring adequate documentation of QC procedures, and guaranteeing that all QC problems are handled in an expeditious and conscientious manner.

Project Manager. The Project Manager is Reid Wellensiek. She will be responsible for effective day-to-day management of all operations. As the Project Manager, her responsibilities include:

1. Review and approval of sampling procedures and QA plans, including monitoring site locations, chemical analysis parameters, geophysical techniques, schedules, and personnel assignments;

2. Preparation of progress reports with the assistance of key support personnel;

3. Management of all funds for labor and materials procurement;

4. Management of daily field activities;

5. Direct communication and liaison with the AFCEE RTC and ASC RPM;

6. Technical leadership and technical review of all task deliverables; and

7. Communication of work progress to the Program Manager.

In order to supervise the day-to-day operations of the project, the Project Manager has the authority to:

1. Allocate budgets among the work elements required for the project;

2. Approve or disapprove any labor, material, or subcontractor charges to the project;

3. Establish and enforce work element milestones to ensure timely completion of project tasks;

4. Approve or disapprove elements of any technical deliverable for each work element; and

5. Communicate as necessary with the USAF/AFCEE RTC and ASC RPM with regard to day-to-day progress of the project.

Project QA Coordinator. Judy Solomon is the Project QA Coordinator for this investigation. She is primarily responsible for directing the laboratory activities described in the QAPP. Her responsibilities include: keeping the Project Manager fully informed of laboratory and field activities as it pertains to sampling; being the liaison between the laboratory Project Manager and the Earth Tech Project Manager; and overall management of the laboratory data. She will also provide required input to technical and QA reports and other project documents.

1.3.1.2 Laboratory Project Personnel

Laboratory QA Officer. Linda Fowler will be the QA Officer for CompuChem Environmental Corporation. In this capacity, she will have responsibility for monitoring the quality of the laboratory's work and taking appropriate actions to ensure that quality standards are being met, including stopping the release of data which are of suspect quality. Under her direction, her staff is responsible for the following specific functions.

- Establishing QC procedures, providing control samples, and setting warning and control limits for every test.

- Monitoring compliance with the laboratory's QA/QC plan including:

  - reviewing QC-related activities and documentation and completeness;

- identifying data that does not meet QC objectives and ensuring that the QC problem is resolved; and

- ensuring that suspect data are not included in the laboratory results.

Laboratory Project Manager. Stephanie Winfield has been designated as the Laboratory Project Manager. She will be in charge of all technical laboratory operations for the AFP 59 project, which includes sample control, inorganic analysis, organic analysis, data management, and QA/QC. In addition, she will direct the activity of the personnel in each operational section through the supervisors, to ensure the QC procedures are being performed and any out-of-control situations or discrepancies are remedied properly and promptly. Her responsibilities include serving as the laboratory point-of-contact for exchange of QC information and approving the release of QA/QC information, such as:

- the laboratory QC plan and any changes to it;
- corrective action plans;
- client notifications of out-of-control events; and
- the final QC report (in conjunction with the QA Officer).

1.4 Quality Assurance Objectives for Measurement Data

Data needs for the project include both screening measurements and data of sufficient quality to be used for site characterization. QA objectives are established for these measurement data and address the following data characteristics: accuracy, precision, completeness, representativeness, and comparability. Goals for the data quality objectives are also provided below.

1.4.1 Definition of Criteria

All measurements and analyses required at AFP 59 will be completed in a manner which ensures that they are scientifically accurate, legally valid, and comparable in quality and type with the data from previous studies. To help achieve these objectives, standards for data quality characteristics will be established that ensure a consistently high degree of analytical reliability. These data quality characteristics consist of accuracy, precision, completeness, representativeness, and comparability.

Accuracy. Accuracy is the degree of agreement of a measurement or average of measurements with an accepted reference or "true" value and is a measure of bias in the system. For this project, accuracy of the measurement data shall be assessed and controlled. Results for the laboratory or method blank, laboratory control sample (LCS), and surrogate spikes shall be the primary indicators of accuracy. These results shall be used to control accuracy within acceptable limits by requiring that they meet specific criteria. As spikes and surrogates are analyzed, target concentrations versus found concentrations shall be assessed by the calculation of percent recoveries, as stipulated in the SW846 methods. Percent recoveries are calculated by the following equation:

$$\text{Percent Recovery} = \frac{\text{Concentration in Spiked Aliquot} - \text{Concentration in Unspiked Aliquot}}{\text{Concentration of Spike Added}} \times 100$$

Precision. Precision is a measure of mutual agreement among individual measurements of the same property under prescribed similar conditions. It is independent of the error (accuracy) of the analyses and reflects only the degree to which the measurements agree with one another, not the degree to which they agree with the "true" value for the parameter measured. Precision of the measurement data for this project shall be based upon matrix spike (MS)/MS duplicate (MSD) analyses (replicability), LCS analyses (repeatability), and results for replicate/duplicate field samples (sampling replicability).

Discretely sampled field replicates/duplicates are useful in determining sampling variability. However, greater than expected differences between replicates may occur because of inhomogeneity in the sample material. In these instances a visual examination of the sample material shall be performed in order to document the reason for the difference. Field sample duplicates/replicates shall be used as a QC measure to monitor precision relative to sample collection activities.

Analytical precision shall be evaluated by calculating the percent relative standard deviation (% RSD) of an in control LCS as defined in Section 5, Chapter 1 of SW846, Revision 2, May 1991. The analyst or his supervisor must investigate the cause of data outside stated acceptance limits. Follow-up action includes recalibration, reanalysis of QC samples if justified, sample reanalysis, or flagging the data as suspect if problems cannot be resolved. The following equation shall be used in precision calculations for spikes:

$$RPD = \frac{|SR - SDR|}{(SR + SDR)\ 0.5} \times 100$$

Where:	RPD	=	Relative Percent Difference
	SR	=	Spike Recovery
	SDR	=	Spike Duplicate Recovery.

For duplicate/replicate analyses precision will be calculated as follows:

$$RPD = \frac{|Rep\ 1 - Rep\ 2|}{0.5\ (Rep\ 1 + Rep\ 2)} \times 100$$

Where:	RPD	=	Relative Percent Difference
	REP1	=	Concentration in Sample
	REP2	=	Concentration in Replicate/Duplicate.

The vertical bars indicate the absolute value of the difference; therefore RPD is always expressed as a positive value.

Completeness. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected under correct normal conditions. To maximize completeness of laboratory analyses, it is essential to have a sufficient quantity of each sample to provide for original and repeat analyses should the original analysis fail to meet acceptance criteria. Completeness is a measure of the extent to which the database resulting from a measurement effort fulfills data usage objectives. For this program, completeness shall be defined as the valid data versus the number of the total analyses requested, expressed as a percent.

Valid data are defined as those where the sample arrived at the laboratory intact, properly preserved, in sufficient quantity to perform the requested analyses, and accompanied by a completed COC. Furthermore, the sample must be analyzed within the specified holding time and in such a manner that analytical QC acceptance criteria are met. The following equation shall be used to calculate completeness:

$$C = 100 \frac{(V)}{(T)}$$

Where:	C	=	Percent completeness
	V	=	Number of valid data
	T	=	Total number requested.

Completeness for the entire project also involves completeness of field and laboratory documentation, whether all samples and analyses specified in the Statement of Work have been processed and the procedures specified in this document and laboratory SOPs have been implemented.

Representativeness. Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Field replication and field duplication are also used to assess representativeness. Two or more samples which are collected at the same location and at the same time, are considered to be equally representative of this condition, at a given point in space and time. To maximize representativeness of results, sampling techniques, sample size, and sample locations shall be carefully chosen so they provide laboratory samples representative of the site and the specific area. Properly installed monitoring wells ensure that the groundwater being sampled originates from the aquifer of concern. Care must be taken to ensure proper stabilization of measured water parameters, clarity, and color before groundwater samples are taken. Precautions must be taken, such as not operating combustion engines near a well during sampling, so that introduction of extraneous compounds does not threaten the representativeness of the samples.

Soil samples are even less homogeneous than groundwater samples, and thus it is important for the sampler and analyst to exercise good judgment when removing a sample. Samples exhibiting obvious stratification or lithologic changes should not be used as duplicates/replicates. Within the laboratory, precautions are taken to extract from the sample container an aliquot representative of the whole sample. For samples requiring volatile analysis, premixing or homogenizing should be kept to a minimum.

Comparability. Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Comparability is ensured through the use of established and approved sample collection techniques and analytical methods, consistency in the basis of analysis (wet weight, volume etc.), consistency in reporting units, and analysis of standard reference materials.

Data comparability shall be achieved by using standard units of measure. Standard units of measure for water samples are mg/L for metals and inorganics, and μg/L for organics. Standard units of measure for soil samples are milligrams per kilograms (mg/kg) (dry weight) for both inorganics and organics.

The use of standard methods to collect and analyze samples (in this case ASTM and SW846 methods), along with instruments calibrated against National Institute for Standards and Technology (NIST) traceable standards, shall also ensure comparability.

Comparability also depends on the other data quality characteristics. Only when data are judged to be representative of the environmental conditions, and when precision and accuracy are known, can data sets be compared with confidence.

1.4.2 Goals

Project data quality objectives for the various measurement parameters associated with site characterization efforts are not quantifiable for representativeness and comparability. Subjective factors to be taken into account are as follows:

- Degree of homogeneity of a site;
- Degree of homogeneity of a sample taken from one point in a site; and
- Available information on which a sampling plan is based.

Sampling precision shall be determined by the use of field replicates/duplicates, which shall number 10 percent of the original sample number. The RPD target value for field replicates/duplicates is based on the matrix of the sample. For soil and sediment samples, the target value for the RPD between the field replicate and the original sample is 40 percent. Failure to meet this target may be a reflection on the degree of inhomogeneity between the two soil samples and, therefore, resampling may not be required. For water samples, the target value for the RPD between the field duplicate and the original sample is 30 percent. It is expected that the degree of homogeneity between the duplicate and the original sample may not be a factor if the target value is exceeded, since water samples are more homogeneous than soil samples.

For the project as a whole the target value for completeness is 100 percent. A completeness value of 90 percent, however, shall be considered acceptable. Failure to achieve this goal may necessitate resampling and reanalysis.

Accuracy acceptance limits shall be based upon SW846 protocols and previously established laboratory capabilities for the control analytes using control chart techniques. In this approach, the control limits reflect the minimum and maximum recoveries expected for individual measurements for an in-control system. Recoveries outside the established limits indicate some assignable cause, other than normal measurement error, and the possible need for corrective action. Corrective actions that may be employed if QC problems cannot be resolved include: (1) recalibration of the instrument; (2) reanalysis of the QC sample; (3) reanalysis of the samples in the batch; or (4) flagging the data as suspect. For highly-contaminated samples, recovery of surrogates may depend on sample dilution.

1.5 Sampling Procedures

References for the field sampling procedures to be performed during the investigation are provided below.

1.5.1 Sampling Protocols

Detailed sampling protocols for sample collection, transport, and storage are given in Sections 2.1 and 2.2 of the FSP.

1.5.2 Sample Handling

Sample containers, sample volumes, preservation requirements, and holding times for each sample matrix and analytical method are presented in Table 1-3 for physical parameters. Tables 1-4, 1-5, 1-6, and 1-7 present the same information for laboratory-determined chemical parameters for each matrix to be sampled.

1.6 Sample Custody

Custody of samples will be constantly maintained during the investigation; sample custody procedures both in the field and at the laboratory are described below.

1.6.1 Field Operations

Section 2.2.3 of the FSP provides the procedures and forms for establishing sample custody in the field.

1.6.2 Laboratory Operations

Upon receipt at the laboratory, samples are unpacked, checked against the COC form, and inspected by the sample custodian for breakage, leakage, temperature control (for chilled or ambient temperature samples), or damage to the custody seals. If any sample is not intact, the

TABLE 1-3
SAMPLE HANDLING - PHYSICAL PARAMETERS

Parameters	Matrix	Method	Container[1]	Minimum Volume Required	Preservative	Holding Time
FIELD - DETERMINED PHYSICAL PARAMETERS						
Specific Conductance	W, SW	E120.1	P, G	N/A	None required	Analyze immediately
pH	W, SW	E150.1	P, G	N/A	None required	Analyze immediately
Temperature	W, SW	E170.1	P, G	N/A	None required	Analyze immediately
Turbidity	W	E180.1	P, G	100 mL	Refrigeration is recommended	Analyze immediately
LABORATORY - DETERMINED PHYSICAL PARAMETERS						
Moisture	S, SS	E160.3	P, G, T	200 g	Airtight container, cool 4°C, away from direct sunlight	As soon as possible

Note: The table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

N/A = Not Applicable
S = Soil, W = Groundwater, SS = Sediment, SW = Surface Water
[1]P = Polyethylene, G = Glass, T = Brass sleeve

TABLE 1-4
SEDIMENT SAMPLE HANDLING - CHEMICAL PARAMETERS

Parameters	Method	Container[1]	Minimum Volume Required	Preservative	Holding Time[2]
LABORATORY - DETERMINED CHEMICAL PARAMETERS					
Volatile Organic Compounds	SW8260	T, G with Teflon-lined Cap	4 Ounces	4°C	10 days
Semivolatile Organic Compounds	SW8270	T, G with Teflon-lined Cap	8 Ounces	4°C	*14 days until* extraction; 40 days after extraction
Metals	SW6010	P, G, T	8 Ounces	4°C	6 months
Arsenic	SW7060	P, G, T	8 Ounces	4°C	6 months
Lead	SW7421	P, G, T	8 Ounces	4°C	6 months
Mercury	SW7471	P, G, T	8 Ounces	4°C	38 days glass 13 days plastic
Selenium	SW7740	P, G, T	8 Ounces	4°C	6 months
Thallium	SW7841	P, G, T	8 Ounces	4°C	6 months
Cyanide	SW9010	P, G, T	4 Ounces	4°C	14 days
Pesticides/ PCBs	SW8080	T, G with Teflon-lined Cap	8 Ounces	4°C	14 days until extraction; 40 days after extraction
TOC	SW9060	P, A, T	4 Ounces	4°C	28 days

Note: The table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

[1]P = Polyethylene, G = Glass, T = Brass sleeves, A = Amber glass bottle
[2]The listed holding times are recommended for properly preserved samples based on currently available data. It is recognized that extension of these times may be possible for some sample types while, for other types, the times may be too long. When shipping regulations prevent the use of the proper preservation technique or when the holding time is exceeded, the final reported data for these samples should indicate the specific variance. If samples cannot be analyzed within the specified time intervals, the final reported data should indicate the actual holding times.

TABLE 1-5
SOIL SAMPLING HANDLING - CHEMICAL PARAMETERS

Parameters	Method	Container[1]	Minimum Volume Required	Preservative	Holding Time[2]
LABORATORY - DETERMINED CHEMICAL PARAMETERS					
Volatile Organic Compounds	SW8260	T, G with Teflon-lined Cap	4 Ounces	4°C	10 days[3]
Semivolatile Organic Compounds	SW8270	T, G with Teflon-lined Cap	8 Ounces	4°C	14 days until extraction; 40 days after extraction
Metals	SW6010	P, G, T	8 Ounces	4°C	6 months
Arsenic	SW7060	P, G, T	8 Ounces	4°C	6 months
Lead	SW7421	P, G, T	8 Ounces	4°C	6 months
Mercury	SW7471	P, G, T	8 Ounces	4°C	38 days glass 13 days plastic
Selenium	SW7740	P, G, T	8 Ounces	4°C	6 months
Thallium	SW7841	P, G, T	8 Ounces	4°C	6 months
Cyanide	SW9010	P, G, T	4 Ounces	4°C	14 days
Pesticides/ PCBs	SW8080	T, G with Teflon-lined Cap	8 Ounces	4°C	14 days until extraction; 40 days after extraction
TCLP (full suite)	SW1311	T, G with Teflon-lined Cap	8 Ounces	None	Volatiles - 14 days to TCLP extraction,14 days after extraction; Semivolatiles - 14 days to TCLP extraction, 40 days after extraction; Mercury - 28 days to TCLP extraction, 28 days after extraction; Metals - 180 days to TCLP extraction, 180 days after extraction
TOC	SW9060	P, A, T	4 Ounces	4°C	28 days

Note: The table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

[1]P = Polyethylene, G = Glass, T = Brass sleeves, A = Amber glass bottle
[2]The listed holding times are recommended for properly preserved samples based on currently available data. It is recognized that extension of these times may be possible for some sample types while, for other types, the times may be too long. When shipping regulations prevent the use of the proper preservation technique or when the holding time is exceeded, the final reported data for these samples should indicate the specific variance. If samples cannot be analyzed within the specified time intervals, the final reported data should indicate the actual holding times.
[3]10 days after sampling.

TABLE 1-6
SURFACE WATER SAMPLE HANDLING - CHEMICAL PARAMETERS

Parameters	Method	Container[1]	Minimum Volume Required	Preservative	Holding Time[2]
LABORATORY - DETERMINED CHEMICAL PARAMETERS					
Volatile Organic Compounds	SW8260	G with Teflon-lined Septum	2×40 mL	4°C, HCl to pH <2	10 days[3]
Semivolatile Organic Compounds	SW8270	G with Teflon-lined Cap	1 Liter	4°C	7 days until extraction; 40 days after extraction
Metals	SW6010	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Arsenic	SW7060	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Lead	SW7420	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Mercury	SW7470	P, G	400 mL	4°C, HNO3 to pH<2	38 days glass 13 days plastic
Selenium	SW7740	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Thallium	SW7841	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Cyanide	SW9010	P, G	600 mL	4°C, NaOH to pH>12	14 days
Pesticides/ PCBs	SW8080	G with Teflon-lined Cap	1 Liter	4°C	7 days until extraction; 40 days after extraction
Hardness	E130.1	P	100 mL	4°C, HNO3 to pH<2 or H2SO4 to pH<2	6 months

Note: The table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

[1]P = Polyethylene, G = Glass
[2]The listed holding times are recommended for properly preserved samples based on currently available data. It is recognized that extension of these times may be possible for some sample types while, for other types, the times may be too long. When shipping regulations prevent the use of the proper preservation technique or when the holding time is exceeded, the final reported data for these samples should indicate the specific variance. If samples cannot be analyzed within the specified time intervals, the final reported data should indicate the actual holding times.
[3]10 days after sampling.

TABLE 1-7
GROUNDWATER SAMPLE HANDLING - CHEMICAL PARAMETERS

Parameters	Method	Container[1]	Minimum Volume Required	Preservative	Holding Time[2]
LABORATORY - DETERMINED CHEMICAL PARAMETERS					
Volatile Organic Compounds	SW8260	G with Teflon-lined Septum	2×40 mL	4°C, HCl to pH<2	10 days[3]
Semivolatile Organic Compounds	SW8270	G with Teflon-lined Cap	1 Liter	4°C	7 days until extraction; 40 days after extraction
Metals	SW6010	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Arsenic	SW7060	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Lead	SW7420	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Mercury	SW7470	P, G	400 mL	4°C, HNO3 to pH<2	38 days glass 13 days plastic
Selenium	SW7740	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Thallium	SW7841	P, G	600 mL	4°C, HNO3 to pH<2	6 months
Cyanide	SW9010	P, G	600 mL	4°C, NaOH to pH>12	14 days
Pesticides/ PCBs	SW8080	G with Teflon-lined Cap	1 Liter	4°C	7 days until extraction; 40 days after extraction
Hardness	E130.1	P	100 mL	4°C, HNO3 to pH <2 or H2SO4 to pH <2	6 months

Note: The table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

[1]P = Polyethylene, G = Glass
[2]The listed holding times are recommended for properly preserved samples based on currently available data. It is recognized that extension of these times may be possible for some sample types while, for other types, the times may be too long. When shipping regulations prevent the use of the proper preservation technique or when the holding time is exceeded, the final reported data for these samples should indicate the specific variance. If samples cannot be analyzed within the specified time intervals, the final reported data should indicate the actual holding times.
[3]10 days after sampling.

Earth Tech Project Manager will be notified immediately. The condition of the samples will be recorded in a sample control logbook.

1.6.2.1 Sample Handling. The Sample Control department personnel accept custody of samples by signing and dating the COC form. Samples are logged onto a Commercial Receiving Log Sheet. The following items, where applicable, are noted on the sheet.

- Case number
- CompuChem ID number (CC#)
- Client name or order number
- Field ID (sample ID)
- Receiving date (RD)
- Sampling date (SD)
- Residual chlorine and sulfide check (cyanide only)
- Matrix
- Temperature
- Analysis codes
- Volume received
- pH (inorganics only)
- SampleSaver number

The condition of the refrigerant (whether any ice remains) is checked and the temperature of a representative sample (liquid samples only) is ascertained by wrapping a temperature strip around the outside of the container. The temperature is recorded on the Sample Record and on the Receiving Log Sheet. When it is apparent through these checks that a sample was not properly preserved, Earth Tech will be notified and a standard QA Notice will be completed and placed in the sample file. Each log sheet and COC will be reviewed by the Sample Control department supervisor who will ensure that all information is properly documented. Each log sheet will be stamped as having been reviewed, initialled, and dated.

Samples are tracked through CompuChem's Laboratory Information Management System (LIMS). As information for each sample is received into the LIMS, a CompuChem number (CCN) is generated. A CCN is a unique, six-digit laboratory identifier. It is added to the accessioning log sheet and to the COC (adjacent to the associated field ID number when possible).

Once labeled, samples are transferred to the locked walk-in cooler. Samples to be analyzed for extractable components and inorganics are stored separately from samples to be analyzed for purgeable components. Standards are stored in separate refrigerated units away from the field samples.

1.6.2.2 Sample Identification. Sample labels containing the CCN are generated from the LIMS in numerical sequence. Each sample is labeled by wrapping the bottle with its unique computer-generated label, leaving as much of the field label exposed as possible. The sample labels are color-coded, and colors are rotated every two weeks by the supervisor of the receiving department or designee. Rotating the colored labels helps sample custodians to locate and purge sample bottles, extracts, or digestates after the required storage-to-disposal period has passed.

After samples are properly labeled and identified, the samples are batched in preparation for analysis. The analytical or preparation batch is comprised of a maximum number of 20 samples which are analyzed together through the rate-determining step of the method, and with the manipulations common to each sample within the same time period, or in continuous sequential time periods. Samples in each batch should be of similar composition and include QC samples, such as blanks and spiked samples.

1.6.2.3 Sample Custody Records. All samples shall be accompanied by a field COC record. All field COC records are filed permanently with the analytical data. A COC record must also be used if the laboratory relinquishes control of the samples to subcontractor laboratories or returns the samples to Earth Tech. In addition, an internal laboratory COC is used to track the samples within the laboratory. The completed original field COC shall be forwarded to the Earth Tech Project Manager.

When sample COC is initiated in the field by Earth Tech, the person responsible for initiating COC in the laboratory is the receiving clerk. The receiving clerk signs and dates the COC form. The samples are then assigned unique, sequential six-digit identification numbers by the LIMS.

Once the receiving clerk has logged in and documented the receipt of the sample, the sample is relinquished to the sample custodian on duty. The sample custodians and the supervisor of the Sample Control department have keys that unlock the sample storage coolers. Samples are filed in walk-in coolers until laboratory staff request specific samples by completing internal COC forms or batch sheets (Figure 1-5). The internal COCs are completed the same way, and the sample custodian relinquishes the samples to the laboratory staff member. The internal COC form is used to document the sample's movement from the custodian to the analyst to final disposition.

1.7 Calibration Procedures and Frequency for Field Test Equipment

Field equipment will be calibrated prior to use in the field as appropriate. The calibration procedures will follow standard manufacturers' instructions and/or Earth Tech's calibration/service specifications to ensure that the equipment is functioning within tolerances established by the manufacturers and required by the project. In addition to regularly scheduled calibration, some instruments such as pH meters require calibration checks before use. All instruments will be monitored for evidence of non-reproducible or erratic readings, and recalibration performed as required. Calibration procedures and the frequency of calibration are described in Section 2.3 of the FSP. A daily record of field analytical instrument (e.g., pH meter and conductivity meter) daily calibration will be maintained in the field logbook or calibration logbook by field personnel. Copies of calibration records for equipment that only needs periodic calibration (e.g., thermometers and sounders) will be available in the field. These records will be subject to QA audit. In addition, any notes on unusual results, changing of standards, battery charging, and operation and maintenance will be included in the logbook.

All instruments are to be stored, transported, and handled with care to preserve equipment accuracy. Damaged instruments will be taken out of service immediately and not used again until a qualified technician repairs and recalibrates the instruments.

Figure 7-2. Internal COC Form

COMPUCHEM ENVIRONMENTAL CORPORATION

Internal Chain-of-Custody

Laboratory: ________________ **Requested By:** ____________

Samples For: 1 2 3 (circle one) **Time Requested:** ____________

Date Requested: ____________

Check Where Applicable:

EPA ____ Water ____

Commercial ____ Soil ____

	CompuChem #'s	Bottle	Containers		CompuChem #'s	Bottle	Containers
1.				11.			
2.				12.			
3.				13.			
4.				14.			
5.				15.			
6.				16.			
7.				17.			
8.				18.			
9.				19.			
10.				20.			

RELINQUISHED BY: ____________ **RECEIVED BY:** ____________
RELINQUISHED BY: ____________ RECEIVED BY: ____________
RELINQUISHED BY: ____________ RECEIVED BY: ____________

COMMENTS

____
____

EARTH TECH | Figure 1-5

CompuChem Internal COC

1.8 Analytical Procedures

Analytical procedures concerning sample preparation, analysis, and reporting must be in accordance with the specified analytical methods and the guidelines in The Handbook (USAF, 1993). The analytical methods to be used during the RI are discussed below.

1.8.1 Identification of Methods

The purpose of the laboratory analyses is to identify the types and concentrations of contaminants in soil, sediment, surface water, and groundwater. The analytical methods to be conducted on samples of these matrices were chosen based on the history of the site and the contaminants which were identified during previous investigations. The contaminants of potential concern include volatiles, semi-volatiles, pesticides/PCBs, and metals.

Analytical methods used in sample analysis for this study are described in:

- SW846: Test Methods for Evaluating Solid Waste (Physical/Chemical Methods) Third Edition, September, 1986, Update I (July, 1992);
- USEPA: Method for Chemical Analysis of Water and Wastes, March, 1983; and
- ASTM.

1.8.2 Detection and Quantitation Limits

1.8.2.1 ***Terminology.*** Two types of detection limits are routinely determined at CompuChem: the Practical Quantitation Limit (PQL) and the Method Detection Limit (MDL). The PQL is defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The MDL is the minimum concentration that can be measured with 99 percent confidence that the parameter is greater than zero. The MDLs are determined from the analysis of a sample in a given matrix (using both laboratory pure water and laboratory pure sand or furnaced sodium sulfate matrices) containing the analyte.

MDLs and PQLs are to be reported by the laboratory prior to sample analysis. Experimentally determined quantitation limits must be approved by the USAF prior to AFP 59 sample analysis. Detection and quantitation limits should never exceed the maximum quantitation limits as presented in Table 2-3 of The Handbook (USAF, 1993)[1]. Values which fall below the PQL but above the MDL will be reported with a J qualifier (estimated).

1.8.2.2 ***Procedures.*** In order to determine the MDL, at least eight replicate samples are prepared containing the analyte(s) to be tested, at a concentration that is equal to or in the same concentration range as the estimated MDL. It is recommended that the concentration fall

[1]Lab-derived PQLs for 8260 that exceed the Handbook quantitation limits but are at or below the PQLs for 8010/8020 (as provided in the Handbook) are an exception.

between one and five times the estimated MDL. The samples are processed through the entire analytical method. The MDL is calculated using the standard deviation of the replicate measurements and the Student's T value at the 99 percent confidence level. The mean analyte value and the mean percent recovery are also calculated.

After determining the MDL for each method, the MDL is then multiplied by four (4) and rounded using CompuChem's rounding and significant figure policies. This rounded raw number is then rounded up to the nearest multiple of five (5), and the result is the PQL.

Therefore, CompuChem's PQLs are in most cases multiples of five (5), allowing for ease in creating standards equal to or less than the PQLs, and standardizing the reporting formats.

1.8.2.3 ***Values***. Analytical methods and CompuChem's associated MDLs and PQLs for the AFP 59 investigation are listed in Tables 1-8 and 1-9, respectively.

1.8.3 Method Calibration

Prior to sample analysis, all analytical instrumentation must be calibrated to ensure the instrumentation is functioning within the established sensitivity range. Instruments must be calibrated and recalibrated at regular intervals as specified by the applicable method, and consistent with the manufacturer's recommendations. The nature and frequency of such checks are specified in the analytical SOPs describing the instrumental analyses performed at CompuChem. Appendix A lists the acceptance criteria and frequencies of the initial and continuing calibrations for the AFP 59 specified methods. Specific method calibration requirements are followed if they are more stringent than those listed here. CompuChem maintains records of all calibrations, recalibrations, and in-service checks of instruments. All calibrations are traceable to primary standards of measurement. Where the concept of traceability of measurement to primary standards is not applicable, CompuChem provides satisfactory evidence of correlation or accuracy of test results.

All standards used for calibration are either provided by the USEPA ("USEPA-certified"), traceable to an USEPA or NIST standard source. Organic standards used in the gas chromatograph (GC) and gas chromatography/mass spectrometry (GC/MS) laboratories are prepared by a fulltime organic standards chemist. Standards are prepared from neat chemicals of guaranteed purity. The stock (primary) standard is then diluted and the working level standard is tested for accuracy of dilution by comparing the new working level standard lot concentrations against the previously prepared lot (before expiration). This standard lot preparation test is described fully in CompuChem's GC/MS Laboratory SOP.

The 1000 parts per million stock cyanide solution is prepared using KCN in a 1:1 ratio. The potassium concentration of the solution is verified by inductively coupled plasma (ICP) analysis, which in turn verifies the cyanide concentration. This standardization is performed with each preparation of the stock solution. The primary standards used for standardization of the ICP are obtained from SPEX and are certified as being traceable to an USEPA or NIST standard source.

TABLE 1-8
ANALYTICAL PARAMETERS AND METHOD DETECTION LIMITS FOR COMPUCHEM

Parameter	Method Detection Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Semivolatile Organic Compounds (Method SW8270)		
Phenol	0.116	2.48
bis(2-Chloroethyl)ether	0.094	2.38
2-Chlorophenol	0.101	5.91
1,3-Dichlorobenzene	0.103	2.56
1,4-Dichlorobenzene	0.106	2.00
Benzyl Alcohol	0.106	3.35
1,2-Dichlorobenzene	0.099	2.52
2-Methylphenol	0.100	4.73
bis(2-Chloroisopropyl)ether	0.138	2.50
4-Methylphenol	0.356	14.13*
N-Nitroso-Di-N-propylamine	0.100	2.31
Hexachloroethane	0.095	3.19
Nitrobenzene	0.125	2.02
Isophorone	0.106	1.31
2-Nitrophenol	0.079	7.25
2,4-Dimethylphenol	0.078	3.81
Benzoic Acid	0.721	10.92
bis(2-Chloroethoxy)methane	2.917*	2.46
2,4-Dichlorophenol	0.073	7.21
1,2,4-Trichlorobenzene	0.096	1.79
Naphthalene	0.089	1.95
4-Chloroaniline	0.118	1.46
Hexachlorobutadiene	0.094	2.24
4-chloro-3-methylphenol	0.068	4.12
2-Methylnaphthalene	0.097	2.17
Hexachlorocyclopentadiene	0.088	1.97
2,4,6-Trichlorophenol	0.144	13.57*
2,4,5-Trichlorophenol	0.177	15.43
2-Chloronaphthalene	0.106	2.08
2-Nitroaniline	0.355	2.87
Dimethyl phthalate	0.089	3.51
Acenaphthylene	0.083	1.64
3-Nitroaniline	0.227	3.73
Acenaphthene	0.091	1.82
2,4,-Dinitrophenol	0.146	22.36
4-Nitrophenol	0.220	7.88
Dibenzofuran	0.086	2.45
2,4,-Dinitrotoluene	0.098	2.25

Table 1-8
Analytical Parameters and Method Detection Limits for CompuChem

Continued

Parameter	Method Detection Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Semivolatile Organic Compounds (Method SW8270) (Continued)		
n-Nitrosodiphenylamine	0.214	3.23
Anthracene	0.102	1.29
Benzo(a)anthracene	0.098	2.98
Benzo(b)fluoranthene	0.079	3.34
Benzo(k)fluoranthene	0.144	7.28
Benzo(g,h,i)perylene	0.090	4.37
Benzo(a)pyrene	0.071	3.26
bis(2-ethylhexyl)phthalate	0.144	2.62
4-Bromophenylphenylether	0.084	2.34
Butylbenzylphthalate	0.070	3.70
4-Chlorophenyl phenyl ether	0.071	2.52
Chrysene	0.152	2.72
Dibenz(a,h)anthracene	0.101	4.34
Di-n-butylphthalate	0.227	9.77
3,3'-Dichlorobenzidine	0.097	2.78
Diethylphthalate	0.069	1.86
2,6-Dinitrotoluene	0.085	2.00
Di-n-octyl phthalate	0.093	3.92
Fluoranthene	0.071	2.54
Fluorene	0.081	1.33
Hexachlorobenzene	0.082	1.60
Indeno(1,2,3,-cd)pyrene	0.156	5.99
Phenanthrene	0.078	1.84
Pyrene	0.079	2.56
4,6-Dinitro-2-methylphenol	0.205	19.86
Pentachlorophenol	0.182	20.63*
Organochlorine Pesticides & PCBs (Method SW8080)		
Aldrin	0.001	0.006
alpha-BHC	0.0005	0.003
beta-BHC	0.001	0.007
delta-BHC	0.0001	0.0002
gamma-BHC (Lindane)	0.0005	0.003
Chlordane	0.0026	0.002
4,4'-DDD	0.001	0.009
4,4'-DDE	0.003	0.007
4,4'-DDT	0.001	0.012
Dieldrin	0.001	0.011
Endosulfan I	0.0009	0.004
Endosulfan II	0.004	0.005
Endosulfan sulfate	0.003	0.047
Endrin	0.001	0.011

Table 1-8
Analytical Parameters and Method Detection Limits for CompuChem

Continued

Parameter	Method Detection Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Organochlorine Pesticides & PCBs (SW8080) (Continued)		
Endrin aldehyde	0.002	0.012
Heptachlor	0.005	0.004
Heptachlor epoxide	0.002	0.009
Methoxychlor	0.007	0.045
Toxaphene	0.027	0.658
PCB-1016	0.011	0.071
PCB-1221	0.010	0.479
PCB-1232	0.009	0.230
PCB-1242	0.007	0.608
PCB-1248	0.039	0.181
PCB-1254	0.004	0.382
PCB-1260	0.013	0.0835
Volatile Organics (Method SW8260 25mL purge)		
Dichlorodifluoromethane	0.004	0.16
Benzene	0.008	0.07
Bromodichloromethane	0.011	0.17
Bromoform	0.002	0.08
Bromomethane	0.0008	0.12
2,2-Dichloropropane	0.002	0.23
Carbon tetrachloride	0.006	0.07
Chlorobenzene	0.001	0.10
Chlorodibromomethane	0.002	0.10
Chloroethane	0.001	0.12
Trichlorofluoromethane	0.003	0.16
Chloroform	0.003	0.13
Chloromethane	0.003	0.13
1,1-Dichloroethane	0.004	0.18
1,2-Dichloroethane	0.006	0.07
1,1-Dichloroethene	0.002	0.17
trans-1,2-Dichloroethene	0.002	0.18
1,2-Dichloropropane	0.004	0.13
cis-1,3-Dichloropropene	0.007	0.48
trans-1,3-Dichloropropene	0.007	0.15
Ethylbenzene	0.001	0.10
cis-1,2-Dichloroethene	0.005	0.22
Methylene chloride	0.014	1.64
Bromochloromethane	0.004	0.18
Styrene	0.002	0.09
1,1,2,2-Tetrachloroethane	0.003	0.10
Tetrachloroethene	0.002	0.10

Table 1-8
Analytical Parameters and Method Detection Limits for CompuChem

Continued

Parameter	Method Detection Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Volatile Organics (Method SW8260 25 mL purge) (Continued)		
Toluene	0.007	0.12
1,1,1-Trichloroethane	0.002	0.10
1,1,2-Trichloroethane	0.006	0.10
Trichloroethene	0.005	0.10
1,1-Dichloropropene	0.007	0.10
Vinyl chloride	0.003	0.13
Total Xylenes	0.001	0.11
n-Propyl Benzene	0.003	0.17
Dibromomethane	0.011	0.22
1,3-Dichloropropane	0.003	0.15
1,2-Dibromoethane	0.006	0.09
1,1,1,2-Tetrachloroethane	0.007	0.09
Isopropyl Benzene	0.002	0.12
1,2,3-Trichloropropane	0.003	0.20
Bromobenzene	0.002	0.12
2-Chlorotoluene	0.001	0.12
4-Chlorotoluene	0.001	0.13
tert-Butyl Benzene	0.001	0.13
1,3,5-Trimethyl Benzene	0.001	0.13
1,2,4-Trimethyl Benzene	0.002	0.13
sec-Butyl Benzene	0.001	0.13
1,3-Dichlorobenzene	0.001	0.12
p-Isopropyl Toluene	0.001	0.13
1,4-Dichlorobenzene	0.002	0.12
1,2-Dichlorobenzene	0.002	0.10
n-Butyl Benzene	0.002	0.13
1,2-Dibromo-3-Chloropropane	0.004	0.10
1,2,4-Trichlorobenzene	0.003	0.13
Naphthalene	0.002	0.09
Hexachlorobutadiene	0.003	0.14
1,2,3-Trichlorobenzene	0.003	0.17
Total Organic Carbon (Method SW9060)		
TOC	78.78	NA
Cyanide, Total (Method SW9010)		
Cyanide, Total	0.22	0.0004 mg/L

TABLE 1-8
ANALYTICAL PARAMETERS AND METHOD DETECTION LIMITS FOR COMPUCHEM

Continued

Parameter	Method Detection Limits	
	Soil (mg/kg)	Water (mg/L, unless otherwise indicated)
ICP Screen for Metals (Method SW6010)		
Aluminum (Al)	33.56	0.028
Antimony (Sb)	1.68	0.044
Arsenic (As)	4.07	0.133
Barium (Ba)	0.16	0.0009
Beryllium (Be)	0.14	0.0005
Cadmium (Cd)	0.26	0.004
Calcium (Ca)	16.76	0.251*
Chromium (Cr)	0.57	0.004
Cobalt (Co)	0.42	0.004
Copper (Cu)	0.73	0.002
Iron (Fe)	9.52*	0.028
Lead (Pb)	1.50	0.041
Magnesium (Mg)	12.99	0.014
Manganese (Mn)	1.31	0.0008
Molybdenum (Mo)	2.75	0.015
Nickel (Ni)	2.04	0.012
Potassium (K)	132.27	0.539
Selenium (Se)	3.83	0.168
Silver (Ag)	0.19	0.001
Sodium (Na)	94.87*	0.108
Thallium (Tl)	5.84	0.079
Vanadium (V)	1.00	0.001
Zinc (Zn)	2.15*	0.002
Mercury (SW7470, SW7471)		
Mercury	0.073	0.00006
Arsenic (SW7060)		
Arsenic	0.21	0.0004
Lead (SW7421)		
Lead	0.07	0.001
Selenium (SW7740)		
Selenium	0.19	0.001
Thallium (SW7841)		
Thallium	0.15	0.0007
Soil Moisture Content (ASTM D2216)	NA	NA

*Method detection limits are greater than the practical quantitation limits as stated in Table 2-3 of The Handbook (USAF, 1993).

TABLE 1-9
ANALYTICAL PARAMETERS AND PRACTICAL QUANTITATION LIMITS FOR COMPUCHEM

Parameter	Practical Quantitation Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Semivolatile Organic Compounds (Method SW8270)		
Phenol	0.470	10
bis(2-Chloroethyl)ether	0.380	10
2-Chlorophenol	0.410	25
1,3-Dichlorobenzene	0.420	15
1,4-Dichlorobenzene	0.430	10
Benzyl Alcohol	0.430	15
1,2-Dichlorobenzene	0.400	15
2-Methylphenol	0.410	20
bis(2-Chloroisopropyl)ether	0.560	15
4-Methylphenol	2.900	120
N-Nitroso-Di-N-propylamine	0.410	10
Hexachloroethane	0.390	15
Nitrobenzene	0.510	10
Isophorone	0.430	10
2-Nitrophenol	0.320	30
2,4-Dimethylphenol	0.320	20
Benzoic Acid	2.900	45
bis(2-Chloroethoxy)methane	12.000	10
2,4-Dichlorophenol	0.300	30
1,2,4-Trichlorobenzene	0.390	10
Naphthalene	0.360	10
4-Chloroaniline	0.480	10
Hexachlorobutadiene	0.380	10
4-chloro-3-methylphenol	0.280	20
2-Methylnaphthalene	0.400	10
Hexachlorocyclopentadiene	0.360	10
2,4,6-Trichlorophenol	0.580	55
2,4,5-Trichlorophenol	0.710	65
2-Chloronaphthalene	0.430	10
2-Nitroaniline	1.500	15
Dimethyl phthalate	0.360	15
Acenaphthylene	0.340	10
3-Nitroaniline	0.920	15
Acenaphthene	0.370	10
2,4,-Dinitrophenol	0.590	90
4-Nitrophenol	0.890	35
Dibenzofuran	0.350	10
2,4,-Dinitrotoluene	0.400	10

TABLE 1-9
ANALYTICAL PARAMETERS AND PRACTICAL QUANTITATION LIMITS FOR COMPUCHEM

Continued

Parameter	Practical Quantitation Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Semivolatile Organic Compounds (Method SW8270) (Continued)		
n-Nitrosodiphenylamine	0.860	10
Anthracene	0.420	10
Benzo(a)anthracene	0.400	15
Benzo(b)fluoranthene	0.320	15
Benzo(k)fluoranthene	0.580	30
Benzo(g,h,i)perylene	0.370	20
Benzo(a)pyrene	0.290	15
bis(2-ethylhexyl)phthalate	0.580	15
4-Bromophenylphenylether	0.340	10
Butylbenzylphthalate	0.290	15
4-Chlorophenyl phenyl ether	0.290	15
Chrysene	0.610	15
Dibenz(a,h)anthracene	0.410	20
Di-n-butylphthalate	0.910	40
3,3'-Dichlorobenzidine	0.400	15
Diethylphthalate	0.280	10
2,6-Dinitrotoluene	0.350	10
Di-n-octyl phthalate	0.380	20
Fluoranthene	0.290	15
Fluorene	0.330	10
Hexachlorobenzene	0.330	10
Indeno(1,2,3,-cd)pyrene	0.630	25
Phenanthrene	0.320	10
Pyrene	0.320	15
4,6-Dinitro-2-methylphenol	0.830	80
Pentachlorophenol	0.730	85
Organochlorine Pesticides & PCBs (Method SW8080)		
Aldrin	0.010	0.025
alpha-BHC	0.0025	0.025
beta-BHC	0.010	0.050
delta-BHC	0.00075	0.0010
gamma-BHC (Lindane)	0.0025	0.025
Chlordane	0.015	0.020
4,4'-DDD	0.010	0.050
4,4'-DDE	0.015	0.050
4,4'-DDT	0.010	0.075
Dieldrin	0.010	0.050
Endosulfan I	0.0050	0.025
Endosulfan II	0.020	0.025
Endosulfan sulfate	0.020	0.025
Endrin	0.010	0.050

TABLE 1-9
ANALYTICAL PARAMETERS AND PRACTICAL QUANTITATION LIMITS FOR COMPUCHEM

Continued

Parameter	Practical Quantitation Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Organochlorine Pesticides & PCBs (SW8080) (Continued)		
Endrin aldehyde	0.015	0.075
Heptachlor	0.0025	0.025
Heptachlor epoxide	0.015	0.050
Methoxychlor	0.030	0.025
Toxaphene	0.110	3.0
PCB-1016	0.050	0.50
PCB-1221	0.045	2.0
PCB-1232	0.040	1.0
PCB-1242	0.030	2.5
PCB-1248	0.160	0.75
PCB-1254	0.020	2.0
PCB-1260	0.060	0.50
Volatile Organics (Method SW8260 25mL purge)		
Dichlorodifluoromethane	0.010	1.0
Benzene	0.015	0.75
Bromodichloromethane	0.015	0.50
Bromoform	0.020	0.50
Bromomethane	0.010	0.50
2,2-Dichloropropane	0.015	0.50
Carbon tetrachloride	0.015	1.0
Chlorobenzene	0.015	0.50
Chlorodibromomethane	0.015	0.50
Chloroethane	0.020	0.50
Trichlorofluoromethane	0.010	1.0
Chloroform	0.015	0.75
Chloromethane	0.015	1.0
1,1-Dichloroethane	0.015	0.75
1,2-Dichloroethane	0.020	0.75
1,1-Dichloroethene	0.015	0.75
trans-1,2-Dichloroethene	0.015	1.0
1,2-Dichloropropane	0.015	0.75
cis-1,3-Dichloropropene	0.015	0.50
trans-1,3-Dichloropropene	0.015	0.50
Ethylbenzene	0.015	0.75
cis-1,2-Dichloroethene	0.015	0.50
Methylene chloride	0.035	15
Bromochloromethane	0.015	1.0
Styrene	0.015	0.50
1,1,2,2-Tetrachloroethane	0.030	0.50
Tetrachloroethene	0.015	0.75

TABLE 1-9
ANALYTICAL PARAMETERS AND PRACTICAL QUANTITATION LIMITS FOR COMPUCHEM

Continued

Parameter	Practical Quantitation Limits	
	Soil (mg/kg)	Water (µg/L, unless otherwise indicated)
Volatile Organics (Method SW8260 25 mL purge) (Continued)		
Toluene	0.015	0.75
1,1,1-Trichloroethane	0.015	0.75
1,1,2-Trichloroethane	0.020	0.75
Trichloroethene	0.015	0.75
1,1-Dichloropropene	0.015	1.0
Vinyl chloride	0.010	1.0
Total Xylenes	0.015	0.50
n-Propyl Benzene	0.015	0.75
Dibromomethane	0.020	0.75
1,3-Dichloropropane	0.010	0.75
1,2-Dibromoethane	0.020	0.75
1,1,1,2-Tetrachloroethane	0.015	0.75
Isopropyl Benzene	0.015	0.75
1,2,3-Trichloropropane	0.025	1.0
Bromobenzene	0.015	0.50
2-Chlorotoluene	0.015	0.50
4-Chlorotoluene	0.015	0.50
tert-Butyl Benzene	0.015	0.75
1,3,5-Trimethyl Benzene	0.015	0.50
1,2,4-Trimethyl Benzene	0.015	0.50
sec-Butyl Benzene	0.015	0.75
1,3-Dichlorobenzene	0.015	0.50
p-Isopropyl Toluene	0.015	0.75
1,4-Dichlorobenzene	0.015	0.75
1,2-Dichlorobenzene	0.020	0.50
n-Butyl Benzene	0.015	0.75
1,2-Dibromo-3-Chloropropane	0.030	1.5
1,2,4-Trichlorobenzene	0.025	0.50
Naphthalene	0.035	0.75
Hexachlorobutadiene	0.025	0.75
1,2,3-Trichlorobenzene	0.020	0.75
Total Organic Carbon (Method SW9060)		
TOC	78.78	NA
Cyanide, Total (Method SW9010)		
Cyanide, Total	0.90	0.018 mg/L

Table 1-9
Analytical Parameters and Practical Quantitation Limits for CompuChem

Continued

Parameter	Practical Quantitation Limits	
	Soil (mg/kg)	Water (mg/L, unless otherwise indicated)
ICP Screen for Metals (Method SW6010)		
Aluminum (Al)	135	0.12
Antimony (Sb)	7.0	0.180
Arsenic (As)	--	--
Barium (Ba)	0.65	0.0040
Beryllium (Be)	0.60	0.0025
Cadmium (Cd)	1.5	0.019
Calcium (Ca)	68.0	1.0
Chromium (Cr)	2.5	0.019
Cobalt (Co)	2.0	0.020
Copper (Cu)	3.0	0.010
Iron (Fe)	38.5	0.12
Lead (Pb)	--	--
Magnesium (Mg)	52.0	0.058
Manganese (Mn)	5.5	0.0035
Molybdenum (Mo)	11.0	0.056
Nickel (Ni)	8.5	0.050
Potassium (K)	530	2.2
Selenium (Se)	--	--
Silver (Ag)	0.80	0.0080
Sodium (Na)	380	0.44
Thallium (Tl)	--	--
Vanadium (V)	4.0	0.0065
Zinc (Zn)	9.0	0.0095
Mercury (SW7470, SW7471)		
Mercury	0.30	0.00025
Arsenic (SW7060)		
Arsenic	0.85	0.018
Lead (SW7421)		
Lead	0.30	0.0075
Selenium (SW7740)		
Selenium	0.80	0.0075
Thallium (SW7841)		
Thallium	0.25	0.0035
Soil Moisture Content (ASTM D2216)	NA	NA

1.9 Data Reduction, Validation, and Reporting

The process for data management, reduction, validation and reporting throughout the entire data collection process is described in the following sections.

1.9.1 Data Management

The following data management flow chart addresses laboratory data review. Contractor data validation will be discussed in Section 1.9.4.

LABORATORY DATA REVIEW

REVIEW LEVEL 1 (BENCH LEVEL)

- Cross-check Sample ID
- Verify QC acceptance criteria are met
- Verify target analytes are within instrumentation range and determining appropriate dilutions when necessary
- Verify COC is intact based on accompanying paperwork

↓

REVIEW LEVEL 2 (IN-LAB DATA REVIEW STAFF)

- Verify all assessments previously made
- Verify accuracy and precision QC criteria are met
- Verify analytical worksheets, preparation and instrument logs have been correctly completed by the operator/analyst, including date and initials
- Verify that good laboratory practices were followed relative to the correct procedure in making changes to data

↓

REVIEW LEVEL 3 (FINAL TECHNICAL REVIEW)

- Assess the complete data report
- Double check all items previously verified by the in-lab data reviewer
- Review all data summary documents and verify correct transcription from raw data
- Check the data report or case for completeness, including requirements for the complete sample delivery group
- Make a comparative evaluation of data from individual fractions of a sample, and of samples from the same site, project, or case for consistency of analytical results and resolution of discrepancies

↓

CONTRACTOR DATA REVIEW/VALIDATION

1.9.2 Data Reduction

Chemical data shall be submitted to Earth Tech in hardcopy data packages and in the Installation Restoration Program Information Management System (IRPIMS) electronic format. It shall be the responsibility of the laboratory QA Officer to check the raw laboratory data for completeness and accuracy. Raw laboratory data shall be transferred from the laboratory reports to the IRPIMS database. In addition, the IRPIMS data shall be checked for errors using the IRPIMS quality control tool (QCTOOL).

1.9.3 Data Quality Assessment

Data quality assessment will occur in two parts. Part one involves identifying valid data by reviewing field and analytical data. Part two of the data quality assessment will identify and compare valid data to environmental conditions. Both parts of the assessment are discussed below.

1.9.3.1 Field Record Review. At a minimum, 100 percent of the field records shall be reviewed for the following.

- Field record completeness
- Valid sample identification
- Correlation of field test data
- Field test data anomalies
- Assessment of the accuracy and precision of the field test data and measurements.

1.9.3.2 Laboratory Data Review. Laboratory data review shall emphasize the following items.

- COC forms
- Holding times
- Method calibration limits
- Method blanks
- Laboratory verification of quantitation limits
- Preparatory batch control records
- Corrective actions
- Formulas used for analyte quantitation
- Examples of analyte quantitation
- Completeness of data.

In addition to the above items, the data reviewer shall review control charts and assess associated statistical trends, to ensure that the analytical process is in control. The control chart is generated by the analysis of the LCSs (blank spikes). After 20 data points are generated, the LCS results are used to calculate method control limits, and subsequently the control chart.

Laboratory and field blanks will be reviewed and qualified based on the USEPA's 5x and 10x rules. If there is any contamination in the blank, the associated sample must be greater than 5 or 10 times (depending on the constituent) the amount in the blank in order to be considered valid; otherwise, qualification of the sample may be necessary.

1.9.3.3 Procedures for Handling Out-of-Control Data. If after the review it is ascertained that certain field and/or laboratory data is out-of-control, these samples (either normal environmental samples or QC samples) shall be identified, and a corresponding corrective action report shall accompany the out-of-control event. In addition, all anomalies will be noted and discussed in the technical report.

1.9.4 Data Validation and Reporting

USEPA CLP "National Functional Guidelines for Organic Data Review" (USEPA, 1993) and "National Functional Guidelines for Inorganic Data Review" (USEPA, 1994) protocols shall be followed in validating the data. A total of 10 percent of the complete data set will be validated by Earth Tech. Qualifiers will be used as dictated by the aforementioned protocols, in conjunction with the field record and laboratory data reviews.

1.10 Internal Quality Control Checks for Field and Laboratory Operations

Field and laboratory QC checks are discussed below.

1.10.1 Field Quality Control

Field QC procedures are discussed in Section 2.4 of the FSP.

1.10.2 Laboratory Quality Control

Laboratory QC focuses on ensuring that each chemical measurement has the highest probability of achieving method protocols for precision and accuracy. QC samples such as method blanks, spikes, and duplicates are evaluated and documented on a routine basis. Spike and surrogate recoveries, as appropriate, are calculated and this QC data is compared with laboratory-established control limits. NIST-traceable standards should be used for spiking compounds and surrogates when available. Laboratory QC procedures are discussed below.

Analytical Batch. The analytical or preparation batch is comprised of a maximum number of 20 samples which are analyzed together through the rate-determining step of the method, and with the manipulations common to each sample within the same time period, or in continuous sequential time periods. Samples in each batch should be of similar composition and include QC samples, such as blanks and spiked samples. Accuracy will be determined through the recoveries of surrogate compounds or LCSs. Precision within an analytical batch will be assessed by the % RSD of the LCS analytes.

Method Blank. A method blank is an analyte-free matrix used to monitor the system for interferences and contamination from glassware, reagents, etc. The method blank is taken through the entire sample preparation process and is included with each lot of extractions/digestions prepared, regardless of method.

Matrix Spikes. A matrix spike is an aliquot of the environmental sample which is spiked with the analytes of interest prior to analysis. At a minimum, for every 20 samples analyzed, there shall be a MS/MSD pair analyzed for organics, and a MS sample analyzed for inorganics. All MS and MSD samples shall be project-specific.

Laboratory Control Samples. A laboratory control sample is a method blank which is spiked with the analytes of interest in order to monitor the performance of the analytical method. Historical data of the LCSs are used to generate control charts.

Surrogate Compounds. For GC and GC/MS analyses, the analytical process includes the addition, subsequent detection, and recovery calculations of surrogate spiking compounds. Surrogate compounds are added to every field and QC sample at the beginning of the sample preparation. The surrogate recovery is used to monitor matrix effects and sample preparation. Compounds that meet the following criteria are suitable surrogate compounds:

- Compounds not requested for analysis.
- Compounds that do not interfere with the determination of required analytes.
- Compounds that are not naturally occurring, yet are chemically similar to the required analytes.

1.10.3 Control Limits

CompuChem's control limits, acceptance criteria and frequencies for laboratory QC samples are listed in Appendix A. Corrective actions to be taken if analytes are not within the control limits are also listed in this appendix.

1.11 Performance and System Audits

Performance and system audits shall be used to monitor project activities to assure compliance with the QA objectives and procedures. Audits may be performed by AFCEE, Earth Tech, or the laboratory QA Officer. Major aspects of the system and performance audits are described below.

1.11.1 System Audits

System audits are performed both by internal and external auditors. The QA department performs quarterly internal system audits. Earth Tech and federal and state certifying agencies may perform external system audits. Certification officers from various state agencies, including North Carolina, California, New Jersey, New York, Wisconsin, Florida, Massachusetts, South Carolina, Connecticut, and New Hampshire, conduct system audits of CompuChem. Most of these state certification programs specify that onsite inspections are to be conducted annually. A system audit is performed to qualitatively assess CompuChem's control system and is intended to provide evidence of the laboratory's competence.

1.11.2 Performance Audits

CompuChem's QA staff conduct performance audits to evaluate the quality of the data produced by the analytical system. These audits are performed independently of and in addition to routine QC checks, and reflect as closely as possible laboratory performance under normal operating conditions. Often, as a result of deficiencies observed during ongoing performance audits, a full system audit may be initiated.

1.11.2.1 Internal Performance Audits. Internal performance audits include analysis and assessment of double-blind performance evaluation (PE) samples (analyzed semi-annually) and single-blind QC reference standards (analyzed quarterly); assessment of proficiency tests for new methods; assessment of MDL and method validation studies (performed annually); and assessment of QC repeat statistics.

The data reports for the PE samples are mailed to a cooperative laboratory and reported back to CompuChem's QA auditor. Only the QA auditor and marketing representative are aware of the introduction of the PE sample into the system. The results of the single-blind QC reference standards are filed for historical performance review and trend analysis as needed. Method validation studies are performed as part of the development process for new methods and are reviewed and assessed by the QA department. QC repeat statistics are summarized by the QA manager in the QA monthly report.

1.11.2.2 External Performance Audits. CompuChem also participates in a number of external, interlaboratory PE studies; one to four external PE studies are conducted each month throughout the year. These include the Water Pollution studies originating from USEPA-Cincinnati, the New York Department of Health non-potable PE series, the EMSL-LV radiological PE studies, the DOE-EML radiological intercomparison studies, samples from state certifying agencies, and independent PE studies to support the HAZWRAP/NEESA/DOE and the Army Corps of Engineers programs.

1.12 Preventive Maintenance

The primary objective of a preventive maintenance program is to help ensure the timely and effective completion of a measurement effort by minimizing the down time of crucial sampling and/or analytical equipment due to expected or unexpected component failure. In implementing the preventive maintenance program, efforts are focused in three primary areas: maintenance responsibilities, maintenance schedules, and maintaining an adequate inventory of critical spare parts and equipment.

1.12.1 Procedures

CompuChem is a high-capacity laboratory that maintains a large inventory of instrumentation that facilitates rapid sample turnaround time. Expert technicians maintain and service the instruments, which reduces the possibility of time lost due to instrument failure. Historically, instruments have been properly functioning 97 percent of the time. Alternative instruments are always available.

Full-time experts maintain the analytical instruments, and perform routine and preventive maintenance and major instrument repairs on site. The instrument repair experts have a large in-house stock of spare parts to expedite repairs. CompuChem also has service agreements with instrument manufacturers to further support the instrument maintenance and repair program.

1.12.2 Schedule

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each major equipment item. A specific schedule is established for all routine maintenance activities. Other maintenance activities may also be identified as requiring attention on an as-needed basis. Manufacturers' recommendations and/or sample throughput provide the basis for the established maintenance schedules. Manufacturers' service contracts provide primary maintenance for many major instruments (e.g., GC/MS instruments, atomic absorption spectrometers, analytical balances, etc.). Maintenance activities for each instrument are documented in a maintenance log which indicates the required frequency for each procedure and provides for dated entries.

1.12.3 List of Critical Spare Parts

The respective laboratory managers are responsible for maintaining an adequate inventory of necessary spare parts. Sufficient equipment should be on hand to continue analyses in the event that an instrument encounters problems. In addition to backup instrumentation, a supply of spare parts such as GC columns, fittings, septums; atomic absorption lamps, mirrors, diaphragms; graphite furnace tubes, and other ancillary equipment should be maintained.

1.13 Field and Laboratory Procedures Used to Assess Chemical Data Precision, Accuracy, and Compliance

1.13.1 Formulas

Formulas used to calculate precision, accuracy and completeness are presented in Section 1.4.1.

1.13.2 Control Limits

CompuChem's control limits, spiking compounds and their concentrations are presented in Appendix A.

1.13.3 Documentation

Documentation and reporting requirements are presented in Section 1.15.

1.14 Corrective Action

The response to out-of-control events, the reestablishment of control, and the documentation of these activities are summarized in the following sections.

1.14.1 Response

The need for corrective action comes from several sources: equipment malfunction; failing internal QA/QC checks; failing performance or system audits; and noncompliance with QA requirements.

When measurement equipment or analytical methods fail QA/QC, the problems shall immediately be brought to the attention of the Project Manager and the QA Officer. Corrective measures to be taken shall depend on the type of analysis, the extent of the error, and whether the error is determinant or not. The corrective action to be taken is determined by either the Technical Operations Manager, analyst, Project Manager, QA Officer, or by all of them in conference.

A corrective action can be as extensive as replacing a complete lot of contaminated extraction solvent; reextracting and analyzing of a complete batch of samples due to reagent blank contamination; or as simple as recalculating a series of results because a wrong dilution factor was applied. The proper corrective action shall be determined on a case by case basis. Any out-of-control event must be documented on a non-conformance or similar report, which will identify the event, the problem resolution, and how analytical control is reestablished. Non-conformance documentation is filed in binders and kept in the QA department office. Corrective action procedures are provided in Appendix A.

1.14.2 Reestablishment of Control

If corrective action is necessary because of equipment malfunction, the equipment shall be repaired, precision and accuracy of the repaired equipment shall be reassessed, and the analysis shall be rerun. All attempts shall be made to reanalyze all samples affected by the equipment malfunction so that the product is not affected by failure of QA requirements.

When a result in a performance audit is unacceptable, the laboratory shall identify the problems and implement corrective actions immediately. A step-by-step analysis and investigation to determine the cause of the problem shall take place as part of the corrective action program. If the problem cannot be controlled, the laboratory shall analyze what the impact shall be on the data results.

When a system audit reveals unacceptable performance, work shall be suspended until corrective action has been implemented and performance has been proven to be acceptable.

1.14.3 Documentation

When out-of-control events occur, they are documented and corrective action is implemented. How such events are documented depends on the type of event and area in which the out-of-control event occurs. Most out-of-control events identified during routine sample processing are restricted to single samples, batches, or data reports. Some examples of these types of events include:

- Incorrect client identifier on COC documents
- Broken or unpreserved samples received
- Lab accident during sample processing
- Accuracy failures for surrogate and/or spike standards
- Precision failures between duplicates
- Variations in internal standard responses
- Contamination of method blank
- Errors or omissions in data reports.

An example of the CompuChem "Customer Problem Resolution Report" form is shown in Figure 1-6. This form shall be used by CompuChem to document non-conformance events.

1.15 Quality Assurance Reports

Effective management of a field sampling and analytical effort requires timely assessment and review of field and laboratory activities. This shall require effective interaction and feedback between the field team members, the Earth Tech Project Manager, the Earth Tech QA Coordinator, and the laboratory QA Officer.

1.15.1 Reporting Procedures

The laboratory QA Officer and appropriate project team members shall be responsible for keeping the Earth Tech Project Manager up to date regarding the status of their respective tasks so that quick and effective solutions can be implemented should any data quality problems arise.

Sampling activities shall be reviewed on a daily basis by the Earth Tech Project Manager to determine if the sampling QC requirements are being fulfilled, such as whether the proper number of blank and duplicate samples are taken for each parameter sampled. All data sheets and logbooks shall be reviewed daily. Any needed corrective action shall be initiated and documented daily.

The laboratory QA Officer has the responsibility of reviewing all laboratory analytical activities to ensure compliance with the QC requirements outlined in this QAPP. This review serves as a control function in that it should be conducted frequently so deviations from method requirements shall be immediately identified and corrected.

1.15.2 Report Content

The QA Officer in conjunction with the laboratory Project Manager, will provide tabulation of all QC sample data and documentation of all events or components that have the potential to affect data quality. The contents of the QA document will include:

- An assessment of data quality indicators, i.e. precision, accuracy, and completeness;

- Rationale for any deviations from target detection limits or associated QC criteria;

Figure 15-1

COMPUCHEM LABORATORIES, INC.
CUSTOMER PROBLEM RESOLUTION REPORT

ORIGINATOR (TO BE COMPLETED BY ORIGINATOR)

Client Name/Project ____________
Address ____________
Address ____________ Phone # ______
Priority ____________ Account # ______
Case # ____________ SDG # ______
Rpt. Style ____________ Order # ______

CC #s

Date inquiry rcvd _____ Internal? Y or N
Originator/AA/Sales Rep ______
Desired response date ______
Priority Code
CPR Codes

Attachments

_____Order _____Req _____Phonelog
_____Quote _____Note _____Other

Notes/Problems/Background ____________

RESOLUTION (TO BE COMPLETED BY ASSIGNEE)

Date rcvd ______ Referred to ____________
Commit date ______ Client issue valid? Y or N
Completed date ______ Resolved by ____________
Resolution time ____________
Notes/Action/Info ____________

CPR Contact date ______
Contact with Originator ______
New Codes

QA/CORRECTIVE ACTION/NON-CONFORMANCE RECURRENCE CONTROL

Corrective Action Required? Y or N
QA Person Responsible ____________
Deficiency ____________

Target completion date ______
Actual completion date ______

Action to be taken/Assignment ____________

QA follow-up/recurrence audit findings ____________

SOP modified? Y or N Target date ____

Auditor ______ CAR closed ______

SPR# 0202

WHITE: ASSIGNEE/RESOLUTION COPY CANARY: CPRTC COPY PINK: CPR TRACKING GOLDENROD: ORIGINATOR COPY

EARTH TECH | Figure 1-6

CompuChem
Non-Conformance Report

- Possible effects on sample data of contaminants found in sample blanks; and

- Documentation of any QA problem, its solution, and its possible effect on the sampling or analysis program results.

In addition, the report will include a discussion of laboratory data, including:

- Spike levels and the reasons for choosing those levels;

- Possible effects on environmental sample results of detected concentrations in method blanks;

- Unique matrix characteristics of environmental samples that may have affected analysis; and

- Documentation of any out-of-control events, including cause, remediation, and actions taken to prevent recurrence.

Return to control is verified through the use of CompuChem's "Customer Problem Resolution Report" form, which documents the return to control target and actual completion dates.

1.16 Variations

If a task is to be completed in a manner other than described in this QAPP or the Statement of Work (SOW), written approval will be obtained from AFCEE prior to implementing the deviation.

SECTION 2.0

FIELD SAMPLING PLAN

This FSP documents the field and laboratory procedures that will be implemented in completing the RI of AFP 59. Adherence to these procedures ensures that all information and data collected lead to technically sound, statistically valid, and properly documented conclusions.

2.1 Field Operations

The overall objectives of the RI field sampling program are to:

- Collect environmental samples which best characterize soil, groundwater, sediment, and surface water quality at AFP 59.
- Handle environmental samples in a manner which ensures their safe, predictable, and timely delivery to a laboratory for analysis.

It is the responsibility of the Project Manager to verify that all fieldwork conducted during the RI complies with the procedures outlined in this FSP.

Fieldwork will be conducted in two phases. Phase I is scheduled to start in July 1994 and Phase II in October 1994.

Phase I

- Collect soil and groundwater samples using the direct push sampling method, and analyze for VOCs using an onsite mobile laboratory equipped with a GC.
- Collect grab samples of groundwater from existing monitoring wells and analyze for VOCs at an onsite mobile laboratory.
- Obtain synoptic round of water level measurements from accessible, existing wells.

Phase II

- Perform an aquifer pumping test using the onsite production well and existing monitoring wells.

- Collect soil samples during drilling for lithologic description and chemical analysis.

- Install and develop new monitoring wells.

- Collect groundwater samples for chemical analysis in all new and existing monitoring wells.

- Collect surface water and sediment samples from Little Choconut Creek for chemical analysis.

- Survey the locations and elevations of the new monitoring wells, soil borings, and surface water and sediment sampling locations.

2.1.1 Site Reconnaissance, Preparation, and Restoration Procedures

Prior to subsurface sampling, a geophysical subsurface utility clearance survey will be conducted (see Section 2.1.2). Earth Tech personnel performing the geophysical survey will be assisted through the use of utility maps provided by AFP 59 personnel. All underground utilities will be marked, and the locations of all subsurface sampling locations will be marked with pin flags or spray paint. All subsurface sampling locations will be approved by the Earth Tech Project Manager as well as the AFCEE RTC, ASC RPM, and AFP 59 point-of-contact (POC) before sampling activities are begun.

Fieldwork associated with the RI will be coordinated with the AFP 59 POC to minimize disruption of plant activities during the fieldwork. AFP 59 will provide the following support for the completion of the fieldwork.

(1) Assist Earth Tech in locating underground utilities by providing site utility maps.

(2) Approve a location for an equipment decontamination pad.

(3) Approve accumulation points at AFP 59 where containerized decontamination fluids, drill cuttings, and development/purge water can be stored prior to disposal.

(4) Provide Earth Tech with existing engineering plans, drawings, diagrams, aerial photographs, etc. necessary to complete the RI.

(5) Prior to initiation of fieldwork, arrange for the following to support Earth Tech field personnel and subcontractors.

    - Personnel identification badges, vehicle passes, and/or entry permits
    - A secure staging area for storing equipment and supplies
    - A sufficient potable water supply.

All downhole drilling tools (drill bits and rods, augers, etc.) and equipment will be decontaminated before drilling each new borehole. Decontamination activities will follow the procedures outlined in Section 2.1.11.

Emergency equipment (fire extinguishers, personal safety equipment, etc.) will be kept in plain view where fieldwork is being conducted. In addition, work crews may be equipped with a mobile telephone that allows them to quickly alert security and the appropriate emergency services should their assistance be required.

One of the objectives of the RI fieldwork at AFP 59 is to leave the site essentially as it was before the beginning of the RI, except for the physical addition of monitoring wells and guard posts. Drill cuttings, unused monitoring well construction materials, stakes, flagging, etc. will be removed after drilling the borings and installing and developing the monitoring wells. It is anticipated that vegetation will not be disturbed or the erosion potential increased as a result of the fieldwork. Any necessary restoration will be completed in close coordination with the AFP 59 POC to ensure that all operations are in accordance with the overall management of the plant.

2.1.2 Subsurface Utility Clearance Surveys

Prior to sampling subsurface locations at AFP 59, Earth Tech will conduct a geophysical clearance survey to determine the locations of underground utilities or other objects buried beneath the ground surface. The geophysical methods used for the clearance will be electromagnetic imaging (EMI), ground penetrating radar (GPR), and magnetic profiling. Site utility maps will be used in conjunction with these three methods to locate buried utilities. These complimentary techniques will be used because underground utilities are made of many different materials (ferrous steel, aluminum, polyvinyl chloride, and ceramic). EMI profiling can detect changes in electrical properties due to changes in soil conductivity related to changing soil types, groundwater, or anthropogenic metal objects. EMI has an effective penetration depth of approximately 8 feet. GPR responds to changes in dielectric properties and is usually effective to approximately 10 feet. Magnetic profiling can detect steel and iron objects and has an effective penetration depth of approximately 10 feet.

The EMI, GPR, and magnetic profiling instruments are calibrated once by the factory and maintained according to manufacturers' specifications. Each instrument has built-in functional tests which will be performed daily and the results will be documented. If the instruments are not functioning properly, they will be sent to the manufacturer for repair and recalibration. Any data recorded with a possibly malfunctioning instrument will be remeasured.

Any underground utilities detected during the geophysical clearance survey will be marked in paint. Subsurface sampling locations will also be marked with spray paint or with a pin flag. Sampling locations will be mapped along with all utilities and anamolies.

2.1.3 Direct Push Soil and Groundwater Sampling

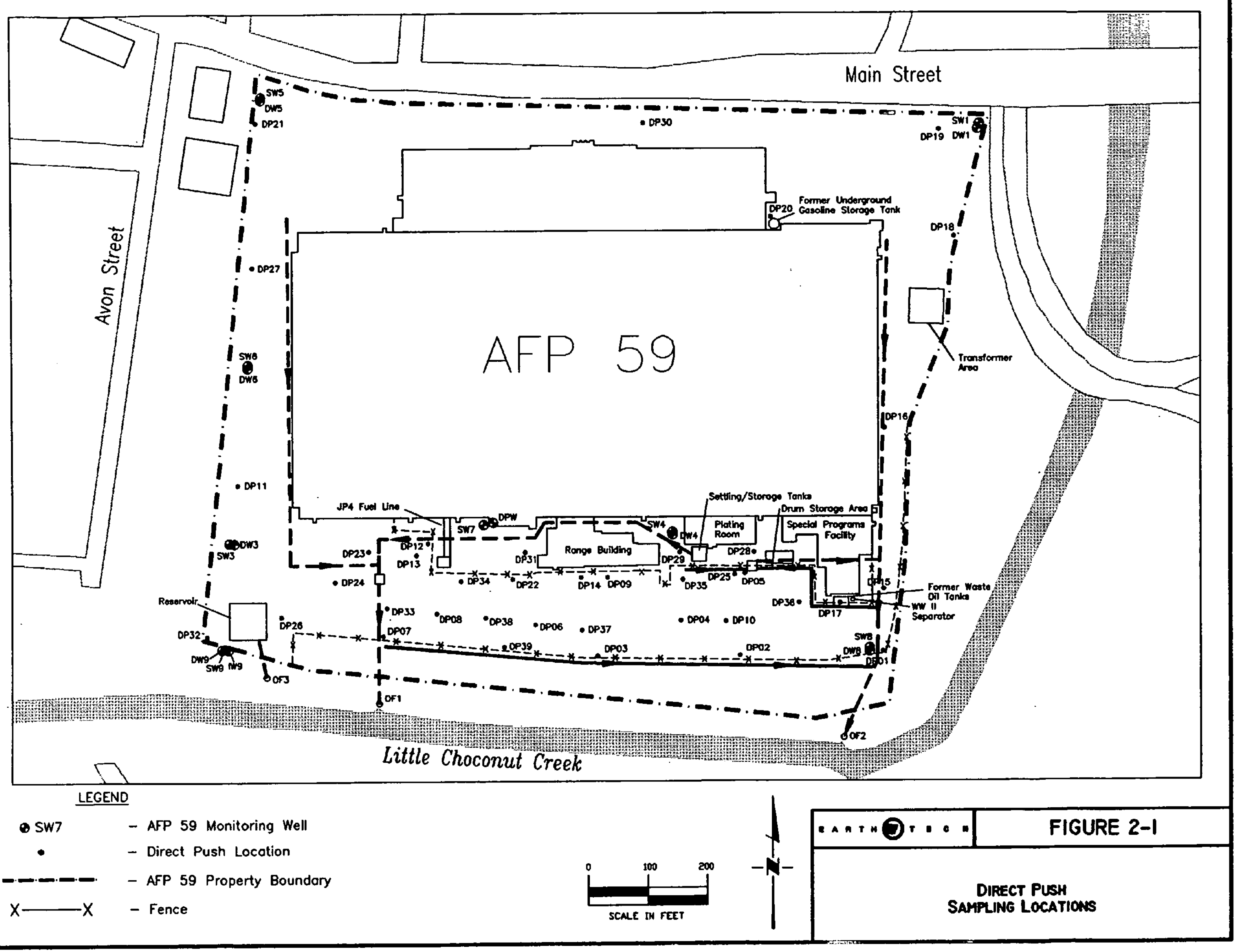
As part of the first phase of the field investigation, Target Environmental Services Inc. will perform direct push sampling of soil and groundwater at AFP 59. Soil and groundwater samples will initially be collected at approximately 39 locations throughout AFP 59 (see Figure 2-1). These samples will be collected along drains, next to the plating room, near the reservoir, and along the perimeter of the plant. In general, the sampling grid is more closely spaced in areas where the greatest data resolution is required. The sampling grid can be modified in the field as data are acquired.

Soil samples will be collected by hydraulically driving a 1.25-inch diameter, 2-foot long piston-type sampler to the top of the desired sampling interval. The piston inside the drive rod will then be released, allowing movement of the piston within the rod and the collection of soil into a non-reactive plastic (acetate) liner. The drive rod will then be pushed through a 2-foot soil interval, allowing soil to enter the sampler. The sampler and drive rod will then be removed from the soil and the liner containing the sample will be removed from the sampler.

To collect a groundwater sample, the drive rods will be removed and replaced with a 0.5-inch diameter PVC pipe with either a 5 or 10 foot slotted screen to allow groundwater to enter from the water-saturated zone. The groundwater sample will then be collected with a stainless steel mini-bailer lowered through the PVC. If the hole collapses prior to inserting the PVC, or if direct push refusal is encountered prior to reaching groundwater, then another method of sampling will be performed. A new hole will be driven with an expendable point attached to the 1.25-inch pipe. The pipe and tip will be driven to the desired depth, and the pipe will be raised back off of the tip a few inches. This will allow groundwater to enter the pipe. The groundwater will then be collected with a stainless steel mini-bailer lowered through the pipe. Section 2.2.1.1 provides a more detailed description of the direct push sampling procedures.

At each location, soil samples will be collected every 5 feet until groundwater is reached (approximately 15-20 feet bgs). Prior to capping and storing each sample, a portion of the soil will be placed in a jar, allowed a minimum of fifteen minutes for contaminant volatilization, and used for headspace analysis. An Earth Tech field member will use an HNu-brand photoionization detector (PID) equipped with an 11.7 eV lamp to screen each sample for organic vapors. The sample liners containing the soil will be capped and stored on ice in a cooler at 4°C. The soil sample at each location with the highest PID reading will be analyzed at the onsite laboratory for VOCs. If none of the samples from a location have elevated PID readings, the sample closest to the groundwater table will be analyzed onsite for VOCs. Additional soil samples may be analyzed onsite depending on the capacity of the mobile laboratory. Based on the results of the onsite analysis, soil samples (which were retained and maintained at 4°C) will be sent to a fixed laboratory for confirmation and quantification of VOCs. These soil samples will be analyzed by Method SW8260. In addition, approximately 10 percent of the soil samples will be sent to a fixed laboratory for metals analysis. The soil samples chosen for metals analysis will be background samples and samples from areas where metals contamination is suspected based on previous investigations.

At each sampling location, a groundwater sample will be collected from the shallow water-bearing zone and analyzed onsite for VOCs. Grab samples of existing onsite and offsite monitoring wells will also be collected at this time and analyzed onsite for VOCs. Two split groundwater samples will be sent to an offsite fixed laboratory for VOC analysis by Method SW8260: one sample from a location estimated to have a high concentration of VOCs and one


Main Street
Avon Street
AFP 59
Little Choconut Creek
Former Underground Gasoline Storage Tank
Transformer Area
Settling/Storage Tanks
Drum Storage Area
Plating Room
Special Programs Facility
Range Building
JP4 Fuel Line
Former Waste Oil Tanks
WW II Separator
Reservoir
SW1
DW1
SW3
DW3
SW4
DW4
SW5
DW5
SW6
DW6
SW7
DPW
SW8
DW8
SW9
DW9
IW9
OF1
OF2
OF3
DP01
DP02
DP03
DP04
DP05
DP06
DP07
DP08
DP09
DP10
DP11
DP12
DP13
DP14
DP15
DP16
DP17
DP18
DP19
DP20
DP21
DP22
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DP24
DP25
DP26
DP27
DP28
DP29
DP30
DP31
DP32
DP33
DP34
DP35
DP36
DP37
DP38
DP39
LEGEND
SW7 - AFP 59 Monitoring Well
- Direct Push Location
- AFP 59 Property Boundary
X——X - Fence
0
100
200
SCALE IN FEET
N
EARTH TECH
FIGURE 2-1
DIRECT PUSH SAMPLING LOCATIONS

sample from a location estimated to have a low concentration of VOCs. The split sample groundwater analysis will provide a comparison of the onsite mobile laboratory results to those of the fixed laboratory. This
will provide an indication of the accuracy of the onsite mobile laboratory and the limits of the sampling protocol.

As part of the direct push sampling QA/QC procedures, Target will decontaminate all equipment prior to the first sampling and between each sampling location thereafter. Decontamination of the sampling equipment will consist of washing with a mild soap (Alconox™) and water, rinsing with distilled water under high pressure, rinsing with ASTM Type II water, and finally rinsing with methanol and hexane. All equipment will be thoroughly dried prior to inserting a clean acetate liner in the sampler.

2.1.4 Borehole Construction, Lithologic Sampling, and Logging

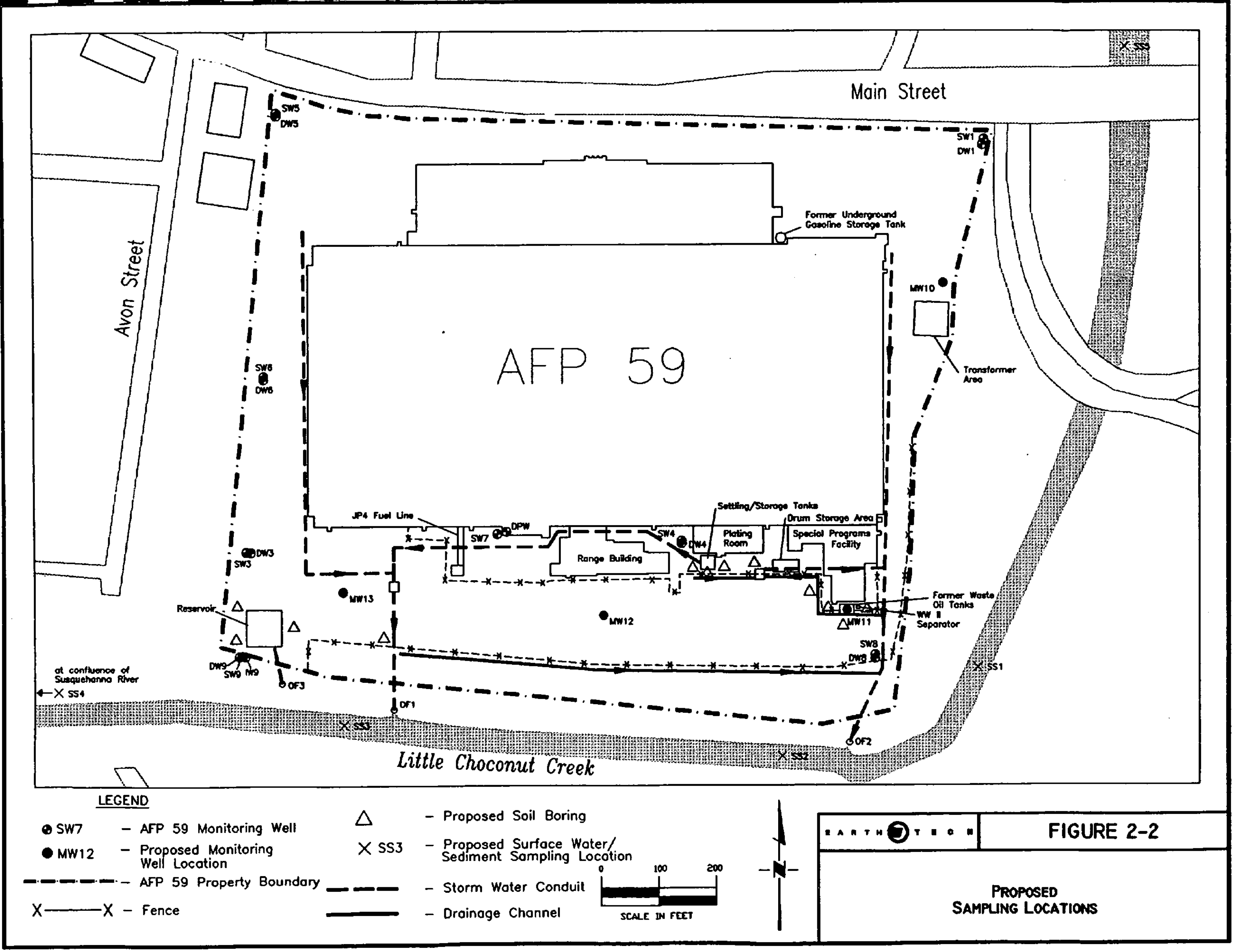
During the second phase of the investigation, four monitoring well clusters will be installed consisting of a shallow monitoring well screened in the outwash deposits (shallow zone of the aquifer) and a deep monitoring well screened in the ice-contact deposits (deep zone of the aquifer). In addition to the shallow and deep wells, intermediate monitoring wells will be installed at locations where fine-grained deposits (glacial lakebed or fine-grained ice-contact deposits) are encountered which may impede vertical groundwater flow. Proposed locations of monitoring wells are shown in Figure 2-2. Proposed monitoring well locations are based on the results of the direct push sampling conducted during the first phase of the field program.

Two drilling methods will be used to drill monitoring well boreholes during the RI: hollow-stem auger (HSA) and drive and wash. The drilling, sampling and well construction activities will be conducted in the following sequential order at each location.

(1) A pilot hole at the deep monitoring well borehole location will be drilled with 4.25-inch or 6.25-inch inside diameter (I.D.) HSAs. The pilot hole will be continuously sampled using a 5-foot long, 3-inch diameter continuous tube sampler until fine-grained deposits (glacial lakebed or fine-grained ice-contact deposits) are encountered. Soil samples from the pilot boreholes will be collected to characterize the stratigraphy only; no samples will be collected for chemical analysis.

(2) Surface casing will be set in the upper portion of the deep monitoring well borehole to prevent cross-contamination between the upper and lower zones of the aquifer. The augers will be pulled from the pilot hole, and surface casing will be set by drilling to the known depth of the fine-grained deposits with 10.25-inch I.D., 14.25-inch O.D. HSAs. The surface casing will be constructed of 8-inch diameter PVC and set approximately 2 feet into the fine-grained deposits. The casing will be grouted with a Portland cement/bentonite grout and allowed to set for a minimum of 24 hours.

(3) The deep portion of the deep monitoring well borehole will be drilled through the surface casing, after allowing the grout to set, using rotary wash and temporary 6-inch steel driven casing until bedrock is encountered, approximately 90 to 100 feet bgs. The



Main Street
Avon Street
AFP 59
Little Choconut Creek
Former Underground Gasoline Storage Tank
Transformer Area
MW10
SW1
DW1
SW5
DW5
SW6
DW6
SW3
DW3
Reservoir
DW9
SW9
MW9
at confluence of Susquehanna River
SS4
OF3
OF1
SS3
SS2
OF2
SS1
SS5
MW13
MW12
MW11
SW8
DW8
JP4 Fuel Line
SW7
DPW
Range Building
SW4
DW4
Settling/Storage Tanks
Plating Room
Drum Storage Area
Special Programs Facility
Former Waste Oil Tanks
WW II Separator
LEGEND
SW7 – AFP 59 Monitoring Well
MW12 – Proposed Monitoring Well Location
AFP 59 Property Boundary
X——X – Fence
– Proposed Soil Boring
X SS3 – Proposed Surface Water/ Sediment Sampling Location
– Storm Water Conduit
– Drainage Channel
0 100 200
SCALE IN FEET
N
EARTH TECH
FIGURE 2-2
PROPOSED SAMPLING LOCATIONS

subsurface geology will be characterized by logging the drill cuttings only; no soil sampling will be conducted. Bedrock will be confirmed by coring 2 feet into competent rock. The monitoring well will be completed on top of bedrock as described in Section 2.1.5.

If, during drilling of the pilot hole, the fine-grained deposits are not encountered by a predetermined depth estimated from existing information (i.e., existing well logs, borehole geophysics), continuous sampling will cease, and the pilot augers will be pulled from the borehole. The deep monitoring well borehole will then be completed to bedrock using drive and wash techniques, during which drill cuttings from the deep zone of the aquifer will be logged. No surface casing will be necessary if the fine-grained deposits are not encountered. The deep monitoring well will then be completed as described in Section 2.1.5. No intermediate monitoring well will be constructed at locations where fine-grained deposits are absent.

(4) The intermediate (when fine-grained deposits are present) and shallow monitoring wells will be drilled and constructed adjacent to the deep monitoring well borehole. The intermediate monitoring well boreholes will be drilled with 6.25-inch I.D., 8.25-inch O.D. HSAs. No soil sampling will be conducted during the drilling of the intermediate monitoring well boreholes (since continuous soil samples will have been obtained from the pilot borehole) until the depth of the fine-grained deposits, as determined in the pilot borehole, is approached. When within 5 feet of the fine-grained deposits, continuous split-spoon sampling will be conducted to accurately define the upper surface of the fine-grained deposits. Total depth of the intermediate monitoring well will be approximately 2 feet into the top of the fine-grained deposits (approximately 40 to 50 feet bgs). Intermediate monitoring well completion details are described in Section 2.1.5.

(5) The shallow monitoring wells will be drilled with 6.25-inch I.D., 8.25-inch O.D. HSAs. Sampling for chemical analysis will be conducted above the water table at 5-foot intervals using 5-foot long, 3-inch diameter split-spoon samplers with brass liners. No sampling will take place below the water table since continuous soil samples will have been obtained from the pilot borehole for lithology. Total depth of the shallow monitoring wells will be approximately 10 feet below the water table (approximately 30 feet bgs). Shallow monitoring well completion details are described in Section 2.1.5.

Twelve additional boreholes will be drilled in areas requiring further analytical and/or lithologic characterization. Split-spoon (3-inch diameter) soil samples will be collected in brass liners at 5-foot intervals above the water table. No sampling will be conducted below the water table. Upon completion, each borehole will be grouted to the surface with a grout slurry consisting of a mixture of one 94-pound sack of Type I Portland cement, not more then 4 pounds of 100 percent sodium bentonite powder, and not more than 8 gallons of potable water. Grouting will be done while the augers are being removed and will be tremied from the bottom of the borehole to the ground surface.

All soil cuttings generated during drilling will be handled as described in Section 2.1.12. Subsurface soil sample collection procedures are described in detail in Section 2.2.1.2. All downhole drilling equipment will be decontaminated before moving to each new drilling location following procedures described in Section 2.1.11. Well completion details are described in Section 2.1.5. Each borehole location will be permanently marked with a stamped metal bar identifying the boring number, and the location will be recorded on a project map.

One water sample from the onsite source of potable water to be used during drilling activities will be sent to an AFCEE-approved laboratory for the following chemical analyses: VOCs, SVOCs, pesticides/PCBs, ICP metals, arsenic, lead, mercury, selenium, thallium, cyanide, and hardness.

Drilling records will be kept in the daily field logbook for the program and on logs for each borehole (see Figure 2-3). The items to be included in the daily field logbook are described in Section 2.5, Record Keeping.

Ambient air will be monitored during all drilling and sampling activities. An OVA using a FID or an HNu using a PID will be used to monitor concentrations of total volatile organic compounds in the breathing space at worker chest level and down the borehole immediately below the ground surface. Air monitoring concentrations will be recorded in the remarks column on the borehole logs. If ambient air concentrations exceed those specified in the Site Health and Safety Plan, drilling will be stopped and appropriate action taken according to the guidelines established in the Site Health and Safety Plan.

The Field Task Manager will supervise drilling, soil sampling, and the installation and development of monitoring wells during the RI. The State of New York does not currently have a state-licensing program for geologists.

The following information will be recorded in the logbook and/or on the borehole log for each boring.

- Boring or well identification (a unique identification)
- Purpose of boring (e.g., soil sampling, well installation)
- Location in reference to identifiable landmarks
- Names and affiliations of driller and logger
- Start and finish dates and times
- Drilling method
- Types of drilling fluids and depths at which they were used
- Diameters of surface casing, casing type, and methods of installation of any wells
- Depth at which saturated conditions were first encountered
- Lithologic descriptions and depths of boundaries
- Depths of sampling intervals
- Zones of caving or heaving
- Depth at which any drilling fluid was lost and volume lost
- Drilling rate and observations.

BOREHOLE LOG

Project Name:		
Project Number:	Borehole Number:	Sheet 1 of ___
Borehole Location:	Elevation and Datum:	
Drilling Company: / Driller:	Date Started:	Date Finished:
Drilling Equipment:	Total Depth (feet):	
Drilling Method:	Borehole Diameter:	Ambient OVA:
Drilling Fluid:	Depth to Water (feet) First:	Completed::
Completion Information:	Logged By:	Checked By:

Depth (feet)	Description	USCS or Rock Type	FID/PID (ppm) Spoon/Headspace	Samples			Drilling Rate/Time	Remarks
				Number	Recovered Length (inches)	Blow Count		
5								
10								
15								
20								

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Figure 2-3

Borehole Log

2.1.5 Monitoring Well Construction and Development

Monitoring well installation will include monitoring well construction and development, and wellhead completion. These procedures follow methods described in the Handbook for the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (the Handbook) (USAF, 1993) and the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (USEPA, 1986) and are described below. A Monitoring Well Construction Log (Figure 2-4) and a Monitoring Well Development Log (Figure 2-5) will be completed for each monitoring well installed during the RI. Well construction activities will be summarized in the field logbook, and any changes from the planned well construction will be noted. Lithologic symbols on the well completion diagrams will correspond to the descriptions on the borehole logs. The well completion logs will include the following information.

- Well identification (identical to the boring identification on the associated borehole log)
- Drilling method
- Installation date
- Elevations of ground surface and notched measuring point (to be added upon completion of geodetic survey)
- Total boring depth
- Lengths, depths, and descriptions of screen and casing
- Depths and descriptions of filter pack, bentonite seal, and grout
- Elevation of water before and immediately after development.

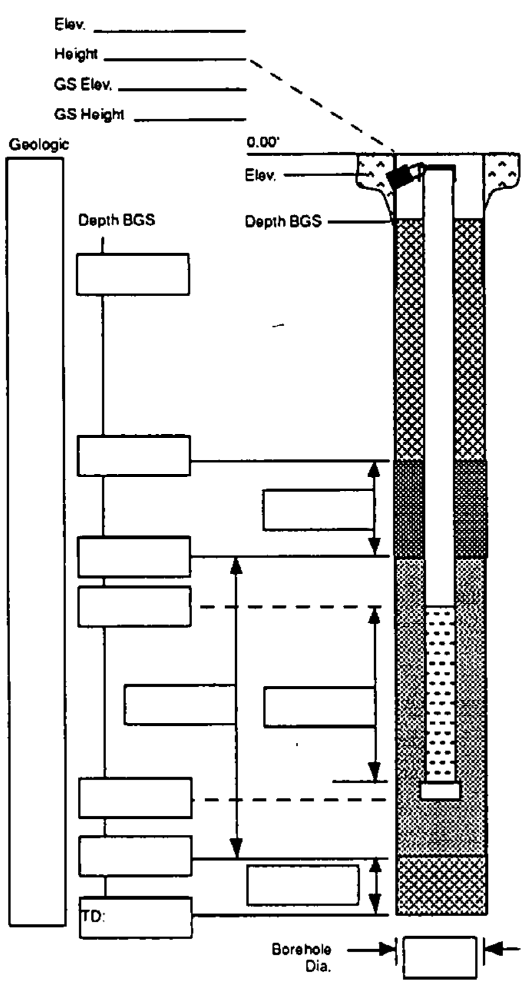
2.1.5.1 Monitoring Well Construction. Monitoring wells will be installed in clusters consisting of a shallow well screened in the outwash deposits and a deep well screened in the ice-contact deposits. Intermediate monitoring wells will also be installed if fine-grained glacial lakebed deposits or fine-grained ice-contact deposits are encountered, and will be screened on top of the fine-grained deposits in the outwash deposits. Deep wells will be double-cased in each location where fine-grained deposits are encountered to avoid cross-contamination between the upper and lower zones of the aquifer. If the lakebed deposits are absent, no double casing of the deep wells will be necessary. Shallow and intermediate monitoring wells installed in the shallow zone of the aquifer will be drilled with HSA techniques as described in Section 2.1.4. Monitoring wells installed in the deep zone of the aquifer will be drilled with drive and wash techniques described in Section 2.1.4. Typical monitoring well construction diagrams for the shallow and intermediate wells, and the deep wells are provided in Figures 2-6 and 2-7, respectively.

Surface Casing. For deep monitoring wells which intersect fine-grained deposits, surface casing will be set from the ground surface to 2 feet below the top of the fine-grained deposits to prevent cross-contamination between the upper and lower zones of the aquifer. The upper portions of the deep monitoring well borings will be drilled with 10.25-inch I.D., 14.25-inch O.D. HSA. The surface casing will be constructed of 8-inch diameter PVC. Portland cement grout will be pumped through a rigid, side-discharging tremie pipe between the surface casing and the HSA. At a minimum, 10 feet of grout will remain within the HSAs. Therefore, 20 feet of grout will be emplaced within the augers prior to removing 10 feet of auger flight. The grout will be pumped until 20 percent of the grout has returned to the surface. The tremie pipe and the

EARTH TECH

Monitoring Well Construction Log - Flush Mount

Project Name:	Project Number:	Date:
Well	Well ID:	Sheet ____ of ____
Driller:	Borehole Diameter (in):	Total Depth (ft):
Drilling Agency:	Date Started:	Depth to Water (ft):
Drilling Equipment:	Date Finished:	Elevation and Datum:
Drilling Method:	Logged by:	Checked by:
Drilling Fluid:	Number of Samples:	Date:



PROTECTIVE CSG
Material / Type:
Diameter: ____
Depth BGS: ____ Weep Hole (Y / N)

GUARD POSTS (Y / N)
No. ____ Type: ____

SURFACE PAD
Composition and Size: ____

RISER PIPE
Type: ____
Diameter: ____
Total Length (TOC to TOS): ____
Ventilated Cap (Y / N)

GROUT
Composition and Proportions: ____
Tremied (Y / N)
Interval BGS: ____

CENTRALIZERS
Depth(s) ____

SEAL
Type: ____
Source: ____
Setup / Hydration Time: ____ Vol. Fluid Added: ____
Tremied (Y / N)

FILTER PACK
Type: ____
Amt. Used: ____
Tremied (Y / N) ____
Source: ____
Gr. Size Dist.: ____

SCREEN
Type: ____
Diameter: ____
Slot Size and Type: ____
Interval BGS: ____

WELL FOOT (Y / N)
Interval BGS: ____ Length ____
Bottom Cap (Y / N)

BACKFILL PLUG
Material: ____
Setup / Hydration Time: ____
Tremied (Y / N)

Form F-1024
9/1/91

EARTH TECH	FIGURE 2-4
Monitoring Well Construction Log	

Graphics/AFP59/Fig 2-4

WELL DEVELOPMENT/PURGE LOG

Project Name_____	Project Number_____	pH Meter Number_____	Date_____
Well No._____	Datum Point_____	Conductivity Meter Number_____	Recorded By_____
Location_____	Elevation of Datum Point_____	Thermometer Number_____	Checked By_____
Dev/Purge Method_____	Static Water Level_____	Casing Diameter_____	Date_____
Equipment_____	Well Depth_____	Average Discharge Rate_____	
Water Column_____	Total Gallons Extracted_____	Well Volumes	

Disposition of Discharge Water_____

Specific Capacity_____gpm/ft. of draw down after_____hours

Time (24 hr.)	Flow Rate	Water Temp. In C°	pH	Cond. μmhos/cm	Turbidity NTU	Gallons Dev./Purge Before Meas.	Water Level (feet)	Remarks (e.g., clarity)

Notes: 1 ft length of 4" = 0.087 ft^3 or 0.65 gal
1 ft length of 2" = 0.022 ft^3 or 0.16 gal

0461 FIG

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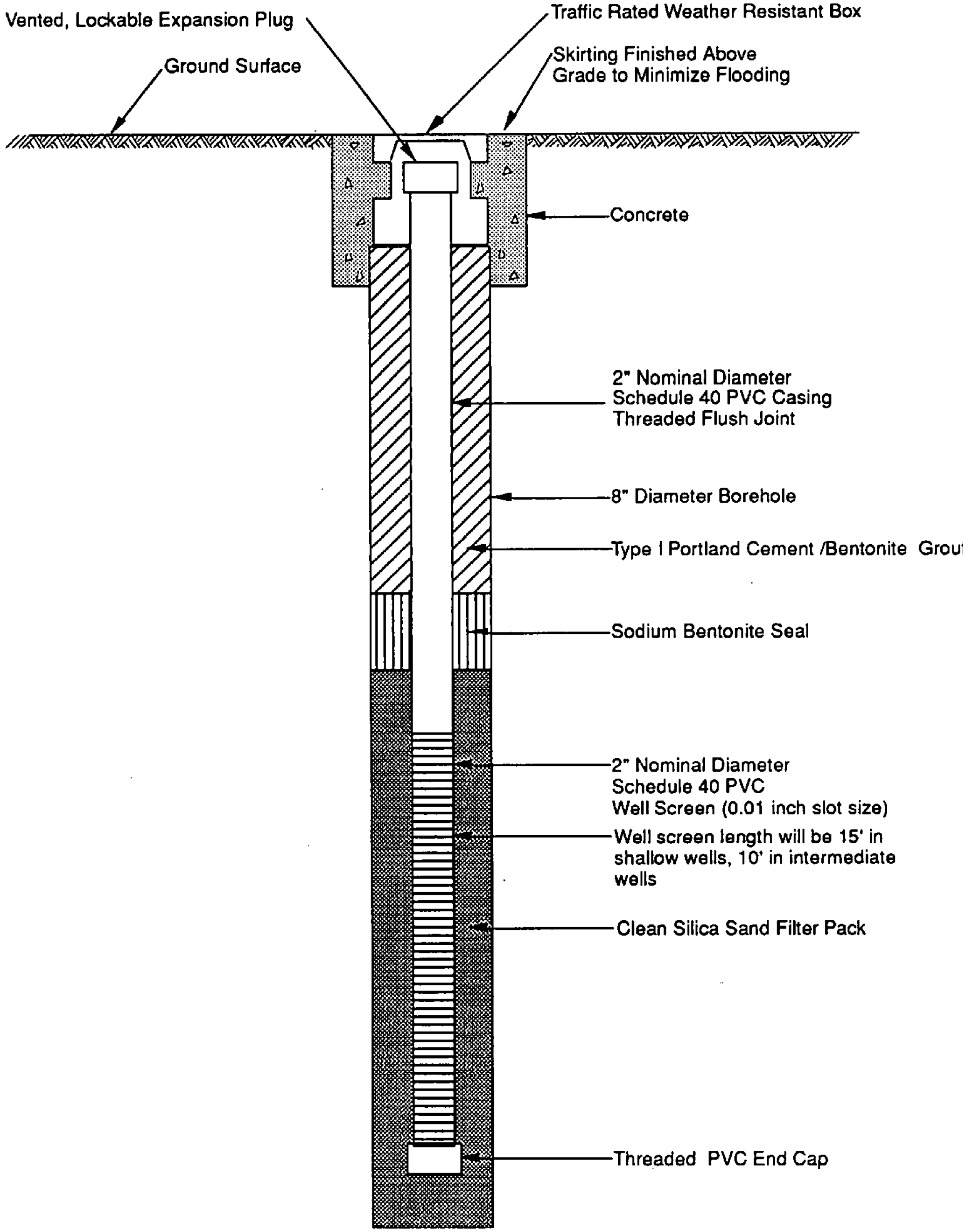
Figure 2-5

Well Development/
Purge Log



EARTH TECH

Figure 2-6

Typical Shallow and Intermediate Monitoring Wells with Flush-Mount Completion

AFP59/Fig 2-6 Typical Shallow

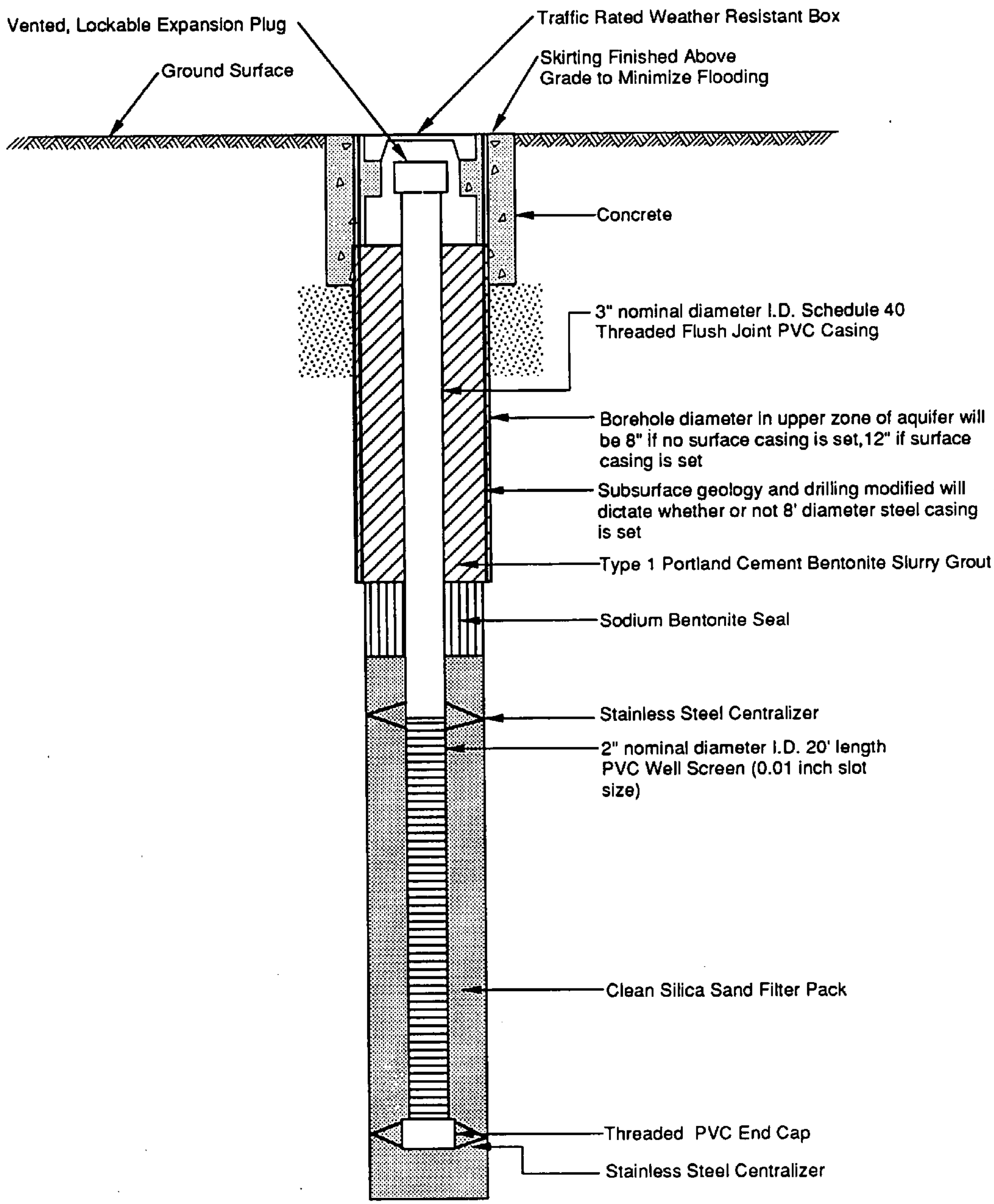


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Figure 2-7

Typical Deep Monitoring Well with Flush-Mount Completion

GF/AFP59/Fig 2-7 Typ Deep Flush Mnt

remainder of the hollow-stem augers will then be removed, and additional grout will be emplaced to compensate for the volume of removed augers. The grout will be allowed to cure for a minimum of 24 hours. The length and diameter of the surface casing, casing type, and method of installation will be recorded in the logbook and on the monitoring well completion form for each well.

Monitoring Well Casing/Screen. During monitoring well installation, casing and screen will be suspended such that it does not rest on the bottom of the borehole. The casing will be straight and plumb within 3 degrees of vertical. The inside diameter of the HSAs or drive casing will be at least 4 inches larger than the outside diameter of the casing and well screen. As described below, filter pack, bentonite seal, and Type I Portland cement/bentonite grout will then be emplaced in the annulus between the borehole wall and casing/screen as the augers or drive casing are withdrawn.

The shallow monitoring wells will be constructed of new and unused 2-inch diameter, Schedule 40 PVC casing and screen. The surface casing for the deep monitoring wells will be constructed of 8-inch diameter PVC, and the inner casing and screen will be constructed of new and unused 2-inch diameter, Schedule 40 PVC. Filter pack and well screen design will be based on the results of field sieve analyses (see Appendices B and D). The particle size of the filter pack will be four to six times the 70 percent retained grain size of the formation material (USEPA, 1991b). The screen slot will be sized to prevent 90 percent of the filter pack from entering the well. All screens will be factory slotted. Based on an analysis of data from the installation of existing monitoring wells, anticipated screen slot sizes are 0.01-inches. Stainless steel centralizers will be placed at the top and bottom of the screened interval and at 20 foot intervals thereafter for deep monitoring wells (greater than 50 feet). The PVC casing and screen will conform to ASTM Standard F-480-88A or National Sanitation Foundation Standard 14 (Plastic Pipe System). Fifteen feet of screen will be installed in the shallow monitoring wells, ten feet of screen in the intermediate monitoring wells, and twenty feet of screen in the deep monitoring wells. Casing and screen joints will be flush threaded. No glue-connected fittings will be used in order to prevent introduction of contaminants into the monitoring wells. The bottom of the screen will be capped using a threaded PVC end cap. All monitoring well components (i.e., PVC casing, screen, and end caps) will be steam-cleaned and kept covered before lowering into the borehole.

Filter Pack. Once the monitoring well casing is in place, filter pack will be added to stabilize the borehole wall adjacent to the screened interval. Only washed and bagged, rounded silica sand with a grain size distribution compatible with the screen and formation will be utilized (Driscoll, 1986). The sand will be clean, inert, and well-rounded, and will contain less than 2 percent flat particles. The sand will be certified free of contaminants by the supplier. Sand will be emplaced between the monitoring well casing and the HSAs or drive casing with a tremie pipe which is at least 1½ inches in diameter. The tremie pipe will be lifted from the bottom of the borehole at the same rate as the filter pack is set. The filter pack will extend from the bottom of the borehole to a minimum of 2 feet above the screen. The top of the filter pack will be periodically measured using a decontaminated steel tape to verify its depth during placement.

After the filter pack is emplaced, the monitoring well will be surged with a surge block for 10 minutes. Additional filter pack will then be added as required to return the level of the filter pack to the correct level above the top of the screen. The monitoring well will be surged for another 5 minutes. Additional filter pack will be added as required to return the level of the filter pack to the correct level above the top of the screen. Potable water may be added during filter pack emplacement if necessary to break bridges. The site geologist will record the beginning and ending times of filter pack emplacement, measured depths of filter pack, amount of sand used, amount of any water used, beginning and ending times of monitoring well surging, and any problems that arise. The geologist will also record the type of material used for the filter pack, including: trade name, source, supplier, and typical grain size distribution. A sample of filter pack will be collected and archived as part of the project files.

Bentonite Seal. A bentonite seal of at least a 2-foot vertical thickness will be emplaced in the annular space above the filter pack to separate the permeable zone from the cement surface seal. The bentonite used for the seal will be 100 percent sodium bentonite. The bentonite will be hydrated before placement and then pump tremied into the annular space between the monitoring well casing and the HSAs or drive casing. The bentonite slurry will be thick enough to prevent significant penetration into the underlying filter pack or a loss of integrity when the cement grout is emplaced above it. The geologist will record the beginning and ending times of the bentonite seal emplacement, the measured interval of the seal, the amount of bentonite used, and any problems that arise. The type of bentonite and the supplier will also be recorded. A sample of the bentonite will be collected and archived as part of the project files.

Cement Grout. The cement grout will consist of a 94 pound bag of Type I Portland cement or American Petroleum Institute Class A cement, not more than 4 pounds of 100 percent sodium bentonite powder, plus 8 gallons of potable water. The mixture will be prepared in an above-ground mixer and mechanically blended onsite to produce a lump-free product. At a minimum, 10 feet of grout will remain within the HSAs or drive casing. Therefore, 20 feet of grout will be emplaced within the drill rods prior to removing each 10 foot section. The grout will be pumped through a side-discharging tremie pipe which will be placed just above the top of the bentonite seal. The grout will be pumped until 20 percent of the grout has returned to the surface. If the bentonite seal is within 30 feet of the surface, the 20 percent grout return is not required; the tremie pipe will be pulled back as the grout is emplaced. The tremie pipe and the remainder of the HSAs or drive casing will then be removed, and additional grout will be added to compensate for the volume of the removed augers and drill rods.

After the grout has completely set, depressions due to settlement will be filled using a grout mixture prepared as described previously. The beginning and ending times of the cement grout emplacement, the grouted interval, the amount of cement grout used, the proportions used to prepare the cement grout (gallons of water per bag of cement and the cement/bentonite ratio), and any problems that arose during grouting will be recorded on the Monitoring Well Construction Log and in the field logbook.

Surface Completion. The type of surface completion required will be coordinated with the AFP 59 POC. For surface completions flush with the land surface, the PVC well casing will be cut approximately 3 inches below the land surface and will be capped with a ventilated, water-tight cap to prevent surface water from entering the monitoring well. A freely draining valve box will be placed over the well casing and positioned so that the top of the casing is at least 1 foot above the bottom of the box. The valve lid will be centered in a 3-foot diameter, 4-inch thick concrete pad that slopes away from the box.

If an above-grade completion is used, the well casing will be cut 2 to 3 feet above the land surface and capped with a ventilated, water-tight cap. After the grout has partially set, a vented, 5-foot length of steel protective casing will be emplaced in the grout. This protective casing will extend approximately 2.5 feet bgs and the diameter will be at least 6 inches greater than the diameter of the well casing. The protective casing will be seated in a 3-foot by 3-foot by 4-inch thick concrete surface pad. The concrete pad will be reinforced with steel reinforcing bars at least ¼ inches in diameter, and will be graded to slope away from the monitoring well. The protective casing will include a lockable, hinged cap.

For monitoring wells which are located in heavy traffic areas, each monitoring well will be protected with three metal guard posts. The guard posts will be 3 inches in diameter and 5 feet in total length. The guard posts will be installed outside of the concrete pad and will be set 2 feet into the ground and filled with concrete.

The identity of each monitoring well will be clearly marked on the monitoring well protective casing and the well casing cap using paint and/or impact numbering. A notch will be cut in the top of each well casing; the elevation of this notch will later be surveyed and used as a measuring point for water levels. All wells will be padlocked for protection with corrosion-resistant locks as soon as possible after completion. The locks for each monitoring well will be keyed-alike, and keyed to match existing monitoring well locks at the site. The key will be provided to the AFP 59 POC upon completion of the field program.

2.1.5.2 Monitoring Well Development. Monitoring well development is the process by which the aquifer's hydraulic conductivity is restored by removing drilling fluids, solids and/or other mobile particulate matter from the monitoring well. All monitoring wells installed during the investigation will be developed no sooner than 24 hours after installation to allow for monitoring well grout curing. No sediment will remain in the bottom of the well after well development is complete. All development equipment will be decontaminated according to the procedures outlined in Section 2.1.11. All development activity will be recorded on the Monitoring Well Development Log illustrated in Figure 2-5. Water color and volume will also be documented.

Surging and overpumping will be used to remove fines from the screened portion of the monitoring well. A close-fitting surge block will be used to surge the well screen. Surging is performed by moving a surge block up and down in the monitoring well in a manner similar to a piston in a cylinder. The screen will be surged in 5-foot sections using 10 to 20 up/down cycles per section. A high-volume pump will be lowered into the well after surging is completed to remove water from the monitoring well. The pump must be rated to achieve the desired yield at a given depth. The pump system should include:

(1) A check valve to prevent water from running back into the monitoring well when the pump is shut off.

(2) Flexible discharge hose.

(3) Safety cable or rope to remove the pump from the monitoring well.

(4) Flow meter system (measuring bucket or inline flow meter).

(5) Electric generator.

The pump will be used to remove a minimum of three times the well bore volume (WBV). The WBV is defined as the combined volume of water in the well and the saturated filter pack. The following calculation will be used to determine the WBV for each well.

(1) Calculate the volume of water in the casing (Volume A). Measure the total depth of the monitoring well (TD) and depth to water (DTW).

 Volume A = (TD - DTW) * c
 where c is the conversion factor to gallons based on casing diameter; c = 0.163 for a 2-inch I.D. casing.

(2) Calculate the volume of the saturated portion of the borehole (Volume B). Measure the total depth of the borehole (TDB) and DTW.

 Volume B = (TDB - DTW) * d
 where d is the conversion factor to gallons based on borehole diameter; d = 4.08 for a 10-inch diameter borehole.

(3) Calculate the volume of the saturated granulated filter pack (Volume C).

 Volume C = (Volume B - Volume A) * 0.30
 where 0.30 is the assumed porosity of the granulated filter pack.

(4) Calculate the WBV.

 WBV = Volume A + Volume C

The temperature, pH, specific conductance, suspended sediment, and turbidity will be measured after each WBV has been removed using a calibrated temperature/pH/conductivity meter, Imhoff cone, and turbidity meter.

The monitoring well will be considered developed when:

(1) The suspended sediment content is < 0.75 mL/L as measured in an Imhoff cone according to method E160.5;

(2) Temperature, pH, and specific conductance are stable (temperature $\pm$ 1°C, pH $\pm$ 0.1 units, specific conductance $\pm$ 5 percent of the previous reading);

(3) Turbidity readings remain within a 10 NTU range for at least 30 minutes; and

(4) At a minimum, three WBVs have been removed.

If these conditions are not met, then purging will continue until six WBVs have been removed or parameters have stabilized, whichever comes first. If the development criteria are still not met, then the AFCEE RTC will be contacted for guidance. Well development water will be handled as described in Section 2.1.12.

2.1.6 Water Level Measurements

A synoptic round of water level measurements will be obtained from all new and existing monitoring wells following completion of well installation, sampling, and aquifer testing. Measurements will be recorded as feet below the measuring point elevation to the nearest 0.01 foot, and will be referenced to MSL. The measurements will be taken within as short a time period as practical so that water levels are representative of a given period. Any conditions that might affect the water levels (i.e., pumping wells) will be recorded in the logbooks. An example of a Water Level Measurement Form is shown in Figure 2-8. Groundwater contour maps of the area will be developed based on the water level elevations recorded. Static water level measurements will also be obtained each time a well is sampled, before any equipment enters the well, and prior to any well purging activities.

The procedures for measuring water levels are based on procedures described in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (USEPA, 1986b), and are as follows.

1. Remove the locking and protective caps. Allow time for equalization of pressures after cap is removed and prior to water level measurement.

2. Sample the air in the well head for the presence of organic vapors using either an OVA or HNu.

3. Conduct a visual (mirror) survey of the well.

4. Determine the static water level depth from the top of the inside well casing (surveyed measuring point) to the nearest 0.01 foot using an electric water level meter.

5. Measure the total depth of the well.

Monitoring the air above the well head will indicate toxic potential for workers. Action levels are listed in the Site Health and Safety Plan. The air monitoring may also indicate the presence of immiscible layers. The electric water level meter will be used to measure the static water

GROUNDWATER LEVEL MEASUREMENT FORM

Project Name:	Project Number:
Date:	Measurements Taken By:

Date (M/D/YR)	Time	Well Number	Reference Point	Depth to Water	Well Depth	Recorded By	Comments

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Figure 2-8

Groundwater Level Measurement Form

level depth if no immiscible layers are suspected. If immiscible layers are suspected, an interface probe will be lowered down the well to measure both the static water level and light or heavy immiscible layers. The interface probe will first measure the air/floater interface and the floater/water interface to establish the thickness of the floater layer. The probe can then be lowered to the bottom of the intermediate and deep monitoring wells to register the presence of free-phase "sinker" organic compounds.

The calibrated water level probes (i.e., electric water level meters and interface probes) will be decontaminated before use in each well. Decontamination procedures will follow those for the water sampling equipment as described in Section 2.1.11.

2.1.7 Aquifer Tests

A constant-rate pumping test will be conducted using the onsite production well as the pumping well and existing onsite and offsite monitoring wells as observation wells. If there is sufficient flow, Little Choconut Creek will also be monitored to determine possible communication between the creek and the aquifer. The objective of the pumping test will be to provide information on the hydraulic properties of the aquifer, the connection between the upper and lower zones of the aquifer, the effect of pumping on Little Choconut Creek, and the potential presence and extent of any semi-confining layers (glacial lakebed or fine-grained ice-contact deposits). The basic procedures which will be utilized are described below.

(1) Measure the static water levels in all accessible onsite and offsite wells, and in Little Choconut Creek (Figure 2-2). Stream gaging stations will be established to provide surface water levels. Johnson City Municipal Well #2 is expected to be pumping during the static water level measurements and the AFP 59 pumping test.

(2) Begin pumping the onsite production well at the optimum discharge rate determined by a review of plant usage of the well. Pump the production well at a constant rate continuously until water levels in the production well and at least one observation well are essentially at equilibrium, or for a maximum of 24 hours, whichever occurs first. Water will be discharged to the plant's non-contact cooling system as required for production; excess water may be discharged to outfall 003. Discharge of the pump test water will be coordinated with the NYSDEC.

(3) Measure the drawdown at the intervals indicated on Table 2-1 for the pumping well and Table 2-2 for the observation wells and stream gaging. Record the data on the Aquifer Test Data Form (Figure 2-9). Pressure transducers will be installed in at least two well pair locations, and water level measurements will be recorded with an electronic data logger. The data logger will provide more accurate data and can measure water levels at more frequent intervals. The water levels at all other locations will be measured manually.

(4) At the conclusion of the pumping test, turn the pump off and record the water level recovery in the pumping and selected observation wells until the water levels have reached their approximate initial static water levels, or for the same length of time the

TABLE 2-1
RECOMMENDED TIME INTERVALS FOR MEASURING DRAWDOWN/RECOVERY IN THE PUMPING WELL DURING A PUMPING/RECOVERY TEST

Time Since Pumping Started (or Stopped) (minutes)	Interval Between Measurements (minutes)
0-10	0.5-1
10-15	1
15-60	5
60-300	30
300-1440	60

TABLE 2-2
RECOMMENDED TIME INTERVALS FOR MEASURING DRAWDOWN/RECOVERY IN THE OBSERVATION WELL(S) AND STREAM GAGING STATION DURING A PUMPING/RECOVERY TEST

Time Since Pumping Started (or Stopped) (minutes)	Interval Between Measurements (minutes)
0-10	2
60-120	5
120-240	10
240-360	30
360-1440	60

AQUIFER TEST DATA FORM

Page ___ of ___

Project Name ______________	Project Number ______________
Location ______________	Date ______________
Pumping/Observation Well No. ______________	Recorded by ______________
Distance from Pumped Well ______________	Datum Point ______________
Static Water Level ______________	Elevation of Datum Point ______________
Screen Interval ______________	Depth to Bottom Well (ft.) ______________
Duration of Test: ______________	Saturated Thickness (ft.) ______________
Pumping ______________ Recovery ____	Check by ______________ Date ______
Water Level Measurement Equipment ______________	Flow (Q) Measuring Equipment ______________

Time			Time Since Pumping Started	Time Since Pumping Stopped	Ratio	Water Level (ft. below datum)	Water Level Change s or s'	Flow Rate (Q) gal/min.	Remarks
Date	Hour	Minute	t (min.)	t' (min.)	t/t'				

(Attach Hermit data log to data sheet)

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Figure 2-9

Aquifer Test Data Form Record

pumping test was conducted, whichever occurs first. Measurement intervals for recovery will be the same as for drawdown.

There are several methods available for calculating aquifer properties using data from constant rate discharge tests. The applicable method depends on the test duration, the confining conditions of the aquifer, the boundary conditions of the aquifer, and whether or not the observation well data are used during the analysis. All pumping/recovery test water-level/time data and all test analysis calculation sheets will be included in an appendix to the RI report.

2.1.8 Surface Water and Sediment Sampling

Five surface water and sediment sample pairs will be collected from Little Choconut Creek during the RI. The field team will sample two background locations upstream of the facility: one from the portion of the creek which flows along the eastern boundary of the plant, and one from the area north of Main Street. The other three sample pairs will be collected at locations which are downstream from Outfalls 001, 002, and 003, respectively. The location downstream of Outfall 003 will be taken at the convergence of the creek and the Susquehanna River. Figure 2-2 shows the proposed locations of each surface water and sediment sample.

Surface water and sediment samples will be collected from the same location. Surface water samples will be collected first to avoid excess suspended particles from the sediment sampling operations. Samples will be collected at the downstream locations first and the upstream locations last. Samples will be collected in areas of similar environment at all locations. Samples will be collected from active portions of the creek, and from the side of the creek nearest the plant.

Field team members will collect surface water in pre-cleaned containers and transfer that water to laboratory-provided bottles. Preservatives will be added as appropriate for the analyses requested. Sediment samples will be collected by scooping sediment at the sample location and placing the sediment directly into the sample jars via a stainless steel scoop. Sediment sample jars will be triple rinsed with the surface water from the appropriate location prior to collecting the sediment sample. If multiple aliquots are required, all aliquots (except VOA aliquot) will be placed in a stainless steel bucket and mixed thoroughly before placement into sample containers. Sediment samples will be collected 0-6 inches below the sediment-water interface. Sediment VOA samples will be packed as full as possible. Replicates will be collected at the same time and from the same bucket of composite soil.

Temperature, pH, and specific conductance of the surface water will be measured and recorded at each location. Typical surface water and sediment sampling forms are shown in Figures 2-10 and 2-11, respectively. All sampling locations will be marked with a pin flag and surveyed upon completion of the field program. All sampling equipment will be decontaminated prior to each sampling activity as described in Section 2.1.11. The following additional information will be documented in the logbook.

- Width, depth, and estimated flow rate of creek.
- Surface water conditions (e.g., floating debris).

SURFACE WATER SAMPLING RECORD

Project Name_______________ Project Number_______________

Location_______________ Sample Number_______________

Site_______________ Duplicate Number_______________

Recorded By_______________ Date_______________

Checked By_______________ Date_______________

Sampling Point Location (sketch)

Water Parameters

Before Sampling: pH__________ EC__________ Temperature__________

After Sampling: pH__________ EC__________ Temperature__________

Sampling Information

Analytical Parameter	Sampling Depth	✓ If Field Filtered	Preservation Method	Volume Required	Sample Bottle IDs

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Figure 2-10

Surface Water Sampling Record

SOIL/SEDIMENT SAMPLING RECORD

Project Name________________ Project Number________________

Location________________ Sample Number________________

Recorded By________________ Duplicate Number________________

Date________________ Checked By________________

Site________________ Date________________

Sampling Equipment________________

Sample Type Soil Sediment Rock

Sample Type Description

USCS Soil Type________________
Color________________
Odor________________
Depth________________
Number of Samples________________
Comments________________

Sampling Point (sketch)

Decontamination

Equipment:
- ☐ Hand auger
  Type________
- ☐ Trowel
- ☐ Other________

Decontamination Fluids:________________
- ☐ Steam/Hot Water
- ☐ Detergent/Water
- ☐ Potable Water
- ☐ Deionized Water
- ☐ Methanol
- ☐ Hexane
- ☐ HNO_3; dilution
- ☐ Other________

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Figure 2-11

Soil/Sediment Sampling Record

- Locations of discharge pipes, sewers, and/or tributaries.

Surface water and sediment sample collection procedures are described in detail in Sections 2.2.1.4 and 2.2.1.5, respectively.

2.1.9 Fish and Wildlife Impact Analysis

As part of the RI at AFP 59, Earth Tech will perform a Fish and Wildlife Impact Analysis under the guidance of the NYSDEC Division of Fish and Wildlife (NYSDEC, 1991). The Fish and Wildlife Impact Analysis is a stepwise process requiring decisions at a number of points in its development. The five steps of the analysis include a Site Description, Contaminant-Specific Impact Analysis, Ecological Effects of Remedial Alternatives, Implementation of Selected Alternative in Design, and a Monitoring Program. A complete analysis may not include all five steps, depending on whether or not certain criteria are met. The Fish and Wildlife Impact Analysis for AFP 59 and the surrounding areas will at least be performed through Step IIB; these steps are described below.

The main objectives of Step I are to: (1) identify if fish and wildlife resources that may be affected by site-related contaminants are present or were present prior to contaminant introduction; and (2) if resources are or were present, provide appropriate information for designing a RI of these resources (NYSDEC, 1991). Step I of the analysis includes the creation of a topographic map showing the location of the site and documented fish and wildlife resources, habitats supporting endangered, threatened, or rare species, species of concern, regulated wetlands, wild and scenic rivers, significant coastal zone areas, streams, lakes, and other major resources within 2 miles of the perimeter of the site. A covertype map will also be drawn for the site and an area within 0.5 miles of the perimeter. The map will include major vegetative communities including wetlands, aquatic habitats, NYSDEC Significant Habitats, and areas of special concern. A qualified biologist will perform the covertype identification during Phase II of the RI. Step I of the analysis also includes: a description of fish and wildlife resources; identification of the value of fish and wildlife resources; and identification of applicable fish and wildlife regulatory criteria.

The objective of Step II is to determine the impacts of site-related contaminants on fish and wildlife resources. From this step, the analysis should either demonstrate that impacts on resources due to contamination are minimal or, if significant impacts exist, determine the impacts of site-related contaminants on productivity and diversity of fish and wildlife resources (NYSDEC, 1991). Within Step II, three more steps assess the impacts of site-related contaminants to fish and wildlife resources; these include pathway analysis, criteria-specific analysis, and analysis of toxicological effects. In the pathway analysis (Step IIA), fish and wildlife resources, contaminants of concern, sources of contaminants, and potential pathways of contaminant migration and exposure will be identified. If it is determined that potential pathways are present, Step IIB will be completed. In Step IIB, the criteria-specific analysis, impact is assessed by comparing contaminant levels with numerical criteria such as Applicable or Relevant and Appropriate Requirements (ARARs); Standards, Criteria and Guidance (SCGs); and To Be Considereds (TBCs). If contaminant levels are below criteria, impact on the resource is considered minimal and additional analyses are not required. If levels are not below numerical criteria, an analysis of toxicological effects is required to demonstrate the degree of impact. Toxicological impact will be assessed by determining the degree to which contaminants affect the productivity of populations, communities, or ecosystems and the diversity of species assemblages, communities, or entire ecosystems through direct toxicological and indirect ecological effects (NYSDEC, 1991).

2.1.10 Surveying

A third order survey of sampling locations will be conducted by a certified land surveyor upon completion of the field program. The ground surface elevation, top of casing elevation, and location of all newly installed monitoring wells will be surveyed. Additional boreholes where monitoring wells were not completed and surface water and sediment sampling locations will also be surveyed.

An xy-coordinate system will be used to identify locations with the x-coordinate as the east-west axis, and the y-coordinate as the north-south axis. All surveyed locations, benchmarks, and permanent markers will be recorded on both unit-specific and facility maps. Horizontal locations will be referenced to the New York State Plane Coordinate System and measured to the nearest 0.1 foot. Ground surface elevation will be referenced to mean sea level and measured to the nearest 0.1 foot. The elevation of the top of the monitoring well casing will be surveyed from a notch in the casing, referenced to mean sea level, and surveyed to the nearest 0.01 foot.

2.1.11 Equipment Decontamination

Decontamination will be performed at a location designated by the AFP 59 POC. The Field Task Manager will be responsible for the supervision of all decontamination procedures. Activities associated with decontamination procedures will be recorded on a Decontamination Record (Figure 2-12). The drilling rig and associated equipment will be steam cleaned before each borehole to prevent cross-contamination. At a minimum, drilling bits and drilling pipe will be steam cleaned with a solution of potable water and Alconox™ and rinsed with potable water after each monitoring well is installed. If visible dirt remains after steam cleaning, hand brushing will be performed and the equipment steam cleaned and rinsed with potable water a second time.

Soil sampling equipment (split-spoons, continuous tube samplers, etc.) and Teflon™ bailers used for groundwater sampling will be decontaminated after every sample is collected using the following method.

- Wash with a solution of potable water and Alconox™
- Rinse with potable water
- Rinse with Type II reagent-grade water
- Rinse with pesticide-grade methanol
- Rinse with pesticide-grade hexane
- Allow sampling equipment to air dry on a clean surface such as Teflon™, stainless steel, or oil-free aluminum foil at least 2 feet above ground prior to

DECONTAMINATION RECORD

Project Name ______________________________ Project Number ______________________________

Recorded By ______________________________ Site ______________________________

Date ____________ Time ______________________________ Checked By ______________________________

Date ______________________________

Decontamination after borehole/well/sampling point ______________________________

Equipment	Use	Steam/ Hot Water	Detergent/ Water	Potable Water	Deionized Water	Type II Water	Other Water	Methanol	Hexane	HNO_3 (Dilution)	Equip. Blank No.
Drill Rig											
Drill Rods											
Augers											
Soil sampler											
Pump											
(Type)											
Bailer											
Trowel											
Hand auger											

Use key: GS - Groundwater Sampling, SS - Soil Sampling, WP - Well Purging

Comments (e.g., initial decon, between which locations, or if last decon for the day)

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Figure 2-12

Decontamination Record

further use. If the equipment is not to be used immediately, it will be wrapped in oil-free aluminum foil and covered with a plastic bag for storage.

Sampling equipment will not be allowed to come in contact with any type of plastic since samples will be analyzed for organic compounds.

Analytical data or manufacturer's certification which verifies the quality of Type II reagent-grade water will be provided with the analytical results. Solvents used to decontaminate sampling equipment will be stored in glass or Teflon™ containers.

All PVC casing, screen, and end caps used in constructing the monitoring wells will be steam cleaned and rinsed with potable water prior to being placed in the borehole. All monitoring well development, purging, and groundwater sampling equipment and apparatus, including internal components, will be thoroughly decontaminated prior to use and between monitoring well locations to avoid cross-contamination. All decontamination information will be recorded on the Decontamination Record (see Figure 2-12). Purging equipment, including bailers and pumps, will be decontaminated by flushing/pumping an Alconox™-water solution, potable water, then ASTM Type II reagent-grade water through the components. The exterior of the pump inlet hose will be steam cleaned. Sampling equipment that is not readily decontaminated will be discarded after each use.

Decontamination fluids will be containerized in 55-gallon drums and transported to a temporary storage area designated by the AFP 59 POC. Appropriate disposal will be the responsibility of the Earth Tech waste management subcontractor (see Section 2.1.12).

2.1.12 Waste Handling

The following section describes the procedures for handling and disposing of waste generated onsite during the field investigation. These wastes include: soil cuttings, monitoring well development/purge water, equipment decontamination fluids, and disposable protective clothing and supplies.

2.1.12.1 Soil Cuttings. Soil cuttings generated during drilling will be placed into labeled 55-gallon drums. Drums will be transported to a location designated by the AFP 59 POC and AFCEE RTC, and stored there pending laboratory characterization. Cuttings suspected of being contaminated will be segregated to the greatest extent practical. The decision to segregate cuttings will be based on elevated PID readings or obvious staining/discoloration of the cuttings. Waste characterization and appropriate disposal of the generated soil cuttings will be the responsibility of the Earth Tech waste management subcontractor. Due to contingencies and the normal turnaround for laboratory analysis during waste characterization, it is expected that soil cuttings and decontamination fluids will be stored 12-16 weeks before disposal.

2.1.12.2 Monitoring Well Development/Purge Water. Groundwater evacuated during monitoring well development and purging will be discharged to the ground surface in an area that is grass-covered. The groundwater will infiltrate into the ground and will not be discharged at a rate which would allow drainage into the storm water system or the creek. If the ground is frozen during these activities, the water will be containerized and disposed of offsite in accordance with all applicable regulations.

*2.1.12.3 **Disposable Protective Clothing and Supplies.*** A variety of wastes will be generated as a result of sampling activities. These wastes include disposable clothing such as Tyvek, gloves, rags used to wipe equipment, plastic sheeting, and aluminum foil. All disposable protective clothing and supplies will be presumed hazardous and will be placed in 55-gallon drums and stored until field work is completed. All drums will be labeled and sealed. The label will describe the contents and the date(s) of collection. Waste characterization and appropriate disposal will be the responsibility of the Earth Tech waste management subcontractor.

2.1.13 Summary of Field Activities

Table 2-3 summarizes the type and number of field activities to be performed during the RI.

2.2 Environmental Sampling

2.2.1 Procedures

Detailed descriptions of the methods and procedures to be used for collecting environmental samples of groundwater, surface water, soil, and sediment are provided below. Methodologies for collecting field QA/QC samples are also discussed.

*2.2.1.1 **Direct Push Soil and Groundwater Sampling.*** The procedures discussed below will be followed in collecting direct push soil and groundwater samples during the first phase of the field investigation at AFP 59. Target Environmental Services will be the subcontractor performing the direct push sampling. The procedures for sampling are Target's standard operating procedures which comply with the project requirements.

Soil Sampling

(1) Hydraulically drive a 1.25-inch diameter piston-type sampler to the top of the desired sampling depth.

(2) Release the piston within the bore sampler so that the core barrel is free to move.

(3) Drive the sampler an additional 2 feet through the sampling interval to collect the soil in a non-reactive plastic (acetate) liner.

(4) Remove the drive rod and sampler. Remove the liner containing the soil sample.

(5) Cut a portion (approximately 3 inches) of the liner off of the 2-foot interval and place some of the soil in a 4- ounce jar for a headspace reading. Allow at least 15 minutes for the soil volatiles to collect in the headspace. Cap the two ends of the remaining liner, making sure no headspace remains, and store on ice, at 4°C, in an insulated cooler.

Table 2-3
Summary of RI Activities at AFP 59

Environmental Matrix	Field Activities	
	Phase I (Reconnaissance Survey)	Phase II
Groundwater	Collect 33 direct push groundwater samples for onsite VOC analysis.	Drill and install monitoring well clusters at 4 locations. Clusters will consist of 1 shallow, 1 deep, and potentially 1 intermediate well.
	Collect groundwater samples from existing monitoring wells and screen onsite for VOCs.	Collect groundwater samples from all new and existing monitoring wells onsite. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, and hardness.
	Take a synoptic round of water level measurements.	Take a synoptic round of water level measurements. Conduct an aquifer pumping test.
Soil	Collect direct push soil samples from approximately 39 locations and analyze onsite for VOCs.	Collect 3 soil samples from each shallow monitoring well boring and soil boring. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, percent moisture, and Total Organic Carbon (TOC).
	Analyze select soil samples from the direct push sampling at an offsite laboratory for metals and VOCs.	
Surface Water	None.	Collect 5 surface water samples from Little Choconut Creek. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, and hardness.
Sediment	None.	Collect 5 sediment samples from Little Choconut Creek. Analyze for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, percent moisture, and TOC.

(6) Using a PID, take a headspace reading from the soil sample which was set aside. Record the time, sample interval, and PID reading. Use the remaining soil to log the lithology on a direct push log form and in the logbook.

(7) Repeat steps 1 through 6 for each soil sample. Samples will be collected at 5 foot intervals until groundwater is reached (approximately 15-20 feet bgs).

(8) Once all soil samples have been collected at a location, the sample with the highest PID reading will be taken to the mobile laboratory for onsite analysis. If none of the samples from a location have elevated PID readings, the sample closest to the groundwater table will be analyzed onsite for VOCs. Additional samples may be analyzed depending on the capacity of the laboratory.

(9) Based on onsite analytical results, some samples will be sent to an offsite laboratory for VOC analysis to confirm the onsite screening results. If a sample is sent offsite for VOC analysis, the soil which was retained and maintained at 4°C will be placed in a 4-ounce jar. The sample jar will be tightly packed so that there is a minimum headspace. Label the sample and document the sample on the COC form. If insufficient sample volume remains in the original sample liner to allow the jar to be completely filled, the capped liner will be sent directly to the laboratory; this will minimize volatilization due to excess headspace.

(10) Approximately 10 percent of the soil samples will be sent to an offsite laboratory for metals analysis. Samples selected for metals analysis will be from background locations and areas where metals contamination is suspected. To collect a metals sample, the soil will be transferred to an 8-ounce jar. Label the sample and document the sample on the COC form.

(11) Collect 10 percent replicates for onsite analysis and 10 percent replicates for offsite analysis.

(12) Collect a matrix spike every twentieth sample for offsite analysis.

Groundwater Sampling. Once the soil samples have been collected at each location, a groundwater sample will be collected.

(1) After driving the rods and sampler into the saturated zone, remove and replace the rods and sampler with a 0.5-inch diameter PVC pipe with a 5 or 10 foot screened interval to allow groundwater to enter from the saturated zone.

(2) Collect the groundwater sample with a stainless steel mini-bailer lowered through the PVC pipe.

(3) The groundwater sample will then be collected in a pre-preserved 40 mL vial. No headspace will remain in the vial. The sample will be immediately taken to the onsite laboratory for proper storage and VOC analysis. Offsite analysis of groundwater samples

is not planned; however, two split groundwater samples will be analyzed by method SW8260 to compare the results from the fixed laboratory and the onsite mobile laboratory. When collecting a groundwater sample for offsite, the sample should be collected in three pre-preserved 40 mL vials.

(4) Collect 10 percent duplicates for onsite analysis.

It is anticipated that groundwater sampling following the above method may not be possible at some locations due to either hole collapse prior to inserting the PVC or direct push refusal prior to encountering groundwater. In these instances, the following method will be followed.

(1) A new location will be driven adjacent to the original location with an expendable point attached to the 1.25-inch diameter rods.

(2) After driving into the saturated zone, the rods will be raised back off of the expendable point a few inches, allowing groundwater to enter the rods.

(3) The groundwater sample will then be collected with a stainless steel mini-bailer lowered through the rods and contained in a pre-preserved 40 mL vial. No headspace will remain in the vial. The samples will be immediately taken to the onsite laboratory for proper storage and VOC analysis.

2.2.1.2 Subsurface Soil Sampling. Ambient air will be monitored during all drilling and soil sampling activities. A photoionization detector (PID) will be used to monitor volatile organic compound vapors in: (1) the breathing space at worker chest level; (2) down the borehole or monitoring well; and (3) in background locations. Air monitoring concentrations will be recorded in the remarks column on the borehole logs. If ambient air concentrations exceed those specified in the Health and Safety Plan, fieldwork will be stopped and action taken according to contingencies in the Health and Safety Plan.

Two drilling methods will be used to drill monitoring well boreholes during the RI: HSA and drive and wash. During the drilling of the deep monitoring well boreholes, soil samples will be collected continuously with a continuous tube sampler for lithologic description from the ground surface to the depth of the fine-grained deposits. After encountering the fine-grained deposits, or the if fine-grained deposits are not encountered by the anticipated depth, continuous sampling will cease, and lithologies will be described through the logging of drill cuttings until the total borehole depth is reached. Soil samples from the deep boreholes will be collected to characterize the stratigraphy only; no samples will be collected for chemical analysis. During the drilling of the shallow monitoring well boreholes, soil samples for potential chemical analysis will be collected above the water table at 5-foot intervals using split-spoon sampling techniques (ASTM D1586). No soil sampling will be conducted during the drilling of the intermediate monitoring well boreholes, but cuttings will be logged.

A PID will be used to screen all soils during drilling. Soil samples from shallow monitoring well boreholes and soil borings will be selected for chemical analysis based on field screening results: odor, discoloration, or elevated headspace readings. If no soil samples from a borehole are identified for analysis based on the field screening results, the samples will be selected at evenly spaced intervals from the ground surface to the water table. Up to three soil samples per borehole will be selected for chemical analysis. The types of samples to be collected and the proposed analytical methods are summarized in Section 2.2.5. Recommended sample containers, preservatives, and holding times for selected methods are provided in Section 2.2.2.1.

Split-Spoon Drive Sampling Techniques. A split-spoon sampling device will be used to collect subsurface soil samples from the shallow monitoring well boreholes according to ASTM D1586.

(1) The augers will be advanced to the desired depth and excess cuttings will be removed.

(2) A 24-inch long by 3-inch diameter split-spoon sampler will be attached to the sampling rods and lowered into the borehole. The sampler will contain four, 6-inch long by 3-inch diameter brass liners. The sampler will not be allowed to drop onto the soil being sampled.

(3) The hammer will be positioned above the sampler and the anvil will be attached to the top of the sampling rods.

(4) The dead weight of the sampler, rods, anvil, and drive weight will be rested on the bottom of the borehole and a seating blow will be applied. If the sampler advances below the bottom of the boring under the static weight of the drill rods and the static weight of the hammer, this information will be noted on the boring log. If excessive cuttings are encountered at the bottom of the borehole, the sampler and sampling rods will be removed, the excess cuttings will be removed, and the sampling procedure repeated.

(5) The sampler will be driven 24 inches with blows from a 140-pound hammer dropped 30 inches. Blow counts will be recorded on the borehole log. If 50 blows are applied during a 6-inch increment, the hammering will stop and the sampler will be brought to the surface.

(6) The raising and dropping of the 140-pound hammer will be accomplished using either of the following two methods.

- A trip, automatic, or semiautomatic hammer drop system that drops the hammer 30 inches.

- A cathead to pull a rope attached to the hammer. The cathead will be essentially free of rust, oil, or grease. For each hammer blow, a 30-inch lift and drop will be employed by the operator. The operation of pulling and throwing the rope will be performed rhythmically without holding the rope at the top of the stroke.

(7) After driving the sampler to the desired depth, it will be brought to the surface and opened. The percent recovery or the length of sample recovered will be recorded on the borehole log.

(8) The first and second brass liners will be collected for potential laboratory analysis. The liners will be sealed at both ends using Teflon™ paper and covered with plastic end caps. Labels will be affixed to sample liners bearing job designation, borehole number, sample depth, sampler signature, and date. The samples will then be put in a plastic bag and placed in an ice-filled cooler to be maintained at 4°C.

(9) The third liner within the sample barrel or the sample in the shoe (if extraction is difficult) will be extruded into a glass sample jar which will be covered with oil-free aluminum foil and sealed with a Teflon™-lined lid and allowed to volatilize for approximately 30 minutes. A headspace measurement will be taken from this sample for volatile organic compounds using a PID.

(10) The sample in the remaining liner will be used for lithologic descriptions including composition, color, stratification, and condition following the Unified Soil Classification System (USCS).

Sample data will be recorded on the Borehole Log (Figure 2-3) and in the field logbook. Details of data to be included on the logs, including lithologic descriptions, are discussed in Section 2.5.

Continuous Tube Sampling. A continuous tube sampler will be used during the drilling of the pilot boreholes for deep monitoring wells with HSA techniques. The continuous tube sampler is a 5-foot long by 3-inch I.D. split-spoon-like sampling device that is placed inside the hollow stem augers and pushed into the soil as the augers are advanced, collecting a continuous soil sample. It is exchanged for an empty sampler after the borehole is advanced 5 feet. The continuous tube sampler will be used without the optional polycarbonate liner so that subsurface soil samples can be collected and/or examined from arbitrary depths (e.g., at prominent changes in soil type). The continuous tube sampler can provide a nearly continuous soil profile that results in improved soil classification. It also helps to locate saturated zones, thus enabling the appropriate screen length to be chosen when monitoring wells are being installed in the shallow water-bearing zone.

2.2.1.3 Groundwater Sampling. The groundwater sampling program at AFP 59 will include sampling all new and existing monitoring wells. Section 2.2.5 lists the total anticipated number of samples to be collected for each sample type (e.g., environmental sample, duplicate), and the types of analyses. Section 2.2.2 provides recommended sample containers, preservatives, and holding times for the selected methods. Groundwater samples will be collected from the new monitoring wells no sooner than three days following development. This will allow the groundwater in the monitoring well to return to equilibrium conditions. Groundwater samples will be collected in order from least likely contaminated monitoring well locations to most likely contaminated monitoring well locations to lower the probability of cross-contamination. Groundwater sampling methods (discussed below) follow procedures described in the Handbook (USAF, 1993) and in the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (USEPA, 1986).

Static Groundwater Level Measurement. Groundwater elevations (static water level elevations) will be measured according to the RCRA Groundwater Monitoring Technical

Enforcement Guidance Document (USEPA, 1986) at each monitoring well prior to sampling. Additionally, a synoptic round of groundwater level measurements will be taken at all wells on AFP 59 property at least once within a single 24-hour period.

When obtaining water level measurements, the depth to groundwater will be measured from a clearly-marked reference point on the top of each monitoring well casing and recorded on a Water Level Measurement Form similar to the one illustrated in Figure 2-8. The depth-to-groundwater measurements will be made with a battery-powered water level meter. The measurements will be made by lowering the probe into the monitoring well until it contacts the groundwater surface. The depth to groundwater will be measured to the nearest 0.01 foot from the reference point on the top of the monitoring well casing. These measurements will be taken at least twice for each monitoring well; the variation between the two measurements must be less than 0.01 foot. The groundwater elevation is computed by subtracting this depth measurement from the elevation of the reference point on the monitoring well casing. The elevation of this reference point will be survey-established from a benchmark located at AFP 59.

The water level meter will be decontaminated prior to initial use and after each use following procedures outlined in Section 2.1.11. The alarm function on the meter will be checked by immersion in water. The length of tape is calibrated annually by manually checking against a surveyor's steel tape.

Monitoring Well Purging. The water standing in the monitoring well may not be representative of in-situ groundwater quality. Therefore, it is necessary to purge the monitoring well prior to sampling to obtain a representative groundwater sample. Purging and sampling activities will be recorded on a Groundwater Purging and Sampling Record (Figure 2-13). Before purging the monitoring well, the static water level will be measured using an electric water level meter and the depth to the bottom of the monitoring well will be determined using a weighted calibrated measuring tape. After the static water level and monitoring well depth have been measured, a variable rate pump will be used to purge water from the monitoring well. Purging will be conducted from the top of the water column to assure complete excavation of stagnant water.

If the monitoring well is capable of yielding three WBVs, groundwater will be collected after each WBV has been removed and tested for temperature, pH, specific conductance, and turbidity. Samples will be measured quickly to have as little contact with the atmosphere as possible. If the parameters have stabilized using the following criteria: temperature $\pm$ 1°C, pH $\pm$ 0.1 units, EC $\pm$ 5 percent, and turbidity within 10 NTUs of the previous reading, then a groundwater sample will be collected for laboratory analysis after the water level has reached 80 percent of its static level or 16 hours after completion of purging, whichever occurs first.

If all the parameters have not stabilized after three WBVs have been removed, then purging will continue until six WBVs have been purged, or parameters have stabilized, whichever comes first. Groundwater samples will be collected after the water level has recovered to 80 percent of its static level or 16 hours after completion of purging, whichever occurs first.

GROUNDWATER PURGING AND SAMPLING RECORD

Date:	Well ID:	Sample Number:	Recorded By:
Project Name:	Well Location:	Duplicate Number:	Checked By:
Project Number:			

EQUIPMENT

pH/Conductivity/Temperature Meter #:	Purging Equipment:
PID #:	Sampling Equipment:
Electric Sounder #:	

WELL DATA

Elevation:	Water Column in Well:	Total Vol. Extr.:
Well Diameter:	Borehole Diameter:	Ambient PID:
Well Depth:	Water Column in Borehole:	Well Mouth PID:
Depth to Well Water:	Standing Water Vol.:	

Ground Condition of Well:
Remarks:

	PURGING				SAMPLING	
	1	2	3	4	1	2
Time						
Rate						
Temperature						
pH						
Conductivity						
Vol. Purged						
Remarks						

COLLECTED SAMPLES

	1	2	3	4	5	6
Sample Time						
Analytical Param						
Volume Required						
Preservation						
Field Filtered						
Time						

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Figure 2-13

Groundwater Purging and Sampling Record

If the monitoring well is incapable of yielding three WBVs, the monitoring well will be purged until it has been purged dry, and a sample will be collected as soon as enough water has entered into the monitoring well to collect a groundwater sample.

The temperature, pH, specific conductance, and turbidity of the groundwater will be measured after each WBV has been removed using calibrated temperature, pH, conductivity, and turbidity meters. Duplicate measurements will be taken at a frequency of one in 10 samples and used to estimate the precision of the field analytical measurements. During purging, values for temperature, pH, EC, and turbidity will be recorded on the Groundwater Purging and Sampling Record (see Figure 2-13). Color and any odor will be recorded under the remarks column.

Sample Withdrawal. With the exception of samples collected for metals analysis, samples will be collected in order of decreasing volatilization. Samples for metals analysis will be collected first by using a variable rate pump, and will be allowed to flow directly into the sample containers. The pump will not be removed from the well between purging and sampling for metals in order to keep the turbidity of the water to a minimum. Additionally, the rate of the pump will be adjusted to maintain sediment-free samples, if possible.

After the metals sample has been collected and the pump has been removed from the monitoring well, the remaining samples will be collected in order of decreasing volatilization as follows: VOCs, SVOCs, pesticides/PCBs, cyanide, and hardness. These groundwater samples will be collected with a teflon bailer rather than the pump in order to prevent potential volatilization associated with the collection of groundwater samples through a pump.

For each VOC groundwater sample, three 40 mL glass volatile organic analysis (VOA) vials will be filled allowing no headspace. This will be accomplished by filling the bottles until a meniscus forms over the top, and then fitting the cap securely. Headspace will be checked by inverting the bottle and tapping the lid to see if any air bubbles are visible in the bottle. If an air bubble appears, the sample will be collected again in a new vial. The pH of acidified VOC samples will not be measured.

Metals, SVOCs, pesticides/PCBs, cyanide, and hardness groundwater samples will be placed in 1 liter plastic or glass containers filled to the top. If preservatives are in the containers, they will not be allowed to overflow while filling. The pH of preserved samples will be checked in the field by pouring a small amount of sample onto pH paper. The paper will not touch the sample inside the container.

The groundwater samples will be collected in order of decreasing volatilization (with the exception of metals) as follows:

(1) Metals,
(2) VOCs,
(3) SVOCs,
(4) Pesticides/PCBs,
(5) Cyanide, and
(6) Hardness

Following sample collection, the labeled sample jars will be placed in plastic bags and stored on ice in insulated coolers to maintain the samples at 4°C. Samples will be kept under strict COC (see Section 2.2.3).

2.2.1.4 Surface Water Sampling. Surface water samples will be collected from five locations in Little Choconut Creek (see Section 2.1.8). Samples will be collected as follows.

(1) Before sampling, all sampling equipment will be decontaminated as described in Section 2.1.11.

(2) Surface water and sediment sample pairs will be collected from the same location in the stream. To avoid cross-contamination, the surface water sample will always be collected prior to the sediment sample at each location. Samples will be collected first at the furthest downstream location, moving upstream for subsequent samples.

(3) Prior to collecting each surface water sample, the approximate sample location and depth will be noted as well as the temperature, pH, and conductivity of the creek water. Thermometers, pH meters, and electrical conductivity meters will be calibrated as described in Section 2.3.2. The approximate width, depth, and flow rate of the stream will be recorded as well as surface conditions and the locations of any discharge pipes, sewers, or tributaries.

(4) Samples will be collected in areas of similar environment at all locations. Samples will be collected from active portions of the creek, and from the side of the creek nearest the plant. A sample will be collected by standing downstream of the sample location and submerging a decontaminated container into the water column while positioning the container mouth so that it faces upstream.

(5) The surface water will then be transferred from the container to laboratory-provided bottles containing the appropriate preservative. Each sample will be analyzed for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, and hardness. The VOC sample will be collected first in two pre-preserved 40 mL VOA vials. No headspace will remain in the VOA vials. The SVOC sample will be collected next, followed by the pesticides/PCBs, metals, cyanide, and hardness.

(6) The date, time, location, analysis, preservatives, and initials of the sampler will be noted on each container label.

Following sample collection, the labeled sample jars will be placed in plastic bags and stored on ice in insulated coolers to maintain the samples at 4°C. Samples will be kept under strict COC (see Section 2.2.3).

2.2.1.5 Sediment Sampling. Sediment samples will be collected as follows.

(1) Prior to sampling, all sampling equipment will be decontaminated as described in Section 2.1.11.

(2) Sediment sample jars will be triple rinsed with the surface water from the appropriate location prior to collecting the sediment sample.

(3) A sediment sample will be collected from 0 to 6 inches below the sediment-water interface by scooping sediment at the sample location and placing it directly into the laboratory-provided bottles via a stainless steel scoop.

(4) Each sediment sample will be analyzed for VOCs, SVOCs, pesticides/PCBs, metals, cyanide, and Total Organic Carbon (TOC). The VOC sediment sample will be packed as full as possible.

(5) If multiple aliquots are required for a sediment sample, all aliquots (except for VOAs) will be placed in a stainless steel bowl and mixed thoroughly before placement into sample containers. Replicates will be collected at the same time and from the same container of composited sediment.

(6) The date, time, location, analysis, and initials of the sampler will be noted on each container label.

(7) Finally, a flag will be placed in the sediment to indicate the location of both the sediment and surface water sample for later surveying.

Following sample collection, the labeled sample jars will be placed in plastic bags and stored on ice in insulated coolers to maintain the samples at 4°C. Samples will be kept under strict COC (see Section 2.2.3).

2.2.2 Sample Handling and Labeling

The following section identifies the types of sample containers, sample volumes, methods of preservation, sample identification, sample holding times, sample labeling, sample packaging, and shipping method.

2.2.2.1 Sample Containers, Volumes, Preservation, and Holding Times. Sample methods, containers, volumes, preservatives, and holding times are summarized in Table 2-4.

2.2.2.2 Sample Identification, Labels, and Shipping. Throughout the field program, consistent and thorough sample identification will be maintained by field personnel. This section documents the requirements and contingencies for this procedure.

Sample Identification Code. Sample identification will be achieved through the use of a four-part code. The first part indicates the location according to the following list:

TABLE 2-4
RECOMMENDED SAMPLE CONTAINER, VOLUME, PRESERVATION, AND HOLDING TIME

Parameter	Matrix[1]	Method	Container[2]	Minimum Volume Required	Preservative	Holding Time[3]
FIELD - DETERMINED PHYSICAL PARAMETERS						
Specific Conductance	W	E120.1	P, G	N/A	None (field test)	Analyze Immediately
pH	W	E150.1	P, G	N/A	None (field test)	Analyze Immediately
Temperature	W	E170.1	P, G	N/A	None (field test)	Analyze Immediately
Turbidity	W	E180.1	P, G	100 mL	Refrigeration is recommended	Analyze Immediately
LABORATORY - DETERMINED PHYSICAL PARAMETERS						
Moisture	S, SS	E160.3	P, G, T	200 g	Airtight container, cool 4°C, away from direct sunlight	As soon as possible
LABORATORY - DETERMINED CHEMICAL PARAMETERS						
Volatile Organic Compounds	S, SS	SW8260	T, G with Teflon-lined cap	4 ounces	4°C	10 days
	W, SW	SW8260	G with Teflon-lined Septum	2 × 40 mL	4°C, HCl to pH<2	7 days
Semivolatile Organic Compounds	S, SS	SW8270	T, G with Teflon-lined cap	8 ounces	4°C	14 days until extraction; 40 days after extraction
	W, SW	SW8270	G with Teflon-lined cap	1 liter	4°C	7 days until extraction; 40 days after extraction
Metals	S, SS	SW6010	P, G, T	8 ounces	4°C	6 months
	W, SW	SW6010	P, G	500 mL	4°C, HNO3 to pH<2	6 months
Arsenic	S, SS	SW7060	P, G, T	8 ounces	4°C	6 months
	W, SW	SW7060	P, G	500 mL	4°C, HNO_3 to pH <2	6 months

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TABLE 2-4
RECOMMENDED SAMPLE CONTAINER, VOLUME, PRESERVATION, AND HOLDING TIME

Continued

Parameter	Matrix[1]	Method	Container[2]	Minimum Volume Required	Preservative	Holding Time[3]
Lead	S, SS	SW7421	P, G, T	8 ounces	4°C	6 months
	W, SW	SW7420	P, G	500 mL	4°C, HNO3 to pH<2	6 months
Mercury	S, SS	SW7471	P, G, T	8 ounces	4°C	28 days
	W, SW	SW7470	P, G	500 mL	4°C, HNO3 to pH<2	28 days
Selenium	S, SS	SW7740	P, G, T	8 ounces	4°C	6 months
	W, SW	SW7740	P, G	500 mL	4°C, HNO3 to pH<2	6 months
Thallium	S, SS	SW7841	P, G, T	8 ounces	4°C	6 months
	W, SW	SW7841	P, G	500 mL	4°C, HNO3 to pH<2	6 months
Cyanide	S, SS	SW9010	P, G, T	4 ounces	4°C	14 days
	W, SW	SW9010	P, G	500 mL	4°C, NaOH to pH >12	14 days
Pesticides/PCBs	S, SS	SW8080	T, G with Teflon-lined Cap	8 ounces	4°C	14 days until extraction; 40 days after extraction
	W, SW	SW8080	G with Teflon-lined Cap	1 liter	4°C	7 days until extraction; 40 days after extraction
Hardness	W, SW	E130.1	P	100 mL	4°C, HNO_3 to pH <2 or H_2SO_4 to pH <2	6 months
TOC	S, SS	SW9060	P, A, T	4 ounces	4°C	28 days

Note: This table includes absolute minimum volumes for the implementation of each appropriate chemical analysis. Typical sample volumes collected are far in excess of minimum volumes stated.

Key:

[1]W = Water Matrix, S = Solid Matrix, SW = Surface Water Matrix, and SS = Surface Sediment Matrix.
[2]Polyethylene (P); Glass (G); Brass Sleeves in the sample barrel, sometimes called California Brass (T); Amber glass bottle (A).
[3]The listed holding times are recommended for properly preserved samples based on currently available data. It is recognized that extension of these times may be possible for some sample types while, for other types, the times may be too long. When shipping regulations prevent the use of the proper preservation technique or when the holding time is exceeded, the final reported data for these samples should indicate the specific variance. If samples cannot be analyzed within the specified time intervals, the final reported data should indicate the actual holding time.

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Location	Code
Onsite (AFP 59)	59
Offsite (Johnson City)	JC

The second part indicates the source of the sample and will use the abbreviation system described below. Each source will be numbered, as indicated by the "n" in the following designations.

Location Type	Code
Direct Push	DPn
Groundwater Monitoring Wells	
Shallow Wells	SWn
Intermediate Wells	IWn
Deep Wells	DWn
Borehole	BHn
Creek	CRn

The third part indicates the sampling matrix, according to the following abbreviations:

Sampling Matrix	Code
Groundwater	WG
Soil (during Reconnaissance Survey)	SO
Surface Water	WS
Sediment	SE

The fourth part indicates the specific number of the sample obtained from the location. This numbering will begin with 1 and will increase by one unit each time a sample is collected from that location, regardless of date or time.

Two examples of this numbering system are presented below:

- Fourth subsurface soil sample collected from the deep monitoring well number 12 borehole onsite AFP 59: 59DW12SO4
- First groundwater sample from shallow monitoring well number 9 onsite AFP 59: 59SW9WG1.

The only exception to the sequential numbering system is when a duplicate or replicate sample is collected. In either case, the specific number (fourth part) of the duplicate/replicate sample will be recorded as 9. For example, a duplicate from the second subsurface soil sample collected for analysis from borehole number 3 onsite AFP 59 would be labelled: 59BH03SO9.

Each sample number, along with the sample depth, and the date and time the sample was obtained, will be recorded in the bound logbook and written on the sample label. After collection and identification, the sample will be handled under COC procedures.

Sample Labels. Samples are identified by a sample label which includes the following information for soil samples.

- Project number
- Sample identification
- Depth of sample
- Date and time of sample collection
- Initials of the sampler
- Analyses to be conducted

Sample labels will be affixed by the samplers to the brass sample liners or other containers.

The information recorded on the sample label for a groundwater or surface water sample will include:

- Project number
- Sample identification
- Date and time of sample collection
- Initials of the sampler
- Preservatives used (when appropriate)
- Analyses to be conducted

Sample labels will be affixed by the samplers to the sample containers.

Sample Packaging, and Shipping. All samples will be packaged carefully to avoid breakage or contamination and will be shipped to the laboratory at proper temperatures. The following sample packaging requirements will be followed.

- Sample container tops will not be mixed. All tops will stay with the original containers.

- If the sample volume is low because of limited sample availability, the level will be marked on the sample container with a grease pencil. This procedure will help the laboratory determine if any leakage occurred during shipment.

- All glass sample bottles will be wrapped in bubble pack and placed in plastic bags to minimize the potential for contamination and breakage during shipment. Plastic bottles will not be wrapped, but will be placed in plastic bags. Subsurface soil samples contained in brass liners will be placed in plastic bags.

- All samples will be cooled to 4°C. The coolers will be filled with blue ice or ice within Zip-lock™ bags.

- Empty space in the cooler will be filled with vermiculite. Under no circumstances will locally obtained material (sawdust, sand, etc.) be used.

- The COC record and IRPIMS data sheet will be placed in a plastic bag and taped to the inside of the cooler lid.

- All shipping containers will be custody-sealed for shipment to the laboratory. The custody seal will be covered with filament tape wrapped around the shipping container at least twice before the sample container is shipped to the laboratory.

2.2.3 Sample Custody

In order to maintain and document sample custody, the following COC procedures will be strictly followed. A sample is considered to be under custody if:

- It is in actual possession of the responsible person;

- It is in view, following physical possession;

- It is in the possession of a responsible person and is locked or sealed to prevent tampering; or

- It is in a designated secure area.

2.2.3.1 Chain-of-Custody Record. Sample custody is maintained by a "COC Record" as illustrated in Figure 2-14. The custody record is completed by the individual designated by the Project Manager as being responsible for sample shipment and must be completed at the sampling location. The information recorded on this record includes the following.

Laboratory	-	Name of laboratory samples are to be shipped to
Address	-	Address of laboratory doing the analysis
Project Name	-	The project title: Air Force Plant 59
Sampler Name	-	Name of person collecting the samples
Sampler Signature	-	Signature of person collecting the samples
Method of Shipment and Airbill Number	-	E.g., FEDEX, courier
Field Point-of-Contact	-	Reid Wellensiek
Telephone No.	-	(703) 549-8728

COMPUCHEM
ENVIRONMENTAL
CORPORATION

3306 Chapel Hill/Nelson Highway
Research Triangle Park, NC 27709

1-800-833-5097

CHAIN-OF-CUSTODY RECORD

Ship to:	Project Name:	Field Point-of-Contact:
	Sampler Name:	Telephone No: Sampling for project complete? Y or N (See Note 1.)
Carrier: Airbill No.:	Sampler Signature:	Project-specific (PS) or Batch (B) QC: ____

Box #1 1. Surface Water 2. Ground Water 3. Leachate 4. Rinsate 5. Soil/Sediment/Sludge 6. Trip Blank 7. Oil 8. Waste 9. Other ____	Box #2: A. HCl B. HNO_3 C. $NaHSO_4$ D. $Na_2S_2O_3$ E. Ice Only O. Other ____ N. Not Preserved	Box #3: F. Filtered U. Unfiltered	Box #4: C. CLP 3/90 S. SW-846 W. CWA 600-series L. Low Conc. CLP R. Radiological T. TCLP O. Other	Box #5: H - High M - Medium L - Low

Sample ID (Organics: 9 characters max, Inorganics: 6 characters; see Note 2)	Date: Year: 19__	Time	Matrix (Box #1)	Preservative (Box #2)	Filtered/Unfiltered (Box #3)	Method (Box #4)	Expect. Conc. (Box #5)	No. of Bottles	Use for Lab QC (MS or DUP)	Organics Analysis: VOA-GC/MS	SV-GC/MS	Pest/PCB-GC	Herb-GC	VOA-GC			Inorganics: Metals	Mercury	Cyanides	Other: Radiologicals		TOC/TOX	O&G/TPH	Phenols	Other	Remarks/Comments
	/	:																								
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Client's Special Instructions:

Lab: Received in Good Condition? Y or N   Describe Problems, If Any:

#1 Relinquished By: (Sig.)	Date:	#2 Relinquished By: (Sig.)	Date:	#3 Relinquished By: (Sig.)	Date:	Sample storage time requested? ____ (in days, see Note 3)
Company Name:	Time:	Company Name:	Time:	Company Name:	Time:	
#1 Received By: (Sig.)	Date:	#2 Received By (Sig.)	Date:	#3 Received By: (Sig.)	Date:	DESTROY or RETURN data after five years of archival? (Circle choice; see Note 4)
Company Name:	Time:	Company Name:	Time:	Company Name:	Time:	

Note (1): If "N" lab will hold samples to await remainder of project-maximizing batch size and minimizing QC ratio; if "Y" lab will begin processing batches now. Note (2): If CLP Inorganics diskette required, ID limited to maximum of six characters.
Note (3): Samples stored 60 days after data report mailed at no extra charge. Note (4): All lab copies of data destroyed after five years unless client requests and pays for return of copies; annual storage fee billed in January of year six.

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Figure 2-14

Chain-Of-Custody Record

Project-Specific or Batch QC	-	Project-specific
Field Sample Identification	-	The four part sample identification code (e.g., 59SW1WG1)
Date, Time	-	Date and time sample was collected
Matrix	-	Numerical code for sample matrix (e.g., 2 = groundwater)
Preservative	-	Letter code for preservative (e.g., A = HCl)
Filtered/Unfiltered	-	Whether or not a sample has been filtered in the field
Method	-	Analytical protocol is SW846
Expected Concentration	-	Expected contaminant concentration (e.g., high, medium, low)
Number of Bottles	-	Number of sample containers
Use for Lab QC	-	Specify if sample is for matrix spike
Analysis Required	-	Mark the analyses required
Relinquished by	-	Signature and printed name of the person giving up the sample
Company	-	Print the name of the organization relinquishing the sample
Date/Time	-	Date and time at which sample custody was transferred
Received by	-	Signature and printed name of the receiving person
Company	-	Print the name of the receiving organization

In addition, the shipment number will be written in the upper righthand corner of the COC.

The completed original COC form will be returned promptly to Earth Tech by laboratory personnel upon initial receipt of the samples and completion of the form. The original form will be a permanent part of the project records.

Data which are required to complete the IRPIMS files are included on an IRPIMS data sheet and sent to the laboratory along with the COC forms. An IRPIMS data sheet is illustrated in Figure 2-15. Data which is required to complete this form includes: the field sample ID, the location cross reference (i.e, borehole number, monitoring well number, etc), the sample matrix, the sample code (i.e., normal sample, field blank, duplicate, etc.), the sample beginning depth, and the sample end depth.

2.2.3.2 Transfer of Custody. Field personnel initially collecting the samples are responsible for the care and custody of the samples until they are properly transferred or delivered to laboratory personnel. All samples will be accompanied by a COC record. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC record. The company from which the sample is relinquished and to which it is delivered will be noted. This record documents the transfer of samples from the custody of the sampler to that of another person, or the laboratory.

The relinquishing individual will record specific shipping data (air bill number, office, time, and date) on the original and duplicate custody records. It is the Project Manager's responsibility to ensure that all shipping data are consistent and that they are made part of the permanent job file.

If sent by mail, the package will be sent by registered mail, with a return receipt requested. If sent by common carrier, a bill of lading will be used. Freight bills, postal service receipts, and bills of lading will be retained as part of the permanent documentation.

2.2.4 Quality Control Samples

Five types of field QC samples will be collected during the investigative effort. The number, type, and composition of these samples will comply with the requirements outlined below.

Replicate samples, duplicate samples, and field blanks are defined in the following sections, and their use during the RI is explained. All replicate and duplicate samples will be labeled as normal field samples (Section 2.2.2.2) so that laboratory personnel analyzing the samples are unable to distinguish them from normal samples; the IRPIMS data sheets which indicate whether a sample is a replicate or duplicate go directly to the IRPIMS data manager so that the appropriate IRPIMS files can be completed. The labeling system for field blanks includes the letters TB for trip blanks, AB for ambient conditions blanks, and EB for equipment blanks, plus a number to identify the sequential number. This is followed by the date of collection. As an example, TB1072794 would be the first trip blank collected on July 27, 1994.

Replicates. A field replicate is a single soil sample divided into two equal parts for analysis. Field replicates will be labeled so that laboratory personnel are unable to distinguish them from normal samples. For split-spoon samples, the first and second brass liners from the bottom of the split-spoon will be used as the sample and replicate, respectively. So that the normal and replicate samples are located as close together as possible, arrows will be placed (by marker) on the liners such that they point toward the interface where the liners met in the split-spoon sampler. The laboratory is notified on the COC that "Liners are marked by arrows. Take soil

AFP 59 Field Number-IRPIMS Cross Reference
Project Number: 949033-09

Shipment No.:________________
COC No.:________________
Date:________________

AFIID: AFP59
CONTID: F41624-94-D-8055
DONUM: 04

Field Sample ID	LOCXREF	MATRIX	SACODE	SBD	SED
59DP01SO3	DP01	SO	N1	5.0	7.0
JCMW2DWG1	MW2D	WG	N1	0.0	0.0
EB1071094	FIELDQC	WQ	EB1	0.0	0.0

Legend:

LOCXREF:
DP# - Direct Push
MW# - Monitoring Well
FIELDQC - All TB, EB, AB

MATRIX:
WG - Groundwater
SO - Soil
SE - Sediment
WS - Surface Water
WQ - Field Blanks (Water)

SACODE:
N1 - Normal Sample
FD1 - Field Duplicate (Water)
FR1 - Field Replicate (Soil)
AB1 - Ambient Blank
EB1 - Equipment Blank
TB1 - Trip blank
MS1 - Matrix Spike

SBD:
Sample beginning depth (in feet bgs)
For groundwater and field blanks enter 0.0

SED:
Sample ending depth (in feet bgs)
For groundwater and field blanks enter 0.0

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Figure 2-15

IRPIMS Data Sheet

for analysis from liner end marked by arrow". Field replicates will number 10 percent of the total sample number and be analyzed for all parameters.

Duplicates. Field duplicates are two samples collected independently at a sample location during a single act of sampling. Field duplicates will be labeled so that laboratory personnel are unable to distinguish them from normal environmental samples. Ten percent of all groundwater and surface water samples will be field duplicates and be analyzed for all parameters.

Trip Blanks. A trip blank is a VOC sample bottle filled in the laboratory with Type II reagent-grade water, transported to the site, handled like a sample, and returned to the laboratory for analysis. Trip blanks will not be opened in the field. One trip blank will accompany each cooler containing samples for VOC analysis. The trip blank will be analyzed for the same VOCs as the environmental samples (SW8260).

Ambient Conditions Blanks. An ambient conditions blank is defined as Type II reagent-grade water that is poured into a sample container at a sampling site. It will be handled like a sample and transported to a laboratory for analysis. One ambient conditions blank will be collected at each sampling site during each VOC sampling round. The ambient conditions blank will be analyzed for the same VOCs as the groundwater samples (SW8260).

Equipment Blanks. An equipment blank is defined as Type II reagent-grade water that is poured into or pumped through (in the case of pumps) the sampling device, transferred to a sample bottle, and transported to a laboratory for analysis. One set of equipment blanks will be collected by each sampling team for each day of sampling. The equipment blanks will be analyzed for all laboratory analyses requested for normal samples collected at a site the day the equipment blank is collected.

2.2.5 Sample Analysis Summary

Several analytical methods will be performed on the environmental soil, groundwater, surface water, and sediment samples. The following methods will be performed on all samples.

- VOCs - SW8260
- SVOCs - SW8270
- Pesticides/PCBs - SW8080
- Metals - SW6010
- Arsenic - SW7060
- Lead - SW7420/SW7421
- Mercury - SW7470/SW7471
- Selenium - SW7740
- Thallium - SW7841
- Cyanide - SW9010.

In addition to these methods, groundwater and surface water will be tested for hardness by method E130.1. The sediment and soil samples will have an additional analysis for TOC

(SW9060). Moisture content will be reported for all environmental soil and sediment samples.

Table 2-5 summarizes the sample analyses for both environmental samples and QA/QC samples. The summary presents the reporting units, the total number of laboratory analyses for all media, the number of trip blanks, the number of ambient conditions blanks, the number of equipment blanks, and the number of field replicate/duplicate samples; the numbers of laboratory analyses are estimated maxima.

2.3 Field Measurements

2.3.1 Parameters

Table 2-6 identifies the parameters to be measured in the field and the equipment that will be used for these measurements.

2.3.2 Equipment Calibration

The collection of field data during the RI will require a variety of field instruments. Proper maintenance, calibration, and operation of each instrument will be the responsibility of the field task manager and the instrument technicians assigned to the project. All instruments and equipment used during the investigation will be maintained, calibrated, and operated according to the manufacturers' guidelines and recommendations.

Field instruments will be calibrated prior to use in the field as appropriate. Calibration procedures are described below. Copies of the instrument manuals will be maintained in Earth Tech's field office at AFP 59. A record of field calibration of analytical instruments (e.g., PID, temperature/pH/conductivity meter) will be maintained on the Equipment Calibration Daily Log (Figure 2-16) by field personnel. These records will be subject to QA audit. In addition, any notes on unusual results, changing of standards, battery charging, and operation and maintenance will be included in the log.

All instruments are to be stored, transported, and handled with care to preserve equipment accuracy. Damaged instruments will be taken out of service immediately and not used again until a qualified technician repairs and recalibrates the instruments.

All field instruments and other equipment will be thoroughly decontaminated prior to use and between sampling points to avoid cross-contamination. Instruments such as the PID will be wiped with a moist towel at the end of each work day. Water level meters will be thoroughly rinsed with deionized water after each use. All other equipment will be scrubbed in Alconox solution, rinsed with potable or deionized water, and finally rinsed with ASTM Type II water. Discarded materials, including paper towels and decontamination fluids, will be accumulated and stored in appropriate receptacles for proper disposal as described in Section 2.1.12.

Field calibration for the instruments that will be used to monitor groundwater purging and sampling at AFP 59 is described below.

TABLE 2-5
SUMMARY OF PHASE II SAMPLE ANALYSES

Analytical Method	Reporting Units	Environmental Samples	Trip Blanks	Ambient Conditions Blanks	Equipment Blanks	Duplicate/ Replicate Samples	Total Analyses
SOIL ANALYSES							
SW8260 Volatile Organics	mg/kg	48	10	1	10	5	74
SW8270 Semivolatile Organics	mg/kg	48	--	--	10	5	63
SW6010 Metals	mg/kg	48	--	--	10	5	63
SW7060 Arsenic	mg/kg	48	--	--	10	5	63
SW7421 Lead	mg/kg	48	--	--	10	5	63
SW7471 Mercury	mg/kg	48	--	--	10	5	63
SW7740 Selenium	mg/kg	48	--	--	10	5	63
SW7841 Thallium	mg/kg	48	--	--	10	5	63
SW8080 Pesticides/PCBs	mg/kg	48	--	--	10	5	63
SW9010 Cyanide	mg/kg	48	--	--	10	5	63
ASTM D2216 Moisture	Percent (%)	48	--	--	--	5	53
SW9060 TOC	mg/kg	48	--	--	10	5	63

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TABLE 2-5
SUMMARY OF PHASE II SAMPLE ANALYSES

Continued

Analytical Method	Reporting Units	Environmental Samples	Trip Blanks	Ambient Conditions Blanks	Equipment Blanks	Duplicate Samples	Total Analyses
GROUNDWATER ANALYSES							
SW8260 Volatile Organics	μg/L	29	10	1	10	3	53
SW8270 Semivolatile Organics	μg/L	29	–	–	10	3	42
SW6010 Metals	mg/L	29	–	–	10	3	42
SW7060 Arsenic	mg/L	29	–	–	10	3	42
SW7420 Lead	mg/L	29	–	–	10	3	42
SW7470 Mercury	mg/L	29	–	–	10	3	42
SW7740 Selenium	mg/L	29	–	–	10	3	42
SW7841 Thallium	mg/L	29	–	–	10	3	42
SW8080 Pesticides/PCBs	μg/L	29	–	–	10	3	42
SW9010 Cyanide	mg/L	29	–	–	10	3	42
E130.1 Hardness	mg/L	29	–	–	–	3	32

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TABLE 2-5
SUMMARY OF PHASE II SAMPLE ANALYSES

Continued

Analytical Method	Reporting Units	Environmental Samples	Trip Blanks	Ambient Conditions Blanks	Equipment Blanks	Duplicate Samples	Total Analyses
SEDIMENT ANALYSES							
SW8260 Volatile Organics	mg/kg	5	1	1	1	1	9
SW8270 Semivolatile Organics	mg/kg	5	–	–	1	1	7
SW6010 Metals	mg/kg	5	–	–	1	1	7
SW7060 Arsenic	mg/kg	5	–	–	1	1	7
SW7421 Lead	mg/kg	5	–	–	1	1	7
SW7471 Mercury	mg/kg	5	–	–	1	1	7
SW7740 Selenium	mg/kg	5	–	–	1	1	7
SW7841 Thallium	mg/kg	5	–	–	1	1	7
SW8080 Pesticides/PCBs	mg/kg	5	–	–	1	1	7
SW9010 Cyanide	mg/kg	5	–	–	1	1	7
SW9060 TOC	mg/kg	5	–	–	1	1	7
ASTM D2216 Moisture	Percent (%)	5	–	–	–	1	6

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TABLE 2-5
SUMMARY OF PHASE II SAMPLE ANALYSES

Continued

Analytical Method	Reporting Units	Environmental Samples	Trip Blanks	Ambient Conditions Blanks	Equipment Blanks	Duplicate Samples	Total Analyses
SURFACE WATER ANALYSES							
SW8260 Volatile Organics	μg/L	5	1	1	1	1	9
SW8270 Semivolatile Organics	μg/L	5	--	--	1	1	7
SW6010 Metals	mg/L	5	--	--	1	1	7
SW7060 Arsenic	mg/L	5	--	--	1	1	7
SW7420 Lead	mg/L	5	--	--	1	1	7
SW7470 Mercury	mg/L	5	--	--	1	1	7
SW7740 Selenium	mg/L	5	--	--	1	1	7
SW7841 Thallium	mg/L	5	--	--	1	1	7
SW8080 Pesticides/PCBs	μg/L	5	--	--	1	1	7
SW9010 Cyanide	mg/L	5	--	--	1	1	7
E130.1 Hardness	mg/L	5	--	--	1	1	7

Note: Number of sample analyses is based on the maximum number of samples expected to be collected during Phase II of the investigation.

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TABLE 2-6
FIELD MEASUREMENT PARAMETERS AND EQUIPMENT

Parameter	Instrument	Remarks
Conductivity	pH/Conductivity meter	Method E120.1 will be used to determine the conductivity of the groundwater during development and purging of the monitoring wells.
pH	pH/Conductivity meter	Method E150.1 will be used to determine the pH of the groundwater during development and purging of the monitoring wells.
Temperature	Digital Thermometer	Method E170.1 will be used to determine the temperature of the groundwater during development and purging of the monitoring wells.
Turbidity	Nephelometric Turbidimeter	Method E180.1 will be used to determine the turbidity of the groundwater during development and purging of the monitoring wells.
Suspended Sediment Content	Imhoff Cone	Method 160.5 will be used to determine the suspended sediment of the groundwater during development and purging of the monitoring wells.
Organic Vapors in the Breathing Zone	Photoionization Detection (HNu), Organic Vapor Analyzer (OVA)	These instruments will be used to monitor the concentration of total organic vapors in the breathing zone during field operations.
Groundwater Level	Water Level Meter	The water level meters will be used to measure depth to groundwater in monitoring wells.

EQUIPMENT CALIBRATION DAILY LOG

Time

Date______________ AM______________ Midday______________ PM______________ Operator______________

pH Meter

Serial Number:______________

	AM	Midday	PM		
*pH 7.00 buffer solution: pH				Exp. Date______	Lot #______
*pH 4.00 buffer solution: pH				Exp. Date______	Lot #______
*pH 10.00 buffer solution: pH				Exp. Date______	Lot #______
Temperature					
Comments					
Operator Signature					

Conductivity Meter

Serial Number______________

Calibration solution______________ Exp. Date______________ Lot #______________

*MICROMHO reading AM______________ Midday______________ PM______________

Calibration solution______________ Exp. Date______________ Lot #______________

*MICROMHO reading AM______________ Midday______________ PM______________

Temperature AM______________ Midday______________ PM______________

Comments______________

Operator Signature AM______________ Midday______________ PM______________

Organic Vapor Analyzer

Type______________

Serial number______________

Calibration gas______________

*Reading AM______________ Midday______________ PM______________

*Background reading AM______________ Midday______________ PM______________

Comments______________

Operator Signature AM______________ Midday______________ PM______________

*Positive response checks will be done every 4 hrs: AM, Midday and PM

Checked by______________ Date______________

EARTH TECH

Figure 2-16

Equipment Calibration Daily Log

Temperature/pH/Conductivity Meter. Electronic thermometers will be calibrated monthly to NIST standards prior to initial use and are visually inspected at least once a year.

The pH meter will be calibrated at the beginning of each day. At least two buffer solutions that bracket the expected sample pH will be used. Either pH 4 and 7 buffers or 7 and 10 buffers will be used. Calibration knobs are used to set the meter to read the value of the standards. The pH meter is also checked periodically during the sampling period (midday and end of day) using a pH 7 buffer. If the reading varies more than two-tenths of a unit between calibration checks, the meter will be recalibrated.

The conductivity meter will be calibrated at the start of each sampling day by using two KCl standard solutions supplied by the instrument manufacturer. These solutions will bracket the expected range of the groundwater sample. The meter must read within 1 percent of full scale to be considered in calibration. Readings from conductivity meters are normally stable; thus, calibration checks are usually limited to checks at the beginning and end of the sampling day. If the calibration check at the end of the day indicates the meter is not within tolerance, the data will be flagged to note the percent difference between the meter and standard.

Turbidimeter. Turbidity range calibration is checked at the beginning and end of each sampling day using factory-supplied latex turbidity standards. Calibration knobs are used to set the analog meter to read the value of these standards. The meter is also checked during the sampling period (midday and end of day) with the standard most representative of the anticipated turbidity of the groundwater (typically 0 to 10 NTUs). If the reading varies by more than one unit between calibration checks, the meter will be recalibrated. Multiple physical conditions can cause variations in readings, including bubbles in the sampled water, wet or dirty sample container, wet or dirty lens, wet or dirty optical sensor, or leakage of incidental light into the sample chamber.

The range of the instrument is calibrated every 4 months using the latex turbidity standards. If discrepancies are noted, the potentiometer on the amplifier circuit board is adjusted. The lamp alignment and focus are also checked and adjusted at this time, as necessary.

Imhoff Cone. The Imhoff cone, for determining the solids content in water samples, is factory calibrated and does not need any calibration in the field.

Photoionization Detector. The PID will be calibrated in Earth Tech's field office at the beginning and end of each day using isobutylene as the standard calibration gas. The instrument will be recalibrated if it experiences abnormal perturbations or readings become erratic. Calibration and test results will be recorded on the Equipment Calibration Daily Log.

Electric Water Level Meter. The alarm function on the water level meter is checked by immersion in water. The length of tape is manually checked against a surveyor's steel tape annually.

2.3.3 *Equipment Maintenance*

Maintenance responsibilities for field equipment are coordinated through an instrument technician who has as his or her primary duty responsibility for ensuring that available equipment and instrumentation are ready for use, and that returned equipment is checked out, serviced, and returned to available inventory in a timely manner. Maintenance during use is the responsibility of the project team using the equipment. Calibration/maintenance logbooks contain information on instrument maintenance, calibration, and repair. Backup equipment, spare parts, and other supplies will be brought to the field to every extent possible. In addition to spare parts and supply inventories, Earth Tech nonassigned equipment represents an extensive in-house source of backup equipment and instrument.

2.3.4 *Equipment Decontamination*

Equipment decontamination will follow the procedures outlined in Section 2.1.11.

2.4 Field Quality Assurance/Quality Control Program

Field parameters to be measured for this program include temperature, pH, specific conductance, turbidity, and settleable solids. A brief description of the methods to be used can be found in Appendix C, Field Water Testing Procedures. Soils will be described using the Unified Soil Classification System and ASTM Method D2488, and particle size distribution will be determined using a modified ASTM D422-63 procedure (see Appendix D).

2.4.1 *Control Parameters*

Temperature, pH, specific conductance, turbidity, and suspended sediment are monitored during development and purging to establish whether they have stabilized or not. Stability is achieved when the suspended sediment is <75 mL/L and the other four parameters have stabilized using the following criteria: temperature $\pm$ 1°C, pH $\pm$ 0.1 units, EC $\pm$ 5 percent, and turbidity within 10 NTUs of the previous reading. Temperature, pH, and specific conductance measurements will be taken when groundwater samples are collected for laboratory analysis. Duplicate groundwater samples, which will number 10 percent of the entire sampling program, will be measured for temperature, pH, and specific conductance.

2.4.2 *Control Limits*

Table 2-7 provides the control limits for the field parameters which will be measured during the investigation.

2.4.3 *Corrective Actions*

Corrective actions required if measurements are not within the specified limits are provided in Table 2-7.

TABLE 2-7
SUMMARY OF FIELD QUALITY CONTROL PROCEDURES

Method	Parameter	QC Performed	Frequency	Acceptance Criteria	Corrective Action
E120.1	Specific Conductance (aqueous)	Duplicate Analysis	10%	RPD <5%	1) Obtain third value 2) Recalibrate
E150.1	pH (aqueous)	Duplicate Analysis	10%	± 0.1 pH	1) Obtain third value 2) Recalibrate
E170.1	Temperature (aqueous)	Duplicate Analysis	10%	± 1.0°C	1) Obtain third value 2) Use different thermometer
E180.1	Turbidity (aqueous)	Duplicate Analysis	10%	RPD <15%	1) Obtain third value 2) Recalibrate
ASTM D422	Grain Size (Soil)	Duplicate Analysis	10%	RPD <10%	1) Obtain third value

Key: RPD = Relative Percent Difference

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2.5 Record Keeping

Field records will be maintained in sufficient detail to recreate all sampling and measurement activities and meet all IRPIMS data loading requirements.

Drilling records will be kept in the daily field logbook for the investigation and on logs for each borehole. The items that will be included in the daily field logbook are described in the following sections.

Daily Logs. All information pertinent to the field program for the RI will be recorded on appropriate data sheets and/or in the daily field logbook which will be a waterproof, bound book with consecutively-numbered pages. Entries in the logbook will be made in indelible ink and will include the following information.

- Name and address of field contact (on logbook cover)
- Names and affiliations of personnel on site
- General description of each day's field activities
- Documentation of daily weather conditions during fieldwork
- Sample locations (e.g., borehole number and description).

Entries in the logbook for each sample collected during the investigation will include the following additional information.

- Location
- Observations of the sample (e.g., color, odor, clarity) or collection environment (e.g., refueling operations)
- Identification of sampling device and sampling method
- Numerical value and units of field measurements made during sample collection (e.g., air monitoring etc.)
- Sequence of sample collection
- Sample matrix (e.g., soil, groundwater, etc.)
- Sample volume
- Sample depth (if applicable)
- Date and time of collection
- Field sample identification number
- Sampler's name
- Sample type (composite, split, etc.)
- Preservatives used
- Sample distribution (e.g., laboratory).

The bottom of each page in the logbook will be signed or initialed by the person making the entries. No pages may be removed from the field logbooks for any reason. Only persons authorized by the Project Manager or the Project Manager's designee may make entries in the logbook.

In addition to the information entered into the logbook, the following data sheets must be filled out: Decontamination Record, Equipment Calibration Daily Log, Borehole Log, Monitoring Well Construction Log, Monitoring Well Development Log, Potentiometric Level Measurement Form, and Groundwater Sampling Log.

Corrections to Documentation. All original data recorded in field logbooks and data entry sheets, on sample labels, or in COC records, will be written with waterproof ink. If an error (e.g., incorrect date or sample depth) is made on the document, corrections will be made simply by crossing a line through the error in such a manner that the original entry can still be read, and entering the correct information. All corrections will be initialed and dated.

Photographs. Photographs, if taken, will be recorded in the appropriate logbook. Information to be recorded includes:

- Roll and frame number,
- Time,
- Photographer,
- Location, e.g., "east side of Building 3",
- Subject, e.g., "installation of Borehole XX",
- Significant features, and
- Names of any personnel included in the photograph.

Borehole Logs. The information to be recorded on a field Borehole Log including lithologic descriptions are listed below:

- Boring or monitoring well identification,
- Purpose of boring,
- Location in relation to an easily identifiable landmark,
- Name of drilling contractor and logger,
- Drilling method,
- Types of drilling fluids and depths at which they were used,
- Lithologic descriptions and depths of lithologic boundaries,
- Depths at which saturated conditions were first encountered,
- Sample depths,
- Zones of caving or heaving,
- Drilling rate,
- Drilling rig reactions,
- Soil classification,
- Unified Soil Classification symbol,
- Secondary components and estimated percentage,
- Color (Munsell),
- Plasticity,

- Consistency (cohesive soil),
- Density (non-cohesive soil),
- Moisture content,
- Texture/fabric/bedding and orientation, and
- Grain angularity.

2.6 Site Management

The goal of site management is to conduct all field operations in an appropriate and efficient manner while minimizing impacts to plant operations and personnel. This goal will be met by establishing effective communications between all parties involved, and through thorough planning and preparation prior to beginning the field investigation.

Mr. John McCown (210-536-3360) is the AFCEE Restoration Team Chief (RTC). Mr. George Walters (513-255-4151) is the Aeronautical Systems Center (ASC) Remedial Program Manager (RPM). Ms. Melonie Sviatyla is the Martin Marietta POC for AFP 59. Ms. Reid Wellensiek (703-549-8728) is the Earth Tech Project Manager. All activities by both Earth Tech and their subcontractors at AFP 59 will be conducted in close coordination with all parties and will be conducted in accordance with AFCEE standard operating procedures.

The AFP 59 POC will provide or arrange for numerous support services during the field investigation. The AFP 59 POC will:

- Approve accumulation points within the installation property to which Earth Tech can deliver any suspected hazardous drill cuttings or well installation/development fluids generated from the required work. Earth Tech is responsible for providing all necessary containers (e.g., 55-gallon drums), for transporting the containerized material to the accumulation point, and for proper disposal.

- Provide Earth Tech with access to existing engineering plans, drawings, diagrams, aerial photographs, digitized map files, etc., to facilitate the evaluation of areas under investigation.

- Arrange for the following:

  a. Personal identification badges

  b. A secure staging area for storing equipment and supplies

  c. A supply (e.g., fire hydrant) of large quantities of potable water for drilling activities, equipment decontamination, etc.

  d. A paved area where drilling and sampling equipment can be decontaminated.

  e. A set of keys to the locks on any existing onsite monitoring wells

The Earth Tech Project Manager will coordinate the safe and proper conduct of employees and subcontractors during the field investigation at AFP 59. As part of her responsibilities, the Project Manager will keep the AFP 59 POC informed of the field investigation process, schedule changes, and personnel roster.

2.7 Variances

A variance is a deviation from project requirements. All variances from procedural and planning or design documents and other project requirements will be documented. The AFCEE RTC and the ASC RPM will approve variances that have an impact on cost, schedule, and/or technical performance prior to incorporation.

Field changes and deviations from project planning documents shall also be reviewed and approved by the AFCEE RTC. All deviations from procedural and planning documents will be recorded in the site logbook and documented on a field change request form. These deviations will be included in the RI report.

SECTION 3.0

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OHM Remediation Services Corporation, 23 June 1994. Analytical Report for Chip Samples 011 through 013 (settling tank) and Soil Samples 025 through 027 (plating room).

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APPENDIX A

LABORATORY INTERNAL QUALITY CONTROL PROCEDURES AND ACCEPTANCE CRITERIA

(COMPUCHEM ENVIRONMENTAL CORPORATION)

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8260 (25 mL purge)	Volatile Organics	**Laboratory Quality Control**			
		Laboratory Control Samples	1 per 20 samples or per batch, whichever is greater	% recoveries must be within laboratory established control limits (see Table A-3)	Halt analysis until problem is identified and corrected. Re-extract/reanalyze entire batch to verify system control is restored.
		Matrix Spike/Matrix Spike Duplicates	1 set per 20 samples	% recoveries and RPDs must be within laboratory established control limits (see Table A-2)	Samples are reanalyzed. If after reanalysis event is reproduced, run a lab control sample. If the lab control sample meets criteria, then the MS/MSD results are reported but flagged.
		Method Blank	Daily or 1 per 20 samples whichever is greater	Target compounds ≤ PQLs except common lab solvents at a level of 5× the PQL	Halt analysis until problem is identified and corrected. Re-extract the entire batch.
		Surrogates	Included in all lab and field samples	% recoveries must be within laboratory established control limits (see Table A-2)	Sample must be reanalyzed.
		Calibration Control Checks	Daily or at the beginning of every batch	Linear range of the instrument	Recalibrate the instrument.
		Tuning Checks	Beginning of every 12 hour analytical run period	% relative abundance must be within ion abundance criteria	No samples or calibration control checks can be analyzed until instrument is tuned.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8260 (25 mL purge) (Continued)	Volatile Organics (Continued)	**Field Quality Control**			
		Trip Blank	1 per shipment or cooler, whichever is more frequent, for VOC samples	Target compounds < PQLs	Review laboratory QC data to determine if a problem exists in the laboratory. If no problems exist in the lab and if target compounds > PQLs, and the same compounds are detected in the samples, qualification of the samples may be needed, based on the 5× and 10× rule.
		Equipment Blank	1 each day field samples are collected per sampling team	Absence of target compounds	If target compounds are detected in both the field samples and the equipment blanks, qualification of the samples may be necessary. If VOCs are only detected in the equipment blanks, no qualification is required.
		Ambient Blank	1 during each VOC sampling round	Absence of target compounds	If target compounds > PQLs and the same target compounds are detected in the field samples, then it may be an indication of the site conditions. Qualification of the samples may be necessary based on the 5× and 10× rule.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8260 (25 mL purge) (Continued)	Volatile Organics (Continued)	**Field Quality Control**			
		Field Duplicates/Field Replicates	1 per 10 field samples	RPD < 40% (soils) RPD < 30% (water)	Ensure lab QC is in control. If so, an RPD > 40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD > 30% for water data, samples may need qualification.
SW8270	Semi-Volatiles	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 samples or per batch, whichever is greater	% recoveries must be within laboratory established control limits (see Table A-3)	Halt analysis until problem is identified and corrected. Re-extract/reanalyze entire batch to verify system control is restored.
		Matrix Spike/Matrix Spike Duplicates	1 set per 20 samples	% recoveries and RPDs must be within laboratory established control limits (see Table A-2)	If 4 or more compounds are not within limits, analyze LCS. If the LCS is acceptable, report MS/MSD and LCS with data qualifier noting sample matrix interference.
		Method Blank	Daily or 1 per 20 samples whichever is greater	Target compounds < ½ PQLs except: phthalate esters ≤ 2× PQLs; one surrogate may be out of the acid fraction if > 10% R; one surrogate may be out of the base/neutral fraction if > 10% R	Halt analysis until problem is identified and corrected. Re-extract the entire batch.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8270 (Continued)	Semi-Volatiles (Continued)	Surrogates	Included in all lab and field samples	% recoveries must be within laboratory established control limits (see Table A-2); one surrogate may be out of the acid fraction if > 10% R; one surrogate may be out of the base/neutral fraction if > 10% R	Sample must be reanalyzed.
		Calibration Control Checks	Daily or at the beginning of every batch	Linear range of the instrument	Recalibrate the instrument.
		Tuning Checks	Beginning of every 12 hour analytical run period	% relative abundance must be within ion abundance criteria	No samples or calibration control checks can be analyzed until instrument is tuned.
		Field Quality Control			
		Field Duplicates/Field Replicates	1 per 10 field samples	RPD < 40% (soils) RPD < 30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data, samples may need qualification.
		Equipment Blank	1 each day field samples are collected per sampling team	Absence of target compounds	If target compounds are detected in both the field samples and the equipment blanks, qualification of the samples may be necessary. If target compounds are only detected in the equipment blanks, no qualification is required.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8080	Organochlorine Pesticides and PCBs	**Laboratory Quality Control**			
		Laboratory Control Samples	1 per 20 samples or per batch, whichever is greater	% recoveries must be within laboratory established control limits (see Table A-3)	Halt analysis until problem is identified and corrected. Re-extract/reanalyze entire batch to verify system control is restored.
		Matrix Spike/Matrix Spike Duplicates	1 set per 20 samples	% recoveries and RPDs must be within laboratory established control limits (see Table A-2)	If 4 or more compounds are not within limits, analyze LCS. If the LCS is acceptable, report MS/MSD and LCS with data qualifier noting sample matrix interference.
		Method Blank	1 per 20 samples	Target compounds < PQLs	Halt analysis until problem is identified and corrected. Re-extract the entire batch.
		Surrogates	Included in all lab and field samples	% recoveries must be within laboratory established control limits (see Table A-2)	Sample must be reanalyzed.
		Calibration Control Checks	Daily or at the beginning of every batch	Linear range of the instrument	Recalibrate the instrument.
		Field Quality Control			
		Field Replicates/Field Duplicates	1 per 10 field samples	RPD <40% (soils) RPD <30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data samples may need qualification.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8080 (Continued)	Organochlorine Pesticides and PCBs (Continued)	Equipment Blank	1 each day field samples are collected per sampling team	Absence of target compounds	If target compounds are detected in both the field samples and the equipment blank, qualification of the samples may be necessary. If target compounds are only detected in the equipment blank, no qualification is required.
SW6010	Metals	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 samples	Recovery must be within ± 20% of true value	Prepare and reanalyze batch.
		Matrix Spike	1 per 20 samples	80-120% recovery	See footnote C.
		Method Blank	1 per 20 samples	< CRDL or PQL	Reprepare and reanalyze entire batch.
		Sample Duplicates (Lab requirements)	1 per 20 samples	Must agree to within ± 20% RPD[b]	Flag data outside acceptance criteria with an "*".[b]
		Field Quality Control			
		Field Replicates/Field Duplicates	1 per 10 field samples	RPD < 40% (soils) RPD < 30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data, samples may need qualification.
		Equipment Blank	1 each day field samples are collected per sampling team	Absence of target analytes	If target analytes are detected in both the field samples and the equipment blank, qualification of the samples may be necessary. If target analytes are only detected in the equipment blank, no qualification is required.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW7000 Series	Arsenic, Lead, Selenium, Thallium, Mercury	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 samples	Recovery must be within ± 20% of true value	Prepare and reanalyze batch
		Matrix Spike	1 per 20 samples	75-125% recovery[a]	Flag data with "N".[a]
		Method Blank	1 per 20 samples	< CRDL or PQL	Reprepare and reanalyze entire batch.
		Sample Duplicates (Lab requirements)	1 per 20 samples	Must agree to within ± 20% RPD[b]	Flag data outside acceptance criteria with an "*".[b]
		Field Quality Control			
		Field Replicates/Field Duplicates	1 per 10 field samples	RPD < 40% (soils) RPD < 30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data, samples may need qualification.
		Equipment Blank	1 per sampling team per day	Absence of arsenic, lead, selenium, thallium, mercury	If analytes are detected in both the field samples and the equipment blank, qualification of the samples may be necessary. If analytes are only detected in the equipment blank, no qualification is required.
SW9060	Total Organic Carbon	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 digested samples	Recovery must be within 75-125% of true value	Prepare and reanalyze entire batch.
		Matrix Spike	1 per 20 samples	1. Recovery must be within 75-125% of true value 2. RPD ≤ 25%	Analyze LCS or reprepare and reanalyze MS/MSD.

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TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW9060 (Continued)	Total Organic Carbon (Continued)	Method Blank	1 per 10 samples minimum	1. Must be ≤ 1 ppm (aqueous) 2. Must be ≤ 50 ppm (soil)	If blank is out of control, reprepare and reanalyze entire batch.
		Field Quality Control			
		Field Replicates	1 per 10 field samples	RPD <40%	Ensure lab QC is in control. If so, an RPD >40% may reflect the degree of inhomogeneity between the 2 soil samples.
		Equipment Blank	1 each day field samples are collected	Absence of TOC	If TOC is detected in both the field samples and the equipment blank qualification of the samples may be necessary. If TOC is only detected in the equipment blank, no qualification is required.
SW9010	Cyanide	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 samples	Recovery must be within ± 20% of true value	Prepare and reanalyze entire batch.
		Matrix Spike	1 per 20 samples	75-125% recovery[a]	Flag data with "N".[a]
		Method Blank	1 per 20 samples	Cyanide must be < PQL	Reprepare and reanalyze entire batch.
		Field Quality Control			
		Field Replicates/Field Duplicates	1 per 10 field samples	RPD < 40% (soils) RPD <30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data, samples may need qualification.

TABLE A-1
COMPUCHEM'S INTERNAL QUALITY CONTROL PROCEDURES

Continued

Analytical Method	Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW9010 (Continued)	Cyanide (Continued)	Equipment Blank	1 per sampling team per day	Absence of cyanide	If cyanide is detected in both the field samples and the equipment blanks, qualification of the samples may be necessary. If cyanide is only detected in the equipment blanks, no qualification is required.
E130.1	Hardness as Calcium Carbonate	**Laboratory Quality Control**			
		Laboratory Control Sample	1 per 20 samples	Recovery must be within ± 20% of true value	Prepare and reanalyze entire batch.
		Matrix Spike	1 per 20 samples	Recovery must be within ± 20% of true value	Prepare and reanalyze entire batch.
		Method Blank	1 per 20 samples	Hardness must be < PQL	Prepare and reanalyze entire batch.
		Field Quality Control			
		Field Replicates/Field Duplicates	1 per 10 field samples	RPD < 40% (soils) RPD <30% (water)	Ensure lab QC is in control. If so, an RPD >40% for soil may reflect the degree of inhomogeneity between the 2 samples. If the RPD >30% for water data, samples may need qualification.

[a]A majority of percent recoveries (%R) must fall within the acceptance range or repreparation of the entire sample batch must occur unless the limits are advisory and holding times have expired. If an individual recovery is not within acceptance, the data for all samples associated with the spike samples and determined by the same analytical method must be flagged with an "N" on Forms I and V. If the sample concentration exceeds the spike concentration by a factor of four or more, the data is reported unflagged, even if the spike recovery is outside the acceptance range.

[b]The ± 20% RPD is used when the sample and duplicate results are greater than or equal to 5 times the CRDL or reporting limit. A control limit of ± the CRDL/reporting limit is used if either the samples or duplicate value is less than 5 times the CRDL/reporting limit. If both the duplicate and sample values are less than the IDL, then the RPD is not calculated and no acceptance criteria can be applied. If an individual RPD is not within acceptance criteria, the data for all samples associated with the duplicate must be flagged with an asterisk (*) on Forms 1 and VI.

[c]When the matrix spike sample recovery is out of the control limits of (80% - 120%), and the sample result does not exceed 4X the spike added for Inductively Coupled Plasma (ICP), a Post Digestion Spike (PDS) is required at 2X the Contract Required Detection Limits (CRDL) or at 2X the indigenous level of the original sample, whichever is greater. The PDS should recover between 75% - 125%. The technical reviewer will note in the case summary narrative if the PDS is outside of criteria.

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TABLE A-2
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits			
				Percent Recovery (%)		RPD (%)	
		Water (μg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment	Water	Soil/Sediment
SW8260 (25 mL purge)	Matrix						
	1,1-Dichloroethane	5	0.05	50-150	50-150	≤50	≤50
	cis-1,2-Dichloroethene	5	0.05	50-150	50-150	≤50	≤50
	1,1,1-Trichloroethane	5	0.05	50-150	50-150	≤50	≤50
	1,1-Dichloroethene*	5	0.05	61-145	59-172	≤14	≤22
	Trichloroethene*	5	0.05	71-120	62-137	≤14	≤24
	Chlorobenzene*	5	0.05	75-130	60-133	≤13	≤21
	Toluene*	5	0.05	76-125	59-139	≤13	≤21
	Benzene*	5	0.05	76-127	66-142	≤11	≤21
	Surrogate*						
	Dibromofluoromethane	5	0.05	86-118	80-120		
	Toluene-D8	5	0.05	88-110	81-117		
	Bromofluorobenzene	5	0.05	86-115	74-121		
SW8270	Matrix*						
	1,2,4-Trichlorobenzene	50	3.3	39-98	38-107	≤28	≤23
	Acenaphthene	50	3.3	46-118	31-137	≤31	≤19
	2,4-Dinitrotoluene	50	3.3	24-96	28-89	≤38	≤47
	Pyrene	50	3.3	26-127	35-142	≤31	≤36
	N-Nitroso-Di-n-Propyl-amine	50	3.3	41-116	41-126	≤38	≤38
	1,4-Dichlorobenzene	50	3.3	36-97	28-104	≤28	≤27
	Pentachlorophenol	100	6.6	9-103	17-109	≤50	≤47

TABLE A-2
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS

Continued

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits			
				Percent Recovery (%)		RPD (%)	
		Water (μg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment	Water	Soil/Sediment
SW8270 (Continued)	Phenol	100	6.6	12-89	26-90	≤42	≤35
	2-Chlorophenol	100	6.6	27-123	25-102	≤40	≤50
	4-Chloro-3-Methylphenol	100	6.6	23-97	26-103	≤42	≤33
	4-Nitrophenol	100	6.6	10-80	11-114	≤50	≤50
	Surrogate						
	Phenol-d5	200	6.6	15-53	24-113		
	2-Fluorophenol	100	3.3	19-73	31-118		
	2,4,6-Tribromophenol	200	6.6	24-104	25-114		
	Nitrobenzene-d5	100	3.3	27-101	37-112		
	2-Fluorobiphenyl	100	3.3	36-102	48-116		
	Pyrene-d10	200	6.6	40-130	48-126		
	Terphenyl-d14	100	3.3	31-125	50-132		
SW8080	**Matrix**						
	Heptachlor	0.1	0.030	34-111	34-111	≤ 20	≤ 20
	Aldrin	0.1	0.030	42-122	42-122	≤ 20	≤ 20
	Dieldrin	0.5	0.075	65-123	36-146	≤ 20	≤ 20
	4,4'-DDT	0.5	0.080	60-123	25-160	≤ 20	≤ 20
	gamma-BHC	0.1	0.030	64-127	32-127	≤ 20	≤ 20
SW8080	**Surrogate**						
	Tetrachloro-m-xylene	0.2	0.125	56-140	20-150		
	Decachlorobiphenyl	0.2	0.125	20-150	20-150		

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits			
				Percent Recovery (%)		RPD (%)	
		Water (mg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment	Water	Soil/Sediment
SW6010**	**Matrix**						
	Aluminum	2	–	80-120	–	±20	–
	Antimony	0.5	100	80-120	80-120	±20	±20
	Barium	2	400	80-120	80-120	±20	±20

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TABLE A-2
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS

Continued

Analytical Method	Matrix Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits			
				Percent Recovery (%)		RPD (%)	
		Water (mg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment	Water	Soil/Sediment
SW6010 (Continued)	Beryllium	0.05	10	80-120	80-120	±20	±20
	Cadmium	0.05	10	80-120	80-120	±20	±20
	Calcium	--	--	--	--	--	--
	Chromium	0.2	40	80-120	80-120	±20	±20
	Cobalt	0.5	100	80-120	80-120	±20	±20
	Copper	0.25	50	80-120	80-120	±20	±20
	Iron	1	--	80-120	--	±20	--
	Magnesium	--	--	--	--	--	--
	Manganese	0.5	100	80-120	80-120	±20	±20
	Molybdenum	1	50	80-120	80-120	±20	±20
	Nickel	0.5	100	80-120	80-120	±20	±20
	Potassium	--	--	--	--	--	--
	Silver	0.05	10	80-120	80-120	±20	±20
	Sodium	--	--	--	--	--	--
	Vanadium	0.5	100	80-120	80-120	±20	±20
	Zinc	0.5	100	80-120	80-120	±20	±20
SW7060	Arsenic	0.040	8	75-125	75-125	±20	±20
SW7740	Selenium	0.010	2	75-125	75-125	±20	±20
SW7421	Lead	0.020	4	75-125	75-125	±20	±20
SW7841	Thallium	0.050	10	75-125	75-125	±20	±20
SW7471/ SW7470	Mercury	1	1	75-125	75-125	±20	±20
SW9010	Cyanide	0.094	5.6	75-125	75-125	±20	±20
SW9060	TOC	10	2000	75-125	75-125	≤25	≤25

*CompuChem is currently using the method recommended control limits until enough data points have been collected to establish laboratory limits.

**RPD limits are based on concentrations which are at least 10 times the Instrument Detection Limit.

TABLE A-3
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS (LABORATORY CONTROL SAMPLES)

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits Percent Recovery (%)	
		Water (μg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment
SW8260 (25 mL purge)	Laboratory Control Sample*				
	All Target Compounds***	1	0.01	50-150+	50-150+
SW8270	Laboratory Control Sample*				
	All Target Compounds except those listed below	20	0.667	50-150++	50-150++
	1,2,4-Trichlorobenzene	20	0.667	39-150	38-150
	Acenaphthene	20	0.667	46-150	31-150
	2,4-Dinitrotoluene	20	0.667	24-150	28-150
	Pyrene	20	0.667	26-150	35-150
	N-Nitroso-Di-n-Propyl-amine	20	0.667	41-150	41-150
	1,4-Dichlorobenzene	20	0.667	36-150	28-150
	Pentachlorophenol	20	0.667	9-150	17-150
	Hexachlorocyclopenadiene	20	0.667	D-150	D-150
	Benzoic Acid	20	0.667	20-150	20-150
	Dimethylphthalate	20	0.667	20-300	20-300
	Phenol	20	0.667	%R-150	%R-150
	2-Chlorophenol	20	0.667	%R-150	%R-150
	4-Chloro-3-Methylphenol	20	0.667	%R-150	%R-150
	4-Nitrophenol	20	0.667	%R-150	%R-150
SW8080 (PCBs)	Laboratory Control Sample*				
	Heptachlor	20	0.667	30-150	30-150
	Aldrin	20	0.667	30-150	30-150
	Dieldrin	50	1.667	30-150	30-150

TABLE A-3
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS (LABORATORY CONTROL SAMPLES)

Continued

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits Percent Recovery (%)	
		Water (μg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment
SW8080 (PCBs) (Continued)	4,4'-DDT	50	1.667	30-150	30-150
	gamma-BHC	20	0.667	30-150	30-150
	alpha-BHC	20	0.667	30-150	30-150
	beta-BHC	20	0.667	30-150	30-150
	delta-BHC	20	0.667	30-150	30-150
	Heptachlor epoxide	20	0.667	30-150	30-150
	Endrin	50	1.667	30-150	30-150
	Endosulfan sulfate	50	1.667	30-150	30-150
	Chlordane	40	1.333	30-150	30-150
	4,4'-DDD	50	1.667	30-150	30-150
	4,4'-DDE	50	1.667	30-150	30-150
	Endosulfan I	50	1.667	30-150	30-150
	Endosulfan II	50	1.667	30-150	30-150
	Methoxychlor	50	1.667	30-150	30-150
	Toxaphene	50	1.667	30-150	30-150
	PCB-1254+++	10	0.667	30-150	30-150

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits Percent Recovery (%)	
		Water (mg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment
SW6010	LABORATORY CONTROL SAMPLE				
	Aluminum	20	325	90-104	64-122
	Antimony	6	211	85-111	69-127
	Barium	20	4.8	89-104	102-130
	Beryllium	0.500	19.4	90-111	82-106
	Cadmium	0.500	45.4	87-104	73-98
	Calcium	50	196,200	91-105	79-103
	Chromium	1	99.6	85-103	83-104

TABLE A-3
COMPUCHEM'S ESTABLISHED CONTROL LIMITS AND SPIKE CONCENTRATIONS (LABORATORY CONTROL SAMPLES)

Continued

Analytical Method	Spiking Compounds	Spike Concentrations		Laboratory Established Control Limits Percent Recovery (%)	
		Water (mg/L)	Soil/Sediments (mg/kg)	Water	Soil/Sediment
SW6010 (Continued)	Cobalt	5	144	87-103	83-107
	Copper	2.5	6910	89-103	86-102
	Iron	10	22,430	86-105	77-108
	Magnesium	50	118,100	91-104	85-103
	Manganese	1.5	208	88-103	83-104
	Molybdenum*	1	50.0	80-120	80-120
	Nickel	4	60.9	84-103	74-109
	Potassium	50	50.0	88-105	D-500**
	Silver	1	22.2	86-104	62-111
	Sodium	50	50.0	91-105	D-500**
	Vanadium	5	65.8	89-104	77-113
	Zinc	2	187	86-104	77-105
SW7060	Arsenic	1	917	81-124	80-134
SW7740	Selenium	0.500	39.2	76-126	67-131
SW7421	Lead	0.300	236	82-115	74-122
SW7841	Thallium	1	39.0	76-117	64-121
SW7471	Mercury	3	12.7	80-120*	66-136
SW9010	Cyanide	0.094	5.6	80-120	82-129
SW9060	TOC	10	2000	75-125	75-125
E130.1	Calcium Carbonate	338	NA	80-120	NA

+Methylene chloride control limits have been set at 50-300%.
++Phthalate esters have control limits of 50-300%.
+++PCB-1254 was chosen to represent PCBs in the SW8080 pesticides LCS. CompuChem is spiking pesticides and PCBs in separate LCSs as allowed by the Handbook.
*CompuChem is currently using preliminary control limits until enough data points have been collected to establish laboratory limits.
**D = Detected
***Recovery limits for 1,2-dibromo-3-chloropropane are 20-150%.

APPENDIX B

FILTER PACK AND WELL SCREEN DESIGN

APPENDIX B

FILTER PACK AND WELL SCREEN DESIGN

In designing a monitoring well, the filter pack is selected prior to the well screen slot size because the filter pack is the interface with the formation. Following filter pack selection, the screen slot size is chosen based on the results of the filter pack design. After completion of a monitoring well, the well screen should be surrounded by filter pack materials that are coarser, have a uniform grain size, and have a higher permeability than the natural formation (USEPA, 1991a).

FILTER PACK DESIGN

In selecting the proper filter pack for a monitoring well, the following four steps are followed (USEPA, 1991a).

1. A sample of the formation material is collected from the intended screened interval.

2. A sieve analysis is conducted to determine the grain size distribution of the formation material.

3. The 70 percent retained grain size of the formation (determined during the sieve analysis) is multiplied by a factor of between 4 and 6.

4. A uniform, well-sorted grain size filter pack is chosen based on the results of Step 3.

Obtaining an accurate formation sample is important since the sieve analysis is the basis for monitoring well design. Results of the sieve analysis dictate what the correct filter pack grain size is for the well. Based on previous sieve analyses conducted at the site (ANL, 1994), and due to the large difference in the diameters of the boreholes and well casing/screens designed for this investigation, monitoring wells at AFP 59 will be artificially filter-packed.

As described in Driscoll (1986), the required equipment for a sieve analysis includes a hot plate for drying samples, a set of standard testing sieves, and an accurate balance for weighing sample material. After drying and weighing the sample, it is placed in the top sieve of a series of sieves which are aligned with the coarsest sieve on the top and the finest sieve on the bottom. A bottom pan underlies the finest sieve. The sieves are then shaken either by hand or in a vibration machine. Transfer the coarsest sieve contents to the previously weighed drying pan. The weight of the contents of the coarsest sieve and the drying pan are recorded. The material of the second sieve is then added to the pan, and the combined weight is recorded. Each sieve and the bottom pan is emptied successively, and the weight of the accumulated sample is recorded. The cumulative percent retained for each sieve is then calculated by dividing the cumulative weight retained by the total weight of the sample. The cumulative percent retained or cumulative percent finer can then be plotted versus sieve opening size (grain size) to show the grain size distribution of the sample. The sieve analysis procedures are described in detail in Appendix D.

From the cumulative percent retained versus grain size plot, the 70 percent retained grain size for the formation material is determined. This grain size is then multiplied by a factor of between 4 and 6, depending on the grain size distribution of the sample. Based on the sieve analyses conducted by ANL (1994), a multiplier of 6 is more appropriate for the subsurface materials at AFP 59.

A uniform, well-sorted grain size filter pack is selected according to the filter pack grain size calculations. A uniform, well-sorted filter pack is chosen over a graded grain-size filter pack for the following reasons (USEPA, 1991a):

1. Graded packs are more susceptible to the invasion of formation materials at the formation-filter pack interface, leading to a reduction in permeability.

2. Graded packs are more difficult to install.

3. With a uniform pack, the fine formation materials can travel between the grains of the pack and be pulled into the well during development, increasing formation permeability and retaining pack permeability.

SCREEN SLOT SIZE DESIGN

After determining the appropriate filter pack grain size, the screen slot size will be designed to prevent 90 percent of the filter pack material from entering the well. It is important to prevent at least 90 percent of the filter pack from entering the well during and subsequent to development to avoid settling of the materials adjacent to the well. In order to obtain a representative groundwater sample from a monitoring well, it is necessary to minimize disturbances or distortions to the flow lines from the aquifer to the well caused by post-development settling of materials. Therefore, a screen slot size equal to or finer than the 90 percent retained grain size of the filter pack will be used for well design purposes.

APPENDIX C

FIELD WATER TESTING PROCEDURES

CONDUCTANCE

Method 120.1 (Specific Conductance, μmhos at 25°C)

STORET NO. 00095

1. Scope and Application
   1.1 This method is applicable to drinking, surface, and saline wates, domestic and industrial wastes and acid rain (atmospheric deposition).
2. Summary of Method
   2.1 The specific conductance of a sample is measured by use of a self-contained conductivity meter, Wheatstone bridge-type, or equivalent.
   2.2 Samples are preferable analyzed at 25°C. If not, temprature corrections aremade and results reported at 25°C.
3. Comments
   3.1 Instrument must be standardized with KCl solution before daily use.
   3.2 Conductivity cell must be kept clean.
   3.3 Field measurements with comparable instruments are reliable.
   3.4 Temperature variations and corrections represent the largest source of potential error.
4. Sample Handling and Preservation
   4.1 Analyses can be performed either in the field or laboratory.
   4.2 If analysis is not completed within 24 hours of sample collection, sample should be filtered through a 0.45 micron filter and stored at 4°C. Filter and apparatus must be washed with high quality distilled water and pre-rinsed with sample before use.
5. Apparatus
   5.1 Conductivity bridge, range 1 to 1000 μmho per centimeter.
   5.2 Conductivity cell, cell constant 1.0 or micro dipping type cell with 1.0 constant. YSI #3403 or equivalent.
   5.4 Thermometer
6. Reagents
   6.1 Standard potassium chloride solutions, 0.01 M: Dissolve 0.7456 gm of pre-dried (2 hour at 105°C) KCl in distilled water and dilute to 1 liter at 25°C.
7. Cell Calibration
   7.1 The analyst should use the standard potassium chloride solution (6.1) and the table below to check the accuracy of the cell constant and conductivity bridge.

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Conductivity 0.01 m KCl

°C	Micromhos/cm
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

8. Procedure
   8.1 Follow the direction of the manufacturer for the operation of the instrument.
   8.2 Allow samples to come to room temperature (23 to 27°C), if possible.
   8.3 Determine the temperature of samples within 0.5°C. If the temperature of the samples is not 25°C, make temperature correction in accordance with the instruction in Section 9 to convert reading to 25°.
9. Calculation
   9.1 These temperature corrections are based on the standard KCl solution.
      9.1.1 If the temperature of the sample is below 25°C, add 2% of the reading per degree.
      9.1.2 If the temperature is above 25°C, subtract 2% of the reading per degree.
   9.2 Report results as Specific Conductance, μmhos/cm at 25°.
10. Precision and Accuracy
   10.1 Forty-one analysts in 17 laboratories analyzed six synthetic water samples containing increments of inorganic salts, with the following results:

Increment as Specific Conductance	Precision as Standard Deviation	Accuracy as Bias, %	Accuracy as Bias, umhos/cm
100	7.55	−2.02	−2.0
106	8.14	−0.76	−0.8
808	66.1	−3.63	−29.3
848	79.6	−4.54	−38.5
1640	106	−5.36	−87.9
1710	119	−5.08	−86.9

(FWPCA Method Study 1, Mineral and Physical Analyses.)

   10.2 In a single laboratory (EMSL) using surface water samples with an average conductivity of 536 μmhos/cm at 25°C, the standard deviation was ±6.

Bibliography

1. The procedure to be used for this determination is found in:
   Annual Book of ASTM Standards Part 31, "Water," Standard D1125-64, p. 120 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p. 71, Method 205 (1975).
3. Instruction Manual for YSI Model 31 Conductivity Bridge.
4. Peden, M. E., and Skowron. "Ionic Stability of Precipitation Samples," Atmospheric Environment, Vol. 12, p. 2343-2344, 1978.

pH

Method 150.1 (Electrometric)

STORET NO.
Determined on site 00400
Laboratory 00403

1. Scope and Application
   1.1 This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes and acid rain (atmospheric deposition).
2. Summary of Method
   2.1 The pH of a sample is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode.
3. Sample Handling and Preservation
   3.1 Samples should be analyzed as soon as possible preferably in the field at the time of sampling.
   3.2 High-purity waters and waters not at equilibrium with the atmosphere are subject to changes when exposed to the atmosphere, therefore the sample containers should be filled completely and kept sealed prior to analysis.
4. Interferences
   4.1 The glass electrode, in general, is not subject to solution interferences from color, turbidity, colloidal matter, oxidants, reductants or high salinity.
   4.2 Sodium error at pH levels greater than 10 can be reduced or eliminated by using a "low sodium error" electrode.
   4.3 Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by distilled water rinsing. An additional treatment with hydrochloric acid (1 + 9) may be necessary to remove any remaining film.
   4.4 Temperature effects on the electrometric measurement of pH arise from two sources. The first is caused by the change in electrode output at various temperatures. This interference can be controlled with instruments having temperature compensation or by calibrating the electrode-instrument system at the temperature of the samples. The second source is the change of pH inherent in the sample at various temperatures. This error is sample dependent and cannot be controlled, it should therefore be noted by reporting both the pH and temperature at the time of analysis.
5. Apparatus
   5.1 pH Meter-laboratory or field model. A wide variety of instruments are commercially available with various specifications and optional equipment.

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5.2 Glass electrode.

5.3 Reference electrode–a calomel, silver-silver chloride or other reference electrode of constant potential may be used.

NOTE 1: Combination electrodes incorporating both measuring and reference functions are convenient to use and are available with solid, gel type filling materials that require minimal maintenance.

5.4 Magnetic stirrer and Teflon-coated stirring bar.

5.5 Thermometer or temperature sensor for automatic compensation.

6. Reagents

6.1 Primary standard buffer salts are available from the National Bureau of Standards and should be used in situations where extreme accuracy is necessary.

6.1.1 Preparation of reference solutions from these salts require some special precautions and handling[1] such as low conductivity dilution water, drying ovens, and carbon dioxide free purge gas. These solutions should be replaced at least once each month.

6.2 Secondary standard buffers may be prepared from NBS salts or purchased as a solution from commercial vendors. Use of these commercially available solutions, that have been validated by comparison to NBS standards, are recommended for routine use.

7. Calibration

7.1 Because of the wide variety of pH meters and accessories, detailed operating procedures cannot be incorporated into this method. Each analyst must be acquainted with the operation of each system and familiar with all instrument functions. Special attention to care of the electrodes is recommended.

7.2 Each instrument/electrode system must be calibrated at a minimum of two points that bracket the expected pH of the samples and are approximately three pH units or more apart.

7.2.1 Various instrument designs may involve use of a "balance" or "standardize" dial and/or a slope adjustment as outlined in the manufacturer's instructions. Repeat adjustments on successive portions of the two buffer solutions as outlined in procedure 8.2 until readings are within 0.05 pH units of the buffer solution value.

8. Procedure

8.1 Standardize the meter and electrode system as outlined in Section 7.

8.2 Place the sample or buffer solution in a clean glass beaker using a sufficient volume to cover the sensing elements of the electrodes and to give adequate clearance for the magnetic stirring bar.

8.2.1 If field measurements are being made the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to insure sufficient sample movement across the electrode sensing element as indicated by drift free (<0.1 pH) readings.

8.3 If the sample temperature differs by more than 2°C from the buffer solution the measured pH values must be corrected. Instruments are equipped with automatic or manual

[1]National Bureau of Standards Special Publication 260.

compensators that electronically adjust for temperature differences. Refer to manufacturer's instructions.

8.4 After rinsing and gently wiping the electrodes, if necessary, immerse them into the sample beaker or sample stream and stir at a constant rate to provide homogeneity and suspension of solids. Rate of stirring should minimize the air transfer rate at the air water interface of the sample. Note and record sample pH and temperature. Repeat measurement on successive volumes of sample until values differ by less than 0.1 pH units. Two or three volume changes are usually sufficient.

8.5 For acid rain samples it is most important that the magnetic stirrer is not used. Instead, swirl the sample gently for a few seconds after the introduction of the electrode(s). Allow the electrode(s) to equilibrate. The air-water interface should not be disturbed while measurement is being made. If the sample is not in equilibrium with the atmosphere, pH values will change as the dissolved gases are either absorbed or desorbed. Record sample pH and temperature.

9. Calculation

9.1 pH meters read directly in pH units. Report pH to the nearest 0.1 unit and temperature to the nearest °C.

10. Precision and Accuracy

10.1 Forty-four analysts in twenty laboratories analyzed six synthetic water samples containing exact increments of hydrogen-hydroxyl ions, with the following results:

pH Units	Standard Deviation pH Units	Accuracy as Bias, %	Bias, pH Units
3.5	0.10	–0.29	–0.01
3.5	0.11	–0.00	
7.1	0.20	+1.01	+0.07
7.2	0.18	–0.03	–0.002
8.0	0.13	–0.12	–0.01
8.0	0.12	+0.16	+0.01

(FWPCA Method Study 1, Mineral and Physical Analyses)

10.2 In a single laboratory (EMSL), using surface water samples at an average pH of 7.7, the standard deviation was ±0.1.

Bibliography

1. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 460, (1975).
2. Annual Book of ASTM Standards, Part 31, "Water", Standard D1293–65, p 178 (1976).
3. Peden, M. E. and Skowron, L. M., Ionic Stability of Precipitation Samples, Atmospheric Environment, Vol. 12, pp. 2343-2349, 1978.

SETTLEABLE MATTER

Method 160.5 (Volumetric, Imhoff Cone)

STORET NO. 50086

1. Scope and Application
   1.1 This method is applicable to surface and saline waters, domestic and industrial wastes.
   1.2 The practical lower limit of the determination is about 0.2 ml/l/hr.
2. Summary of Method
   2.1 Settleable matter is measured volumetrically with an Imhoff cone.
3. Comments
   3.1 For some samples, a separation of settleable and floating materials will occur; in such cases the floating materials are not measured.
   3.2 Many treatment plants, especially plants equipped to perform gravimetric measurements, determine residue non-filterable (suspended solids), in preference to settleable matter, to insure that floating matter is included in the analysis.
4. Precision and Accuracy
   4.1 Data on this determination are not available at this time.
5. References
   5.1 The procedure to be used for this determination is found in:
   Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 95, Method 208F, Procedure 3a (1975).

Approved for NPDES
Issued 1974

TEMPERATURE

Method 170.1 (Thermometric)

STORET NO. 00010

1. Scope and Application
   1.1 This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.
2. Summary of Method
   2.1 Temperature measurements may be made with any good grade of mercury-filled or dial type centigrade thermometer, or a thermistor.
3. Comments
   3.1 Measurement device should be routinely checked against a precision thermometer certified by the National Bureau of Standards.
4. Precision and Accuracy
   4.1 Precision and accuracy for this method have not been determined.
5. Reference
   5.1 The procedure to be used for this determination is found in:
   Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 125, Method 212 (1975).

Approved for NPDES
Issued 1971

TURBIDITY

Method 180.1 (Nephelometric)

STORET NO. 00076

1. Scope and Application
   1.1 This method is applicable to drinking, surface, and saline waters in the range of turbidity from 0 to 40 nephelometric turbidity units (NTU). Higher values may be obtained with dilution of the sample.
   NOTE 1: NTU's are considered comparable to the previously reported Formazin Turbidity Units (FTU) and Jackson Turbidity Units (JTU).
2. Summary of Method
   2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. Readings, in NTU's, are made in a nephelometer designed according to specifications outlined in Apparatus. A standard suspension of Formazin, prepared under closely defined conditions, is used to calibrate the instrument.
      2.1.1 Formazin polymer is used as the turbidity reference suspension for water because it is more reproducible than other types of standards previously used for turbidity standards.
      2.1.2 A commercially available polymer standard is also approved for use for the National Interim Primary Drinking Water Regulations. This standard is identified as AMCO-AEPA-1 available from Amco Standard International, Inc.
3. Sample Handling and Preservation
   3.1 Preservation of the sample is not practical; analysis should begin as soon as possible. Refrigeration or icing to 4°C, to minimize microbiological decomposition of solids, is recommended.
4. Interferences
   4.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles will affect the results in a positive manner.
   4.2 The presence of true color, that is the color of water which is due to dissolved substances which absorb light, will cause turbidities to be low, although this effect is generally not significant with finished waters.
5. Apparatus
   5.1 The turbidimeter shall consist of a nephelometer with light source for illuminating the sample and one or more photo-electric detectors with a readout device to indicate the intensity of light scattered at right angles to the path of the incident light. The turbidimeter should be so designed that little stray light reaches the detector in the

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Editorial revision 1978

absence of turbidity and should be free from significant drift after a short warm-up period.

5.2 The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 unit or less in waters having turbidities less than 1 unit. The instrument should measure from 0 to 40 units turbidity. Several ranges will be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.

5.3 The sample tubes to be used with the available instrument must be of clear, colorless glass. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. They must not be handled at all where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be handled.

5.4 Differences in physical design of turbidimeters will cause differences in measured values for turbidity even though the same suspension is used for calibration. To minimize such differences, the following design criteria should be observed:

5.4.1 Light source: Tungsten lamp operated at a color temperature between 2200–3000°K.

5.4.2 Distance traversed by incident light and scattered light within the sample tube: Total not to exceed 10 cm.

5.4.3 Detector: Centered at 90° to the incident light path and not to exceed ±30° from 90°. The Detector, and filter system if used, shall have a spectral peak response between 400 and 600nm.

5.5 The Hach Turbidimeter, Model 2100 and 2100 A, is in wide use and has been found to be reliable; however, other instruments meeting the above design criteria are acceptable.

6. Reagents

6.1 Turbidity-free water: Pass distilled water through a 0.45*u* pore size membrane filter if such filtered water shows a lower turbidity than the distilled water.

6.2 Stock formazin turbidity suspension:

Solution 1: Dissolve 1.00 g hydrazine sulfate, $(NH_2)_2 \cdot H_2SO_4$, in distilled water and dilute to 100 ml in a volumetric flask.

Solution 2: Dissolve 10.00 g hexamethylenetetramine in distilled water and dilute to 100 ml in a volumetric flask.

In a 100 ml volumetric flask, mix 5.0 ml Solution 1 with 5.0 ml Solution 2. Allow to stand 24 hours at 25 ±3°C, then dilute to the mark and mix.

6.3 Standard formazin turbidity suspension: Dilute 10.00 ml stock turbidity suspension to 100 ml with turbidity-free water. The turbidity of this suspension is defined as 40 units. Dilute portions of the standard turbidity suspension with turbidity-free water as required.

6.3.1 A new stock turbidity suspension should be prepared each month. The standard turbidity suspension and dilute turbidity standards should be prepared weekly by dilution of the stock turbidity suspension.

6.4 The AMCO-AEPA-1 standard as supplied requires no preparation or dilution prior to use.

7. Procedure

7.1 Turbidimeter calibration: The manufacturer's operating instructions should be followed. Measure standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales. At least one standard should be run in each instrument range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities. Reliance on a manufacturer's solid scattering standard for setting overall instrument sensitivity for all ranges is not an acceptable practice unless the turbidimeter has been shown to be free of drift on all ranges. If a pre-calibrated scale is not supplied, then calibration curves should be prepared for each range of the instrument.

7.2 Turbidities less than 40 units: Shake the sample to thoroughly disperse the solids. Wait until air bubbles disappear then pour the sample into the turbidimeter tube. Read the turbidity directly from the instrument scale or from the appropriate calibration curve.

7.3 Turbidities exceeding 40 units: Dilute the sample with one or more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and the diluted sample showed a turbidity of 30 units, then the turbidity of the original sample was 180 units.

7.3.1 The Hach Turbidimeters, Models 2100 and 2100A, are equipped with 5 separate scales: 0–0.2, 0–1.0, 0–100, and 0–1000 NTU. The upper scales are to be used only as indicators of required dilution volumes to reduce readings to less than 40 NTU. NOTE 2: Comparative work performed in the MDQAR Laboratory indicates a progressive error on sample turbidities in excess of 40 units.

8. Calculation

8.1 Multiply sample readings by appropriate dilution to obtain final reading.

8.2 Report results as follows:

NTU	Record to Nearest:
0.0 – 1.0	0.05
1 – 10	0.1
10 – 40	1
40 – 100	5
100 – 400	10
400 – 1000	50
> 1000	100

9. Precision and Accuracy

9.1 In a single laboratory (EMSL), using surface water samples at levels of 26, 41, 75 and 180 NTU, the standard deviations were ±0.60, ±0.94, ±1.2 and ±4.7 units, respectively.

9.2 Accuracy data are not available at this time.

Bibliography

1. Annual Book of ASTM Standards, Part 31, "Water", Standard D1889–71, p 223 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 132, Method 214A, (1975).

APPENDIX D

GEOLOGIC CLASSIFICATION AND GRAIN SIZE ANALYSIS METHODS

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS (MORE THAN 50% OF COARSE FRACTION IS LARGER THAN THE NO. 4 SIEVE SIZE)	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
			GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVELS WITH FINES (APPRECIABLE AMT. OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.
	SANDS (MORE THAN 50% OF COARSE FRACTION IS SMALLER THAN THE NO. 4 SIEVE SIZE)	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS WITH FINES (APPRECIABLE AMT. OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES.
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES.
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS (LIQUID LIMIT LESS THAN 50)		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS AND CLAYS (LIQUID LIMIT GREATER THAN 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS.
			AF	ARTIFICIAL FILL MATERIAL

PARTICLE SIZE LIMITS

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COURSE	FINE	COARSE		

NO. 200 NO. 40 NO. 10 NO. 4 ¾ in. 3 in (12 in.)

U.S. STANDARD SIEVE SIZE

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS.

DEFINITION OF TERMS USED TO DESCRIBE SUBSURFACE MATERIALS

SOILS

DENSITY OF GRANULAR SOILS IS BASED ON STANDARD PENETRATION RESISTANCE

DESIGNATION	STANDARD PENETRATION RESISTANCE (BLOWS/FOOT)
VERY LOOSE	0 - 4
LOOSE	5 - 10
MEDIUM DENSE	11 - 30
DENSE	31 - 50
VERY DENSE	OVER 50

CONSISTENCY OF COHESIVE SOILS IS BASED ON FIELD AND/OR LABORATORY TESTS

CONSISTENCY	UNC. COMPRESSIVE STR. (TONS PER SQUARE FOOT)	FIELD IDENTIFICATION
VERY SOFT	LESS THAN 0.25	EASILY PENETRATED SEVERAL INCHES BY FIST
SOFT	0.25 TO 0.50	EASILY PENETRATED SEVERAL INCHES BY THUMB
MEDIUM STIFF	0.50 TO 1.0	CAN BE PENETRATED SEVERAL INCHES BY THUMB WITH MODERATE EFFORT
STIFF	1.0 TO 2.0	READILY INDENTED BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT
VERY STIFF	2.0 TO 4.0	READILY INDENTED BY THUMBNAIL
HARD	MORE THAN 4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL

ADDITIONAL TERMS USED IN THE DESCRIPTION OF SOILS:

AND	INDICATES APPROXIMATELY EQUAL AMOUNTS OF MATERIALS, SUCH AS A SAND AND GRAVEL MIXTURE. IF THE MATERIALS OCCUR IN THIN SEPARATE SEAMS, IT IS NOTED IN THE DETAILED WORD CLASSIFICATION. THE THICKNESS IS GIVEN WHERE POSSIBLE. EXAMPLE: MEDIUM DENSE SAND AND GRAVEL, OR DENSE INTERBEDDED COARSE SAND AND GRAVEL (¼" - ¾") THICK
SOME	INDICATES A SIGNIFICANT AMOUNT OF THE ACCESSORY MATERIAL. EXAMPLE: MEDIUM DENSE SILTY SAND - SOME GRAVEL
TRACE	INDICATES A MINOR AMOUNT OF THE ACCESSORY MATERIAL. EXAMPLE: LOOSE SILTY SAND - TRACE OF GRAVEL
INTERBEDDED	USED TO DESCRIBE THIN ALTERNATING SEAMS. THICKNESS IS GIVEN WHERE POSSIBLE. EXAMPLE: HARD INTERBEDDED SILT AND CLAY (APPROXIMATELY 1/16" THICK)

ROCK

TERM	DEFINITION
SEAM	THIN (12 INCHES OR LESS) PROBABLY CONTINUOUS LAYER
SOME	INDICATES SIGNIFICANT (15 to 40 PERCENT) AMOUNTS OF THE ACCESSORY MATERIAL. EXAMPLE: ROCK COMPOSED OF SANDSTONE (70%) AND SEAMS OF SHALE (30%) WOULD BE: SANDSTONE – SOME SHALE SEAMS
FEW	INDICATES MINOR (0-15 PERCENT) AMOUNTS OF THE ACCESSORY MATERIAL. EXAMPLE: ROCK COMPOSED OF SANDSTONE (90%) AND SEAMS OF SHALE (10%) WOULD BE: SANDSTONE - FEW SHALE SEAMS
INTERBEDDED	USED TO INDICATE THIN OR VERY THIN ALTERNATING SEAMS OF MATERIAL OCCURRING IN APPROXIMATELY EQUAL AMOUNTS. EXAMPLE: ROCK COMPOSED OF SANDSTONE (50%) AND SHALE (50%) SEAMS WOULD BE INTERBEDDED SANDSTONE AND SHALE

THE DEGREE OF BROKENNESS OF THE ROCK IS DESCRIBED BY ONE OF THE FOLLOWING TERMS:

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
VERY BROKEN	(V. BR.)	LESS THAN 2 INCHES
BROKEN	(BR.)	2 INCHES - 1 FOOT
BLOCKY	(BL.)	1 FOOT - 3 FEET
MASSIVE	(M.)	3 FEET - 10 FEET

RQD–ROCK QUALITY DESIGNATION IS CUMULATIVE LENGTH OF PIECES OF CORE EQUAL TO OR GREATER THAN FOUR INCHES IN LENGTH DIVIDED BY THE TOTAL LENGTH OF CORE RUN, EXPRESSED AS A PERCENTAGE

THE FOLLOWING BASIC NAMES ARE APPLIED TO THE TYPE OF ROCK FOUND AT THE SITE:

ROCK TYPE	CHARACTERISTICS
SANDSTONE	MADE UP PREDOMINANTLY OF GRANULAR MATERIALS RANGING BETWEEN 1/16 AND 2MM IN DIAMETER
SILTSTONE	MADE UP OF GRANULAR MATERIALS LESS THAN 1/16MM IN DIAMETER. FRACTURES IRREGULARLY. MEDIUM THICK TO THICK BEDDED
CLAYSTONE	VERY FINE GRAINED ROCK MADE UP OF CLAY MATERIALS. FRACTURES IRREGULARLY. VERY SMOOTH TO TOUCH. GENERALLY HAS IRREGULARLY SPACED PITTING ON SURFACE OF DRILLED CORES.
SHALE	A FISSILE VERY FINE GRAINED ROCK. FRACTURES ALONG BEDDING PLANES
LIMESTONE	ROCK MADE UP PREDOMINANTLY OF CALCITE ($CaCO_3$) EFFERVESCES UPON THE APPLICATION OF HYDROCHLORIC ACID.
COAL	ROCK CONSISTING MAINLY OF ORGANIC REMAINS.

LEGEND

RESIDUAL SOIL
GRAVEL
SAND OR ALLUVIUM
SILT
CLAY
ORGANIC MATERIAL
SLAG
FILL

CLAYSTONE
LIMESTONE
SILTSTONE
SANDSTONE
SHALE
CONCRETE
COAL
VOID

2" O.D. SPLIT BARREL SAMPLE
CASING SAMPLE
ST-1 — SAMPLE NUMBER. 3" DIA. UNDISTURBED SAMPLE
4.6 / 5.0 — LENGTH OF CORE RECOVERED / LENGTH OF DRILL RUN
3-10-66 — GROUND WATER LEVEL AND DATE OF OBSERVATION
60/0.3' — INDICATES 60 BLOWS REQUIRED FOR SPLIT BARREL TO PENETRATE 0.3 FEET
APPROXIMATE TOP OF ROCK

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

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

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

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

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

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.1.7 *sand*—particles of rock that will pass a No. 4

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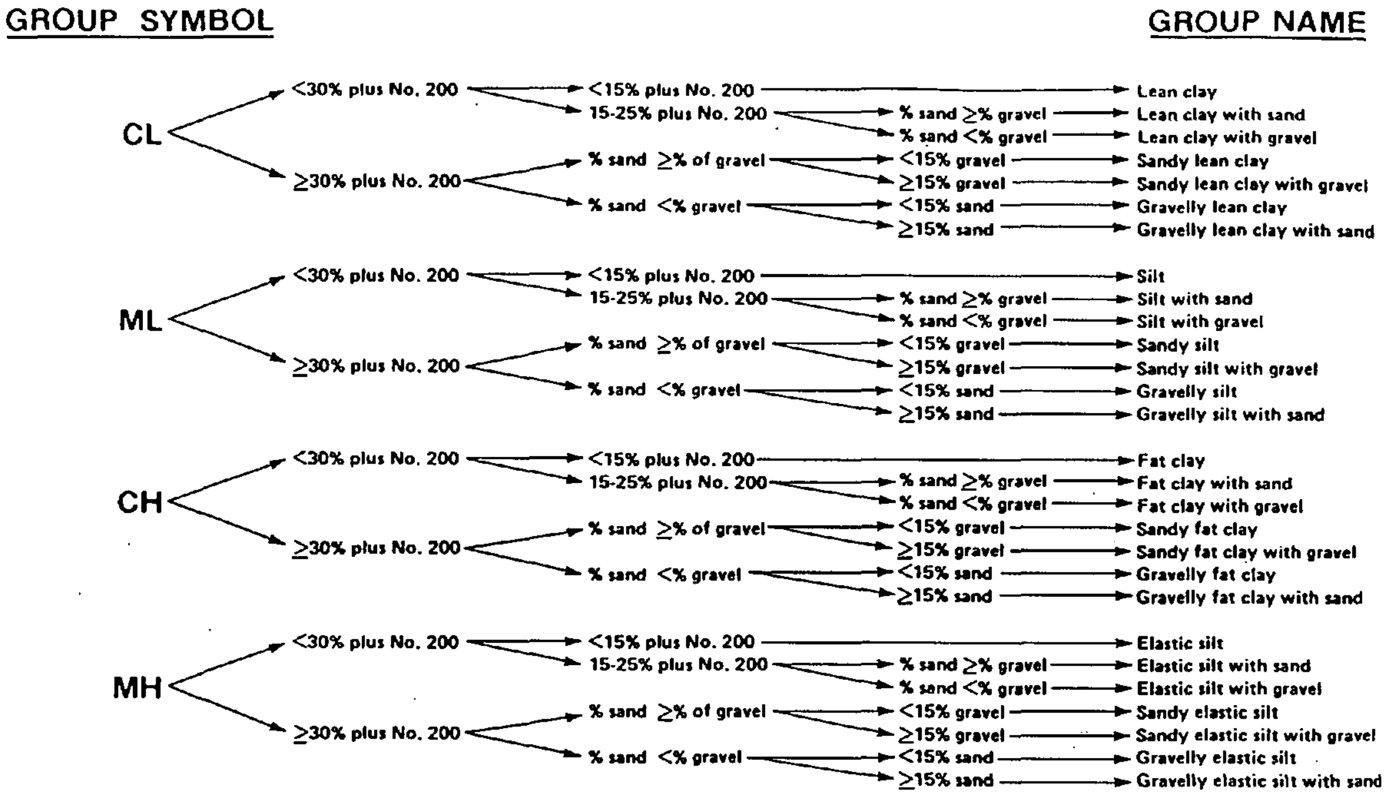
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Sept. 15, 1993. Published November 1993. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 90.

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



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

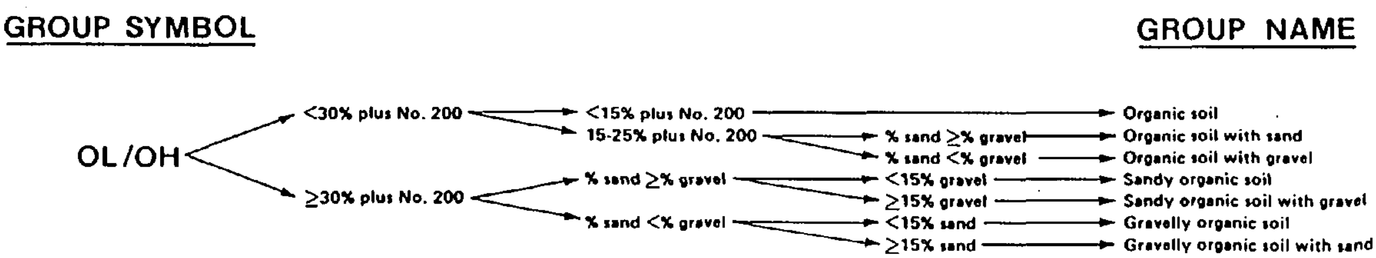
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

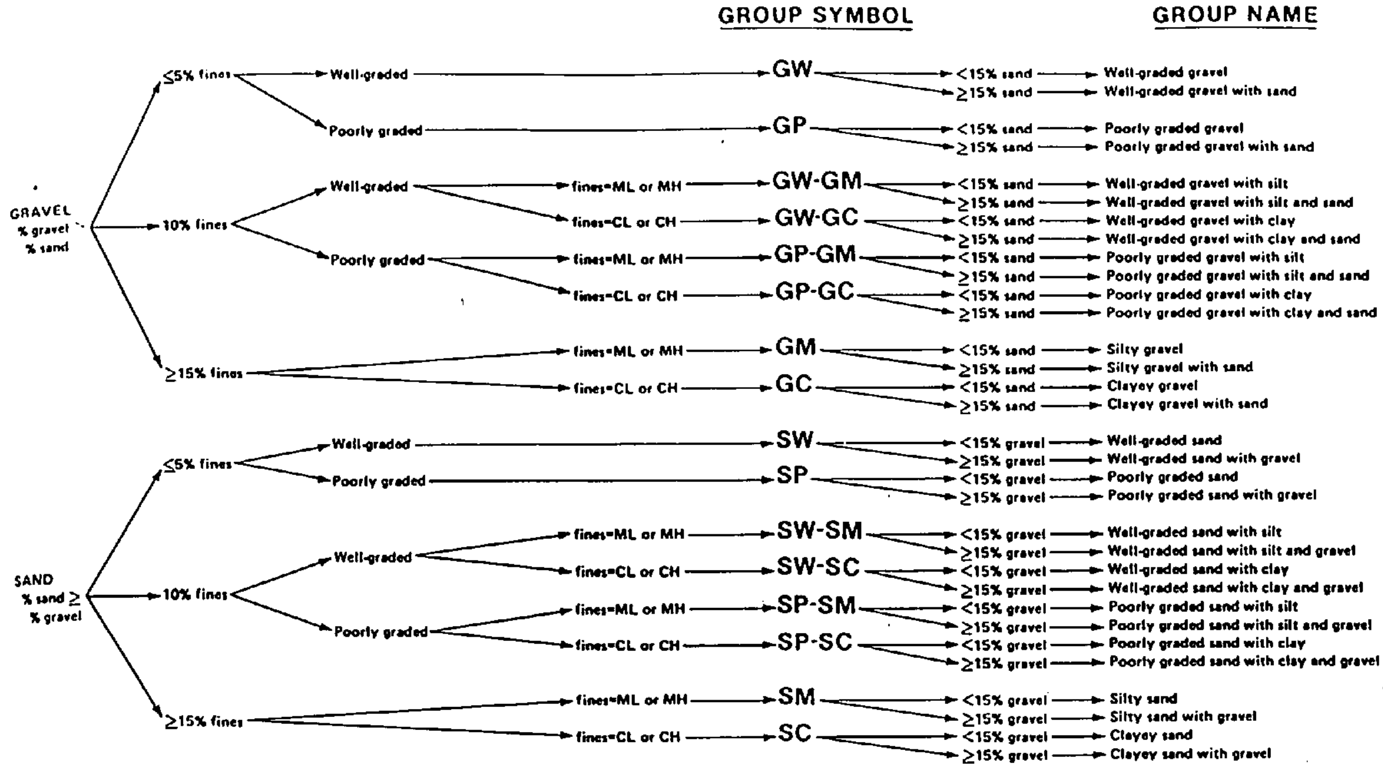
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

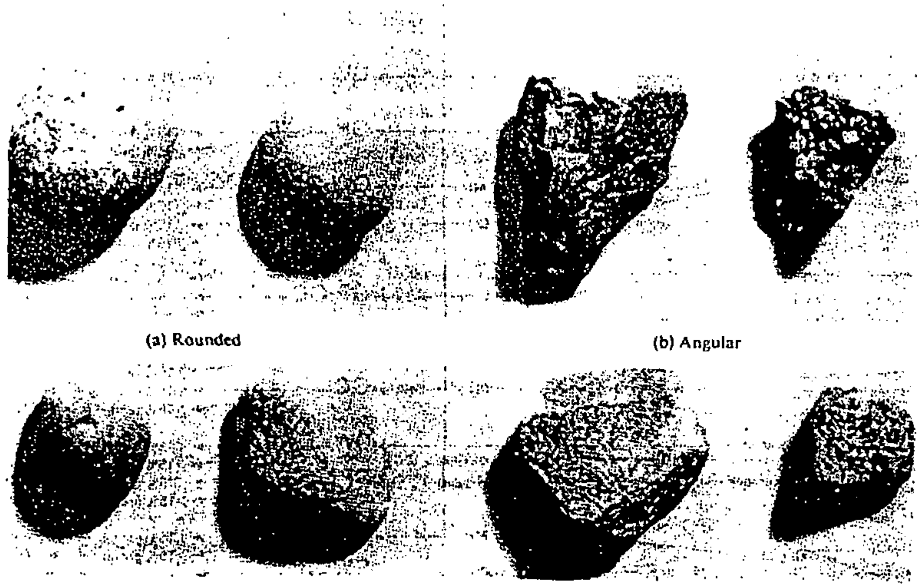
6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.



(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

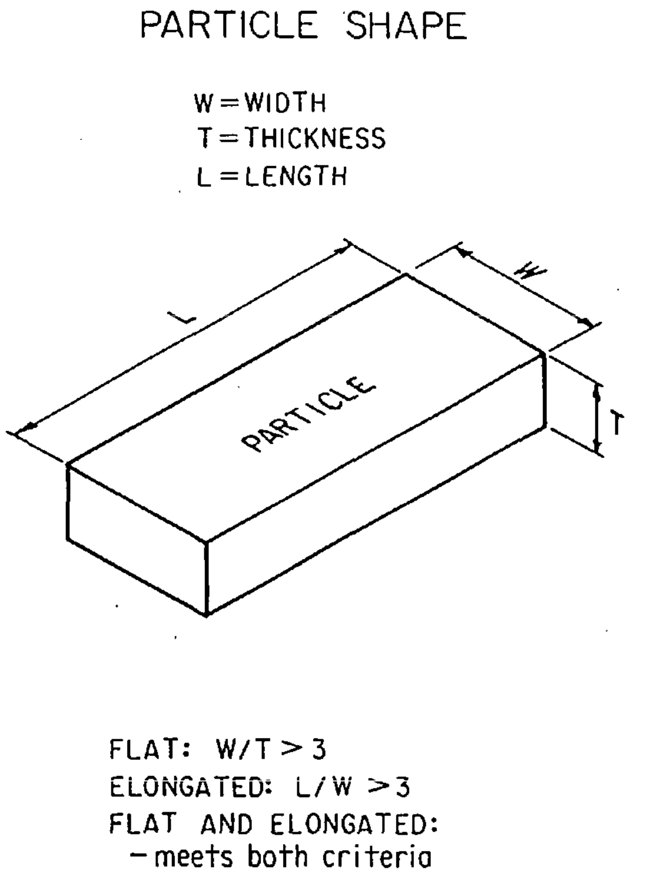


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpre-

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

MODIFIED METHOD ASTM D422-63
GRAIN SIZE ANALYSIS

SCOPE AND APPLICATION

A Modified Method ASTM D422-63 is used to determine the distribution of grain sizes in selected soil samples in the field. Particles will be identified as gravel, various grades of sand, silt and clay.

SUMMARY OF THE METHOD

A weighed quantity of moist soil is dried in the field by heating over a flame. When dry, the soil is weighed again. The dried soil is transferred to a stacked series of sieves, with the coarsest sieve at the top, grading to progressively finer sieves and finally to a solid pan at the bottom. The soil/sieves are shaken and rotated until the various contained grain sizes have come to rest on the appropriate sieve. The weight of the soil and drying pan are determined and recorded in increments as each sieve is emptied into the pan. The percent of material finer than each sieve is calculated, and plotted vs. grain size on semilog paper, giving the sample's grain size curve.

DRYING AND SIEVING OF SOIL

Apparatus and Materials

- Scale (beam balance or equivalent), readable to 0.01 g, with a capacity >500 grams. Calibrated per C/SS EW-321.
- Drying pan (aluminum pie pan will do).
- Heat source (hot plate or camp stove).
- Sieves - Typically #10, #20, #40, #60, #100, and #200, with bottom pad and lid. Calibrated per C/SS EW-452.
- Spatula.
- Fine-bristled brush.
- Semilog paper.
- Hand lens (optional).
- Squirt bottle.

- Distilled water.
- Paper towels.
- Matches (to light camp stove).

PROCEDURE

- Record all weights and calculations on Form F-1.
- Weigh drying pan and record weight. *1*
- Place portion of moist soil (between 300 to 500 grams) in drying pans and weigh. *2*
- Heat soil in drying pan. Shake pan or stir soil during heating to thoroughly dry all portions of soil. Be careful not to shake or stir so strongly as to cause a portion of the soil to fall out of the pan.
- Heat soil in well-ventilated area only. Environmental samples may contain quantities of organic compounds which may be volatilized by heating. If unusual odors are noted, check breathing zone with an OVA or HNu, and follow recommended field action levels of respiratory protection, as presented in the Site Health and Safety Plan.
- When soil has been dried, examine soil particles closely. Drying sometimes causes fines to stick to sand and gravel. If a coating of fines is noted, gently rub the soil with your finger or a solid soft tool to break up the agglomerates. Do not rub so strongly as to crush existing grains.
- Weigh the drying pan with the dried soil. Record weight. *3*

<u>Before Sieve Analysis, Compute</u>

Weight of Wet Soil *4*	=	Weight of Pan and Moist Soil *2*	−	Weight of Pan *1*
Weight of Dried Soil *5*	=	Weight of Pan and Dried Soil *3*	−	Weight of Pan *1*
Weight of Water in Soil *6*	=	Weight of Pan and Moist Soil *2*	−	Weight of Pan and Dried Soil *3*

- Prepare the sieve stack. A typical sieve stack will consist of the following sieves: #10, #20, #40, #60, #100, and #200. The #200 is sometimes deleted, as it is difficult to use and maintain in the field.

- Carefully transfer the dried soil into the top of the sieve stack. Use a fine-bristled brush to get all of the soil out of the pan. Sieves are to be stacked with the coarsest sieve on top grading progressively finer to a solid pan at the bottom.

- Place a lid on the top sieve. Pick up the stack, and shake and rotate until the various grain sizes have come to rest on the appropriate sieve (10-15 minutes).

- Remove each sieve (from top to bottom) one at a time. Carefully transfer the sieve contents to the previously weighed pan. Record the cumulative weight of the dry soil and the pan in column ***A*** of Form F-1. Repeat for each sieve and the bottom pan.

<u>After Sieve Analysis, Compute</u>

Weight of Dried Soil ***8***	=	Weight of Pan and Dried Soil ***7***	−	Weight of Pan ***1***		
% Variance ***9***	=	(Weight of Dried Soil After Sieve Analysis ***8***	÷	Weight of Dried Soil Before Sieve Analysis) ***5***	× 100	

- If the % variance is more than 10%, reevaluate each step of the process to attempt to discover the source of this error (i.e., soil spilled during sieving or soil trapped in the sieve screens).

Plotting the Results

Procedure

<u>Before Plotting, Compute</u>

Cumulative Weight Dry Soil Retained ***B***	=	Cumulative Weight of Dry Soil and Pan ***A***	−	Weight of Pan ***1***	
% Retained ***C***	=	(Cumulative Weight Dry Soil Retained ***B***	÷	Weight of Dry Soil After Sieve Analysis) ***8***	× 100
% Finer ***D***	=	100	−	% Retained ***C***	

- Results are plotted on semilog paper as sieve size (or slot opening size) vs. cumulative percent finer.

- Plot the data on semilog paper, with cumulative percent finer on the standard Y-axis, increasing to 100 percent from 0 percent at the origin, and sieve opening on the logarithmic X-axis, increasing from 0 at the origin.

CONCLUSION

- Accuracy and precision of measurements are improved by maintaining equipment in meticulously clean working order. Sieves should be thoroughly cleaned after each use, removing trapped grains from the sieve screens, and rinsing each with distilled water to wash way fines. Prevent beam balance from receiving physical shocks and make sure it is solidly positioned and zeroed before use.

FORM D-1
Grain Size Analysis of Soils
Field Procedure Modified ASTM D422-63

Project: AFP 59 Remedial Investigation		**Project No.:** 949033	
Client: U.S. Air Force		**Client Project No.:**	
Boring No./Sample Location:	**Tested By:**		**Date:**
Sample No.:	**Computed By:**		**Date:**
Sample Depth/Elevation:	**Checked By:**		**Date:**

Before Sieve Analysis

3 Weight of dry soil + pan ________g	*2* Weight of moist soil + pan ________g
1 Weight of pan ________g	*1* Weight of pan ________g
5 Weight of dry soil (*3* − *1*) ________g	*4* Weight of moist soil (*2* − *1*) ________g
Sieve Set No.________________	*6* Weight of water in soil (*2* − *3*) ________g

U.S. Sieve Size	*A* Cumulative Weight Dry Soil + Pan (grams)	*1* Weight of Pan (grams)	*B* Cumulative Weight Dry Soil Retained (grams) (*A* − *1*)	*C* % Retained (*B* ÷ *8* × 100)	*D* % Finer (100 − *C*)
6"					
3"					
1½"					
1"					
¾"					
½"					
3/8"					
4					
10					
20					
40					
60					
100					
200					
Pan	7				

After Sieve Analysis

7 Weight of dry soil + pan (Last entry in column *A*) ________g

1 Weight of pan ________g

8 Weight of dry soil (*7* − *1*) ________g

9 % Variance (*8* / *5*) × 100 = ______%

Remarks:______________________________

Note: Pie pans are to be used for a drying pan.