DEPARTMENT OF THE AIR FORCE
27TH CIVIL ENGINEER SQUADRON (ACC)
CANNON AIR FORCE BASE NEW MEXICO

MAY 0 5 2005

Lieutenant Colonel Alexander P. Karibian
Commander
506 N DL Ingram Blvd
Cannon AFB NM 88103-5003

Mr. David Cobrain
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Dr E Building 1
Santa Fe NM 87505-6303

RECEIVED
MAY 2005
NMED Hazardous Waste Bureau

Dear Mr. Cobrain

Enclosed for your review and records are two copies of the Work Plan Phase I Investigation Soil Corrective Measures Fire Training Area 04, Cannon Air Force Base, New Mexico, dated Nov 04 and two copies of the Final Work Plan Addendum for the removal of Contaminated Soil at SWMU 109 (Fire Training Area 04) Cannon Air Force Base, New Mexico, dated Mar 05. Fire Training Area 04 consists of Solid Waste Management Units 109, 110, 111, and 112.

The purpose of this work plan and addendum was to articulate the removal and disposal of contaminated soils at Fire Training Area 04.

If you have any questions regarding this information, please contact Mrs. Sheila Newman, Environmental Flight, at (505) 784-6391 or email sheila.newman@cannon.af.mil.

Sincerely

ALEXANDER P. KARIBIAN, Lt Col, USAF

Attachments:
Work Plan Phase 1 Investigation Soil Corrective Measures Fire Training Area 04, Cannon AFB New Mexico (2 cys)
Final Work Plan Addendum for the removal of Contaminated Soil at SWMU 109 (Fire Training Area No. 04) Cannon AFB, New Mexico (2 cys)

LIBRARY COPY

WORK PLAN
PHASE I INVESTIGATION
SOIL CORRECTIVE MEASURES
FIRE TRAINING AREA 04
CANNON AIR FORCE BASE, NEW MEXICO

November 3, 2004

Prepared for

UNITED STATES ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
106 South 15th Street
Omaha, Nebraska 68102-1618

Contract No. DACA45-00-D-0006/0006
Project No. 2002189

Prepared by

T N & Associates, Inc.
1033 N. Mayfair Road
Milwaukee, WI 53226

T N & Associates, Inc.
Engineering and Science

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 SITE DESCRIPTION 1
2.1 Site Background 1
2.2 Physical Conditions 2
2.2.1 Soils and Geology 2
2.2.2 Groundwater 3
2.2.3 Surface Water 3
2.3 Site Investigative History 3
2.4 Corrective Action Implementation at FTA4 4
2.5 Regulatory Framework 4

3.0 PROJECT OBJECTIVES 4
3.1 Sampling Activities 5
3.1.1 Site Access, Utility Clearance, and Permits 5
3.1.2 Drilling and Sampling 5
3.1.3 Decontamination Procedures 6
3.1.4 Sample Location Surveying 7
3.1.5 Borehole Abandonment 7
3.1.6 Site Restoration 7
3.2 IDW Management and Disposal 7
3.3 Sample Analysis 7
3.4 Data Quality Control and Validation 8
3.5 Site Safety and Health 8
3.6 Reports and Documentation 8
3.6.1 Field Records 8
3.6.2 Field Investigation Report 8

4.0 REFERENCES 10

LIST OF FIGURES

Figure 1	Site Location Map
Figure 2	Proposed Sample Locations
Figure 3	Project Schedule

LIST OF APPENDICES

Appendix A	Technical Memorandum
Appendix B	Sampling and Analysis Plan
Appendix C	Standard Operating Practices
Appendix D	Site Safety and Health Plan

ABBREVIATIONS AND ACRONYMS

AFB	Air Force Base
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEV	Base Environmental Flight
CMS	Corrective Measures Study
DPT	direct-push technology
DQCR	Daily Quality Control Report
DRO	diesel-range organics
ft	foot
FTA4	Fire Training Area 04
GPS	Global Positioning System
IDW	investigative-derived waste
JP-4	Jet Propellant 4
LF-5	Landfill 5
mg/kg	milligram per kilogram
MS/MSD	matrix spike/matrix spike duplicate
NMED	New Mexico Environment Department
PID	photoionization detector
PM	Project Manager
PPE	personal protective equipment
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SOP	Standard Operating Procedures
SVE	soil-vapor extraction
SWMU	Solid Waste Management Unit
TCE	trichloroethene
TN&A	T N & Associates, Inc.
TPH	total petroleum hydrocarbons
TtFW	Tetra Tech Foster Wheeler, Inc.
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
WWTP	wastewater treatment plant

1.0 INTRODUCTION

T N & Associates, Inc. (TN&A) has prepared this Work Plan for the United Sates Army Corps of Engineers – Omaha District (USACE) under Contract Number DACA45-00-D-0006, Delivery Order 0006. The purpose of this Work Plan is to describe the work that will be performed to confirm petroleum hydrocarbon contaminated soils at the former Fire Training Area 04 (FTA4) at Cannon Air Force Base (AFB) in Clovis, New Mexico. FTA4 consists of Solid Waste Management Units (SWMUs) 109, 110, 111, and 112. SWMU 109 is the primary focus of this Work Plan, as it is the area which was impacted by the most by previous activities at FTA4.

The *Technical Memorandum, Evaluation of Total Petroleum Hydrocarbons in Soil at Fire Training Area 4, Cannon AFB, New Mexico*, dated May 21, 2004, prepared by Tetra Tech Foster Wheeler, Inc. (TtFW) presents the background information and rationale for the sampling to confirm the concentration of total petroleum hydrocarbons (TPH) in soil at FTA4. The *Technical Memorandum* is included as Appendix A of this Work Plan.

This Work Plan presents the project purpose and objectives, background information, and a description of the work to be performed under this delivery order. This Work Plan includes a Sampling and Analysis Plan (SAP) that integrates a Quality Assurance Project Plan (QAPP) for the acquisition of chemical and field data. The SAP is provided as Appendix B. Standard Operating Practices (SOPs) to be followed during the execution of the field effort are included in Appendix C. The Site Safety and Health Plan (SSHP) is provided as Appendix D.

This Work Plan is required reading for all staff participating in the work effort and will be in the possession of the field team executing the work described within. All TN&A staff and subcontractors will be required to comply with the procedures and standards document in the Work Plan to maintain comparability and representativeness of the collected and generated data.

2.0 SITE DESCRIPTION

2.1 Site Background

Cannon AFB is an active U. S. Department of Defense installation located in southeastern Curry County, New Mexico, approximately 5 miles west of Clovis and south of U.S. Highway 60/84 (Figure 1). The installation has been used by the Department of Defense for more then 50 years. The Base started as a training base for B-17 crews during World War II.

As stated above, FTA4 consists of SWMUs 109, 110, 111, and 112. SWMU 109 was used as a fuel truck cleaning area between 1961 and 1974. An estimated 3,000 to 4,000 gallons of fuel percolated into the ground as a result of these activities [Walk, Haydel, and Associates, Inc.

(Walk, Haydel, and Associates), 1990]. In 1974, the SWMU 109 site was activated as a fire training area. Commingled waste oils, solvents, and recovered Jet Propellant 4 (JP-4) were burned during fire training exercises conducted from 1974 to 1975. An underground storage tank (SWMU 110) was installed in 1975. Only recovered JP-4 was used as fuel for fire training exercises from 1975 to 1995. After that, SWMU 109 was no longer used as a fire training area [Harza Environmental Services (Harza), 1997].

SWMU 109 contained a 40 foot by 70 foot rebar-reinforced concrete-lined pit with a 4-foot tall berm that was removed in December 2000. The pit was filled with gravel and included internal drainage features that conveyed excess fuel and water to the oil/water separator (SWMU 112) located in the northeastern part of the site. These drainage features included an underground pipe running from pit to the oil/water separator. The separator was removed in 1997; however, the underground pipe is still in place. A mock airplane was formerly located in the center of the pit. Details of pit construction were confirmed using as-built drawings provided by Cannon AFB. The concrete pit was reportedly saturated with water during some fire training exercises. An above-ground fuel tank supplied fuel to the burn pit via an underground pipeline. The above-ground tank is presently empty and remains on site.

As part of the fire training system SWMU 111 (an unlined pit) was used to collect runoff from SWMU 109 after the fires were extinguished. The pit was backfilled in 1985 when the oil/water separator was installed at SWMU 112. One soil sample collected in the vicinity of SWMU 111 (SB14 on Figure 2) identified TPH at 1,040 mg/kg at a depth of 1 foot.

2.2 Physical Conditions

2.2.1 Soils and Geology

Soils underlying FTA4 consist of sandy loam and loamy sand of the Amarillo soil group. The soils consist primarily of a fine-grained, well-sorted silty/clayey, unconsolidated, brown/reddish-brown sand. Such soils are generally classified as silty sand to clayey sand under the Unified Soil Classification System (Harza, 1977).

FTA4 is underlain by Ogallala Formation fluvial deposits consisting primarily of unconsolidated silty sand to clayey sand. These deposits include sporadic caliche layers and more extensive zones containing caliche-cemented nodules (Harza, 1997). The total thickness of the Ogallala Formation beneath the site is not known, as bedrock was not encountered during previous field investigation activities, which were conducted to depths of 90 ft. Based on available regional information, the Ogallala Formation may be as thick as 390 ft at Cannon AFB.

2.2.2 Groundwater

No groundwater was encountered during previous investigations of FTA4 at the maximum drilled depth of 90 ft. Groundwater occurs at depths ranging from 290 to 300 ft at nearby Landfill 5 (LF-04). Occupants of the area surrounding the Base rely primarily on groundwater for irrigation. The nearest downgradient water well is ¼ mile from FTA4.

Groundwater monitoring is conducted annually at several sites on the Base, including LF-05, which is downgradient of FTA4. During sampling conducted in March 2000, wells were monitored for volatile organic compounds, polychlorinated biphenyls, pesticides, and metals. Analytes detected in the downgradient wells included trichloroethene (TCE), chloroform, and metals. Metals were detected at concentrations that were consistent with background levels in the area (U.S. Geological Survey, 2000). Because JP-4 was the fuel used at FTA4 during all but a brief part of its history, TCE and chloroform were not believed to be chemicals of concern at this site. Groundwater analytical data from monitoring wells downgradient of FTA4 indicate that chlorinated solvents have not impacted groundwater due to previous operations at the site (U.S. Geological Survey, 2000).

2.2.3 Surface Water

Stream valleys in Curry County tend to be fairly broad and widely spaced. Streams are ephemeral and drainages are poorly developed. No permanent streams exist on or near Cannon AFB (Harza, 1997).

Historically, runoff at Cannon AFB has drained into four natural ephemeral playas. The two northern playas were converted into plastic-lined golf course ponds. The southern playa is still intact; however, the surrounding drainage patterns have been altered. The eastern playa, known as North Playa Lake, was bermed on the north, west, and south sides with topsoil and concrete debris. Drainage ditches at Cannon AFB are concentrated around the developed/landscaped areas of the Base and carry runoff to the playa lakes and golf course ponds. The playa lakes have no surface outlet, and any water they collect is eventually lost to evaporation or infiltration or is used by plants and animals.

2.3 Site Investigative History

Four investigations have been conducted at FTA4. Radian Corporation installed two soil borings in 1985 and collected five soil samples for analysis for oil and grease, lead and volatile organic compounds. The samples were not analyzed for total petroleum hydrocarbons (TPH).

In 1988, Walk, Haydel and Associates performed a remedial investigation where they installed nine soil borings and collected 26 soil samples. The soil was analyzed for metals

with 13 samples analyzed for benzene, toluene, ethylbenzene, and xylenes. Again, the soils were not analyzed for TPH.

In 1991, Woodward-Clyde installed two soil borings in the vicinity of FTA4 where the concentrations of TPH exceeded the action limits of 5,000 milligrams per kilograms (mg/kg).

A Phase II Remedial Investigation was conducted by Harza in 1996-1997 in which 19 soil borings were installed and 77 soil samples were collected for analysis. A passive soil gas survey was also conducted at that time. Two soil samples collected from borings in the FTA4 area exceed the action limit of 5,000 mg/kg for TPH.

2.4 Corrective Action Implementation at FTA4

The recommended corrective action alternative identified in the *Final Corrective Measures Study Report for SWMUs 109, 110, 111, and 112 – Fire Training Area Four* [Final Corrective Measures Study (CMS) Report][Foster Wheeler Environmental Corporation (Foster Wheeler Environmental), 2001] for SWMU 109 was passive bioventing. Further information on the CMS and the evaluations performed to evaluate corrective measure alternatives is summarized in the *Technical Memorandum* (Appendix A). The analytical data, upon which the selection of the remedial alternative was based, were collected in 1991 and 1997. In order to define the current extent of contamination, additional sampling at FTA4 was proposed to confirm the levels and extent of TPH in soil. Furthermore, Cannon AFB desires to facilitate cleanup and closure of the FTA4 site within the next year. Therefore, corrective measure alternatives will be re-evaluated following implementation of this Work Plan.

2.5 Regulatory Framework

Cannon AFB operates its corrective measures program in accordance with the provisions of the original Hazardous Waste Facility Permit (see Appendix A, "Regulatory Framework" for more information). Based on the investigations conducted to date, the primary chemicals of concern at FTA4 are petroleum hydrocarbons associated with the storage and use of JP-4 during training exercises. Risk assessments performed to date (Appendix A) support that no further action is needed to address health risks at this site. However, the New Mexico Environment Department (NMED) is requiring Cannon AFB to meet the TPH standard for soils in the FTA4 area. The residential direct exposure screening guideline for TPH is 940 mg/kg (NMED, June 2003), which has been selected as the "action level" for the re-evaluation of corrective measure alternatives for this site.

3.0 PROJECT OBJECTIVES

The objective of this project is to confirm subsurface TPH soil contamination in the vicinity of SWMU 109 and 111/112 in the FTA4 area (Figure 2). This work will be considered the

Phase I effort at the site. Once the vertical and horizontal extent has been confirmed, the corrective measure alternatives will be re-evaluated by USACE and TtFW, Inc.

(Note: Confirmation of later soil removal, if selected as the final corrective measure, will include sampling for benzene, toluene, ethylbenzene, and total xylenes as required by the NMED. Future soil cleanup activities and confirmation sampling will be performed in accordance with a corrective measures implementation plan to be developed by the USACE and TtFW at a later date.)

The Phase I sampling program will be performed in accordance with United States Environmental Protection Agency (U.S. EPA) Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) guidance, the USACE Geology supplemental scope of services, and in compliance with the Cannon AFB RCRA Permit. Sample results will be compared to NMED standard for TPH in residential soils (940 mg/kg).

3.1 Sampling Activities

TN&A will perform the field work in accordance with the approved SAP (Appendix B). Pre-field planning and implementation of the SAP will include the activities described in the following sections.

3.1.1 Site Access, Utility Clearance, and Permits

TN&A will coordinate the field schedule and site access with the Base Environmental Flight (CEV). TN&A will obtain vehicle and personnel passes for entry onto the Base. Utility clearance will be coordinated by TN&A with USACE, TtFW and the Base CEV.

3.1.2 Drilling and Sampling

An experienced TN&A field geologist will oversee the drilling, log the boreholes, collect samples, and perform other fieldwork to complete the scope of work. A qualified subcontract driller, ESN Southwest (Tijeras, NM), will perform the direct-push technology (DPT) drilling. All sample collection and field data acquisition will be performed in accordance with the approved SAP (Appendix B). Field activities will conform to TN&A SOPs (Appendix C).

All field work will be performed in Level D personal protective equipment (PPE) in accordance with the approved SSHP (Appendix D). If field conditions encountered are such that a higher level of PPE is required, TN&A will immediately contact USACE to discuss the situation.

Sampling locations were selected by TtFW based on prior investigative information and are shown on Figure 2. Sampling locations will be marked in the field by TtFW prior to the

beginning of drilling. Alternatively, TtFW will provide boring location coordinates to TN&A prior to the field work and TN&A will use a hand-held Global Positioning System (GPS) unit, landmarks, and a scaled map to locate the planned sampling locations. A total of 12 boreholes will be advanced using DPT drilling techniques to an approximate maximum depth of 50 feet (167 linear drilling feet). The drilling depths and sampling intervals are based on Table 3 in the Technical Memorandum (Appendix A). A total of 32 soil samples will be collected for TPH analysis (plus additional samples for QA/QC purposes; see SAP in Appendix B). The field geologist will use professional judgment, field observations, and PID headspace screening results to adjust sampling intervals within each borehole so that the best possible data are generated to support the project objectives.

The drilling site may have some caliche zones that could make penetration using DPT difficult. If this condition is encountered, the driller will switch to use of a solid-stem auger (drill rig will be equipped for both methods of drilling) for the purpose of penetrating the caliche layer. No samples will be collected through the caliche interval. Once the caliche is penetrated, the driller will switch back to the use of DPT and continuous sampling. This approach will prevent the need to off-set or move planned boring locations.

The field geologist will use a properly calibrated photoionization detector (PID) to perform air monitoring in the breathing zone and headspace screening of soil samples. Samples for head-space screening will be collected from every 2-foot interval during drilling.

The field geologist will collect samples into laboratory-provided containers and maintain them on ice in clean coolers. TN&A will follow chain-of-custody procedures in the approved SAP (Appendix B) to manage the samples until shipment by common carrier for overnight delivery to the subcontract laboratory.

The TN&A geologist will log borehole geology following the USACE General Geology Scope of Services and using HTW soil boring logs. Additionally, the TN&A geologist will carefully examine soil cores for visual indications of soil contamination (staining, etc.) and note these observations in the log. The completed HTW boring logs will be submitted to the USACE within three business days of completing drilling at the site.

3.1.3 Decontamination Procedures

TN&A will construct a decontamination pad in the designated decontamination area within the adjacent landfill site (LF-5). The drilling rig and downhole equipment will be decontaminated before and after work at FTA4. If necessary, the heavily contaminated drill-stem will also be steam-cleaned at the decontamination pad between sampling locations. Sampling equipment used to collect soil samples will be disposable and will be used only once per sample.

3.1.4 Sample Location Surveying

TN&A will stake and flag the borehole locations and will survey horizontal coordinates and approximate elevations using a hand-held GPS surveying instrument. The GPS instrument (Geo Explorer XT or equivalent) will have sub-meter accuracy after differential correction.

3.1.5 Borehole Abandonment

Following sampling, the boreholes will be abandoned in accordance with the USACE General Geology Scope of Services, New Mexico Underground Storage Tank Bureau "Guidelines for Corrective Action" (March 2000) and Base requirements. As the drilling locations are not on a flight line, and the area is not paved, no special surface repairs will be performed. Borehole abandonment materials and quantities and method for abandonment will be documented in the field logbook and on the HTW boring log.

3.1.6 Site Restoration

Following completion of all sampling activities, TN&A will manage investigative-derived wastes (IDW) as described below (Section 3.2). TN&A will remove other investigation-related materials and restore the site to pre-drilling condition.

3.2 IDW Management and Disposal

Used PPE and investigation incidental wastes will be managed as trash, being placed in garbage bags and disposed of in a Base dumpster. The drill cuttings will be retained in steel 55-gallon drums labeled with the appropriate collection and contact information. Soils that appear to be contaminated (visually or based on PID readings) will be segregated from apparently clean soils. The drums will be stored on pallets in the LF-5 area. Decontamination fluids will be placed in a 55-gallon drum and allowed to evaporate. Residual solids in the IDW fluid drum will be combined with the IDW solids. IDW solids will be combined with other IDW or soil removed and disposed of as part of the final corrective measure at the site by TtFW. Any residual IDW fluids that have not evaporated by the time of the implementation of the final corrective measure will be taken by TtFW to the headwaters of the Cannon AFB water treatment plant for final disposal.

3.3 Sample Analysis

The soil samples will be analyzed for TPH-diesel range organics (DRO) by Modified Method 8015 in general accordance with the New Mexico Underground Storage Tank Bureau "Guidelines for Corrective Action" (March 2000) and the USACE Chemistry Scope of Services. The subcontractor laboratory, STL Laboratories – Chicago, is a National Environmental Laboratory Accreditation Program certified laboratory. A draft Sampling and Analysis Summary table is provided below in the SAP (Appendix B).

A total of 32 field samples will be collected as well as the following quality control samples at a rate of one per 10 samples for field duplicates (three samples) (minimum of 5 percent duplicate samples) and matrix spike/matrix spike duplicates (MS/MSD) (one per 20 samples or two MS and two MSD). All QC samples will be analyzed for TPH (DRO) by Modified 8015.

3.4 Data Quality Control and Validation

TN&A will perform a Level III data validation on 90 percent of the data and a Level IV on the remaining 10 percent of laboratory data, following the U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA-540/R-94/012) Methods that do not exist within the Functional Guidelines will be evaluated by similar criteria and against similar standards to existing methods. The QAPP is incorporated into the SAP (Appendix B).

3.5 Site Safety and Health

All field work performed by TN&A or under direct supervision of TN&A will be in strict accordance with the approved SSHP (Appendix C). A copy of the SSHP will be available on site and followed during field operations.

3.6 Reports and Documentation

3.6.1 Field Records

Verbal Conversation Records will be completed to document significant changes in scope of work, costs, or deliverables. Other supporting documentation, logs, or records will be provided as necessary to maintain a record of communications and decision-making during the course of the project.

TN&A will prepare and fax (or email) Daily Quality Control Reports (DQCRs) to the USACE Project Manager (PM) during each field event on a daily basis.

With permission of the Cannon AFB CEV, TN&A will photodocument key field activities (soil sampling, drilling) and drilling locations showing relevant landmarks (if practicable). The Field Investigation Report will include photodocumentation

3.6.2 Field Investigation Report

TN&A will prepare a concise Field Investigation Report summarizing the work performed, samples collected, and summarizing the sample analytical results. The report will be submitted in Draft, Final, and Revised Final forms. Annotated "Response to Comments" will be provided for each version.

Figures will include Base and site location maps, a site plan showing prior drilling, and a plan showing new borings (approximate locations) and sample results. Additionally, one or

two cross-sections will be prepared, if warranted by the data, showing geologic layers and sample analytical results.

Appendices will include the chemical analytical data summaries, Data Quality Control Summary, chain-of-custody forms, boring logs, and photodocumentation.

4.0 REFERENCES

Foster Wheeler Environmental (Foster Wheeler Environmental Corporation. December 2001. Final Corrective Measures Study Report for SWMUs 109, 110, 111, 112 – Fire Training Area Four, Cannon Air Force Base, New Mexico.

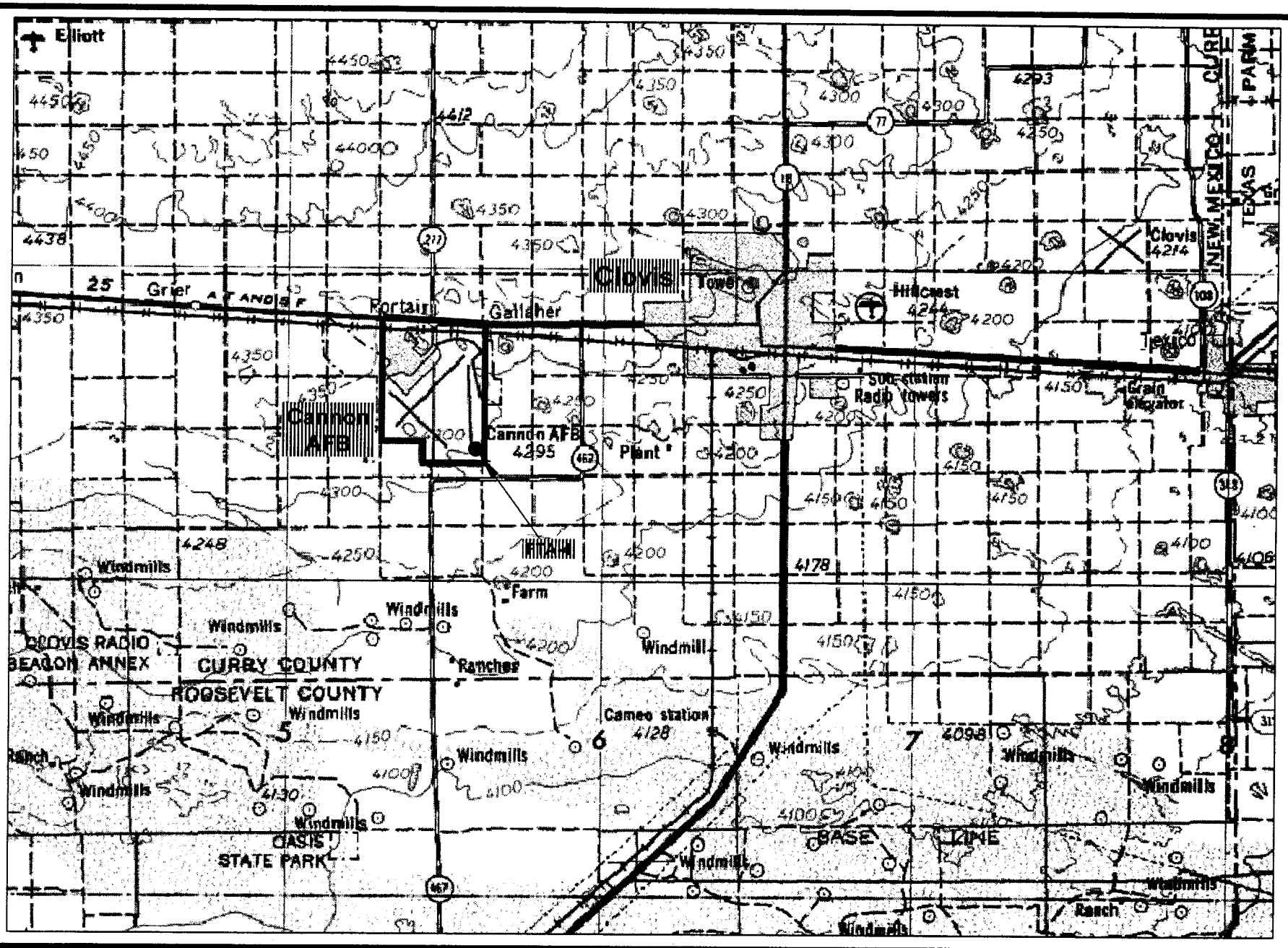
Harza (Harza Environmental Services). August 1997. Phase II RCRA Facility Investigation Report (Draft), Cannon Air Force Base, New Mexico.

New Mexico Environment Department (NMED). June 24, 2003. Total Petroleum Hydrocarbon (TPH) Screening Guidelines.

Radian. August 1988. Site-Specific Quality Management Plan Installation Restoration Program Fire Protection Training Area, Site 9 Tank Removal, Cannon Air Force Base, New Mexico.

Walk, Haydel, and Associates (Walk, Haydel, and Associates, Inc.). January 1990. Final Installation Restoration Program Remedial Investigation, Cannon Air Force Base, New Mexico.

Woodward-Clyde (Woodward-Clyde Consultants). October 1992. Remedial Investigation Report for 18 Solid Waste Management Units, Cannon Air Force Base, New Mexico.



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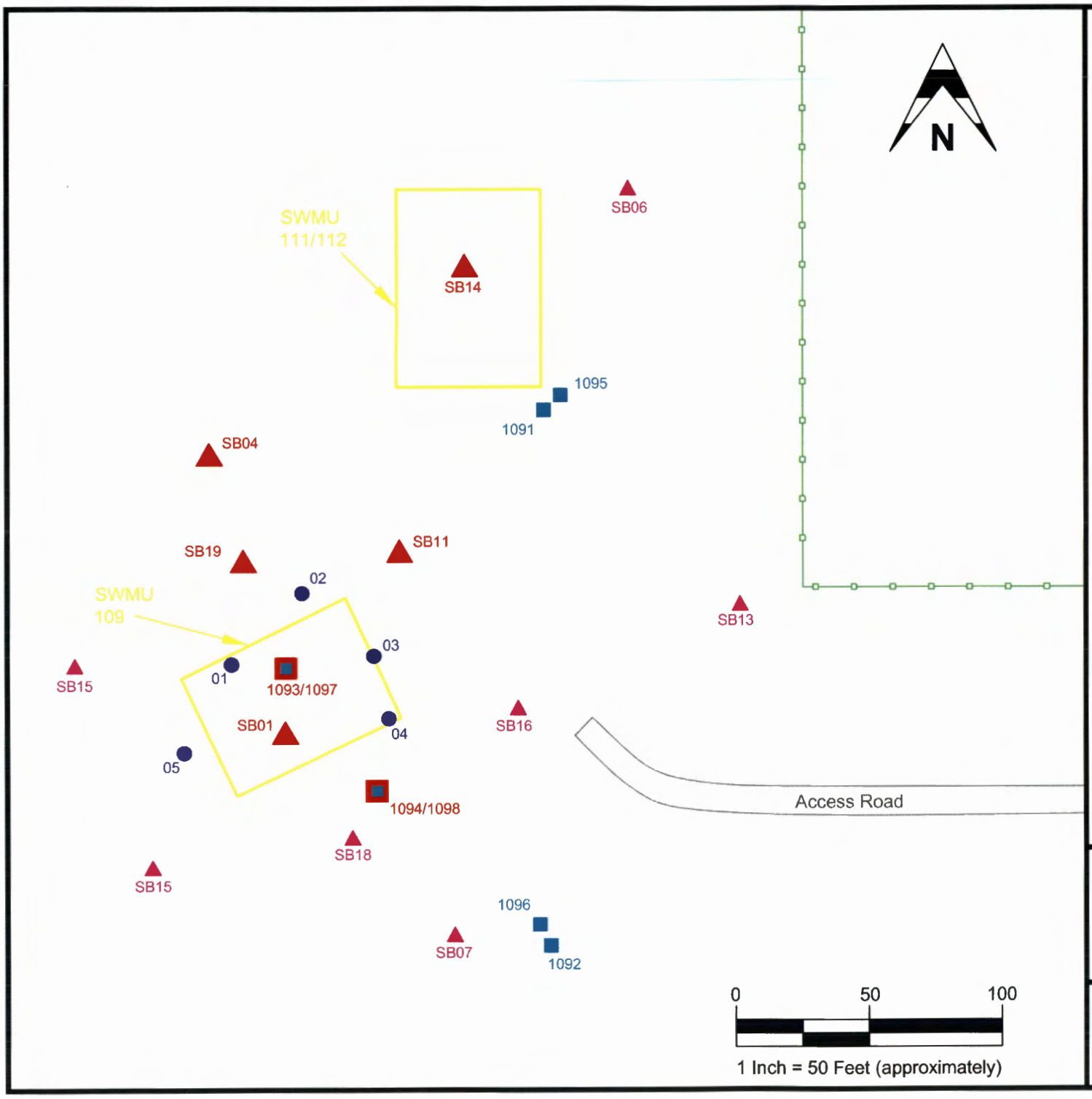
Engineering and Science

Figure was adapted from USGS Quads:
Midway, NM (1985)
Clovis, NM (1978)
Clovis, NM, TX (1972)

0 2.5 5
1 Inch = 2.5 Miles (approximately)

N

Figure 1
Cannon Air Force Base Site
Location Map



Legend

- Woodward-Clyde Sample Location, 1991
- Harza Soil Boring Location, 1997 (approximate locations)
- Confirmation Sample Locations (Previously Drilled)
- New Confirmation Sample Location
- SWMU Locations
- Roads
- Existing Fenceline

Figure was adapted from:
Technical Memorandum
Evaluation of TPH in Soil at FTA4
Cannon Air Force Base, New Mexico

Figure 2
Proposed Sample Locations

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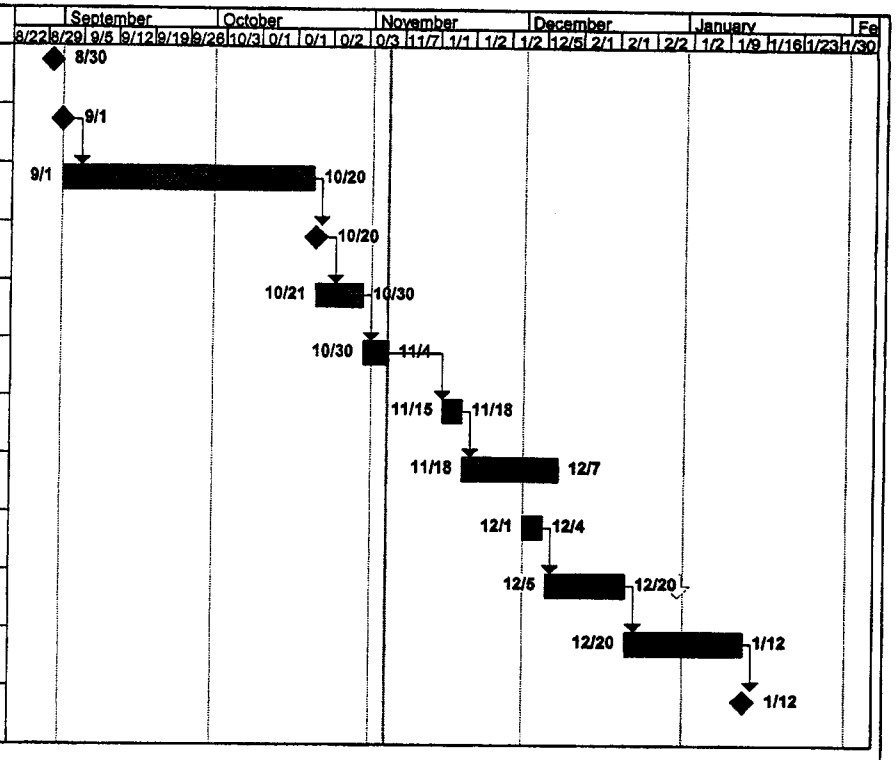
ID	Task Name	Duration	Start	Finish	Resource Names
1	Contract Award	0 days	Mon 8/30/04	Mon 8/30/04	
2	Notice-To-Proceed	0 days	Wed 9/1/04	Wed 9/1/04	
3	Planning & Review	65 days	Wed 9/1/04	Wed 10/20/04	
4	Draft Work Plan Submittal	0 days	Wed 10/20/04	Wed 10/20/04	
5	Review/comment period	12 days	Thu 10/21/04	Sat 10/30/04	
6	Final Work Plan	7 days	Sat 10/30/04	Thu 11/4/04	
7	Phase I investigation	5 days	Mon 11/15/04	Thu 11/18/04	
8	Laboratory Analyses	25 days	Thu 11/18/04	Tue 12/7/04	
9	Lab Date receipt, validation	5 days	Wed 12/1/04	Sat 12/4/04	
10	Draft Removal Report	20 days	Sun 12/5/04	Mon 12/20/04	
11	Review/comment period	30 days	Mon 12/20/04	Wed 1/12/05	
12	Final Removal Report	10 days	Wed 1/12/05	Thu 1/20/05	



Project: Cannon AFB Ph I Investigatoin
Date: Thu 11/4/04

T N & Associates, Inc.

Task		Summary		Rolled Up Progress		Project Summary	
Progress		Rolled Up Task		Split		Group By Summary	
Milestone		Rolled Up Milestone		External Tasks		Deadline	

Figure 3. Project Schedule

APPENDIX A

Technical Memorandum
May 21, 2004

May 21, 2004
TERC-028.001-04X-007

Ms. Jane Davey
U.S. Army Corps of Engineers, Omaha District
Attn: CENWO-PM-HC, 9th FL
106 South 15th Street
Omaha, NE 68102-1618

Subject: TERC Contract No. DACW45-94-D-0003, Delivery Order 28, WAD 1
Submittal of the Final Technical Memorandum for the Evaluation of Total Petroleum Hydrocarbons in Soil at Fire-Training Area 4, Cannon Air Force Base, New Mexico

Dear Ms. Davey:

Enclosed are four copies of the Technical Memorandum for the Evaluation of Total Petroleum Hydrocarbons in Soil at Fire-Training Area 4, Cannon Air Force Base (AFB), New Mexico. By copy of this letter, I am sending four copies of the technical memorandum to Mr. Pete Zamie and Mr. Denny Timmons at Cannon AFB.

This technical memorandum presents the background information and rationale for proposed sampling to confirm the concentration of total petroleum hydrocarbons (TPH) in soil at Fire Training Area 4 (FTA4) at Cannon AFB. The rationale for proposed sampling is presented in this memorandum through supporting information from current site conditions, previous investigations, the *Final Corrective Measures Study Report for SWMUs 109, 110, 111, and 112—Fire Training Area Four* (December 2001), and the regulatory framework for addressing residual TPH contamination in soil at the site.

Comments received from the U.S. Army Corps of Engineers were incorporated into this document. If you have any questions or comments, please call me at (505) 878-8924. Thank you.

Sincerely,
Tetra Tech FW, Inc.

Carol L Bieniulis

Carol L. Bieniulis
Principal Geologist/Delivery Order Manager

CLB/clb
Enclosures

cc: P. Zamie and D. Timmons, Cannon AFB (4 copies)
C. Madewell, TtFW/Albuquerque
S. Seyedian, TtFW/Denver (w/o enclosures)
TERC Project File, Denver

TECHNICAL MEMORANDUM
Evaluation Of Total Petroleum Hydrocarbons In Soil At Fire-Training Area 4
Cannon Air Force Base, New Mexico
May 21, 2004

This technical memorandum presents the background information and rationale for proposed sampling to confirm the concentration of total petroleum hydrocarbons (TPH) in soil at Fire Training Area 4 (FTA4) at Cannon Air Force Base (AFB), New Mexico. The rationale for proposed sampling is presented in this memorandum through supporting information from current site conditions, previous investigations, the *Final Corrective Measures Study Report for SWMUs 109, 110, 111, and 112—Fire Training Area Four* [Final Corrective Measures Study (CMS) Report] [Foster Wheeler Environmental Corporation (Foster Wheeler Environmental), 2001], and the regulatory framework for addressing residual TPH contamination in soil at the site. The primary area of interest at FTA4 addressed in this memorandum is Solid Waste Management Unit (SWMU) 109, the Former Fire-Training Pit. SWMU 109 was identified as the area which was impacted the most by previous activities at FTA4.

CURRENT SITE CONDITIONS

SWMU 109 was used as a fuel truck cleaning area between 1961 and 1974. An estimated 3,000 to 4,000 gallons of fuel percolated into the ground as a result of these activities [Walk, Haydel, and Associates, Inc. (Walk, Haydel, and Associates), 1990]. In 1974 the site was activated as a fire training area. Commingled waste oils, solvents, and recovered Jet Propellant 4 (JP-4) were burned during fire training exercises conducted from 1974 to 1975. The underground waste oil tank (SWMU 110) was installed in 1975, and only recovered JP-4 was burned during exercises conducted from 1975 to 1995. After that time, the SWMU was no longer used as a fire training area [Harza Environmental Services (Harza), 1997).

SWMU 109 contained a 40-foot (ft) by 70-ft rebar-reinforced concrete-lined pit with a 4-ft berm that was removed in December 2000. The pit was filled with gravel and included internal drainage features that conveyed excess fuel and water to the oil/water separator (SWMU 112) located in the northeast part of the site. These drainage features included an underground pipe running from the pit to the oil/water separator. The separator was removed in 1997; however, the underground pipe is still in place. A mock airplane was formerly located in the center of the pit. Details of pit construction were determined using as-built drawings provided by Cannon AFB. The concrete pit was reportedly saturated with water during some fire training exercises. An aboveground fuel tank supplied fuel to the burn pit via an underground pipeline. The aboveground tank is presently empty and remains on site.

PHYSICAL CONDITIONS

Soils and Geology

Soils underlying FTA4 consist of sandy loam and loamy sand of the Amarillo soil group. The soils consist primarily of a fine-grained, well-sorted silty/clayey, unconsolidated, brown/reddish-brown sand. Such soils are generally classified as silty sand to clayey sand under the Unified Soil Classification System (Harza, 1997).

FTA4 is underlain by Ogallala Formation fluvial deposits consisting primarily of unconsolidated silty sand to clayey sand. These deposits include sporadic caliche layers and more extensive zones containing caliche-cemented nodules (Harza, 1997). The total thickness of the Ogallala Formation beneath the site is not known, as bedrock was not encountered during previous field investigation activities, which were

conducted to depths of 90 ft. Based on available regional information, the Ogallala Formation may be as thick as 390 ft at Cannon AFB.

Groundwater

No groundwater was encountered during previous investigations of FTA4 at the maximum drilled depth of 90 ft. Groundwater occurs at depths ranging from 290 to 300 ft at nearby Landfill 5 (LF-05). Occupants of the area surrounding the Base rely primarily on groundwater for irrigation. The nearest downgradient water well is approximately ¼ mile from FTA4.

Groundwater monitoring is conducted annually at several sites on the Base, including LF-05, which is downgradient of FTA4. During sampling conducted in March 2000, wells were monitored for volatile organic compounds, polychlorinated biphenyls, pesticides, and metals. Analytes detected in the downgradient wells included trichloroethylene (TCE), chloroform, and metals. Metals were detected at concentrations that were consistent with background levels in the area (U.S. Geological Survey, 2000). Because JP-4 was the fuel used at FTA4 during all but a brief part of its history, TCE, and chloroform were not believed to be chemicals of concern at this site. Groundwater analytical data from monitoring wells downgradient of FTA4 indicate that chlorinated solvents have not impacted groundwater due to previous operations at the site (U.S. Geological Survey, 2000).

Surface Water

Stream valleys in Curry County tend to be fairly broad and widely spaced. Streams are ephemeral and drainages are poorly developed. No permanent streams exist on or near Cannon AFB (Harza, 1997).

Historically, runoff at Cannon AFB has drained into four natural ephemeral playas. The two northern playas were converted into plastic-lined golf course ponds. The southern playa is still intact; however, the surrounding drainage patterns have been altered. The eastern playa, known as the North Playa Lake, was bermed on the north, west, and south sides with topsoil and concrete debris. Drainage ditches at Cannon AFB are concentrated around the developed/landscaped areas of the Base and carry runoff to the playa lakes and golf course ponds. The playa lakes have no surface outlet, and any water they collect is eventually lost to evaporation or infiltration, or is used by plants and animals.

CONTAMINANT FATE AND TRANSPORT MODELING

Fate and transport modeling of representative contaminants was used to simulate contaminant migration through the unsaturated (vadose) zone to determine whether residual contamination could reach the water table. The representative contaminants modeled were toluene, naphthalene, and total xylenes. These three chemicals were selected based on their mobility and elevated concentrations in soil at FTA4. Simulations were performed assuming excessive precipitation to evaluate the transport effects of these chemicals with increased infiltration.

The Seasonal Soil Compartment (SESOIL) model was used for the fate and transport modeling (General Sciences Corporation, 1998). The SESOIL model has been used by many local, state, and federal agencies at several sites across the country to evaluate unsaturated zone contaminant migration due to surficial or subsurface source releases.

SESOIL is a one-dimensional vertical transport model designed to simultaneously simulate water transport, sediment transport, and contaminant fate for the unsaturated zone (Wisconsin Department of Natural Resources, 1994). Input data include soil physical parameters, contaminant chemical parameters, and meteorological information. The specific input parameters are presented in Appendix A of the Final CMS Report (Foster Wheeler Environmental, 2001).

The processes simulated by the SESOIL model are categorized into three cycles: hydrology, sediment washload, and pollutant transport; each cycle is a separate subroutine within the SESOIL code (Wisconsin Department of Natural Resources, 1994). The SESOIL model is a compartmental model that allows the user flexibility to divide the unsaturated zone into separate layers and simulate contaminant release and migration within each layer down to the water table. The result is a calculated leachate concentration that will be introduced to groundwater. The model simulates leaching to groundwater and subsequent mixing that ultimately provides a groundwater concentration as a calculated result.

The simulations performed for the CMS applied conservative assumptions that tend to overestimate the potential for contaminant migration. The greatest concentrations of residual contamination detected in soil samples from FTA4 were used to calculate loading rates for the representative chemicals. The contaminant sources were modeled as instantaneous releases from the top 22 ft of the soil column. Groundwater was modeled as 290 ft below ground surface (bgs). The simulation of normal conditions for each contaminant used climatic data specific to Clovis, New Mexico.

The results of the 30-year simulations for the current, normal conditions at Cannon AFB predicted vertical contaminant migrations of 101, 65, and 94 ft for toluene, naphthalene, and total xylenes, respectively. Within the 30-year period, simulation under normal, current conditions indicated that none of the contaminants would reach groundwater. The increased infiltration from the addition of one 24-hour, 100-year storm per year had a negligible effect on transport of naphthalene and total xylenes, and these contaminants did not reach groundwater. Under increased infiltration, toluene showed a similar trend in vertical migration as depth increased. The modeling indicated that degradation of groundwater from the migration of the contaminants in soil is unlikely under current conditions where infiltration of water into the vadose zone is minimal.

In summary, even where conservative assumptions are used to overestimate the potential for contaminant migration, the model predicts that there will be no adverse effects on groundwater quality due to the transport of residual contamination in the unsaturated zone at FTA4. An extended discussion of the modeling effort, including model output, is presented in Appendix A of the Final CMS Report.

REGULATORY FRAMEWORK

The New Mexico Environment Department (NMED) is authorized by the U.S. Environmental Protection Agency (EPA) to implement the federal Resource Conservation and Recovery Act (RCRA) hazardous waste program and oversee the corrective action program activities conducted in accordance with Cannon AFB's Hazardous Waste Facility Permit (Permit). NMED issued a RCRA Permit to Cannon AFB on December 17, 1989. Cannon AFB submitted an application to NMED for renewal of the Permit; however, the Permit has not yet been reissued and the Base is operating under the provisions of the original Permit. Cannon AFB's Draft RCRA Part B Permit Application (Operations Plan), refers to the status of various assessment, investigation, and remediation projects for a number of SWMUs on the Base. According to the Operations Plan, SWMUs 109, 110, 111, and 112 were incorporated into one area (FTA4) for the Phase I and Phase II RCRA Facility Investigations (RFIs) based on their proximity and the interrelated nature of their historical operations. Currently, FTA4 is in the CMS phase of the RCRA corrective action process.

Based on the investigations conducted to date, the primary chemicals of concern at FTA4 are petroleum hydrocarbons associated with the storage and use of JP-4 during training exercises (see TCE question above). A risk assessment was conducted as part of the Phase II RFI to evaluate risk to human and ecological receptors from exposure to site contaminants (Harza, 1997). The risk assessment concluded that human health and ecological risks associated with exposure to contamination at FTA4 are negligible under current conditions.

Since the 1997 risk assessment did not characterize potential risks associated with a residential use scenario, the *Technical Background Document for Development of Soil Screening Levels* guidance from NMED (NMED, 2000) was used to identify other chemicals of concern that could require corrective action. Data from the Remedial Investigation (RI) conducted in 1992 by Woodward-Clyde Consultants (Woodward-Clyde) and the RFI conducted in 1997 by Harza were compared to the NMED soil screening levels. This comparison confirmed that there is no significant human health risk requiring further action at FTA4. The detailed results of this evaluation are presented in Appendix B of the Final CMS Report (Foster Wheeler Environmental, 2001).

REGULATION OF TPH IN SOIL

Although no further action is needed to address health risks at this site, NMED is requiring standards for TPH to be met. In June 2003, the NMED Hazardous Waste Bureau issued *Total Petroleum Hydrocarbon (TPH) Screening Guidelines,* a final guidance for RCRA units on the evaluation and determination of cleanup levels for sites impacted by releases of petroleum hydrocarbons (NMED, 2003).

NMED provided a TPH screening guideline for each type of petroleum product based on the assumed composition for petroleum products and the direct soil standards from the Massachusetts Department of Environmental Protection (MADEP) guidance document *Implementation of the MADEP VPH/EPH Approach Final Draft, June 2001* (MADEP, 2001). The TPH screening guidelines are presented in Table 1.

Table 1. TPH Soil Screening Guidelines [a]

Petroleum Product	Residential Direct Exposure (mg/kg)	Industrial Direct Exposure (mg/kg)
Diesel #2/crankcase oil	880	2200
#3 and #6 Fuel Oil	860	2150
Kerosene and jet fuel	940	2350
Mineral oil dielectric fluid	1560	3400
Unknown oil	800	2000
Waste Oil	2500	5000
Gasoline	Not applicable	Not applicable

[a] From NMED (2003)
mg/kg milligrams per kilogram

Based on the fact that JP-4 was the fuel used at FTA4, screening guidelines for jet fuel were used to determine the extent of contaminated soil requiring remediation at the site. The residential direct exposure screening guideline for TPH is 940 mg/kg, and the industrial direct exposure guideline is 2,350 mg/kg. The results of the contaminant fate and transport modeling predict that there will be no adverse effects on groundwater quality due to the transport of residual contamination in the unsaturated zone at FTA4. The results of the modeling are supported by analytical data from annual monitoring downgradient of the site at LF-05 which indicate groundwater has not been impacted by activities at FTA4. Therefore, there is no need to assess groundwater quality at this site.

PREVIOUS INVESTIGATIONS OF FTA4

RI Performed by Radian Corporation (Radian)—1985

The initial RI at FTA4 focused on contamination in the area of SWMU 109. Two soil borings were drilled and from these two soil borings five samples were analyzed for oil and grease, lead, and

chlorinated and aromatic volatile organic compounds (EPA Method 8010/8020). Samples were collected at depths from 5.5 to 45 ft. No TPH data were collected during the 1985 RI. (Radian, 1985).

RI Conducted by Walk, Haydel, and Associates—1988

The 1988 RI included 3 soil borings with 13 samples each (0–101.5 ft bgs) analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX); arsenic; barium; cadmium; selenium; and silver. An additional 6 soil borings with 13 samples each (0–101.5 ft bgs) were analyzed for arsenic, barium, cadmium, selenium, and silver. All borings were located near SWMU 110 and the landfarm area associated with the underground waste oil tank removal. No TPH data were collected during the 1988 RI(Walk, Haydel, and Associates, 1990).

RI Performed by Woodward-Clyde—1991

The 1991 RI investigation evaluated the nature and extent of contamination at 18 Cannon AFB SWMUs, including FTA4. Four surface soil samples (0 to 0.5 ft bgs) and 35 subsurface samples (61 to 100 ft bgs) were collected at FTA4. TPH concentrations at two soil boring locations (1093 and 1094) located near SWMU 109 exceeded the action level of 5,000 mg/kg at depths ranging from 0 to 6 ft (Woodward-Clyde, 1992). A summary of soil boring locations with detected TPH concentrations exceeding 940 mg/kg is presented in Figure 1 and data are summarized in Table 2.

Phase II RFI Conducted by Harza—1996–1997

The Phase II RFI included a passive soil gas survey, 19 soil borings, and 77 soil samples collected at various locations at FTA4. TPH concentrations in soil detected at two borehole locations (SB01 and SB11) associated with SWMU 109 exceeded the action level of 5,000 mg/kg (Harza, 1997). A summary of soil boring locations with detected TPH concentrations exceeding 940 mg/kg is presented in Figure 1 and data are summarized in Table 2.

CORRECTIVE ACTION IMPLEMENTATION AT FTA4

Based on the corrective measures alternative evaluation presented in the Final CMS Report (Foster Wheeler Environmental, 2001), the preferred corrective measures alternative for SWMU 109 was Alternative 5, passive bioventing. This alternative was selected because it can attain all of the evaluation criteria and can meet the corrective action objective for SWMU 109 at the lowest estimated cost. Passive bioventing is relatively easy to implement and can be conducted on site with periodic maintenance and sampling over a period spanning several years.

Prior to implementing the selected remedial alternative, additional sampling should be conducted to determine the current extent of TPH contamination in soil requiring remediation. Figure 1 is a map presenting the locations of TPH in soil samples collected during the 1991 and 1997 site investigations at FTA4. Only data are presented for sample locations where TPH was detected at concentrations that exceed the 940 mg/kg screening level.

The primary area of concern is centered at the location of the former concrete pad at SWMU 109. Additional outlying shallow contamination north of SWMU 109 (to depths ranging from 0–4 ft) and in the area of SWMU 112 (in surface soil, 0–1 ft) are also areas of concern. The deepest contamination was located in soil boring locations SB01 (to a depth of 42 ft bgs) and 1094 (to a depth of 12 ft bgs).

Table 2. TPH Concentrations in Soil Samples Collected During Site Investigations Fire Training Area Four Cannon Air Force Base, New Mexico

Site ID/ Sample Number	Sample Depth (ft bgs)	TPH Concentration (mg/kg)
Phase 2 RFI (Harza, 1997)		
SB01		
SB01-0103	2-3	**1940**
SB01-0119	18-19	**5560**
SB01-0127	26-27	**5120**
SB01-0138	37-38	**1600**
SB01-0142	41-42	**1990**
SB01-0155	54-55	63.2
SB01-0165	64-65	141
SB01-0173	72-73	16.1
SB01-0180	79-80	17.6
SB02		
SB02-0101	0-1	145
SB02-0109	8-9	27.8
SB02-0119	18-19	< 16.7
SB03		
SB03-0101	0-1	24.2
SB03-0109	8-9	< 16.9
SB03-0119	18-19	< 16.9
SB04		
SB04-0101	0-1	**3270**
SB04-0109	8-9	139
SB04-0119	18-19	< 17.2
SB05		
SB05-0101	0-1	73.9
SB05-0109	8-9	< 16.0
SB05-0112	11-12	< 16.3
SB06		
SB06-0101	0-1	118
SB06-0107	6-7	44.2
SB06-0117	16-17	< 16.5
SB07		
SB07-0101	0-1	28.5
SB07-0109	8-9	18.5
SB07-0119	18-19	< 16.8
SB08		
SB08-0101	0-1	380
SB08-0103	2-3	< 16.7
SB08-0110	9-10	16.1
SB09		
SB09-0101	0-1	29.5
SB09-0102	1-2	< 15.9
SB09-0115	14-15	< 16.5
SB10		
SB10-0101	0-1	140
SB10-0106	6-7	< 16.7
SB10-0110	9-10	38.6
SB11		
SB11-0101	0-1	**14,400**
SB11-0107	6-7	< 16.9
SB11-0117	16-17	16.8
SB12		
SB12-0101	0-1	69.7
SB12-0102	1-2	34.4
SB12-0110	9-10	77.5
SB12-0121	20-21	16.9
SB12-0130	29-20	21.5

Table 2. TPH Concentrations in Soil Samples Collected During Site Investigations
Fire Training Area Four Cannon Air Force Base, New Mexico

Site ID/ Sample Number	Sample Depth (ft bgs)	TPH Concentration (mg/kg)
SB13		
SB13-0101	0-1	44
SB13-0104	3-4	< 15.8
SB13-0115	14-15	< 16.2
SB14		
SB14-0101	0-1	**1040**
SB14-0102	1-2	17.6
SB14-0115	14-115	17.9
SB15		
SB15-0101	0-1	185
SB15-0109	8-9	< 16.8
SB15-0119	18-19	< 16.9
SB16		
SB16-0101	0-1	43.9
SB16-0104	3-4	216
SB16-0110	9-10	82.8
SB17		
SB17-0101	0-1	583
SB17-0109	8-9	20.4
SB17-0119	18-19	18
SB17-0129	28-29	18
SB17-0139	38-39	19
SB17-0145	44-45	37.8
SB17-0159	58-59	270
SB18		
SB18-0101	0-1	42.6
SB18-0109	8-9	< 16.9
SB18-0119	18-19	< 16.6
SB18-0124	24	< 16.7
SB18-0133	33	< 16.4
SB18-0143	43	40
SB18-0159	59	< 16.1
SB19		
SB19-0101	0-1	104
SB19-0104	3-4	**1530**
SB19-0117	16-17	< 16.7
SB19-0129	28-29	< 16.8
SB19-0133	32-33	< 16.8
SB19-0145	44-45	< 16.2
SB19-0159	58-59	17.3
Phase 1 RFI (Woodward-Clyde, 1991)		
1091/1095	0-0.5	27.3
(1091 sampled 0-0.5 ft;	5-7	56.6
1095 sampled 0.5-62 ft)	10-12	< 45.1
	20-22	< 45.7
	30-32	< 44.5
	40-42	< 46.3
	50-52	< 43.9
	60-62	< 42.6
1092/1096	0-0.5	TPH not detected
(1092 sampled 0-0.5 ft;	>0.5-62	TPH not detected
1096 sampled 0.5-60 ft	*(multiple samples)*	

Table 2. TPH Concentrations in Soil Samples Collected During Site Investigations Fire Training Area Four Cannon Air Force Base, New Mexico

Site ID/ Sample Number	Sample Depth (ft bgs)	TPH Concentration (mg/kg)
1093/1097	0-0.5	**(38,500)**
(1093 sampled 0-0.5 ft;	4-6	**12900**
1097 sampled 0.5-100 ft)	10-12	< 45
	20-22	< 46.6
	30-32	< 44
	40-42	< 45.6
	50-52	215
	60-62	203
	70-72	< 42.8
	80-82	< 41.8
	90-92	< 40.6
	98-100	< 41.2
1094/1098	0-0.5	**(13,600)**
(1094 sampled 0-0.5 ft;	4-6	**8300**
1098 sampled 4-92 ft)	10-12	**1870**
	20-22	46.7
	30-32	< 44
	40-42	< 44.1
	50-52	< 42.7
	60-62	< 43.2
	70-72	< 43
	80-82	< 42.2
	90-92	< 42.1

Notes:

The values in parentheses are results from samples recollected due to laboratory-missed holding
Values in bold exceed NMED TPH screening guideline of 940 mg/kg.
bgs - below ground surface
ft - feet
mg/kg - milligrams per kilogram
TPH - Total petroleum hydrocarbons analyzed by EPA method 418.1

The analytical data upon which the selection of the remedial alternative is based was collected in 1991 and 1997. In order to define the current extent of contamination, additional sampling at FTA4 is proposed. Sampling is proposed to confirm the levels of TPH in soil at locations where previous investigations indicated elevated levels of contamination and at new locations to help define the lateral and vertical extent of contamination. The new sample locations were further defined by the passive soil gas data collected for diesel-range organics (DRO) as depicted in Figure 5-7 of the Phase II RFI report (Harza, 1997). The area of the highest DRO concentrations in soil gas is presented in Figure 2 and is centered around the former concrete pad at SWMU 109, and the new locations were placed around within this area. Figure 2 presents a map showing the proposed sample locations and Table 3 presents a summary of the proposed sampling program.

Table 3. Proposed Sampling at FTA4

Proposed Sample Location	Sample Depth Intervals (ft bgs)	Rationale	Number of Samples [a]
Confirmation Samples			
SB01	0–1, 9–10, 19–20, 29–30, 39–40, 49–50	Maximum depth of TPH contamination > 940 mg/kg at 42 ft; confirm presence and levels of TPH to depth of 50 ft	6
SB04	0–1	Maximum depth of TPH contamination > 940 mg/kg is 1 ft; Confirm presence and levels of TPH in surface soil	1
SB11	0–1	Maximum depth of TPH contamination >940 mg/kg is 1 ft; Confirm presence and levels of TPH in surface soil	1
SB14	0–1	Maximum depth of TPH contamination >940 mg/kg is 1 ft; Confirm presence and levels of TPH in surface soil	1
SB19	0–1, 3–4	Maximum depth of TPH contamination >940 mg/kg is 4 ft; Confirm presence and levels of TPH in surface soil	2
1093	0–1, 4–5, 9–10	Maximum depth of TPH contamination >940 mg/kg is 10 ft; Confirm presence and levels of TPH in surface soil	3
1094	0–1, 4–5, 9–10, 12–13	Maximum depth of TPH contamination >940 mg/kg is 12 ft; Confirm presence and levels of TPH in surface soil	4
Additional Sample Locations			
2004-01	0–1, 9–10	Determine lateral and vertical extent of contamination in area of former concrete pad at SWMU 109	2
2004-02	0–1, 9–10		2
2004-03	0–1, 9–10		2
2004-04	0–1, 9–10		2
2004-05	0–1, 9–10, 19–20		3

[a] Analytical method proposed at this time is total recoverable petroleum hydrocarbons using EPA Method modified 8015M.

The proposed sampling presented in Table 3 is based on use of an "action level" of 940 mg/kg which corresponds to evaluating the site for direct residential exposure. By comparison, assuming a future use of the site under an industrial scenario with an "action level" of 2,350 mg/kg, fewer samples would need to be collected.

Under a conservative residential future-use scenario using the data currently available, an area approximately 100 ft by 100 ft would require remediation to a depth of 42 ft with a volume of contaminated soil of 16,000 cubic yards (c.y.). If direct exposure is defined to occur to a depth of 12 ft, the volume of contaminated soil decreases to 4,500 c.y. By collecting confirmation samples and additional data to more accurately define the extent of contamination, it is likely that the lateral and vertical extent of contaminated soil has decreased based on the assumption that TPH in soil has degraded over the past seven years since the most recent investigation of the site.

The results of the proposed sampling program will be utilized to determine the final corrective action required for the site. Upon completion of the sampling program, the alternatives evaluated in the Final CMS Report will be re-evaluated to determine the preferred alternative based on the evaluation criteria established during the CMS (Foster Wheeler Environmental, 2001). At this time Cannon AFB would like to accelerate cleanup of FTA4 to facilitate site closure within the next year. In order to accomplish this goal, corrective measures including soil removal and disposal will be the primary focus of the corrective measures evaluation for this site.

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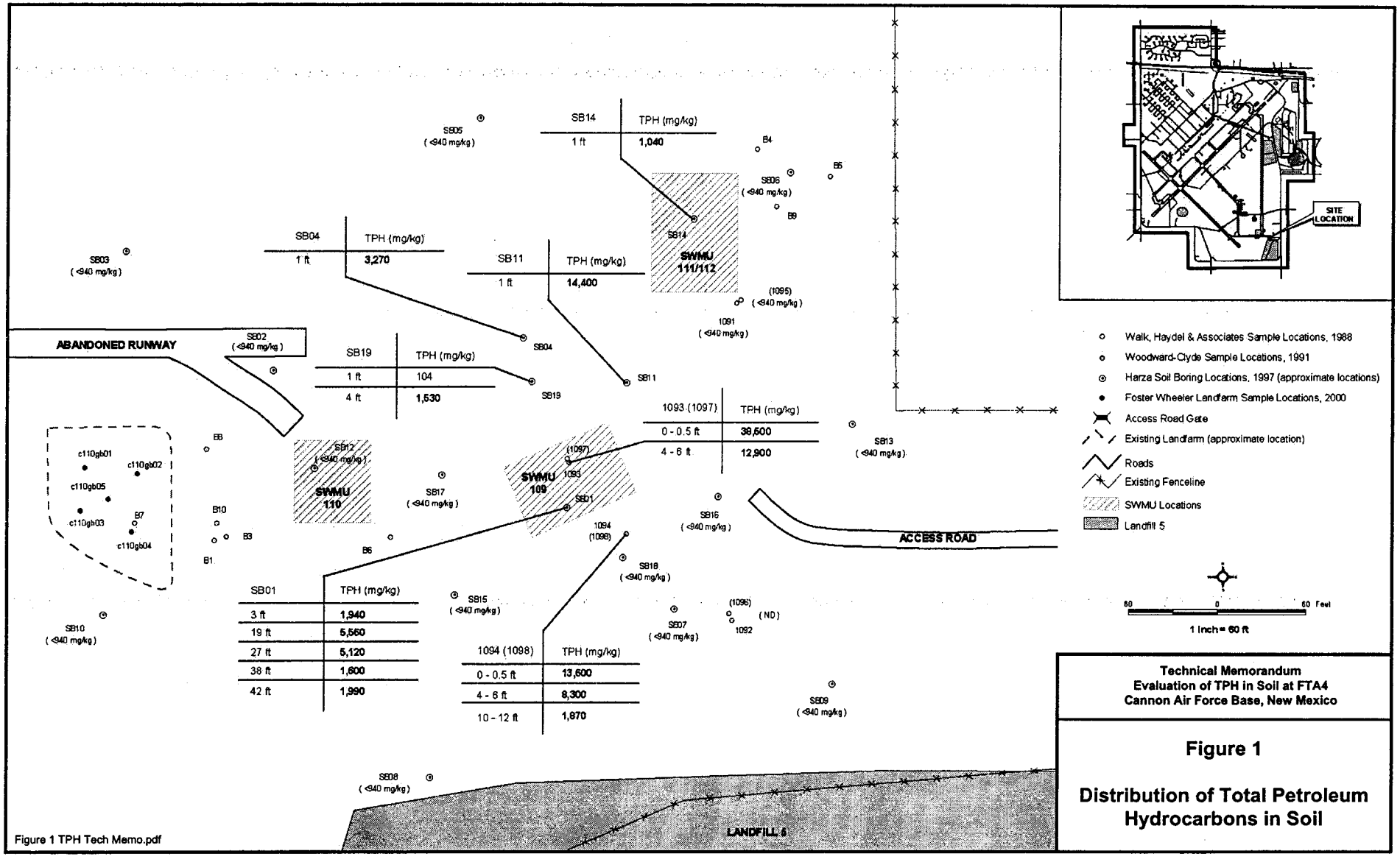

Technical Memorandum
Evaluation of TPH in Soil at FTA4
Cannon Air Force Base, New Mexico

Figure 1

Distribution of Total Petroleum Hydrocarbons in Soil

Figure 1 TPH Tech Memo.pdf

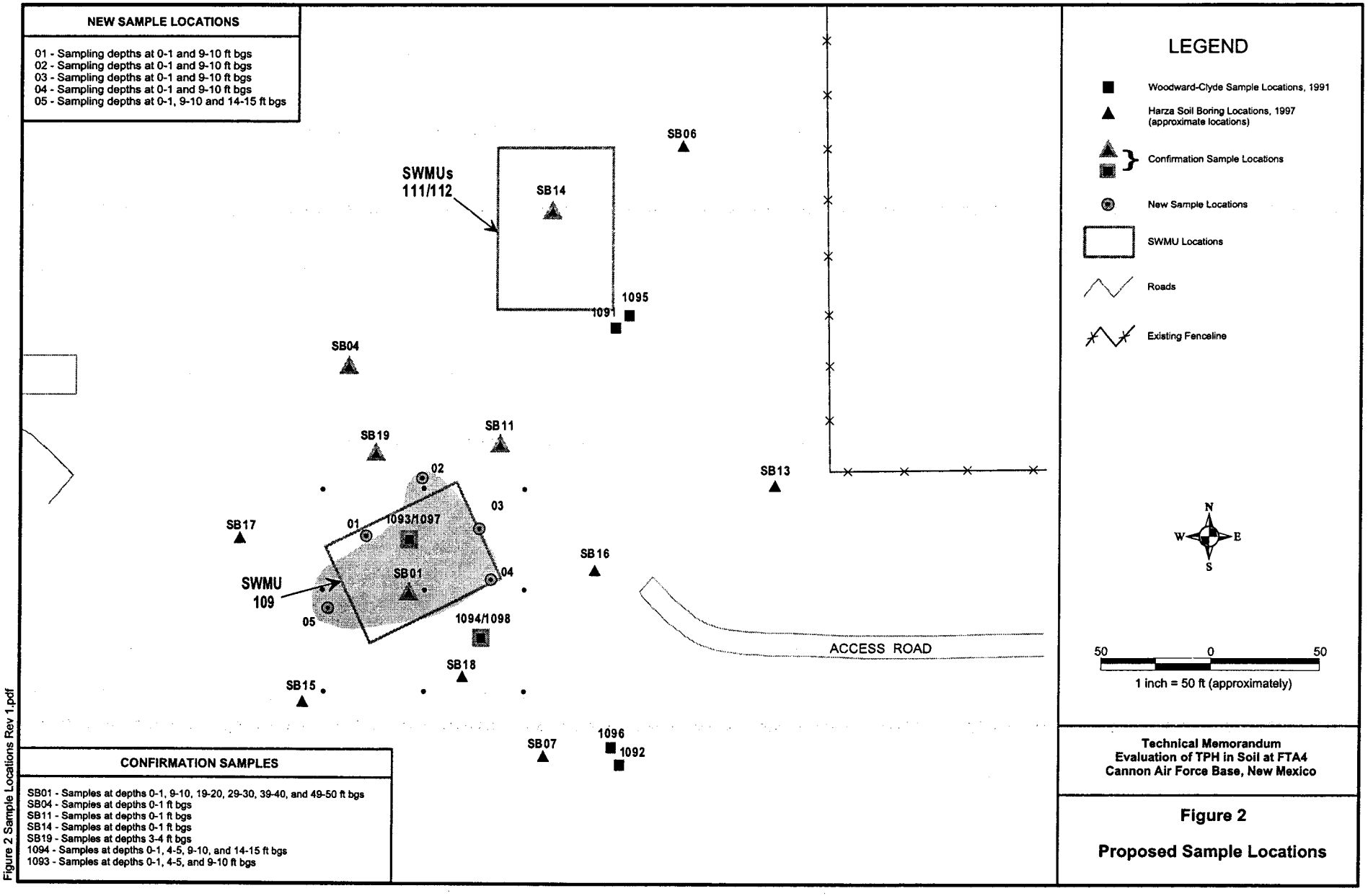

Figure 2 Sample Locations Rev 1.pdf

APPENDIX B

Sampling and Analysis Plan

SAMPLING AND ANALYSIS PLAN
PHASE I INVESTIGATION
SOIL CORRECTIVE MEASURES

FIRE-TRAINING AREA 04
CANNON AIR FORCE BASE, NEW MEXICO

Final: November 3, 2004

Prepared For:

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TABLE OF CONTENTS

Phase I INVESTIGATION Soil CORRECTIVE MEASUREs **1**

List of Tables ..... **iii**

List of Acronyms ..... **iv**

1.0 INTRODUCTION **1-1**
1.1 PROJECT DESCRIPTION 1-1

2.0 CHEMICAL DATA QUALITY OBJECTIVES **2-1**
2.1 Project Objectives 2-1
2.2 Data Quality Objectives 2-1
2.3 Analytical Methodologies 2-5

3.0 FIELD ACTIVITIES **3-1**
3.1 Soil Sampling 3-1
3.1.1 Sample Collection for Laboratory Analysis 3-1
3.1.2 QA/QC and Blank Samples and Frequency 3-1
3.1.3 Sampling Procedures 3-2
3.1.3.1 Site Access and Utility Clearance 3-2
3.1.3.2 Drilling Procedures 3-3
3.1.3.3 Field Screening Method Using PID 3-3
3.1.3.4 Soil Sample Collection 3-4
3.1.3.5 Geologic Logging 3-4
3.1.3.6 Sample Containers and Preservation Techniques 3-4
3.1.4 Decontamination Procedures 3-4
3.2 IDW Management 3-5
3.3 Sample Location Surveying 3-5
3.4 Borehole Abandonment 3-5
3.5 Site Restoration 3-6

4.0 SAMPLE CHAIN OF CUSTODY/DOCUMENTATION **4-1**
4.1 Field Logbook 4-1
4.2 Photographs 4-1
4.3 Sample Numbering 4-1
4.4 Sample Documentation and Control 4-2
4.4.1 Sampling Labels and/or Tags 4-2
4.4.2 Sample Field Sheets and/or Logbook 4-2
4.4.3 Chain of Custody Records 4-2
4.4.4 Receipt for Sample Forms 4-2
4.5 Documentation Procedures 4-2
4.6 Corrections to Documentation 4-2

5.0 SAMPLE PACKAGING AND SHIPPING **5-1**

6.0 SAMPLING APPARATUS AND FIELD INSTRUMENTATION 6-1

7.0 DATA VALIDATION 7-1

8.0 PROJECT ORGANIZATION AND RESPONSIBILITIES 8-1

8.1 TN&A Technical Team 8-1
8.1.1 Program Manager 8-1
8.1.2 Project Manager 8-1
8.1.3 Corporate Safety Officer 8-2
8.2 Project Chemist 8-2
8.3 Field Geologist/Site Safety and Health Officer 8-2
8.4 Subcontracted Services 8-2
8.4.1 Offsite Laboratories 8-2
8.4.2 Direct Push Technologies Services 8-2
8.5 Qualifications and Training of Personnel 8-2

9.0 REPORTING 9-1

Attachment 1 Field Forms
HTW Drilling Log
Waste Inventory Tracking Log
Real Time Air Monitoring Instrument Calibration Log
Chain of Custody Form
Daily quality control report

LIST OF TABLES

Table 2-1. Data Quality Objectives 2-1
Table 2-2. Method 8015 Quality Control Audits for Precision and Accuracy 2-4
Table 2-3. Precision and Accuracy for Method 8015 Modified 2-5
Table 2-4. Analytical Method 2-5
Table 3-1. Summary of Soil Sample Analysis 3-1
Table 3-2. Sampling Summary at FTA4 3-2
Table 3-3. Sample Container, Preservations, and Holding Times 3-4
Table 7-1. Method 8015 Quality Control Audits for Precision and Accuracy 7-2
Table 8-1. Project Organization and Responsibilities 8-1

LIST OF ACRONYMS

AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CEV	Base Environmental Flight
CLP	contract laboratory program
COC	chain-of-custody
DOT	Department of Transportation
DPT	direct push technologies
DQI	data quality indicator
DQO	data quality objective
DQCR	daily quality control report
EDD	electronic data deliverable
ESN	Environmental Services Network – Southwest
FD	Field Duplicate
FTA4	Fire Training Area 04
GC/MS	gas chromatography/mass spectroscopy
GPS	global positioning system
IDW	investigation derived waste
JP4	Jet Propellant 4
LCS	laboratory control sample
LF-5	Landfill 5
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NMED	New Mexico Environmental Department
PARCC	precision, accuracy, representativeness, completeness, and comparability
PID	Photoionozation Detector
PPE	personal protective equipment
QA	quality assurance
QC	quality control
QCSR	quality control summary report
RL	reporting limit
RPD	relative percent difference
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
STL-Chicago	Severn Trent Laboratories – Chicago
SWMU	solid waste management unit
TN&A	T N & Associates, Inc.

LIST OF ACRONYMS (continued)

TPH-DRO	total premium hydrocarbons-diesel-range organics
TtFW	Tetra Tech Foster Wheeler, Inc.
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

As part of the corrective measure efforts at Cannon Air Force Base (AFB) outside Clovis, New Mexico, the United States Army Corps of Engineers (USACE) contracted with T N & Associates, Inc. (TN&A) to conduct a subsurface investigation using Direct Push Technologies (DPT) at Fire Training Area 04 (FTA4). The work is being conducted under Contract No. DACAW45-00-D-0006, Task Order 6.

1.1 PROJECT DESCRIPTION

The purpose of the investigation is to confirm the vertical and horizontal extent of soils contaminated by Jet Propellant 4 (JP-4) at the former fire training area. A total of 12 DPT points up to 50 feet below ground surface (bgs) will be installed to confirm the total petroleum hydrocarbon contaminated area at FTA4. The primary area of concern is centered at the location of the former concrete pad at Solid Waste Management Unit (SWMU) 109. Additional areas of concern are the outlying shallow soil contamination north of SWMU 109 (to depths ranging from 0 – 4 feet) and in surface soil at SWMU 112 (0-1 foot). A total of approximately 32 field samples will be collected and analyzed for total petroleum hydrocarbons-diesel range organics (TPH-DRO) by STL-Chicago, University Park Illinois. Field screening of soil head-space samples will be performed using a calibrated photoionization detector (PID). Subsurface samples will be collected using a DPT drilling rig.

Once the vertical and horizontal extent of TPH soil contamination has been confirmed, the corrective measure alternatives will be re-evaluated by USACE and Tetra Tech Foster Wheeler, Inc. (TtFW).-

2.0 CHEMICAL DATA QUALITY OBJECTIVES

2.1 Project Objectives

The objective of this project is to confirm subsurface TPH soil contamination in the vicinity of SWMU 109 and 111/112 in the FTA4 area. The purpose of this Sampling and Analysis Plan (SAP) is to facilitate project implementation while complying with the project Data Quality Objectives (DQOs). The SAP provides an internal means for control and review so that the environmentally related measurements and data collected by TN&A and its subcontractors are technically sound, scientifically and legally defensible, and of known, acceptable, and documented quality. This project has several general quality assurance (QA) objectives.

- Scientific data generated will be of sufficient quality to withstand scientific and legal scrutiny.
- Data will be gathered or developed in accordance with procedures appropriate for its intended use.
- Data will be of known precision, accuracy, representativeness, completeness, and comparability (PARCC) within the limits of the scope of the project.
- Quantitation (reporting) limits for analysis methods will fall at or below applicable or relevant and appropriate requirement (ARARs) for all potential site contaminants.

2.2 Data Quality Objectives

Samples will be acquired, and chemical analysis and chemical parameter measurements performed in such a manner that the resulting data meets and supports data use requirements. The chemical data shall be acquired, documented, verified and reported in a manner that ensures the precision, accuracy, representativeness, comparability, and completeness goals of the project are achieved. The project DQOs below were developed in accordance with EPA 600/R 96-055, EPA 450/4-89-015, and EPA 450/4-90-005 and are listed in Table 2-1.

Table 2-1. Data Quality Objectives

STEP 1: State the Problem
• SWMU 109 was used as a fuel truck cleaning area from 1961-1974, when an estimated 3,000 to 4,000 gallons of fuel percolated into the ground. From 1974-1995 the site was activated as a fire training area where commingled waste oils, solvents, and recovered JP-4 were burned during fire training exercises. • The selected corrective measure for FTA4 is excavation of the contaminated soil. However, the precise boundaries (vertical and horizontal) of the fuel contaminated soil are not known.
STEP 2: Identify the Decisions
• What is the vertical and horizontal extent of fuel-contaminated soils in the FTA4 area?

Table 2-1. Data Quality Objectives, Continued

STEP 3: Define Study Boundaries
• Subsurface sampling will be focused in those areas where previous investigations have already identified the presence of contaminated soil, specifically in the areas of Solid Waste Management Unit (SWMU) 109 and SWMU 111/112.
STEP 5: Specify Tolerable Limits on Decision Errors
• The detection limits of chemical analytical methods for TPH-DRO must meet the selected action level of 940 mg/kg, which corresponds to evaluating the site for direct residential exposure. • Sampling locations have been selected based on prior investigation data and represent targeted (non-random) sampling. • Standard laboratory methods will be employed for the sampling. TN&A will follow established United States Environmental Protection Agency (U.S. EPA) data validation methods to appropriately qualify the laboratory analytical data.
STEP 6: Optimize the Sampling Design
• Sampling is proposed to confirm the levels of TPH in soil at locations where previous investigations indicated elevated levels of contamination and at new locations to help define the lateral and vertical extent of contamination. • Based on prior analytical data, the deepest vertical sampling is anticipated to be no greater than 50 feet. • The field geologist will use professional judgment, field observations, and PID headspace screening results to adjust sampling intervals within each borehole so that the best possible data are generated to support the project objectives.

For all sample types, the DQOs for the Data Quality Indicators (DQIs), PARCC, are presented below.

- Precision is the reproducibility of individual measurements of the same property. Precision is measured by several chemical quality control (QC) activities including comparison of laboratory control samples (LCSs) and by comparing the specified compound recoveries from the matrix spike and matrix spike duplicate (MS/MSD) samples.
- Accuracy is the reciprocal of bias in a measurement system. Accuracy is measured through several QA/QC activities including: recovery of target analyses from LCS or laboratory fortified blanks, recovery of surrogate compounds from individual samples for volatile organic compound (VOC) analysis and recovery of spiked compounds from MS/MSD samples. The applicable criteria for each of the listed chemical QC activities are presented within the designated laboratory's Standard Operating Procedures (SOPs).
- Representative data will be obtained through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination. Following established field and laboratory procedures will also support the collection of representative data. To aid in evaluating of the representativeness of the sample results, field and

laboratory blank samples will be evaluated for the presence of contaminants. Data confirmed to be non-representative through data validation and by comparison with existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty. The analytical method prescribed for this project is SW846 Method 8015 Modified.

- Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP. When all data validation is completed, the percent completeness value will be calculated by dividing the number of useable sample results by the total number of sample results planned for this investigation. A completeness goal is set at 90 percent.
- Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

In terms of the chemical data acquired, all analytical results will be evaluated in accordance with PARCC parameters to support the attainment of project specific DQOs. Of these PARCC parameters, precision and accuracy will be evaluated quantitatively through the collection of the QC samples listed in Table 2-2. Laboratory established precision and accuracy goals for these QC samples are listed in Tables 2-3 and 2-4.

Table 2-2. Method 8015 Quality Control Audits for Precision and Accuracy

Sample Type	Frequency	Accuracy	Notes
Field QC			
Duplicate	1 for every approximately 10 field samples collected	Soil Samples – RPD , 20%	Review lab QC data to determine if they are in control. If not in control, flag data. Use data to evaluate whether proper collection procedures were followed.
Laboratory QC			
Initial Calibration	Prior to analysis and when continuing calibration criteria fail	5 pt. calibration; RSD of mean, 20%	Recalibrate Instrument
Continuing Calibration	Daily	Response factors deviate < 20% from average of initial calibration.	Rerun continuing calibration. If still out of control, take remedial action and recalibrate instrument.
Laboratory Reagent Blank	Daily	Less than reported detection limit	Step 1: Reanalyze Step 2: If second blank exceeds criteria, clean the analytical system. Step 3: Document the corrective action taken and qualify all associated data.
QC Check Standard	Quarterly	%R = 80 – 120 RSD < 20 %	Step 1: Reanalyze Step 2: If still out of control, perform and document remedial action. Step 3: Reanalyze
Laboratory Fortified Blank	1 per 20 or 1 per sample set	%R = 80 – 120 RSD < 20%	Step 1: Reanalyze Step 2: If still out of control, perform and document remedial action. Step 3: Reanalyze
Surrogate Spike	All blanks, standards, QC samples, field samples	See method or laboratory controls for surrogate spiking compounds control limits	Determine cause (if possible), correct and reanalyze. If cause cannot be confirmed, flag data.
MS/MSD	1 per every 20 samples	%R = 80 – 120 RSD =< 20%	Determine cause (if possible), correct and reanalyze. If cause cannot be confirmed, flag data.

%R Percent recovery
MS/MSD Matrix spike/matrix spike duplicate
RPD Relative percent difference
RSD Relative Standard Deviation

Table 2-3. Precision and Accuracy for Method 8015 Modified

Parameter	MDL[1] (mg/Kg)	Reporting Limit[2] (mg/Kg)	LCS Lower Limit	LCS Upper Limit
Diesel Range Organics	1	4.2	70	106

Notes:
1. STL Chicago Laboratory method detection limits (MDLs) and Control Limits are confirmed annually by the laboratory and are subject to change.
2. Laboratory reporting limits (RLs) will vary depending on sample size/limited sample size, dilution factors, dry weight adjustment, and annual MDL determinations.

2.3 Analytical Methodologies

All laboratory analyses conducted on samples collected during this project are subject to general QC requirements, which are itemized here.

- Holding times and the amount of sample submitted for testing must be reviewed to prioritize sample analyses. Analyses must be performed within holding times according to method procedures.
- Initial calibration will be performed as specified in the laboratory's SOP [including the use of at least one calibration standard at or below the laboratory-reporting limit, using at least three standards and a reagent blank, unless otherwise specified in the analytical method]. Continuing calibration will be performed as specified in the laboratory's SOP. For gas chromatograph (GC)/mass spectroscopy (MS) methods, instrument tune will be verified as specified in the laboratory's SOP.
- Each analytical batch (up to 20 samples) must include at least one method blank, which is prepared and analyzed using the same reagents, equipment, instruments, and procedures as the batch samples. If sufficient sample volume is available, one MS/MSD pair will be prepared and analyzed with each analytical batch (up to 20 samples) or for each significantly different (e.g., soil, groundwater, waste, wastewater) sample matrix included in an analytical batch, unless not specified in the method.

The analytical methods that may be used for analysis of samples collected at Cannon AFB are listed in Table 2-4.

Table 2-4. Analytical Method

Matrix	Analysis	Preparation Method [a/]	Analysis Method [a/]	Parameter List
Soil/Solids	TPH-DRO	SW3550B	SW8015 Mod	JP-4 custom standard

Notes:
a\ Test Methods for Evaluating Wastes, Physical/Chemical Methods (SW-846, Third Edition, Update IIIA)

3.0 FIELD ACTIVITIES

3.1 Soil Sampling

Soil sampling field activities will be performed by experienced field personnel following this SAP and methods and techniques described in the TN&A SOPs provided as Appendix C of the Work Plan.

3.1.1 Sample Collection for Laboratory Analysis

It is currently anticipated that thirty-two (32) soil samples, plus associated field QA/QC samples will be collected for the site analysis as shown in Table 3-1.

Table 3-1. Summary of Soil Sample Analysis

Parameter	Methods	List	Sampling Purpose						
			FS	FD	EB	TB	MS	SD	Total
Soil samples taken during the DPT investigation									
TPH	SW8015 Modified		32	3	0	0	1	1	37
Parameter TPH = Total Petroleum Hydrocarbons			**Sample Purpose** **FS = Field Samples, FD = Field Duplicate, EB = Equipment Rinse Blank, TB = Trip Blank, MS = Matrix Spike Sample, SD = Matrix Spike Duplicate**						
Types of Parameter Lists									

Soil samples will be collected from the intervals specified in Table 3-2 for analysis of TPH-DRO by Method 8W8015 by the subcontracted fixed-base laboratory. Substitute soil samples may be collected to meet the project objectives based on field observations or head-space field screening results at the discretion of the field geologist. Soil sample analysis will adhere to a normal turnaround period.

3.1.2 QA/QC and Blank Samples and Frequency

Soil background samples will not be collected. Field duplicates will be collected at a frequency of at least 10 percent of field samples. Approximately one per 10 samples for a total of three field duplicates will be collected per the direction of the USACE. Additional sample volume (two additional 4-ounce containers) will be collected for MS/MSD samples at a frequency of one pair per 32 field samples.

The field duplicate and MS/MSD soil samples will be collected by filling additional sample containers from soil homogenized in a stainless steel bowl lined with aluminum foil. The sample compositing method described in TN&A SOP FLD007D.

Table 3-2. Sampling Summary at FTA4

Sample Location	Sample Depth Intervals (ft bgs)	Rationale	Number of Samples*
Confirmation Samples			
SB01	0-1, 9-10, 19-20, 29-30, 39-40, 49-50	Maximum Depth of TPH contamination > 940 mg/kg at 42 ft; confirm presence and levels of TPH to depth of 50 ft.	6
SB04	0-1, 9-10	Maximum Depth of TPH contamination > 940 mg/kg ia 1 ft; confirm presence and levels of TPH to depth of 10 ft.	2
SB11	0-1, 9-10	Maximum Depth of TPH contamination > 940 mg/kg is 1 ft; confirm presence and levels of TPH to depth of 10 ft.	2
SB14	0-1, 9-10	Maximum Depth of TPH contamination > 940 mg/kg is 1 ft; confirm presence and levels of TPH to depth of 10 ft.	2
SB19	0-1, 3-4	Maximum Depth of TPH contamination > 940 mg/kg at 4 ft; confirm presence and levels of TPH in surface soil.	2
1093	0-1, 4-5, 9-10	Maximum Depth of TPH contamination > 940 mg/kg at 10 ft; confirm presence and levels of TPH to depth of 10 ft.	3
1094	0-1, 4-5, 9-10, 12-13	Maximum Depth of TPH contamination > 940 mg/kg at 12 ft; confirm presence and levels of TPH to depth of 12 ft.	4
Additional Sample Locations			
2004-01	0-1, 9-10	Determine lateral and vertical extent of contamination in area of former concrete pad at SWMU 109.	2
2004-02	0-1, 9-10		2
2004-03	0-1, 9-10		2
2004-04	0-1, 9-10		2
2004-05	0-1, 9-10, 19-20		3

* Analytical method is total recoverable petroleum hydrocarbons using EPA Method modified 8015M.

3.1.3 Sampling Procedures

3.1.3.1 Site Access and Utility Clearance

TN&A will coordinate getting vehicle and personnel passes with the USACE Albuquerque District Project Engineer Office. Utility clearance will be coordinated by TN&A with USACE, Tetra Tech Foster Wheeler, Inc. (TtFW) and Base civil engineering department (TN&A SOP FLD001A). We assume that no New Mexico Environmental Department (NMED) permits are required to conduct the work at the site (e.g., drilling permits are not required, and the investigative-derived waste (IDW) waste stream is insignificant and will be managed at the site).

3.1.3.2 Drilling Procedures

A TN&A experienced field geologist will oversee the drilling, log the boreholes, collect samples, and perform other fieldwork to complete the scope of work. A qualified subcontract driller will perform the DPT drilling. The drilling rig will be a Geoprobe 66DT track-mounted rig with solid-stem auger capabilities. DPT drilling procedures to be followed during the investigation are described in TN&A SOP FLD007E.

All fieldwork will be performed in Level D personal protective equipment (PPE). If field conditions encountered are such that a higher level of PPE is required, TN&A will immediately contact USACE to discuss the situation.

A total of 12 boreholes will be advanced using DPT drilling techniques to the sampling intervals set by Table 3-2. A total of approximately 32 soil samples will be collected for TPH-DRO analysis (plus additional samples for QC purposes, see Table 3-1). Drilling locations are shown on Figure 2 of the Work Plan.

The site has some caliches zones that could make penetration using DPT method difficult. If this condition is encountered, the driller will switch to use of a solid-stem auger for the purpose of penetrating the caliche layer (no samples will be collected through this interval). Once the caliche is penetrated, the driller will switch back to use of DPT methods and continuous sampling. This approach will prevent the need to off-set or move planned boring locations.

3.1.3.3 Field Screening Method Using PID

The field geologist will use a properly calibrated PID to perform air monitoring in the breathing zone and headspace screening of soil sample. Soil samples for head-space screening will be collected from every 2-foot interval during drilling. The PID will be calibrated to ambient air (away from any fuel or other volatile organic sources) and 100 parts per million in air Isobutylene span gas. PID head space screening will be performed in accordance with TN&A SOP FLD005B and the procedure outlined in the New Mexico Underground Storage Tank Bureau "Guidelines for Corrective Action" (March 2000). The steps for the heated headspace method are:

1. Fill a 0.5 liter/16 ounce or larger clean glass jar half full of soil sample. Plastic bags or other non-glass containers are not acceptable.
2. Seal top of jar with clean aluminum foil and lid ring or equivalent.
3. Ensure sample is at 15ºC to 25ºC or approximately 60ºF to 80ºF. A warm water bath or heated air from the interior of a vehicle should be used, if necessary, to raise sample temperature to the acceptable range. Samples are to be protected from direct sunlight in order to prevent photo-destruction of the volatiles.
4. Aromatic hydrocarbon vapor concentrations should be allowed to develop in the headspace of the sample jar for 5 to 10 minutes. During the initial stages of headspace development, the sample is to be shaken vigorously for one minute.

5. Immediately pierce the foil seal with the probe of the PID and record the highest (peak) measurement. The PID reading will be recorded on the HTRW soil boring log.

3.1.3.4 Soil Sample Collection

The DPT soil core line tube will be sliced open using a sharp safety blade. The soil core will be initially screened using the PID, with any peak readings noted on the HTRW soil boring log. The field geologist will collect one grab soil sample representative of the designated sample interval (Table 3-2). The sample will be collected into a laboratory-provided container (completely fill container so that there is no headspace to the extent possible). Immediately upon collection, each sample container will be properly labeled with the sample ID, sample date and time, and sampler's initials. The labeled container will be placed in a resealable plastic bag and stored on ice in a clean cooler. Sufficient ice will be carried in the field to maintain the samples at 4ºC throughout the day until repacked for shipment. TN&A will follow COC procedures to manage the samples until shipment by common carrier for overnight delivery to the subcontract laboratory.

3.1.3.5 Geologic Logging

The TN&A geologist will log borehole geology using HTRW soil boring logs in accordance with TN&A SOP FLD007B. Additionally, the TN&A geologist will carefully examine soil cores for visual indications of soil contamination (staining, etc.) and note these observations in the log.

3.1.3.6 Sample Containers and Preservation Techniques

Samples will be collected in pre-cleaned, pre-preserved containers and placed into coolers containing ice upon sample collection. A summary of the sample containers, preservation, and holding time specifications is shown in Table 3-3. All samples will be identified, labeled, controlled, and handled in accordance with TN&A SOPs FLD010B and FLD010C.

Table 3-3. Sample Container, Preservations, and Holding Times

Analysis	Container[a]	Preservation	Extraction HT	Analysis HT
Soil Samples				
Total Petroleum Hydrocarbons	1 4-oz. jar	Cool to 4º ± 2ºC, no headspace	--	14 Days

a\ U.S. Environmental Protection Agency (EPA). April 1992. "Specifications and Guidance for Obtaining Contaminant-Free Sampling Containers." OSWER Directive No. 9240.0-05A. Additional sample volume is required for the MS/MSD.

3.1.4 Decontamination Procedures

The need for decontamination of sampling equipment will be minimized by using disposable equipment. Trowels or other tools used to collect soil samples will be disposable and will be used only once per sample. Decontamination of downhole sampling equipment will be conducted in accordance with TN&A SOP FLD011A. An established decontamination area is

available at the adjacent landfill site (LF-5). TN&A and our subcontractor will construct a decontamination pad for cleaning of rig and downhole equipment before and after work at FTA4. If necessary, the heavily contaminated drill-stem will be steam-cleaned at the decontamination pad in between sampling locations. Decontamination of downhole tools will otherwise be accomplished at the drill site by hand scrubbing sample cores using laboratory-grade detergent with a clean water rinse, and de-ionized water final rinse. The DPT sampler (2-inch Macro-Core™) will be lined, thus minimizing the potential for cross-contamination between boreholes. All downhole equipment will be decontaminated prior to beginning drilling, between boreholes, and before demobilizing from the site.

3.2 IDW Management

TN&A will manage IDW in accordance with TN&A SOP FLD012A and Base requirements. Used PPE and investigation incidental wastes will be managed as trash, placed in garbage bags, and disposed of in a Base dumpster. Soil and liquid IDW will be properly containerized and segregated according to matrix. Each container will be labeled with site identification, sampling locations, date of generation, matrix, constituents of concern, and contact information (name of contact and phone number).

Acceptable containers will be open-topped, Department of Transportation (DOT)-approved, steel 55-gallon drums. Soils that appear to be contaminated (visually or based on PID readings) will be segregated in separate drums from apparently clean soils. Decontamination fluids will be placed in a 55-gallon drum and allowed to evaporate. Residual solids in the IDW fluid drum will be combined with the IDW solids. The drums will be stored on pallets in the LF-5 area.

IDW solids will be combined with other IDW or soil removed and disposed of as part of the final corrective measure at the site by TtFW. Any residual IDW fluids that have not evaporated by the time of the implementation of the final corrective measure will be taken by TtFW to the headwaters of the Cannon AFB water treatment plant for final disposal.

3.3 Sample Location Surveying

The TN&A field geologist will stake and flag the borehole locations and will survey (TN&A SOP FLD004A) horizontal coordinates and approximate elevations using a hand-held global positioning system (GPS) surveying instrument. The GPS instrument (Geo Explorer XT or equivalent) will have sub-meter accuracy after differential correction. Borehole coordinates will be downloaded from the hand-held GPS unit to a laptop for input into the project sample database.

3.4 Borehole Abandonment

Following sampling, the boreholes will be abandoned in accordance with the USACE General Geology Scope of Services, New Mexico Underground Storage Tank Bureau "Guidelines for Corrective Action" (March 2000) and Base requirements. All boreholes will be backfilled with high-solids bentonite grout (30% solids) and topped off after 24 hours of settlement. The drilling locations are not on a flight line, so special surface repairs will not be required. The materials,

quantities, and method for borehole abandonment will be documented in the field logbook and on the HTRW boring log.

3.5 Site Restoration

Following completion of the field investigation, TN&A will remove all investigation related materials and equipment. The area of investigation surface will be restored to pre-investigation conditions.

4.0 SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

4.1 Field Logbook

Field logbooks will be prepared and maintained in accordance with TN&A SOP FLD002A.

4.2 Photographs

With permission of the Cannon AFB CEV, TN&A will photodocument key field activities (soil sampling, drilling) and drilling locations showing relevant landmarks (if practicable). Photodocumentation will be done in accordance with TN&A SOP FLD002B.

4.3 Sample Numbering

TN&A will use the U.S. EPA software program *Scribe* to electronically setup sample numbers, print labels, and automatically generate chain-of-custody forms. A laptop computer and printer will be present in the field to facilitate this process. *Scribe* is a database that automatically links sample IDs, sample collection information (date, time), sample location information (e.g., borehole number and sampled interval), GPS coordinates, analyses, and other data collected in the field. Field data recorded in *Scribe* will be downloaded to the TN&A Environmental Data Management System (EDMS) upon completion of the field event.

Each sample, including field duplicates, will be labeled in the field with a unique sample identifier (generated through *Scribe*) consisting of the project identification number (2002189) and a sequential sample number (001, 002, etc.). Sample results will be reported to the stakeholders using a unique sample location identifier. The following are examples of the sample location identifiers to be used for **data reporting** for this project:

> CAFB-SB01-10: Sample taken at Cannon AFB, Harza Soil Boring 01 (SB01), at the 10-foot interval (10).
>
> CAFB-1093-10: Sample taken at Cannon AFB, Woodward-Clyde Soil Boring 1093 (1093), at the 10-foot interval (10).
>
> CAFB-200401-10: Sample taken at Cannon AFB, New Sample Location 2004-01 (200401), at the 10-foot interval (10).
>
> CAFB-FD-01: Sample taken at Cannon AFB, Field Duplicate (FD), followed by the next sequential field duplicate number (01, 02, 03, etc).

Samples designated for **MS/MSD** analyses will be identified on the COC by noting "MS/MSD" in the far-right column on the COC. Three times the normal sample volume will be collected for samples with MS/MSD analyses. Sample containers for MS/MSD analysis will be labeled with the original field sample identifier.

4.4 Sample Documentation and Control

4.4.1 Sampling Labels and/or Tags

All samples will be labeled in accordance with TN&A SOP FLD010C. Sample labels will be printed in the field and affixed to the sample containers. Sample labels will be completely covered with clear tape before the samples are placed in the cooler.

4.4.2 Sample Field Sheets and/or Logbook

All samples will be documented using the *Scribe* program, as described above.

4.4.3 Chain of Custody Records

A sample is considered in custody if:

- It is in the sampler's or the transferee's actual possession.
- It is in the sampler's or the transferee's view, after being in his/her physical possession.
- It was in the sampler's or the transferee's physical possession, and then he/she secured it to prevent tampering.
- It is placed in a designated secure area, with restricted access. This includes a locked, on-site refrigerator or ice chest sealed with custody seals.
- It is released to a courier service for shipment to the laboratory. The TN&A sampler must record the courier's air bill number on the COC form to document custody transfer.

TN&A will document sample custody, from the time of collection until sample disposal, using COC forms. The appropriate sample number, type and number of container, preservative, requested analysis, and method information will be completed by the TN&A sampler on the COC Record forms in accordance with TN&A SOPs FLD002A and FLD010C. The subcontracted laboratory will provide COC forms. TN&A will provide the COC (Attachment 1), which is generated through *Scribe.*

4.4.4 Receipt for Sample Forms

Receipt for samples is documented on the COC Record.

4.5 Documentation Procedures

All fieldwork and sampling will be documented in accordance with TN&A SOPs FLD002A and FLD010C. Field decisions for waste disposal will be recorded on a Daily Quality Control Report (DQCR) and kept with the project record. A DQCR form is attached to this SAP (Attachment 1).

4.6 Corrections to Documentation

All corrections to field logbooks and sampling documentation will be performed in accordance with TN&A SOPs FLD002A and FLD010C.

5.0 SAMPLE PACKAGING AND SHIPPING

All samples will be packaged for shipment to the laboratory in accordance with TN&A SOP FLD010C.

Samples collected during the site work are classified as environmental or hazardous. All sample shipping will be performed in accordance with U.S. Department of Transportation requirements as well as the provisions stated TN&A SOP FLD010C.

- Shipping containers shall be secured using strapping tape and custody seals to ensure that samples have not been disturbed during transport. The custody seals shall also be placed on each container so that they cannot be opened without breaking the seal. All openings will be taped shut to prevent potential leakage during transport.
- Shipment information will be recorded for each shipment of samples at the end of the shift, day, or collection period in the field logbooks and on all appropriate forms.

6.0 SAMPLING APPARATUS AND FIELD INSTRUMENTATION

The following equipment may be used for sampling in the field:

- Disposable Plastic Trowels
- PID
- 100 parts per million Isobutylene in air calibration gas for PID
- Laboratory-supplied 4-ounce glass sample jars
- Protective Gloves (latex or vinyl)
- Clean plastic coolers for samples
- Resealable plastic bags
- Garbage Bags
- Ice
- Packing Material
- Strapping Tape
- Custody Seals

7.0 DATA VALIDATION

STL-Chicago will provide TN&A with Level IV data packages, which shall consist of the following:

- A case narrative discussing in detail any reanalyses, reextractions, variances, nonconformances, or deviations from the laboratory's SOPs or methods must be included.
- A SDG summary sheet showing client sample numbers, lab sample numbers, analyses performed, and matrix of samples must be included.
- Full copies of TN&A or client COCs and laboratory Cooler Receiving Forms/Sample Login Sheets, showing documentation of preservative checks (with the exception of samples for volatile organic analyses) and cooler temperature at the time of receipt by the laboratory must be included.
- U. S. EPA Contract Laboratory Program (CLP) Forms, CLP-like forms or their informational equivalent will be used for data reporting, where available. In addition to summary CLP Forms 1 through 4, all calibration data and instrument tune information must be included.

Data validation will be performed according to the QC acceptance specified in Table 7-1. The TN&A chemist will select review and validate 90 percent of the data for Level III validation, with the remaining ten percent validated at Level IV. Data selected for Level III validation will be evaluated for the following list of QA\QC audits:

- Surrogate Spike Recoveries
- MS/MSD Analysis (where applicable)
- LCS
- Laboratory Blank Analysis Results
- Field Precision Results (when provided)
- Initial and Continuing Calibrations
- Reporting Limit Results

Level IV validation will consist of all the element of a Level III data validation and an evaluation of sample chromatograms, review for transcription errors, and a verification of laboratory calculations.

Table 7-1. Method 8015 Quality Control Audits for Precision and Accuracy

Sample Type	Frequency	Accuracy	Notes
Field QC			
Duplicate	1 for every approximately 10 field samples collected	Soil Samples – RPD , 20%	Review lab QC data to determine if they are in control. If not in control, flag data. Use data to evaluate whether proper collection procedures were followed.
Laboratory QC			
Initial Calibration	Prior to analysis and when continuing calibration criteria fail	5 pt. calibration; RSD of mean, 20%	Recalibrate Instrument
Continuing Calibration	Daily	Response factors deviate < 20% from average of initial calibration.	Rerun continuing calibration. If still out of control, take remedial action and recalibrate instrument.
Laboratory Reagent Blank	Daily	Less than reported detection limit	Step 1: Reanalyze Step 2: If second blank exceeds criteria, clean the analytical system. Step 3: Document the corrective action taken and qualify all associated data.
QC Check Standard	Quarterly	%R = 80 – 120 RSD < 20 %	Step 1: Reanalyze Step 2: If still out of control, perform and document remedial action. Step 3: Reanalyze
Laboratory Fortified Blank	1 per 20 or 1 per sample set	%R = 80 – 120 RSD < 20%	Step 1: Reanalyze Step 2: If still out of control, perform and document remedial action. Step 3: Reanalyze
Surrogate Spike	All blanks, standards, QC samples, field samples	See method or laboratory controls for surrogate spiking compounds control limits	Determine cause (if possible), correct and reanalyze. If cause cannot be confirmed, flag data.
MS/MSD	1 per every 20 samples	%R = 80 – 120 RSD =< 20%	Determine cause (if possible), correct and reanalyze. If cause cannot be confirmed, flag data.

%R Percent recovery
MS/MSD Matrix spike/matrix spike duplicate
RPD Relative percent difference
RSD Relative Standard Deviation

Each result shown on the sample analysis reports will be flagged with the specific data validation qualifiers listed below, as appropriate. During validation, the following qualifiers are applied to the data to replace the laboratory qualifiers.

[=] The analyte was positively identified.

[J] The analyte was positively identified, the quantitation is an estimate. Also used if an organic analyte was positively identified at a concentration above the MDL, but below the Reporting Limit.

[U] The analyte was analyzed for, but not detected. The associated numerical value is at or below the Reporting Limit.

[R] Data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.

[UJ] The analyte was analyzed for, but is estimated to be not detected. Reason for estimation is deficiency in the ability to analyze the sample and meet QC criteria.

Data qualifiers may be added or changed as required by validation guidelines. If 30 percent of the results for a given method, or 50 percent of the results for one compound, are qualified as estimated, the PM will determine an appropriate course of action. Factors that will be considered in determining the appropriate course of action include the number of results qualified, the reason for qualification, any pattern in the qualified data, the importance of the qualified compound(s), and the importance of the samples.

The addition of validation qualifiers does not indicate that data are unusable for any purpose, unless they are rejected. They do, however, identify the level of confidence that can be placed in the data when using it to establish the presence or absence of a compound or to quantify the result.

8.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The key personnel for the DPT investigation project at FTA4 are listed in Table 8-1 below.

Table 8-1. Project Organization and Responsibilities

Organization/Title	Personnel	Phone Number
Cannon AFB Remedial Program Manager	Peter Zamie	(505) 784-1092
USACE-Omaha District Project Manager	Jane Davey	(402) 221-7645
TN&A Program Manager	John Fleissner	(414) 607-6734
TN&A Project Manager	Nova Clite	(414) 607-6727
TN&A Corporate Safety & Health Manager	William Fink	(414) 607-6779 pager: (888) 662-5705
TN&A Field Geologist	John Bruskewitz	(414) 607-6776 cell (414) 526-4265
TN&A Project Chemist	Richard Baldino	cell (847) 494-2685

8.1 TN&A Technical Team

8.1.1 Program Manager

The Program Manager, Mr. John Fleissner, is responsible for the quality of all work performed under this contract. He will monitor the progress of this assignment to ensure that adequate resources are available and that major problems are prevented or minimized. Mr. Fleissner will be responsible for implementing the standard of work for this USACE assignment and will concentrate on the technical quality, schedule, and cost for all work performed.

8.1.2 Project Manager

Ms. Nova Clite, P.G., will serve as Project Manager for this effort. She will be TN&A's primary point-of-contact for this project and will be fully responsible for successful project execution. Her specific responsibilities will include project tracking, cost control, invoicing, assigning resources to the project, direct the development of the SAP, and verifying that client needs are being met. Ms. Clite will also coordinate efforts between project technical personnel and administrative staff to ensure an efficient project.

8.1.3 Corporate Safety Officer

Mr. William Fink, CIH, CSP, CHMM will be the Corporate Safety Officer. He has reviewed the Site Safety and Health Plan (SSHP) and will be the field crew's primary point of contact for resolving safety issues.

8.2 Project Chemist

Mr. Rich Baldino will be the project chemist. He will be the primary author of the SAP and the Quality Control Summary Report (QCSR). He will also manage the laboratory subcontractor and perform the data validation.

8.3 Field Geologist/Site Safety and Health Officer

Mr. John Bruskewitz, P.G. will serve as Field Geologist and Site Safety and Health Officer (SSHO) for this project. His responsibilities will include coordinating the investigative sampling. He will be directly responsible for the implementation of the work plan and for ensuring safety in the field. He will be the field point of contact for the project.

8.4 Subcontracted Services

8.4.1 Offsite Laboratories

The subcontracted laboratory for this project is Severn Trent Laboratories, Inc. of Chicago, IL (STL-Chicago). The subcontracted laboratory is in possession of a current National Environmental Laboratory Accreditation Program Certification.

8.4.2 Direct Push Technologies Services

The subcontracted DPT service provider is Environmental Services Network (ESN) Southwest of Tijeras, NM.

8.5 Qualifications and Training of Personnel

Personnel assigned to the project, including field personnel and subcontractors, will be qualified to perform the tasks to which they are assigned. In addition to minimum education and/or experience requirements specified in Appendix B of EM-200-1-3 for subcontract laboratory personnel, specific training may be required to qualify other project personnel to perform certain activities. The Project Manager is responsible overall for TN&A personnel training.

9.0 REPORTING

The laboratory will provide to TN&A the full Level IV data packages as an electronic deliverable (in adobe Acrobat format, i.e., PDF files) within 25 days of sample receipt. TN&A will validate the results within 10 days of receipt of the laboratory data packages. Following data validation, TN&A will provide to the USACE project chemist the full laboratory data package, with data qualifiers, and a Quality Control Summary Report (QCSR). The QCSR will include a summary of the data validation process, discuss possible biases or other effects on the data, identify affected sample results, and provide a statement regarding the usability of the analytical data. The full data package plus QCSR will be an electronic deliverable only. TN&A will also provide an electronic data deliverable (EDD) in the format specified by the USACE.

TN&A will prepare a concise Field Investigation Report summarizing the work performed, samples collected, and summarizing the sample analytical results. The report will be submitted in Draft, Final, and Revised Final forms. Annotated "Response to Comments" will be provided for each version.

Figures will include Base and site location maps, a site plan showing drilling locations, and sample results. Additionally, one or two cross-sections will be prepared, if warranted by the data, showing geologic layers and sample analytical results.

Appendices will include the QCSR, chemical analytical data summary (table form), COC forms, boring logs, and photodocumentation.

ATTACHMENT 1
FIELD FORMS

HTW DRILLING LOG

HOLE NO.		
1 COMPANY NAME	2. DRILLING SUBCONTRACTOR	SHEET 1 OF SHEETS
PROJECT	4. LOCATION	
5 NAME OF DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL	
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION	
	9. SURFACE ELEVATION	
	10. DATE STARTED	11. DATE COMPLETED
12 OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED	
13 DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14 TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

FORM MRK JUN 89 55	PROJECT	HOLE NO.

HTW DRILLING LOG (CONT.)

HOLE NO.

PROJECT	INSPECTOR	SHEET OF SHEETS

ELEV. a	DEPTH. b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

WASTE INVENTORY TRACKING FORM

LOCATION : _____

PROJECT NAME: _____

ACTIVITIES: _____

Date Waste Generated	Activity Generating Waste (borehole # / well #)	Description of Waste	Field Evidence of Contamination	Estimated Volume	Type of Container (storage ID#)	Location of Container	Waste Characterization	Comments

Note: Describe whether soil or water samples have been collected for waste characterization, include date, if known.

Signature: _____

T N & Associates, Inc.
Engineering and Science

Real Time Air Monitoring Instrument Calibration Log

Date/Time	Calibration Technician Initials	Instrument Calibrated	Serial Number	Calibration Standard	Span	Result	Average Calibration Reading

NOTES:

TN&A Project:
TN&A Project No.:
Other Comments:

CHAIN OF CUSTODY RECORD

EPA Contract #:

Site #: 2002189
Contact Name: Rich Baldino
Contact Phone: (847) 494-2685

No: 2002189-0001
Cooler #:
Lab: STL - Chicago
Lab Phone: (708) 534-5200

Lab #	Sample #	Analyses	Matrix	Date Collected	Numb Cont	Container	Preservative	Sample Time	MS/MSD
	2002189-0001	TPH-DRO	Soil		1	Jar	4 C		N

Special Instructions:	SAMPLES TRANSFERRED FROM CHAIN OF CUSTODY #

Items/Reason	Relinquished by	Date	Received by	Date	Time	Items/Reason	Relinquished By	Date	Received by	Date	Time

Daily Quality Control Report

Date							Report No.
S	M	T	W	Th	F	S	

Site QC Manager: **Project Manager:**	**Weather**	Clear	Cloudy	Overcast	Rain	Snow
Project:	**Temp**	To 32	32:50	50:70	70:85	85:up
Job No.:	**Wind**	Still	Moderate	High		
Contract No.:	**Humidity**	Dry	Moderate	High		

TN&A Personnel On Site:

USACE Personnel On-Site:

Sub-Contractors On Site:;

Equipment on Site:

Work Performed (Including Sampling):

Sheet 1 of 2

Daily Quality Control Report (continued)

Project: **Report No:.:**
Job No: **Date:**

Quality Control Activities (including field calibrations):
Health and Safety Levels and Activities:
Problems Encountered/Corrective Action Taken:
Special Notes:
Tomorrow's Expectations:

Sheet __2__ of __2__
By: _____Title:_____

APPENDIX C

Standard Operating Practices

STANDARD OPERATING PRACTICE TNFLD007B

Soil and Rock Geologic Logging and Classification

TABLE OF CONTENTS

Page

1.0 INTRODUCTION **3**
2.0 FIELD PROCEDURE FOR SOIL AND BEDROCK CLASSIFICATION **3**
2.1 General Considerations 3
2.2 Equipment 4
2.3 Field Classification of Soils 4
2.3.1 Procedure 5
2.3.2 Identification 6
2.3.3 Descriptive Format and Terminology 7
2.3.4 Primary Descriptive Elements 8
2.3.5 Field Tests For Classifying Fines 18
2.4 Field Classification of Bedrock 20
2.4.1 Rock Quality Designation(RQD) 20
2.4.2 Hardness 21
2.4.3 Description 21
2.4.4 Weathering 22
2.4.5 Joint Spacing 23
2.4.6 Remarks 23
2.4.7 Notes 24
2.4.8 Abbreviations 24
2.5 Procedures For Logging Exploratory Borings 24
2.5.1 General Requirements 24
2.5.2 Description of Surface Conditions 25
2.5.3 Documentation of Drilling Procedures and Performance 25
2.5.4 Sampling Data 25
2.5.5 Description of Soils and Bedrock 25
2.5.6 Stratigraphic Contacts and Lithologic Changes 26
2.5.7 Groundwater Observations 26
2.5.8 Environmental Field Measurements and Observations 26
2.5.9 Borehole Stability 26
2.5.10 Quality Assurance 26
3.0 REFERENCES **28**

LIST OF TABLES

Table 1 Bedrock Hardness Terms

Table 2 Grain-Size Classification

Table 3 Bedding Thickness Bedrock Description

Table 4 Fracture Spacing Description of Bedrock

Table 5 Bedrock Log Abbreviations

STANDARD OPERATING PRACTICE TNFLD007B

Soil and Rock Geologic Logging and Classification

1.0 INTRODUCTION

The general objective of this Standard Operating Practice (SOP) is to provide procedures for conducting activities associated with the description, investigation, and characterization of soils, residuum and bedrock. The discussion includes methods to complete the following: describe the collection of soil and bedrock samples obtained during drilling operations, advance soil and bedrock test borings, and collect subsurface soil and bedrock samples.

2.0 FIELD PROCEDURE FOR SOIL AND BEDROCK CLASSIFICATION

Exploratory borings typically represent the single most important source of information used for characterizing subsurface conditions for environmental or geotechnical studies. The analysis and interpretation of subsurface conditions is greatly affected by the quality of the lithologic logs used. This SOP is intended to provide a basis for consistency among practitioners responsible for documenting subsurface conditions encountered in exploratory borings. It provides a discussion of general observations that should be routinely made and documented on every boring log. It also presents standardized terminology and definitions for describing soils, sediments, and bedrock. The intent of this discussion is to promote the recognition that consistent logging provides the foundation for all subsequent analysis and design, and to encourage greater care and standardization in all phases of log preparation.

2.1 GENERAL CONSIDERATIONS

As a general rule, subsurface data will be of sufficient detail and quality to support both environmental and geotechnical analyses. It is critical that an adequate understanding of subsurface conditions is developed prior to the installation of groundwater monitoring wells, or prior to design for environmental restoration or site development, to help ensure further activities are based on sound, reliable data.

This SOP presents detailed procedures for classifying and describing soil and bedrock based upon the Unified Soil Classification System (USCS) and standard practices developed by the American Society for Testing and Materials (ASTM). The USCS is the most widely accepted system within the engineering community.

2.2 EQUIPMENT

Appropriate equipment shall be maintained on-site to classify, describe, and log soil samples and subsurface conditions. At a minimum, this should include the following equipment:

- Log book,
- Indelible black ink pens,
- Clipboard,
- Straightedge,
- Retractable steel tape with increments in 10ths and 100ths of feet,
- Appropriate field forms (e.g., hazardous toxic waste drilling logs),
- Water-level tape,
- 10X magnifying glass, and
- Munsell color chart

Additional items which may be helpful include:

- Pocket penetrometer,
- Torvane (field),
- Stainless steel weight (tag bar),
- Permanent indelible felt-tip marking pens (Sharpie® or equivalent),
- Dilute (10 percent) hydrochloric acid, and
- No. 200 sieve.

Boring logs will be prepared in the field on WDNR drilling log form 4400-122. Each log will be signed by the geologist or geotechnical engineer.

2.3 FIELD CLASSIFICATION OF SOILS

This section establishes guidelines for consistent field classification of naturally occurring soils and sediments based upon the USCS and ASTM Standards D 2487 and D 2488 (ASTM, 1993a; ASTM, 1993b).

- The USCS provides the primary framework for this soil classification scheme. Using the USCS, soils/sediments are divided into 15 soil groups, based upon observations and prescribed manual and/or laboratory tests. The USCS grouping is intended to minimize the number of laboratory tests required for definitive soil classification.

- ASTM D 2487 presents criteria for classifying soils/sediments based on laboratory determination of gradation (particle-size distribution) and behavioral (engineering) characteristics.
- ASTM D 2488 (Standard Practice for Description and Identification of Soils, Visual-Manual Procedure) describes methods for identifying soils/sediments based on visual examination and simple manual tests. ASTM D 2488 also provides standardized terminology for describing other attributes of soils/sediments that should be documented to adequately characterize hydrogeologic and geotechnical conditions. Detailed site-specific analysis of factors such as color, weathering, and geochemical characteristics may be required to provide a thorough understanding of site stratigraphy.

The objectives of this discussion are to provide the following:

- Standard criteria for identifying and classifying soils and/or sediments,
- Standard terminology for describing key attributes of soils and sediments,
- A system that will result in logs that are useful for both engineering and hydrogeologic purposes, and
- A classification system that will allow for reliable comparison of logs prepared by different practitioners.

2.3.1 Procedure

The process for developing consistent soil/sediment descriptions is summarized below:

- Identify the soil components present.
- Determine whether the sample is composed primarily of coarse-grained, fine-grained, or organic soils, or whether a mixture is present.
- Evaluate soil gradation and/or behavioral properties (estimate the degree of plasticity) through a combination of visual inspection and field tests (described in section 2.3.5, below).
- Classify and describe the soils using the results of visual inspection and field tests.
- Assign a USCS group name and symbol.
- Prepare a detailed description of the sample using prescribed (ASTM) terms and definitions.
- Assign a geologic descriptor based upon origin (genetic or formation).

Soils rarely exist in nature as individual components (gravel, sand, silt, or clay). Mixtures of the individual components in varying proportions are much more common. Each component contributes to the characteristics of the soil mixture. In order to classify a soil mixture, the relative percentages of the component grain sizes must be determined. The first step is to

determine whether the soil is predominantly coarse-grained (gravel and/or sand) or fine-grained (silt and/or clay). Although the USCS is based on percentage by weight, estimation of the relative percentage of soil components in the field must be based upon visual assessment of the relative volumes of materials present.

A rough determination of the relative weight percentages of the components present can be made by spreading the sample out in the palm of the hand and making a visual estimate. Carefully washing the fines from a portion of a sample, by mixing the soil with water and pouring off the clouded suspension of fines and water, will aid in estimating the percentage of fines present by comparison with an unaltered portion. Mixing a sample with water in a jar and allowing the mixture to settle is also helpful. The coarse-grained components will fall completely out of suspension in 20 to 30 seconds.

When describing bulk samples or soils exposed in an excavation, the percentages of cobbles and boulders should be estimated by volume. The remaining soil matrix should be described independently.

2.3.2 Identification

The USCS groups soils into three major divisions: coarse-grained soils, fine-grained soils, and highly organic soils. The characteristics that define these soil groups, and procedures involved in identifying the individual components, are described in the following paragraphs.

Coarse-Grained Soils

Coarse-grained soil components are defined as materials that would pass through a 3-inch sieve and which would be retained by a No. 200 sieve (0.075 millimeters [mm]). Coarse-grained soil components are further subdivided by grain. Soil is considered coarse-grained if 50 percent or more of a sample (by dry weight) is larger than 0.075 mm. The range of both fine- and coarse-grained soil components present in a sample should be determined by careful examination.

Fine-Grained Soils

Soil is considered fine-grained if 50 percent or more of a sample (by dry weight) is smaller than 0.075 mm (No. 200 sieve). Fines can be further subdivided into silt and clay. Classification of fine-grained soil components may be based upon mineralogy, grain-size, or physical behavior. Mineralogy is difficult to determine in the field without previous geologic information based upon laboratory techniques, such as X-ray diffraction. Grain-size is difficult to estimate because of the size classes involved and the limitations imposed by field equipment such as hand lenses. Additionally, textural classification of fines can be misleading in terms of geotechnical properties. For these reasons, the USCS defines the terms "silt" and "clay" solely on the basis of the plasticity characteristics of material finer than 0.075 mm.

Organic Soils

Organic soils contain sufficient organic matter, living or in the process of decay, to significantly affect the engineering properties of the soil. Most organic soils can be considered a special category of fine-grained soils. Topsoil, humus, peat, organic silt, organic clay, and diatomaceous earth are common examples. The water content of organic soils is typically very high. Organic soils invariably have very low shear strength in their natural state, but may exhibit high tensile strength in certain directions because of fibrous materials.

Observations of color and odor are of particular value for the identification of soils. Dark gray, black, and various shades of brown are characteristic colors. Organic soils frequently change color when exposed to air. Many organic soils, particularly marine peats and silts, have a distinctive odor of hydrogen sulfide. This odor is especially apparent in fresh samples. Heating the sample intensifies the odor.

Organic silts and clays typically exhibit slight to medium plasticity and form threads that are very weak, soft, and spongy near the plastic limit. Less effort is required to pull fine-grained non-fibrous organic soils apart than inorganic fines. A clean break is generally formed. The smear of organic silts and clays, although smooth, is very dull.

Peat is an organic soil characterized by the presence of vegetable matter (e.g., leaves, sticks, grass, wood, and/or moss) in various stages of decomposition. These components generally impart a fibrous texture to the soil. Peat is typically brown or black in color. Peat and organic silt are common components of fresh water swamps, bogs, and tidal flats.

Diatomaceous earth is an organic soil commonly found in the lower stratum of peat bogs. Diatomaceous earth is composed primarily of the siliceous skeletal remains of diatoms that accumulated in lakes and swamps. The amount and nature of impurities is highly variable and may include sponge spicules and radiolarian remains as well as organic and inorganic silt and clay. Diatomaceous earth reacts rapidly to the dilatancy test and typically dries to a highly friable soil. Color ranges from white to yellow to various shades of brown and gray.

Another important consideration in the identification of organic soils may be the location with respect to topography. Low-lying swampy areas frequently contain highly organic soils.

2.3.3 Descriptive Format and Terminology

The USCS provides useful information about soil gradation and plasticity. However, critical information necessary for site interpretation and evaluation are not included in the USCS. The USCS should therefore be supplemented with additional information. The following discussion identifies features, which should be evaluated and described to supplement the USCS.

Order of Description

The descriptive format begins with the USCS group name and symbol, which will be discussed in more detail below. A detailed description, based upon ASTM standards, follows the USCS

classification. For consistency, the primary descriptive elements, listed below, should be included in all soil descriptions in the following standardized order:

- USCS group name,
- Descriptive USCS classification in accordance with ASTM-2488-84,
- Density or consistency (plasticity and cohesiveness),
- Moisture condition,
- Color,
- Stratification and structure, and
- Deposition environment.

A description of other pertinent properties should be included, as needed, following the primary descriptive elements listed above.

Following the detailed soil description, the probable geologic origin should be provided (in capital letters as shown). Several typical descriptions are presented below:

CH- Clay with some gravel, very stiff, low plasticity, saturated, 10YR 5/4 Yellowish Brown, fractured with silt filling fractures

Silty clay with trace gravel, soft, medium plasticity, moist, 2.5 YR 4/3 Olive Brown, Glacial Till

SP- Poorly graded sand with trace clay, fine to medium grain, well rounded, medium dense, moist, Alluvial deposit.

Soil/sediment descriptions should be as comprehensive as possible, without excessive emphasis on insignificant details. Good judgment and common sense based on an understanding of geology and engineering behavior of soils is required.

2.3.4 Primary Descriptive Elements

Soil Type (Group Name and Symbol)

If a soil is classified as a gravel or sand and it contains 12 percent or less fines, it is considered to be well-graded or poorly graded, depending upon the distribution of grain sizes (gradation) present.

"Well-graded" is an engineering term that indicates a continuous distribution of particle sizes from the coarsest to finest particle size of the relevant fraction. "Poorly-graded" pertains to sediments that lack a continuous distribution of grain sizes. Poorly graded include uniformly-graded (predominantly one particle size or well sorted) and gap-graded or step-graded (one or more particle sizes absent) sediments. These terms may be included as secondary descriptive elements.

These terms should not be confused with the geologic terms used to describe sorting. A uniformly graded sediment would be described as well-sorted using this terminology.

Guidelines for the use of modifiers and other descriptive terms which may be included in the USCS group name are presented below.

Use of "with":

1. If a soil is predominantly sand or gravel but contains an estimated 15 percent or more of the other granular component, add "with sand" or "with gravel" to the group name.
2. If a soil contains any cobbles or boulders, add "with cobbles" or "with boulders" to the group name.
3. If a fine-grained soil contains (little) 15 to 25 percent sand, gravel or both, add "with sand" or "with gravel" to the group name (whichever is more predominant). Use "with sand" if the related percentages are equal.
4. If a granular soil contains 10 percent (few) fines, add "with silt" or "clay" to the group name.

Use of adjective modifier:

1. If a fine-grained soil contains 30 percent or more sand or gravel (some), add "sandy" or "gravelly" to the group name (e.g., SANDY SILT, GRAVELLY LEAN CLAY).
2. If a granular soil contains more than 15 percent (little) fines, use an adjective modifier (e.g., SILTY SAND, CLAYEY GRAVEL).

Use of dual symbols:

1. If a granular soil is estimated to contain 10 percent fines use a dual symbol.

   a) the first symbol shall correspond to a clean gravel or sand,

   b) the second symbol shall correspond to a gravel or sand with fines (e.g., GW - GC, SP - SM).
2. CL-ML (see USCS Plasticity Chart - do not use this combination unless substantiated by laboratory analyses).

Use of borderline symbols:

1. Use to indicate a soil with properties that do not distinctly place the soil into a specific group (e.g., CL/CH, GM/SM, ML/SM).
2. Using the USCS, "and" may be used to indicate that soils are interbedded by linking group names (e.g., LEAN CLAY [CL] AND POORLY GRADED SAND [SP])

Density or Consistency

Density relates to cohesionless (predominantly coarse-grained) materials, while consistency relates to cohesive (predominantly fine-grained) soil. Both can be estimated from the standard penetration test. The standard penetration test is defined as the number of blows required to drive a standard 2-inch outside diameter split-barrel (spoon) sampler through 18 or 24-inches of undisturbed soil using a free falling 140 pound weight. The blow count is recorded in 6-inch increments. The first 6 inches is considered to be a seating drive. The sum of the blows required for the second and third 6-inch increments is defined as the penetration resistance (N-value). Standard penetration tests should be performed in accordance with procedures described in ASTM D 1586. It is essential to ensure that standard penetration test procedures adhere to this ASTM standard so that blow counts yield meaningful N-values.

Consistency can also be readily evaluated by feel or with a pocket penetrometer (PP) or vane shear instrument such as a torvane (TV). When using these methods to estimate consistency, sample disturbance should be considered.

Terms for describing the density or consistency of a soil are presented below:

Cohesionless (Predominantly Coarse-Grained) Soils	
N-Value	**Density**
0-4	Very loose
5-10	Loose
11-30	Medium Dense
31-50	Dense
50+	Very Dense

Cohesive (Predominantly Fine-Grained) Soils

N-Value	Consistency	Manual Criteria	Undrained Compressive Strength, qu (Tons/Sq. Ft.)*	Undrained Shear Strength, SU (Tons/Sq. Ft.)**
<2	Very Soft	Thumb will easily penetrate soil more than 1 inch	<0.25	<0.12
2-4	Soft	Thumb will easily penetrate soil about 1 inch	0.25 - 0.5	0.12 - 0.25
5-8	Medium Stiff	Thumb will easily indent soil about ¼ inch	0.5 - 1	0.25 - 0.5
9-15	Stiff	Indented by thumb ¼ inch only with great effort	1 - 2	0.5 - 1
16-30	Very Stiff	Thumb will not indent soil. Readily indented with fingernail	2 - 4	1 - 2
31+	Hard	Indented with difficulty with thumbnail	>4	>2

* Measured with pocket penetrometer.
** Measured with TV or similar vane shear instrument.

Moisture Condition

The moisture condition of the soil shall be described on the field boring log. Soils are described as being dry, moist, or wet with increasing degrees of saturation based on the following criteria:

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Damp	Slight visible evidence of moisture
Moist	Moisture clearly evident
Saturated	Visible free water, pores filled with water; commonly soils collected from below water table

Color

For consistency purposes color should be identified using the Munsell Soil Color Charts. The charts provide a semi-quantitative aid to correlate color across a site. It also aids in the assessment of secondary weathering zones and moisture relationships.

When naturally wet soils are described after being allowed to dry, it should be noted on the log. The color description should not be capitalized and should be followed by the alpha-numeric Munsell code in parentheses as shown in the following examples:

- Pale red (2.5 YR 6/2), and
- Very dark brown (7.5 YR/2).

Variations due to mottling in the soil color should also be noted using the Munsell soil color notation.

Gradation

The soil components present in a sample should be identified as described at the beginning of this section. The relative percentages of the different fractions present should be described based on estimates to the nearest 5 percent, using the following terms from ASTM D2488:

Description	Percentages
Mostly	50 - 100 percent
Some	30 - 45 percent
Little	15 - 25 percent
Few	5 - 10 percent
Trace	Particles are present but estimated to be less than 5 percent

The component with the highest percentage should be recorded first with the next highest percentage recorded next.

Gradation within the sand and gravel fractions must be defined or it is assumed that all fractions are present. When recording gradation, always begin with the coarser fraction, (e.g., mostly coarse to fine gravel, and mostly medium to fine sand).

Plasticity and Cohesiveness

If a sediment sample is predominantly fine-grained, a plasticity designation should be provided (see section 2.3.5) Additionally, the cohesiveness of soils including both fine- and coarse-grained components should be noted. Soils in which the adsorbed water and particle attraction work together to produce a mass that holds together and deforms plastically at varying water contents

are known as cohesive soils. A predominantly coarse-grained soil could be cohesive in character with as little as 20 percent fines, depending upon the overall gradation of the material and the plasticity characteristics of the fines. A soil accurately classified as GC or SC would always be cohesive.

Mixtures of coarse- and fine-grained soils should be described as cohesive or cohesionless.

Stratification/Structure

Most geologic structures may be characterized as stratified, massive, or some variation of the two. Some terminology for describing soil structure or stratification are defined below:

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 that 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.
Massive (Homogeneous)	Same color and appearance throughout.

Also describe:

Bedding Attitude	Horizontal or Inclined (with angle).
Lithologic Contact	Sharp or Gradational (with nature of gradation).

The identification of naturally occurring fractures or planes of weakness (as opposed to those that may have been produced by the drilling or sampling process) can be made through the recognition of surface coatings, changes in oxidation state of adjacent materials, or stress surfaces such as slickensides. Common surface coatings include carbonates, organics, secondary iron, manganese oxide, and silt or clay. Changes or mottling in color adjacent to a fracture

surface are generally indicative of a change in oxidation state associated with a naturally occurring fracture.

Geologic Interpretation

A geologic interpretation may be provided with each description. This may include a generic interpretation (such as alluvium or saprolite), geologic age, and/or formation name. Accurate field interpretation of geologic origin may support geologic evaluations conducted later in the office. Identification of the geologic origin or depositional environment is often necessary to support interpretations of the distribution, uniformity, or variability of subsurface soils and sediments. The geographic position of individual boring locations (e.g., crest of a hill, terrace, edge of a flood plain, etc.) should be considered when making this determination.

Other Descriptive Elements

Understanding of subsurface conditions at a site is dependent upon detailed descriptions of soil or sediment samples. The following additional characteristics should be considered and described, if pertinent. It is the responsibility of the field geologist and project staff to determine the extent of detail required. These additional elements should be appended to the primary description, separated by a semicolon:

- Angularity, size, and shape of coarse-grained components.
- Hardness of coarse-grained components.
- Presence of boulders or cobbles.
- Fossils.
- Accessory minerals.
- Lithology of coarse-grained components.
- Cementation or presence of calcareous materials.
- Odor.
- Weathering zone.
- Presence of roots, root holes, animal burrows or other macro-pores.

Angularity and Shape of Coarse-Grained Components

A description of the angularity of coarse-grained sand, gravel, cobbles and boulders may provide a basis for interpretation of geologic origin and correlation of geologic units encountered at different locations. The following terminology should be used:

Description	Criteria
Angular	Particles have sharp edges and relatively planar sides with unpolished surfaces.
Sub-angular	Particles are similar to angular description but have rounded edges.
Sub-rounded	Particles have nearly planar sides but have well-rounded edges.
Rounded	Particles have smoothly curved sides, no edges.

The shape of gravel, cobbles, and boulders should be described as follows:

Description	Criteria
Flat	Particles with width/thickness of >3 inches
Elongated	Particles with length/width of >3 inches.
Flat and elongated	Particles meet criteria for both flat and elongated.

Hardness of Coarse-Grained Components

Coarse sand and larger particles may be described as "hard" if particles do not crack, fracture, or crumble under a hammer blow. Alternatively, state what happens when particles are hit with a hammer.

Presence of Cobbles and Boulders

The presence of cobbles or boulders should be noted. This may be evident through observation of drill advance or by fragments recovered in samples. If possible (such as in a test pit), a volumetric estimate of the percent of cobbles or boulder present should be made. Alternatively, a qualitative description such as "occasional" or "numerous" cobbles or boulders should be provided. If any cobbles or boulders are present, "with cobbles" or "with boulders" should be appended to the USCS group name.

Fossils, Accessory Minerals, or Lithology of Coarse-Grained Components

Fossils are generally fragmented in cores and drill holes; however, some whole fossils may be found in cores. The fossils present in a sample may be difficult to classify, depending on the type and quality of the specimen.

Accessory minerals constitute only a minor percentage of the bulk of a sediment sample. However, these minerals provide significant indicators of depositional environment and are useful in correlation.

Common accessory minerals include:

- Glauconite,
- Heavy minerals,
- Sulfides (pyrite and marcasite),
- Manganese oxide,
- Feldspar,
- Chert,
- Mica,
- Kaolin,
- Siderite,
- Gypsum,
- Lignite, and
- Iron oxide.

Lignite and manganese oxide are frequently encountered and frequently confused with each other.

The lithology of coarse-grained soil components can also provide a valuable clue to assist with interpretations of depositional history and stratigraphic correlation. Notations such as "sand predominantly quartz" or "gravel predominantly shale fragments" may be appended to the primary description.

Cementation or Presence of Calcareous Materials

The degree of cementation of coarse grained soils should be described, if relevant to the sample. The criteria for this description is as follows:

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.

Calcium carbonate is a common cementing agent. The amount of calcareous material present in a sample can be classified according to the reaction with dilute hydrochloric acid. The classification is as follows:

Description	Criteria
None	No visible reaction.
Weak	Some reaction with bubbles forming slowly.
Strong	Violent reaction with bubbles forming immediately.

Weathering

The recognition and correlation of weathered zones can provide valuable clues for deciphering site stratigraphy. It is important to recognize, however, that soils, in the engineering sense, encompasses a wide range of materials, all of which represent various stages in the weathering of bedrock. Additionally, a clear distinction must be made between the weathering of transported superficial deposits and the in-place development of residual soils from a bedrock mass. The recognition and description of buried weathered zones is particularly useful in terrain characterized by transported soils and sediments.

Weathering involves two basic processes: mechanical disintegration and chemical decomposition. By decomposition, chemical changes take place that result in the dissolution and leaching of soluble materials. These changes are often manifested by changes in color and the development of zones of cementation that can be readily recognized in the field. Although weathering processes are strongly dependent on local (historic) climatic conditions and the physical and chemical characteristics of the parent materials, color can provide a general indicator of some important chemical weathering processes, such as oxidation, reduction, and hydration. It is also important to remember that the forces of weathering generally lose their intensity with depth below the land surface (at the time the weathering profile developed).

A good example of the effects of oxidation and hydration is the variations in the color of soils in the Southeastern United States (Buckman and Brady, 1969). Red soils are the product of the development of hematite, resulting from oxidation of ferrous oxide. As soils become hydrated, hematite is readily changed to limonite, resulting in a noticeable color change to yellow. When the products of hydration dry out, dehydration may occur and the reaction will reverse itself.

Interpretation based upon color and other field observations should be considered a preliminary interpretation, which may not necessarily delineate zones of past or present weathering.

Roots, Root Holes, Animal Burrows, or Other Macro-Pores

Any potential source of secondary porosity that could be significant in terms of the infiltration and movement of water or the migration of contaminants should be described. This may include root channels (relic or active); animal burrows (krotovinas); cracks related to desiccation and wetting, freezing and thawing, subsidence; or other features not discussed herein.

Odor

Odors should be described if unusual or organic. Soils containing sufficient amount of organic material usually have a distinctive odor. If the samples are dried, odor may be revived by wetting the sample.

2.3.5 Field Tests For Classifying Fines

Several tests can be performed in the field to help determine the plasticity, and hence the assignment, of a group name to a soil sample. These tests, which include the dilatancy test, soil thread test, toughness, dry strength, smear and stickiness, and the test tube test, are described below. Prior to performing these tests, particles larger than the No. 40 sieve (0.42 mm - medium sand and larger) should be removed.

Dilatancy Test

Select a representative sample approximately 0.5 cubic inch in volume and add water, if necessary, until the soil has a soft but not sticky consistency. Form a pat of the wet soil in the palm of one hand and shake it horizontally, vigorously striking the side of the hand with the other hand several times. Alternately squeeze and release the pat of wet soil. Note the rate at which water appears while shaking and disappears while squeezing. Materials that are predominantly silt will show a dull-dry surface upon squeezing and a glassy-wet surface upon releasing the pressure and upon shaking or vibrating the pat. With increasing clay content this phenomenon becomes less pronounced due to lower mobility of pore water. Rapid reaction to the shaking test is typical for uniform fine sand and diatomaceous earth, as well as for inorganic silts.

Soil Thread Test

Following completion of the dilatancy test, attempt to roll the test specimen into a thread between the palms or by hand on a smooth surface. Roll the sample into the smallest thread possible, adjusting the water content as needed. 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. If it is too dry, add water a few drops at a time, thoroughly kneading the soil to assure a uniform moisture content. Note the final minimum diameter attained before the thread breaks or crumbles.

The very fact that a soil can be rolled into threads indicates plasticity and the presence of clay. The smallest thread diameter possible without crumbling is indicative of the degree of plasticity.

Toughness

Fold the sample thread from the test above and reroll the sample into a thread about 1/8-inch in diameter. Repeat this procedure until the thread crumbles at a diameter of approximately 1/8-inch. The thread will crumble at a diameter of 1/8-inch when the soil is near the plastic limit (the boundary between the plastic and semi-solid state). Note the strength of the thread and the pressure required to roll the thread near the plastic limit.

After the thread crumbles, lump the pieces together and knead the sample until the lump crumbles. Note the toughness of the material during kneading.

The higher the degree of plasticity of the soil, the stiffer are the threads as their water content approaches the plastic limit and the tougher are the lumps as the soil is remolded after rolling. The distinction in the toughness of the threads can only be felt at water contents close to the plastic limit. The greater the number of times the soil can be rolled prior to reaching the plastic limit for soils started at the same water content, the more plastic is the material. Cohesive soils containing significant amounts of organic material or mica form threads that are very soft or spongy near the plastic limit.

Dry Strength

Mold the test sample to the consistency of putty, adding water if necessary. Shape the test specimen into a ball or angular fragment about 0.5 inch in diameter. Allow the sample to dry completely by air-drying, sun or oven, as long as the temperature does not exceed 60 degrees Centigrade. Test the strength of the fragment by crushing between the fingers. The dry strength increases with increasing plasticity. Occasionally, the presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strength. The presence of calcium carbonate can be detected with dilute hydrochloric acid. Silty fine sands and silts have about the same slight dry strength, however, they can be distinguished by the feel upon crushing. Fine sand feels gritty, whereas silt typically has the smooth feel of flour.

Smear and Stickiness

A high degree of stickiness and a very smooth smear in the natural state are indicative of high plasticity.

Although the primary basis for classification of fines is soil plasticity as discussed previously, the procedure described below for estimating the grain-size distribution of fine-grained soil components can also be helpful.

Test Tube Test

Silt and clay size particles may also be differentiated by determining their approximate settling rates in water. The settling rate may be measured in the field by shaking a small sample of the soil to be identified in a test tube, or an 8-ounce clear glass jar, filled with water and then allowing the particles to settle. The time required for particles to fall a distance of 4 inches is about 30 seconds for 0.074 mm size (the boundary between sand and silt) and about 50 minutes for particles 0.005 mm in size (the boundary between silt and clay). An approximate idea of the grain sizes present in a sample of fined-grained soil may be obtained by this method.

An additional aid in distinguishing silt and clay is by visual inspection under a hand lens. If grains are visible to indistinctly visible under 6.3x magnification, the sample is silt. If the sample has no visible grains under 6.3x magnification, then the sample is clay. Since most hand lenses

are equipped with 10x magnification, this method is approximate as some clay grains may be indistinctly visible under 10x magnification.

The above tests are approximate and may not correlate precisely to results of laboratory grain size or mineralogical analyses. The tests do provide a method for consistent field classification, however.

The use of all of these tests provides a more accurate determination of the fine-grained material present in a soil sample; however, some of these tests are time consuming and may not be practical in many field situations. At a minimum, the thread test and smear test should be performed. The dilatancy test should be performed whenever possible. If, however, a number of borings are to be drilled through a fine-grained stratum, it may be advisable to perform all of the tests on a few selected, representative samples of each distinct lithologic unit from different boring locations. The results can then be used as a benchmark for classification of samples collected throughout the field program.

2.4 FIELD CLASSIFICATION OF BEDROCK

The purpose of bedrock classification logs is to define subsurface conditions. It is important that classification provide a concise, consistent, and complete representation of subsurface conditions. The following sections discuss the outline for classifying bedrock encountered during a field investigation program. Bedrock classification must be performed by an experienced, professional TN&A geologist.

2.4.1 Rock Quality Designation(RQD)

The RQD is the total length of core pieces (unweathered bedrock) greater than or equal to four inches (10 centimeters) in length divided by the total length of the core run. RQD shall be expressed as a percentage and recorded in the PERCENT RQD column for each core run.

Care must be taken to correctly identify natural bedrock breaks from mechanical breaks (breaks caused by drilling). Mechanical breaks are often, but not always, accompanied by fresh bedrock appearance. Generally, natural breaks should first be considered as caused by a joint. Other natural breaks of the core may be due to:

- Irregular and rounded surfaces that reflect considerable grinding of the core due to rotation during drilling along a plane of weakness.
- Rather smooth surfaces that cannot be rejoined but which show no signs of weathering.
- Weathered surfaces.

Include all pieces of core which are greater than or equal to four inches (10 centimeters) in length and bounded by natural surfaces. As a general guideline, if a core segment can be rejoined with only a hairline separation, it should be included in computing the percent RQD.

2.4.2 Hardness

Hardness, or induration, shall be described per Table 1. If there is no specific column for hardness, it shall be included in the DESCRIPTION column.

2.4.3 Description

Bedrock core descriptions shall be recorded in the DESCRIPTION column for every core run. Consistency is important in describing the core. Describe the major petrologic aspects of the bedrock first. Add minor constituents as needed. Finally, describe structural features of the bedrock.

An acceptable order of description is described below.

Order of Description

The descriptive format begins with the bedrock type, which will be discussed in more detail below. A detailed description will be based upon ASTM standards. For consistency, the primary descriptive elements, listed below, should be included in all bedrock descriptions in the following standardized order:

- Bedrock type,
- Relative hardness,
- Density,
- Texture,
- Color,
- Weathering,
- Bedding,
- Stratification and structure,
- Rock quality designation,
- Other descriptive features, and
- Deposition environment.

Terms such as " AS ABOVE " and "AS BELOW" or drawing a continuous arrow down the drill log to indicate similarity in bedrock descriptions are <u>not acceptable</u> on classification log sheets.

Bedrock Type

The first item in the description should be the bedrock type. Be specific and use the major bedrock classification (e.g., sandstone, basalt, etc.)

When necessary, modify the primary bedrock type with a secondary characteristic descriptions (e.g., silty limestone or lime siltstone). All bedrock should be modified by grain or crystal size. Table 2 lists grain size classifications.

Hardness

If there is no specific column for hardness (Section 4.2) on the classification, it shall be included as part of the DESCRIPTION.

Color

Describe the color of the core when it is wet. The color shall be modified by using adjectives such as light, dark, mottled, or shades and tones of each other (e.g., grayish blue). As an alternative, the Geological Society of America or the Munsell color charts may be used. If color charts are used, the name of the chart should be noted on the log form.

Fracturing

The concentration and fracture spacing shall be described in accordance with Table 5. As an alternative, the observed fracture spacing may be listed on the log.

Bedding Thickness

Bedding thickness modifiers shall be classified in accordance with Table 4. As an alternative, the actual bedding thickness may be listed on the log. If there is no specific column for weathering (Section 2.4.8) on the classification log form, it shall be included as part of the DESCRIPTION.

Other Terms

Other observations are usually necessary to accurately describe the core. These observations should include zones where the core is very broken, where grinding of the core is apparent, cementation and/or friability, zones of mineralization indicating the minerals present, intervals where core samples have been taken for laboratory testing, etc.

2.4.4 Weathering

The degree of weathering shall be described using the following terms:

- Fresh - Crystals bright, joints rarely show staining. Bedrock rings with hammer if crystalline.
- Very slight - Some joints strained, some joints may show clay if open, crystals in broken face show bright. Bedrock rings with hammer if crystalline.
- Slight - Joints strained and discoloration extends into bedrock up to one inch. Open joints contain clay. Some feldspar are dull and discolored. Crystalline rocks ring with hammer.
- Moderate - Significant portions of bedrock show discoloration decomposition and disintegration. Most feldspars are dull and discolored; some show kaolinization. Bedrock

has dull sound with hammer and shows significant loss of strength as compared with fresh bedrock.

- Moderately Severe - all minerals except quartz are discolored or stained. All feldspars are dull and discolored and majority show kaolinization. Bedrock shows severe loss of strength and can be easily picked with a hammer. Dull sound with hammer. Decomposition and/or disintegration at least 50 percent.
- Severe - All minerals except quartz are discolored or stained. Bedrock fabric clear and evident, but reduced in strength to very dense soil. All feldspars kaolinized to some extent. Some fragments of strong bedrock scattered throughout.
- Very Severe - All minerals expect quartz are discolored or stained. Bedrock fabric discernible, but mass effectively reduced to soil with only fragments of strong bedrock remaining. Decomposition and/or disintegration 100 percent with structure/fabric intact.
- Complete - Bedrock reduced to "soil." Bedrock "fabric" not discernible or discernible only in small scattered locations. Quartz may be present as dikes or stringers. All minerals in relic form. Decomposition and/or disintegration 100 percent with structure/fabric destroyed.

If there is no specific column for weathering, it shall be included in the DESCRIPTION column.

2.4.5 Joint Spacing

All joints, fractures, bedding breaks, etc., should be depicted in Section A of the boring log at the exact depth they exist and the attitude they exhibit. Depending upon the classification log form used, the following information shall be provided:

- Maximum, minimum, and average joint spacing for each run. The maximum joint spacing is the length of the longest piece of core bounded at both ends by joint surfaces. The minimum joint spacing is the length of the shortest piece of core bounded at both ends by joint surfaces. Average joint spacing for each core run is determined by dividing the total length of all pieces bounded at both ends by joint surfaces by the total number of these pieces.
- Graphic illustration of joint pattern including orientation and a description of the joint surface (rough, smooth, shiny, dull, etc.).

2.4.6 Remarks

The REMARKS column should include pertinent information such as volume of gain or loss of water, the performance of in situ tests, the time each day's activities begin, tool drops, soft zones, cavities, core losses, secondary minerals, fossils, casing sizes and depths (if no specific space provided), ground water levels (if no specific space provided), artesian conditions, etc.

2.4.7 Notes

NOTES should include items which pertain to the entire drill hole such as the type of drilling equipment used, drilling contractor and personnel, approximate distance drill hole was offset from original location, project-specific bedrock profile symbols (final log only), bit changes, drilling rate, etc. Other information may warrant being recorded at the discretion of field personnel.

In the absence of a NOTES space, the above items should be included in the REMARKS column.

2.4.8 Abbreviations

Abbreviations should be kept to a minimum. However, when expedient, the abbreviations suggested in Table 6 may be used individually or in combination.

2.5 PROCEDURES FOR LOGGING EXPLORATORY BORINGS

2.5.1 General Requirements

All drilling logs shall be prepared in the field, as borings are drilled, by experienced geologists trained in geologic logging and interpretation of subsurface conditions. Each log shall be signed by the geologist. Entries shall be printed neatly in indelible ink. Printing should be dark enough for copying. As a general rule, abbreviations should not be used. When necessary, they should be kept to a minimum to avoid confusion. Abbreviations used should be defined in the log. All lines shall be drawn with a straight edge, not by free hand.

All general information blanks in the log heading shall be completed before drilling, including:

If surveyed horizontal control is not available at the time of drilling, a location sketch with references to measured distances from prominent surface features shall be included on the back of the first page of the log.

The borehole numbering system has been determined in advance to facilitate communications between field and office staff, and avoid inconsistencies between final boring logs and field documentation.

A note should be added to indicate the disposition of the borehole. For example, "Note: Installed 2.0 inch Schedule 40 PVC monitoring well. Screened interval 21.6 to 30.6 feet bls." or "Note: The borehole was abandoned by tremie grouted from 25.0 feet to the ground surface."

Upon completion, all blanks in the log shall be completed. If information for a particular blank is not applicable to that boring, then an "NA" will be inserted.

2.5.2 Description of Surface Conditions

Each drilling log should include a description of surface conditions in the vicinity of the borehole location. This should include geomorphic position (e.g., ridge top, swale, etc.), vegetative characteristics (e.g., prairie sage), and proximity to potential sources of contaminants (e.g., 20 feet south of petroleum underground storage tank, adjacent to drainage ditch, etc.).

2.5.3 Documentation of Drilling Procedures and Performance

The manufacturer's designation of the drill rig should be recorded on the boring log, including notation of the type of vehicle on which the drill is mounted (e.g., truck mounted, rubber tired all terrain vehicle, etc.). Sizes and types of drilling equipment used should be recorded on each boring log. This should include the diameters and lengths of samplers and other equipment. Depths at which drilling or sampling equipment are changed should also be included. The logs should show depths (in feet) and types of temporary casing used.

The behavior of drilling tools provides valuable information for interpreting geologic conditions and planning future drilling projects. This should include observations made by the driller or geologist. Occurrences such as changes in penetration rate and the degree of chattering of the bit provide indirect evidence of soil or sediment types and the depths of stratigraphic contacts. This information is particularly important when sample recoveries are low. Adjustments made to improve sample recovery should be noted. Any special drilling or sampling problems shall be recorded, including descriptions of problem resolutions. A good and continual rapport with the driller is essential to maximize the value of these indirect observations. The amount of water introduced into the boring and the amount not recovered must be noted on the boring log.

2.5.4 Sampling Data

Soil sampling data shall include the sample name, interval sampled, the type of sampler used, and the length of sample recovered for each sample collected. The interval over which sampling was attempted should always be recorded, even if no sample is retrieved. The logs shall clearly show the depth interval retained. If a scheduled sampling interval was 2 feet in length (24-inch split spoon) and due to refusal the total interval was not sampled, then the depth of penetration (e.g., 1.5 feet) becomes the sample interval. For example, if a planned sample interval was from 20 to 22 feet bgs and the split spoon was only advanced 1.2 feet, the recorded interval will be 20 to 21.2 feet bgs. Horizontal lines should be drawn across the appropriate columns at the scaled depths to document sampling intervals. Sample type may be identified using sequential numbers, with a prefix identifying the type of sampler used. Refer tot the Field Sampling Plan for sample nomenclature.

2.5.5 Description of Soils and Bedrock

Refer to Section 2.3 and 2.4 of this SOP.

2.5.6 Stratigraphic Contacts and Lithologic Changes

Identifying stratigraphic contacts and lithologic changes is a field responsibility. Changes in the nature of subsurface materials should be identified by a horizontal line at the appropriate scaled depth. A solid horizontal line should be used to denote the depth of distinct changes identified in samples or identified based upon drill advance. If a contact is gradational, or inferred between two consecutive but separated samples, a dashed line should be used. Inferred or gradational contacts should also be defined as such (e.g., write "inferred contact" or "gradational change"). If the actual depth between two separated samples is unknown, the contact line shall be drawn at half the distance between the samples.

2.5.7 Groundwater Observations

Logs shall identify the depth at which the geologic material is either dry, damp, or saturated, as described in Section 2.3.4 of this SOP. Record the depth to water observed in the borehole during, at the completion of drilling, and the stabilized depth to groundwater (whenever possible). Stabilized water level data shall include the time allowed for levels to stabilize. The absence of water in borings shall also be indicated. If a borehole is left open overnight, water level observations should be taken before leaving the site and prior to starting work the next day.

2.5.8 Environmental Field Measurements and Observations

Evidence of the presence of contaminants in samples or cuttings should be provided. Comments should describe any unusual discoloration, coatings (sheens), odors, or other potential evidence of contamination. The results of field headspace screening or other field screening test results should be included in the appropriate space in the boring log.

2.5.9 Borehole Stability

Logs shall identify any interval of borehole instability. Conditions such as running or heaving sands should be described, including the depths at which such conditions were encountered.

2.5.10 Quality Assurance

Key elements of QA applicable to borehole logging and characterization of subsurface conditions include:

- Planning/definition and communication of procedures and standards,
- Training/staffing,
- Independent review, and
- Laboratory testing of representative samples.

Planning should include review of available site-specific data and selection of appropriate logging criteria, based upon those data and project-specific requirements. Use of a log template with project specific headers will help minimize subsequent editing and facilitate log preparation in the field. As mentioned previously, the borehole/well numbering system should be established in advance. A kick-off meeting is recommended prior to the initiation of field activities to clarify project requirements.

The successful implementation of standards requires training and/or utilization of experienced staff. All staff responsible for borehole logging should review this SOP periodically as a reminder and a basis for continual improvement. At the onset, new staff should be accompanied by experienced personnel in the field until a reasonable level of proficiency is demonstrated. This will, of course, depend upon project specific considerations. Experience has shown that it is cheaper and more efficient in the long run to obtain accurate and consistent records in the field than to try to reconcile discrepancies after the work has been accomplished. In the field, logs should be reviewed on a daily basis to check for completeness and consistency.

Following completion of the field program, field logs should be reviewed and edited prior to preparation of final logs for presentation. The level of review should depend upon the experience level of field staff and project considerations. All logs should be checked for completeness, accuracy, and consistency between soil descriptions. Normally, this review should be performed by a trained and qualified person other than the project field representative(s). When using the USCS, detailed descriptions should be reviewed for consistency with USCS designations. Whenever possible, the review should involve detailed examination of representative samples in conjunction with the logs. It is helpful to lay samples out in a systematic manner, based upon site geology (i.e., based upon local depositional environments).

This process can provide a powerful tool for developing generalized descriptions of geologic units and interpreting site stratigraphy. This also provides a good opportunity to select samples for physical testing. Following completion of physical testing, field descriptions should be compared with test results. If the laboratory classification differs from the field description, the laboratory classification should be included on the final log, in addition to the field classification. It is also important to ensure that the results of laboratory tests are routed back to field personnel to provide a basis for improvement.

Final logs may be edited for presentation to eliminate redundancy. If appropriate, a disclaimer, such as that presented below, should be added to the final log:

> "This log may be an edited version of the field log, incorporating laboratory data and interpretations/correlations based upon in-office review. Additional information that may be contained on the field logs is available upon request."

"Interpretations" provided on final logs should be based upon observations and factual data documented on the original field log. Edited copies of original field logs should be placed in the file for future reference. In addition to technical information, each log should include the

complete job number, client name, project location, name of the drilling contractor, name of the field representative, name of the reviewer, drilling dates, and date edited.

3.0 REFERENCES

American Society for Testing and Materials (ASTM), Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils, ASTM Designation: D 1586, 1984 (Re-approved 1992).

ASTM, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM Designation: D2487-93, 1993a.

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Buckman, H.O. and Brady, N.C., The Nature and Properties of Soils, 1969.

EnNovative Technologies, Inc., EnCore Sampler sampling procedures, Green Bay, Wisconsin.

Travis, R.B., Classification of Rocks, Colorado School of Mines Quarterly, vol. 50, no. 1, 1955.

U.S. Environmental Protection Agency Region IV, Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods, April 1984.

U.S. Environmental Protection Agency, Description and Sampling of Contaminated Soils: A Field Pocket Guide, 1991.

U.S. Environmental Protection Agency Region IV, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Environmental Services Division, May 1996.

TABLE 1

BEDROCK HARDNESS TERMS

DESCRIPTIVE TERMS	DEFINING CHARACTERISTICS	
Extremely Soft	RO	Indented by thumbnail
Very Soft	R1	Crumbles under firm blows with point of geologist's pick, can be peeled with pocket knife
Soft	R2	Can be peeled with pocket knife with difficulty, shallow indentations made by firm blows of geologist's pick
Average	R3	Cannot be scraped or peeled with pocket knife, can be fractured with a single blow from a geologist's hammer
Hard	R4	Requires more than one blow with geologist's hammer to break into pieces with sharp edges
Extremely Hard	R6	Can only be chipped with geologist's hammer

All personnel must refer to the TN&A Safety Policies and follow Safety Procedures before and during handling potentially hazardous and contaminated soil or bedrock.

TABLE 2
GRAIN-SIZE CLASSIFICATION

PARTICLE DIAMETER (mm)	SEDIMENTS (SOILS AND UNCONSOLIDATED BEDROCK)	CONSOLIDATED BEDROCK
256 or more (10 inches or more)	Boulder	Boulder conglomerate
64-256 (2.5 to 10 inches)	Cobble	Cobble conglomerate
4-64	Pebble	Pebble conglomerate
2-4	Granule	Granule conglomerate
1-2	Very coarse sand	Very coarse sandstone
0.5-1	Coarse sand	Coarse sandstone
0.25 -0.5	Medium sand	Medium sandstone
0.125 - 0.25	Fine sand	Fine sandstone
0.625 - 0.125	Very fine sand	Very fine sandstone
0.4- 0.0625	Silt	Siltstone
0.4 or less	Clay	Claystone or shale

TABLE 3

BEDDING THICKNESS BEDROCK DESCRIPTION

THICKNESS (English)	THICKNESS (Metric)	BEDDING CLASSIFICATION
Over 3.3 feet	Over 1 m	Very thickly bedded
3.3 feet - 1 foot	1m - 30 cm	Thickly bedded
1 foot - 4 inches	30cm - 10cm	Medium bedded
4 inches - 1 inch	10 cm - 3 cm	Thinly bedded
1 inch - 2/5 inch	3 cm - 1 cm	Very thinly bedded
2/5 inch - 1/8 inch	1cm - 3 mm	Laminated
1/8 inch - 1/32 inch	3mm - 1mm	Thinly laminated
less than 1/32 inch	less than 1mm	Microlaminated

TABLE 4
FRACTURE SPACING
DESCRIPTION OF BEDROCK

BEDROCK DESCRIPTIVE TERMS	FRACTURE SPACING
Very broken	Less than 1 in.
Broken	1 in. to 3 in.
Slightly broken	3 in. to 6 in.
Massive (unbroken)	6 in. and greater

TABLE 5

SOIL AND BEDROCK LOGGING ABBREVIATIONS

/	And
@	At
Abdt	Abundant
Ang	Angular
Blk	Black
Brn	Brown
Calc	Calcareous
Cgr	Coarse Grained
Cly	Clay
Dk	Dark
Fgr	Fine Grained
Frg	Fragments
Gfy	Gray
Grn	Green
Intbd	Interbedded
Lam	Laminated
Lt	Light
Mrg	Medium Grained
Slt	Silt
Snd	Sand
TD	Total Depth of Boring or Drill Hole
Tr	Trace
V	Very
w/	With
w/o	Without
Wh	White
Yel	Yellow

STANDARD OPERATING PRACTICE TNFLD005B

Field Screening Methods and Procedures

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 2

2.0 SOIL HEADSPACE (VOLATILE VAPORS) SCREENING 2

2.1 OBJECTIVE 2
2.2 PROCEDURES 2

3.0 FIELD SCREENING TEST KITS 3

3.1 OBJECTIVE 3
3.2 BACKGROUND 3
3.3 PROCEDURE 4

4.0 REFERENCES 5

STANDARD OPERATING PRACTICE TNFLD005B

Field Screening Methods and Procedures

1.0 INTRODUCTION

This SOP presents information regarding methods and procedures to conduct field screening of hydrogeologic and geochemical site parameters. The data provided by these methods are not considered of a quality sufficient to meet regulatory requirements regarding site characterization and/or closure, but are used for gross delineation of the extent of contamination and to gain efficiency in the location of permanent monitoring wells and sampling locations.

2.0 SOIL HEADSPACE (VOLATILE VAPORS) SCREENING

2.1 OBJECTIVE

The objective of this section of the SOP is to provide information regarding procedures to be employed primarily for the screening of soil headspace (volatile vapors) in the field. Every soil sample collected will have headspace screening performed and the results recorded. The data provided by this method will be used for gross delineation of the extent of contamination and to gain efficiency in the location of sampling locations. Additional matrices may also be screened using the following procedures..

2.2 PROCEDURES

Soil samples will be screened for VOCs in the field at the time of sample collection. Field screening shall utilize an organic vapor detection instrument equipped with either a photo-ionization detector (PID) or a flame-ionization detector (FID). Typically, TN&A will use a Photovac 2020 PID for field screening activities. If a high humidity condition exists during the time period when field activity is to be performed, a hydrophilic filter will be utilized with the PID. Alternatively, an FID may be used under these conditions. The ionization potential of the lamp for the PID shall be optimum for the contaminants of concern (typically 10.6 ev for petroleum hydrocarbons and other volatile organic compounds). Personnel shall perform field screening using the following procedures:

1. Immediately upon opening the sample collection device (e.g., split-spoon sampler) and after collecting the volatile organic sample for laboratory analysis (if required), a representative portion of the sample shall be collected. The field screening sample will be placed in a clean, contaminant-free resealable plastic bag or 4-ounce or larger glass jar tightly covered with aluminum foil.

2. Vigorously agitate the sample bag or jar for at least 15 seconds and then allow a minimum of 15 minutes (or as the environmental conditions dictate) for the sample to

adequately volatilize and equilibrate to ambient temperatures. During cold weather, the samples should be warmed in field vehicle for 15 to 20 minutes prior to taking the headspace measurement.

3. Following the waiting/warming period, agitate the bag or jar. The headspace is sampled, with an FID/PID in survey mode, by unsealing the bag (or puncturing the aluminum foil) and inserting the FID/PID tip into the headspace while taking care not to push the probe into the soil. The reading is then recorded in the Field Logbook and on the lithologic log.

Note: If the volume of sample recovered is insufficient for all analytical requirements, then the material used in the headspace readings could be utilized for any non-volatile sampling requirements (e.g., the headspace material could be used to fulfill the geotechnical or total organic carbon sample requirements).

Note: Samples with very high headspace concentrations can take the instrument out of calibration. After high headspace readings, observe the instrument's reading in ambient air. If the instrument is slow to return to zero then it must be recalibrated. See SOP No. 011A for quality control procedures for field equipment.

This procedure may also be utilized for other sample matrices (e.g., sediment, groundwater, and waste). If taking a headspace reading of a liquid sample, it is essential that a hydrophilic filter be used with the PID and that the reading be taken in such a way that fluid is prevented from being taken up into the instrument. Unless specifically provided for in the project-specific Sampling and Analysis Plan (or comparable document), it is best to avoid field screening liquid headspace samples due to the risk of damaging the instrument.

3.0 FIELD SCREENING TEST KITS

3.1 OBJECTIVE

This section provides information regarding procedures to be employed for the proper operation of field screening chemical test kits. In general, each test kit will include specific instructions for the field analysis of particular compounds or classes of compounds.

3.2 BACKGROUND

Field screening data provide investigators with data that can be used to make decisions regarding location and number of samples for off-site laboratory analyses, rather than making decisions based on random sampling grids or hypotheses. Data provided by field screening often allow investigators to reduce the number of samples required for off-site analysis by an analytical laboratory. Screening procedures allow sampling personnel on-site to adjust their collection of samples in and around the areas of concern, identified in the field using the screening data, thus eliminating numerous background samples. The use of screening kits must be pre-approved by

the TN&A Project Manager and possibly the Client Representative. These must be described with the associated QC requirements in the Contractor's approved QAPP.

Three types of screening kits that may be employed are immunoassay kits, the Hanby kit, and Hach II (or similar) test kits. These three test kits are described briefly below:

Immunoassay kits have been developed to be selective to one type of chemical compound. The advantage of immunoassay is in its accuracy, usability, and selectivity to a specific class of compounds (e.g., fuels, chlorinated solvents, polychlorinated biphenyls [PCBs]) even when a mixture of these compounds is present. The disadvantage of immunoassay is it will not detect contaminants in a sample that are not specific to the kit selected, as stated above. This type of kit is most effective at a location where the types of contamination have been narrowed down to a limited number. Matrix interferences may reduce accuracy of results. Follow manufacturer's instructions carefully. It is best if field staff using immunoassay test kits have formal training in their use and application.

The Hanby kit is capable of detecting aromatic compounds in soil and/or water that are typically found in fuels. In this kit, a chemical reaction produces various colors that are specific to the type of aromatic compound present. This kit is capable of identifying the type of fuel present and its concentration semi-quantitatively; however, aromatic mixtures may produce less identifiable results.

Hach II (or equivalent) test kits are designed to test water quality parameters such as ferrous iron, sulfate, alkalinity, or other parameters. This type of test kit involves placing the sample fluid in the test kit container and reading a colormetric response in comparison to a provided color chart. The colormetric response is then recorded on sample log form or in the field logbook.

3.3 PROCEDURE

The immunoassay, Hanby, and Hach II testing kits have analytical procedures provided with each kit to allow the technician to perform them accurately. The procedures that are required for each field analysis must be followed to produce correct and repeatable results. Follow test kit instructions and record results in the field log book or field form, where applicable. Additional quality control measures include the analysis of duplicate samples and split samples as recommended by the manufacturer or as required by the project-specific Sampling and Analysis Plan and Quality Assurance Project plan.

Water quality parameters are analyzed immediately following sample collection. Each field analysis will be performed in the field, at the sample collection point, immediately after sample collection using the appropriate field test kits.

4.0 REFERENCES

U.S. Environmental Protection Agency, *Field Measurements Dependable Data When You Need It*. EPA/530/UST-90-003.

U.S. Environmental Protection Agency, SW 846, *Test Methods for Evaluating Solid Waste, Headspace Method 3810.*

STANDARD OPERATING PRACTICE TNFLD004A

Land Surveying Techniques (including GPS)

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 2
2.0 TERMS/DEFINITIONS 2
3.0 SURVEY CONSIDERATIONS 3
4.0 PROFESSIONAL SURVEYING 5
4.1 OPTICAL SURVEYS USING LICENSED SURVEYORS 5
5.0 FIELD SURVEYS BY SITE PERSONNEL 6
5.1 OPTICAL SURVEYS USING SITE PERSONNEL 7
5.1.1 Site Surveys Using Transit Type Survey 7
5.1.2 Preliminary Site Surveys Using Pocket Transit and Tape 8
5.2 GLOBAL POSITIONING SYSTEMS (GPS) SURVEYS 9
5.2.1 Absolute Methodology (High-Accuracy, High-Precision Surveys) 9
5.2.2 Relative Methodology (Relative Accuracy, High Precision) 13
6.0 REFERENCES 17

STANDARD OPERATING PRACTICE TNFLD004A

Land Surveying Techniques (including GPS)

1.0 INTRODUCTION

Professional land surveyors licensed in the state where the project is being performed will conduct all surveying. This procedure is to provide familiarity only. Surveying is described as the art and science of determining the area and configuration of portions of the earth's surface and representing them on maps. Generally, surveying can be divided into two categories or classes: vertical control surveying and horizontal control surveying. Vertical control surveying involves the measurement of the relative difference in vertical location, or elevation, of two or more control points. Horizontal control surveying pertains to the measurement of the relative difference in the horizontal location of two or more control points. This Standard Operating Practice (SOP) includes a discussion on the standard procedures and techniques required to survey or locate sample points or site features. Basic surveying and field geology textbooks will be consulted for more detailed information on this topic.

Surveying will involve field measuring the relative horizontal locations of site features and sampling points, and running vertical control to determine absolute or relative elevations.

2.0 TERMS/DEFINITIONS

The following terms are defined in this section:

Reference Point	A fixed point that will not change that can be used as a point from which all measurements in the area will be made.
Benchmark	A reference point that has been permanently or temporarily installed by a surveyor.
State Plane Coordinates	The northing and easting footage coordinates established by the State.
National American Vertical Datum (NAVD)	This is the established sea level datum for all surveys in the United States
Backsight (BS)	This is the height measurement that the telescope portion of the level is above a point with a known or assumed elevation.
Instrument Height (HI)	This is the elevation of the level's telescope as determined from the BS and the point of known elevation.
Foresight (FS)	This is the height measurement of the level's telescope above the point whose elevation is required. Thus, the point's elevation can be determined.

Turning Point (TP)	This is a point where both FS and BS readings are required because the instrument needs to be moved. This is so elevation references are also transferred with a single survey.
Level or AutoLevel	A small telescope set on a four-screw base with a leveling bubble.
Tripod	A three-legged platform on which the level is set. The legs are extendible individually.
Level Rod	A 15-foot extendible rod that has 0.01-foot divisions.

3.0 SURVEY CONSIDERATIONS

The necessary accuracy, precision, and scale of the survey are major factors in determining which type(s) of surveying method(s) used.

Standard nomenclature for survey accuracies are first-, second-, third-, and fourth-order surveys. First-order surveys are the most accurate and fourth-order the least accurate. The bases of this nomenclature are traverse, triangulation, or circuit length and resultant error for azimuth and level. Individuals considering surveys are encouraged to review appropriate literature for more information. Precision depends on the survey equipment and the survey method. Note that the survey may be precise yet not accurate. Decisions on accuracy and precision should be based on data use. Criteria for groundwater studies are typically more stringent for level than for azimuth. It may be appropriate to use precise, moderately accurate surveys (relative elevation surveys) for small-scale groundwater surveys. As the scale of the survey increases, the need for accuracy will increase, and the need for precision may or may not decrease.

There are multiple azimuthal coordinate systems that may be in use at a given site. The four most common coordinate systems are the North American Datum 27 (NAD 27), NAD 83, State Plane Coordinate 27 (SPC 27) and SPC 83. Be aware the federal government is altering many first-order locations from NAD 27 to NAD 83. Data in any given survey may be in any of these coordinate systems or a mix of two or more systems. It is necessary to convert data from surveys containing multiple coordinate systems such that all data are in one coordinate system. This is particularly true if GPS data are integrated into a standard optical survey. Most GPS data are presently generated in the NAD 83 coordinate system. The majority of land-based optical surveys are in the SPC 27 format. Care should be taken to establish the coordinate system to be used for project purposes.

There are also several vertical datum. Datum in common use are mean sea level (MSL), National Geodetic Vertical Datum of 1929 (NGVD 1929), and National Geodetic Vertical Datum of 1983 (NGVD 1983). Note that the two NGVDs are based on a geocentric model (geoid) that is approximated by an equipotential gravimetric surface equivalent to MSL in the absence of local gravimetric variations.

Elevations (orthometric height) are the distance above or below this geoid. In the past, elevations were developed from triangulation to first-order points. Currently, new elevations are being established that are based on a geoid model. Orthometric heights derived from triangulation and those developed from geoid height at a specific location may differ.

The discrepancy between an optical survey orthometric height and a GPS orthometric height must be resolved such that the data sets for the two surveys are compatible. Methods for this resolution may be absolute determination of the elevations or relative solutions that use existing elevations to adjust GPS-derived elevations. Decisions on whether to use an absolute methodology or a relative methodology will depend on the DQOs.

Integrating several small-scale optical surveys into a larger-scale survey illustrates the problems inherent with old triangulation or traverse surveys. It is not unusual that adjusted azimuthal location and elevation for a given point vary if that point is included in two different survey loops. This is true even if the closure error is acceptable in the separate survey loops. The cause of this difference may be related to incompatible control points. This problem is difficult to solve with conventional land-based optical surveys because of the differences in scale, base line, and uncertainty as to which control point or points are inaccurate. The problem can be resolved with a GPS survey. If a large-scale baseline network is established with a GPS survey, all subsequent surveys may use this network. Essentially, the entire survey is at the same scale and uses the same control points.

Aerial survey flyovers may exist for the subject site even if no aerial survey map has been developed. If the intent of an aerial survey is development of contours or a base map, additional flyovers may not be required. If the intent of the aerial survey is to resolve discrepancies of multiple ground optical surveys or to locate specific small points at the subject site, an aerial survey flyover will be necessary.

Regardless of the type of survey conducted, additional problems may occur when attempts are made to plot the surveyed locations on existing maps or other figures. The most common reason for this difficulty is that accuracy criterion for a base map may not be as stringent as is required for the site survey. The plotted location of major features of the base map, such as roads and buildings, may be 40 to 50 feet (ft) from the true location. Consequently, it has been common to manually "move" the plotted location of the surveyed positions to conform to the base map. This may not be acceptable, particularly if a Global Information System (GIS) or other type of relational database is being used or may be used on the project. As possible, the locations of selected major features of the site should be surveyed during the site survey. Surveying these major features will allow adjustment of the base map or allow relatively precise relational plotting of other site features.

4.0 PROFESSIONAL SURVEYING

4.1 OPTICAL SURVEYS USING LICENSED SURVEYORS

1. Provide the selected surveyor with project requirements for precision, accuracy, and coordinate system.
2. Recommended precision is ±1.0 foot (ft) for azimuthal position and ±0.01 ft for orthometric height (elevation).
3. Accuracy is dependent on site conditions, available control points, and survey scale. Recommended accuracy for small-scale surveys is:

   $$\pm 0.05 \text{ to } 0.1 \text{ ft} \times (\text{traverse distance in miles})^{1/2}$$

   for orthometric height and closure error better than 1/5000 for azimuthal position.
4. Recommended control points should be from established second-order or better points. Lesser order control points may be used if the error from a second-order control point to the lessor order control point is known and is included as part of the survey data.
5. Data on control points must be provided with survey data. Data should include position and a description of the control point.
6. For surveys using different traverse loops and different control points, it is recommended that the traverse include at least one common point between the traverses.
7. It is recommended that the survey include significant features such as roads and buildings to allow plotting of correct spatial relationship of site features on site base maps.

The surveying firm should be licensed in the state where the work will be performed. The licensed surveyor should survey the horizontal and vertical locations of all sampling points as well as important site features. For the monitoring wells, the elevations of both the marked top of the well casing (measuring point) and the ground surface will be surveyed. For the soil and other sampling locations, the horizontal coordinates and the elevations of the ground surface will be surveyed.

The coordinates will be to the closest 0.1-foot and referenced to the State Plane Coordinate System. Elevations to the closest 0.01-foot will be referenced to the North American Vertical Datum (NAVD) of 1988.

The procedure that will be followed in this survey work, outlined below, has been developed to ensure that quality assurance is in place. This will apply to both the fieldwork as well as the processing of the gathered data.

Prior to mobilization, the survey team will be provided with a listing of the well identification numbers assigned to each well to be surveyed. In order to avoid any confusion, a number of the wells will be identified in the field and referenced to an existing structure/landmark. The survey crew will also have to determine where are the closest two or three monuments/benchmarks from

where they can tie into the above referenced coordinate and elevations systems. Once these points are found, a traverse will be run to at least two of the points from a temporary benchmark established by the survey crew near the wells. Each of these traverses will have to be within variance noted above, otherwise new traverses will have to be run to determine the coordinates and elevations of this temporary benchmark.

The most efficient and accurate way to survey these wells will be using a GPS or a total station with a data collector. The gathered data for each surveyed well will be saved in the data collector and labeled with the appropriate well identification number.

Prior to demobilizing from the site, the survey crew will confirm that all the wells have been surveyed, and the data saved in the data collector is complete.

Once the data from the surveyed wells is downloaded from the data collector, the survey crew chief will review to ensure that the initial plot appears to be accurate and complete. In addition, any loops run between various wells will be checked to ensure that the variance noted above has not been exceeded.

If any errors are found which required a return to the site, prior to using the temporary benchmark as the basis for additional survey, traverses will have to be rerun to each of the points to ensure that the temporary benchmark has not been moved.

The final product to be submitted will be provided in both plan form as well as in an Microsoft Excel spreadsheet, showing the well identification number along with the coordinates and elevations for each well.

5.0 FIELD SURVEYS BY SITE PERSONNEL

These types of surveys are recommended as continuing field activities. They facilitate development of real-time data that foster correct placement of sampling points, allow early determination of site-specific groundwater flow direction, provide data for timely interpretation of site conditions, and allow early detection of anomalous data that may affect site activities.

The two most common types of field surveys are surveys using conventional optical equipment and surveys using GPS methodologies. The accuracy of field surveys using optical equipment is generally low and precision is high. This type of survey is applicable only to small-scale surveys, and the data may or may not be compatible with larger-scale surveys.

The precision of GPS type surveys is generally high. Techniques and equipment inherent to the technology result in the high precision. As a general rule, the accuracy of GPS surveys is either very poor or very good. The difference between a good survey and a poor survey depends on the use of a control network. The use and/or development of a control network will result in a survey that is compatible over many points at large distances.

5.1 OPTICAL SURVEYS USING SITE PERSONNEL

5.1.1 Site Surveys Using Transit Type Survey

1. Identify a control point(s). The control point(s) may be from a previous survey or an arbitrary point chosen for the site survey. The control points must be permanent features to which the survey can be related. Possible points may be existing wells, building corners, fire hydrants, survey monuments, etc. Enough control points should be chosen such that the interrelationship of all survey points can be established from the survey data.

2. Set up the optical sighting instrument (transit, engineers level, total station) at a location from which one or more control points, turning points, and/or points of interest can be surveyed. Ideal locations may be available from which all control points and points of interest can be surveyed in a single setup. If additional instrument setups are necessary, it is required that consecutive setups are within view of at least one common point: the turning point. If turning points are required, it is recommended that points of interest be used as turning points if possible.

    a. Level sighting instrument and ensure correct orientation of instrument base to azimuthal coordinate system to be used for the survey. All additional setups must use identical azimuthal orientation.

3. Record instrument location and instrument height.

4. Position and plumb sighting target on control point or other points of interest within range of the optical limitations of the sighting instrument. Grade or stadia rods may be used.

5. Sight on target with the sighting instrument. Record target elevation reading and sighting instrument azimuthal position reading. If a transit and stadia rod or a total station is used, record vertical declination and distance to target.

6. If a transit and grade rod or an engineer's level is used, tape or chain the distance between the sighting instrument and the target. Record the measured distance.

7. Complete steps 4 through 6 for all targets within the range limitations of the sighting instrument. If common targets are in view from subsequent sighting instrument locations, it is recommended that the common targets be surveyed from each location.

8. If necessary, move sighting instrument to new location and set up. Repeat steps 2, 2a, 3, and 7.

9. Repeat steps 7 and 8 as many times as required to survey all points of interest.

10. If two or more instrument setups are necessary to survey all points, a closure traverse must be performed. If a closure traverse is necessary, it is recommended that the survey route be chosen such that a traverse closure can be accomplished with a minimal number of setups.

11. Before leaving the site, reduce the raw survey data and check for survey error. If the scale of the survey dictates multiple days in the field, it is recommended the data be reduced daily. If errors are identified, that part of the survey that is affected by the error must be resurveyed.

12. Recommended precision is ±1.0 ft for azimuthal position and ±0.01 ft for orthometric height (elevation).

13. Accuracy is dependent on site conditions, available control points, and survey scale. Recommended accuracy for small-scale surveys is ±0.05 to 0.1 ft x (traverse distance in miles)$^{1/2}$ for orthometric height and closure error better than 1/5000 for azimuthal position.

5.1.2 Preliminary Site Surveys Using Pocket Transit and Tape

A low-precision survey may be used during the early stages of a project to initially identify points of interest. This type of survey may be used to stake borings or to develop preliminary site maps. Accuracy and precision will be low.

1. Identify a control point(s). The control point(s) may be from a previous survey or an arbitrary point chosen for the site survey. The control points must be permanent features to which the survey can be related. Possible points may be existing wells, building corners, fire hydrants, survey monuments, etc. Enough control points should be chosen such that the interrelationship of all survey points can be established from the survey data.

2. Stand with leveled pocket transit at the control point and sight to the point(s) of interest.

3. Sight on target with the sighting instrument. Record target azimuthal position reading.

4. Elevations may be established using a Jacobs staff or the inclination vernier on the pocket transit.

5. Measure and record distance to point of interest.

6. Continue steps 2 through 5 until all available points of interest have been surveyed from the initial control point.

7. Repeat steps 1 through 6 at additional control points if necessary. If two or more control points are used, it is necessary to survey some identical points of interest from both control points to allow tying of the survey between control points. It is recommended that the control points be in view of each other and that a direct relationship between the two points be established.

8. Measure and record the line-of-sight distance between as many of the points as possible. This process is a check on the survey and allows fixing the points by a method other than the pocket transit. (If a pocket transit is unavailable, the measurement of the distances only will allow a crude map to be formed. It is necessary to have two distances to any single point to spatially fix that point.)

9. Plot all data in field and field check the plot.

5.2 GLOBAL POSITIONING SYSTEMS (GPS) SURVEYS

5.2.1 Absolute Methodology (High-Accuracy, High-Precision Surveys)

The term "absolute methodology" is developed specifically for this procedure. It is a high-accuracy, high-precision survey suitable for large-scale sites at which the integration of data sets across the site benefit from normalization to a common reference plane. It is recommended for projects that may benefit from use of a GIS system or at sites that would benefit from a normalization of survey data to a common reference plane. This type survey sets up a control network to which all subsequent GPS survey work can be integrated. Consequently, the survey data forms one survey data set that is intrinsically compatible between all points. Subsequent to establishment of the control network, optical surveys may also use the control network. Use of the GPS control network, as benchmarks by a conventional optical survey will result in data from the optical survey that is compatible with the GPS survey data.

1. Review site conditions and generally identify overhead obstructions that could obstruct line of sight to satellites. If excessive obstructions exist, consider nearby locations for receiver setup. Degree of obstructions may dictate the type of receiver that will be used. Dual-frequency receivers require between 1 and 5 minutes (min) of observation time to achieve position. Single-frequency receivers may require 1 hour (hr) of observation time. Problems with obstructions may also be overcome if observations are conducted during periods of low Dilution of Precision (DOP). DOP decreases as the number of satellites in view increases.

2. Identify as many high-accuracy GPS control points as possible within 20 miles of the area to be surveyed. National Geodetic Service (NGS) Federal Base Network (FBN) and densification points should be identified. Contact the NGS for points in the vicinity of the study site. Points contained in the FBN are "B order" points [accurate to 8 millimeters (mm) and 1 ppm baseline length]. These high-accuracy points are preferred as the basis for a site network for the survey. In some instances, only densification points may be within range of the site. If so, the densification points are an acceptable basis for a control network.

3. Contact state and/or county agencies in the vicinity of the site for information concerning conventional survey control points. Typical agencies that may provide information include highway departments and civil engineering groups. (Governmental agencies will typically provide a map with plots of control points and description of the points.) It is not unusual to identify multiple first-order control points within 10 miles of the survey area. Survey points from previous surveys at the site may or may not be acceptable. Conventional survey control points will relate to the GPS control network and will provide the basis for adjusting optical survey data to the reference plane defined by the GPS control network.

4. Design a site control network and determine control point occupation sequence to maximize receiver use and network stability. The network should be composed of primary and secondary control points.

a. Use NGS FBN or densification points as primary control points. These points will be used to control the network during fixed network adjustments.

b. Identify location at which secondary control points will be established. Secondary control points should be chosen to facilitate GPS survey activities. The secondary control points will be used to form a geometric network of points that will be used to adjust survey data to a common datum. Consequently, the secondary control points must form a network with intrinsic geometric stability. The optimal network is formed of interlocked triangles. The stability of this type of network is best when the angles formed between the secondary control points are not extreme. The ideal network would be an equilateral triangle. The network will most probably be formed with a series of triangles. The use of a stable network will provide a solid basis for surveying of additional site features.

c. The network should include at least three occupations of secondary control points to establish the knowness (accuracy) of those points for future work. At least one occupation of each secondary control point should be simultaneous with occupation of a primary control network point. This will allow ties to the primary control network.

5. Obtain satellite availability software for those days on which the survey will be conducted. This software and updates are typically available from receiver vendors.

6. Obtain geoid model program and coordinate transformation program. Both programs are public domain and available from NGS.

7. Determine type of receiver to use. It is recommended that a 12-channel or better receiver be used. Single- or dual-frequency receivers may be used. Dual-frequency receivers typically provide best results and require less occupation time to provide acceptable precision.

8. Set up computer with appropriate software including applicable data post-processing software, geoid model files, and coordinate translation programs. Include geoid model files in the directory stipulated by the GPS software manual. Include discrete directories for raw data, processing files, output, conversions, and network adjustment. Subdirectories are recommended. A survey of 100 points may easily develop 1000 files. Logical use of directories and subdirectories will allow coherent backup and archiving of files.

9. Establish a survey point nomenclature scheme. The scheme must be compatible with the file nomenclature inherent to GPS processing software. Typical GPS software will truncate survey point nomenclature and append some type of designator to the truncated survey point nomenclature to create file names. Consequently, it is imperative that those portions of the survey point nomenclature that will be superseded by the software file name not be significant identifiers.

10. Check condition of receivers. Two receivers are required. Charge batteries. (Typical single battery charge lasts less than 4 hr. Multiple batteries may be required for each receiver or alternate power sources used.)

11. If receiver operators are unfamiliar with the specific type of receiver to be used in the survey, set up and operate receivers to ensure correct operation. Download receivers and test process data.

12. Run satellite availability and DOP software to ensure adequate satellite coverage and DOP does not exceed acceptable limits during point occupations. Provide copies of charts to receiver operators. Note: Most GPS planning software will allow obstacle masks to be included in the DOP calculations. If obstacles identified in step 1 are input, ideal times for occupations can be established. This is not a problem with most locations but may be a prerequisite for successful occupation of problem points. If access is difficult, this may significantly affect the quality and/or time required to complete the survey.

13. Begin collecting data for control survey. Set up receivers on primary and secondary GPS control points according to network design developed in step 4 of this procedure and according to restrictions imposed by DOP.

14. Set up receiver at survey point according to manufacturer's specifications.

    a. Level and plumb each receiver over survey point. A fixed-height bipod is recommended for surveys involving only points at ground surface. A tripod may be necessary for locations at which several points of varying elevation are required, such as wells. At wells, it is recommended that the receiver be plumbed over the top of casing (TOC) on a tripod. It is generally acceptable to derive ground elevation, casing elevation, etc., from physical measurements made from TOC.

    b. Turn on and set up receiver as specified by manufacturer. In approved logbook, record the following information: site identification, time, operator identification, antenna height, satellites locked on to by the receiver, azimuthal position of locked satellites, elevation of locked satellites, health of the locked satellites, and elevation mask used.

    c. Ensure a minimum of four satellites are locked. Review satellite azimuth and elevation and determine the satellites will remain in view for the anticipated survey point occupation time. If occupation lasts for extended periods, satellites locked at the initiation of the occupation may not remain locked throughout the occupation. Review DOP charts to ensure DOP is acceptable for site occupation. Better DOP will be achieved if more than four satellites are locked.

    d. Occupy site for time required by type of receiver used and the DOP imposed by satellite configuration and site obstructions. This may vary from 2 min to several hours.

    e. After the required length of site occupation, prepare the receiver for the move to next survey point. Depending on survey type (static, rapid static, or kinematic), this may or may not involve turning the receiver off. Follow manufacturer's specification.

15. Repeat steps 14 through 14e until the day's activities are complete.

16. Continue daily activities until occupations developed in the control network design are complete.

17. Download data from receivers daily or more often if memory capacity or number of files capacity of the receiver dictate frequent downloading.

18. Process vector data between survey points. Follow software documentation. Maintain integrity of raw data in separate directory.

19. After sufficient vectors have been processed to conduct a meaningful network adjustment, run the control network adjustment.

    a. Initial network adjustments should be performed as free adjustments. Do not specify the knowness of points and do not correct known point coordinates to published values. Include only GPS-derived coordinates in the network adjustment. Do not use conventional optical survey control point coordinates to constrain the network.

    b. After satisfactory free network adjustment is complete, perform a constrained network adjustment. For known GPS coordinates (NGS FBN and densification points), alter the free network coordinates to the published coordinates. Specify knowness of these points. It is recommended that the constrained adjustment be performed in an iterative manner. Use FBN coordinates first and allow other coordinates to vary to that constraint. Review results of initial iterations and further constrain the network as indicated by the results.

    c. After the constrained control network is finished, the control network is complete. The control network is the common plane to which all additional survey work will be related. Change the knowness of all the points in the control network to a high knowness. These values are considered fixed for network adjustments performed with the control network.

    d. Include optical survey points that have been surveyed with GPS in the network. Do not constrain the network with published optical survey coordinates. Allow the GPS values of the optical survey points to vary to the constrained control network.

    e. Review the published optical survey coordinates and the corresponding GPS network coordinates. The difference between the coordinates is the variation of the surveys. If desired, the GPS survey can be changed outside of the network to be compatible with the optical survey or vice versa. Generally, altering of the optical survey to the standard reference plane provided by the GPS network is the better alternative. This will allow multiple surveys conducted at various times to be related to a single plane. Also note there may be trends in the optical survey data that become apparent on such a comparison, and problems in old optical survey points can be corrected.

20. Conduct a GPS survey at unknown points of interest. Perform steps 14 through 15 as required to complete the survey. During occupations, one receiver must remain at a control point contained in the constrained control network to allow vector calculations between the control

point and the unknown point of interest. It is recommended that for 20% of the unknown points of interest that a receiver remain at the unknown point and another receiver be used to occupy two or more control points to allow solution of possible rotational biases.

21. After enough data are collected, perform network adjustment using unknown points in the constrained control network. The control network values must remain fixed and the new points allowed to vary to the constrained control network.

22. After final network adjustment, perform coordinate transformation on data to format required by project (NAD 27, SPCS 27, etc.).

23. Backup output from computer on portable media. Include raw receiver files. It is recommended that the entire data set be archived.

24. Provide coordinates. Include coordinates in coordinate system used by GPS and any other systems to which the coordinates have been converted.

25. Provide data of coordinate precision. Required precision is 1 centimeter (cm) (0.03 ft) in all axes.

5.2.2 Relative Methodology (Relative Accuracy, High Precision)

The term "relative methodology" is developed specifically for this procedure. The accuracy is deemed relative because high-accuracy GPS-derived control points are not used in a control network, and consequently the survey is not tied into the national network. Within itself, the survey is as accurate as the coordinates of the optical survey used to constrain the survey. It is highly precise. The primary working difference between a survey using the absolute methodology and the relative methodology is that NGS FBN and densification points are not used as the primary control points.

The results of a relative survey may be tied into a high-accuracy network and become highly accurate if the unconstrained network or raw data are maintained on file. Maintenance of the raw data is required. Maintenance of the unconstrained network is recommended.

1. Review site conditions and generally identify overhead obstructions that could obstruct line of sight to satellites. If excessive obstructions exist, consider nearby locations for receiver set up. Degree of obstructions may dictate the type of receiver that will be used. Dual-frequency receivers require between 1 and 5 min of observation time to achieve position. Single-frequency receivers may require 1 hr of observation time. Problems with obstructions may also be overcome if observations are conducted during periods of low DOP. DOP decreases as the number of satellites in view increases.

2. Contact state and/or county agencies in the vicinity of the site for information concerning conventional survey control points. Typical agencies that may provide information include highway departments and civil engineering groups. (Governmental agencies will typically provide a map with plots of control points and description of the points.) It is not unusual to

identify multiple first-order control points within 10 miles of the survey area. Survey points from previous surveys at the site may or may not be acceptable. Conventional survey control points will related to the GPS survey data and will provide the basis for adjusting the GPS survey data to the conventional survey control.

3. Design a site control network and determine control point occupation sequence to maximize receiver use and network stability.

    a. Identify locations at which control points will be established. Control points should be chosen to facilitate GPS survey activities. The control points must form a network with intrinsic geometric stability. The optimal geometry is either an interlocked set of triangles or a rectangle with vectors between opposite corners. The interlocked triangles or rectangle fix rotation and tilt problems that may occur with other network configurations.

    b. The network should include at least three occupations of control points to establish the knowness of those points for future work.

4. Obtain satellite availability software for those days on which the survey will be conducted. This software and updates are typically available from receiver vendors.

5. Obtain geoid model program and coordinate transformation program. Both programs are public domain and available from NGS.

6. Determine type of receiver to use. It is recommended that a 12-channel or better receiver be used. Single- or dual-frequency receivers may be used. Dual-frequency receivers typically provide best results and require less occupation time to provide acceptable precision.

7. Set up computer with appropriate software including applicable data post-processing software, geoid model files, and coordinate translation programs. Include geoid model files in the directory stipulated by the GPS software manual. Include directories for raw data, processing files, output, conversions, and network adjustment. Subdirectories are recommended. A survey of 100 points may easily develop 1000 files. Logical use of directories and subdirectories will allow coherent backup and archiving of files.

8. Establish a survey point nomenclature scheme. The scheme must be compatible with the file nomenclature inherent to GPS processing software. Typical GPS software will truncate survey point nomenclature and append some type of designator to the truncated survey point nomenclature to create file names. Consequently, it is imperative that those portions of the survey point nomenclature that will be superseded by the software file name not be significant identifiers.

9. Check condition of receivers. Two receivers are required. Charge batteries. (Typical single battery charge lasts less than 4 hr. Multiple batteries may be required for each receiver, or alternate power sources used.)

10. If receiver operators are unfamiliar with the specific type of receiver to be used in the survey, set up and operate receivers to ensure correct operation. Download receivers and test process data.

11. Run satellite availability and DOP software to ensure adequate satellite coverage and DOP not exceed acceptable limits during point occupations. Provide copies of charts to receiver operators. Note: Most GPS planning software will allow obstacle masks to be included in the DOP calculations. If obstacles identified in step 1 are input, ideal times for occupations can be established. This is not a problem with most locations but may be a prerequisite for successful occupation of problem points. If access is difficult, this may significantly affect the quality and/or time required to complete the survey.

12. Begin collecting data for control survey. Set up receivers on primary and secondary GPS control points according to network design developed in step 4 of this procedure and according to restrictions imposed by DOP.

13. Set up receiver according to manufacturer's specifications at survey point.

14. Level and plumb each receiver over survey point.

    a. A fixed-height bipod is recommended for surveys involving only points at ground surface. A tripod may be necessary for locations at which several points of varying elevation are required, such as wells. At wells it is recommended that the receiver be plumbed over the TOC on a tripod. It is generally acceptable to derive ground elevation, casing elevation, etc., from physical measurements made from the TOC.

    b. Turn on and set up receiver as specified by manufacturer. In approved logbook, record site identification, time, operator identification, antenna height, satellites locked on to by the receiver, azimuthal position of locked satellites, elevation of locked satellites, health of the locked satellites, and elevation mask used.

    c. Ensure that a minimum of four satellites are locked. Review satellite azimuth and elevation and determine that the satellites will remain in view for the anticipated survey point occupation time. If occupation lasts for extended periods, satellites locked at the initiation of the occupation may not remain locked throughout the occupation. Review DOP charts to ensure DOP is acceptable for site occupation. Better DOP will be achieved if more than four satellites are locked.

    d. Occupy site for time required by type of receiver that is used and the DOP imposed by satellite configuration and site obstructions. This may vary from 2 min to several hours.

    e. After required length of site occupation, prepare receiver for move to next survey point. Depending on survey type (static, rapid static or kinematic), this may or may not involve turning the receiver off. Follow manufacturer's specifications.

15. Repeat steps 14 through 14e until the day's activities are complete.

16. Continue daily activities until occupations developed in the control network design are complete.

17. Download data from receivers daily, or more often if memory capacity or number of files capacity of the receiver dictates frequent downloading.

18. Process vector data between survey points. Follow software documentation. Maintain integrity of raw data in separate directory.

19. After sufficient vectors have been processed to conduct a meaningful network adjustment, run the control network adjustment.

    a. Network adjustments should be performed as free adjustments. Do not specify the knowness of points and do not correct known point coordinates to published values.

    b. Constraint of the network by the optical survey coordinates is not recommended. The GPS network is inherently stable because of the multiple vector calculations between survey points and between survey points and multiple satellites. Review results of the initial free adjustment and compare to unadjusted positions. Choose the unadjusted points or points that most nearly conform to the adjusted position and use those points to constrain the adjustment. Constrain the network and observe which control points move and by how much. Choose the best constrained solution from the various solutions performed. This generally will be the solution in which the least movement of points is caused by constrainment.

    c. After the constrained control network is finished, the control network is complete. The control network is the common plane to which all additional survey work will be related. Change the knowness of all the points in the control network to a high knowness. These values are considered fixed for network adjustments performed with the control network.

    d. Include optical survey points that have been surveyed with GPS in the network. Do not constrain the network with published optical survey coordinates. Allow the GPS values of the optical survey points to vary to the constrained control network.

    e. Review the published optical survey coordinates and the corresponding GPS network coordinates. The difference between the coordinates is the variation of the surveys. If desired, the GPS survey can be changed outside the network to be compatible with the optical survey or vice versa. Generally, altering the optical survey to the standard reference plane provided by the GPS network is the better alternative.

20. Conduct a GPS survey at unknown points of interest. Perform steps 13 through 15 as required to complete the survey. During occupations, one receiver must remain at a control point contained in the constrained control network to allow vector calculations between the control point and the unknown point of interest. It is recommended that for 20% of the unknown points of interest a receiver remain at the unknown point and another receiver be used to occupy two or more control points. This will allow solution of possible rotational biases.

21. After enough data are collected, perform network adjustment using unknown points in the constrained control network. The control network values must remain fixed and the new points allowed to vary to the constrained control network.

22. After final network adjustment, perform coordinate transformation on data to format required by project (NAD 27, SPCS 27, etc.).

23. Back up output from computer on portable media. Include raw receiver files. It is recommended that the entire data set be archived.

24. Provide coordinates. Include coordinates in coordinate system used by GPS and any other systems to which the coordinates have been converted.

25. Provide data of coordinate precision. Required precision is 1 cm (0.03 ft) in all axes.

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STANDARD OPERATING PRACTICE TNFLD002A

Field Records and Documentation

TABLE OF CONTENTS

Page

1.0 PROCEDURE 2

1.1 Materials 2
1.2 General Requirements for Field Logbooks 2
1.3 Format for Field Logbook Entries 3
1.4 What to Record in the Field Logbook 3
1.5 Site Safety and Health Logbook 4
1.6 Field Forms 5
1.7 Tracking of Field Records 6
1.8 Filing of Field Records 6

2.0 DAILY QUALITY CONTROL REPORTS 6

STANDARD OPERATING PRACTICE TNFLD002A

Field Records and Documentation

The objectives of this Standard Operating Practice (SOP) are to provide consistent procedures and formats by which field records will be kept and activities documented, and a methodology by which field records will be managed.

1.0 PROCEDURE

1.1 MATERIALS

Materials to be used include:

- Field logbooks,
- Pens, containing indelible waterproof black ink,
- Field forms, and
- Watch with team-synchronized time (using the military 2400-hour format).

Bound, water-resistant field logbooks will only be used for the maintenance of field records (except for site specific reporting forms when required). The Project Manager prior to use must approve utilization of any other field logs.

1.2 GENERAL REQUIREMENTS FOR FIELD LOGBOOKS

Logbooks will be assigned by activity for the project until the specific activity is completed. The logbook for a specific activity will be used until the logbook is full. If the logbook for a specific activity is not filled completely, the logbook for that specific activity will be used for any future work of a similar nature e.g. quarterly groundwater sampling.

Each page of the logbook will be signed at the bottom, once filled or once field activities are completed. The logbooks will be turned in for copying/filing/tracking to the Project Manager.

The center of the front cover will be labeled with the project name and logbook number. The logbooks for each project will be sequentially numbered starting with the number one. Below the logbook number will be the activity that has been assigned and the date assigned.

All entries will be recorded in indelible, waterproof black ink. If errors are made in any field logbook, field record (form), chain-of-custody record, or any other field record document, corrections will be made by crossing a single line through the error, entering the correct information, initialing, and dating the correction.

A number of field forms have been adopted to facilitate the collection of consistent data. This will preclude detailed documentation of, for example, lithologic descriptions in the field logbook. A reference to each specific form must be made in the logbook.

Sufficient information will be recorded in the logbooks and on the field forms to permit reconstruction of all field activities conducted. While some duplication of information may occur between the type of logbooks and field forms, this activity will ensure that all required information is being recorded.

1.3 Format for Field Logbook Entries

Entries in field logbooks will be made in the following format:

The date will be placed in the top right-hand corner of every right page. The time of entry recordings will be in columnar form down the left-hand side of each page. All entries should be dated and the time of entry recorded.

At the beginning of each day, the first two entries will be "Personnel, Contractors On Site" and "Weather."

At the end of each day's entry or a particular event, if appropriate, the field person should draw a diagonal line originating from the bottom left corner of the conclusion of the entry to the bottom right corner of the page. The field person will sign along the line indicating the conclusion of the entry or the day's activity. At the end of the day's entry, the personnel should record the time of departure from the work site.

Language should be objective, clear, factual, and free of personal feelings or other terminology that might prove inappropriate, since field records are the basis for later written reports. Field logbooks are legal documents that must be maintained as part of the project files. The TN&A Project Manager should conduct periodic audits of field logbooks to ensure compliance with this SOP.

All aspects of sample collection and handling, as well as visual observations, will be documented in the field logbooks. All sample collection equipment, field analytical equipment, and equipment utilized to make physical measurements will be identified in the field logbooks. All calculations, results, and calibration data for field sampling, field analytical, field screening, and field physical measurements will also be recorded in the field logbooks, except where these are referenced as being recorded on approved field forms. All field analyses and measurements must be traceable to the specific piece of field equipment utilized and to the field investigator collecting the sample, making the measurement, or conducting analyses.

1.4 What to Record in the Field Logbook

Each field crew will be issued a field logbook in which detailed descriptions of all activities completed by the crew for each working day will be noted. The field logbooks will contain, at a minimum, the following:

- Name and title of the originator,
- Purpose of the field activity,
- Name, company name, and address of the site contact,
- Names and responsibilities of field crew members,
- Names and company name of all subcontract personnel,

- Names, titles, and association of any site visitors,
- Description of type and manufacturer of all heavy equipment used during field activities,
- Conversations with client representatives, senior TN&A personnel, landowners, regulatory agency representatives, etc.,
- Sample collection method,
- Quantity, location, and volume of sample(s) collected,
- Location, description, and log of photographs,
- References for all maps of the sampling site(s),
- Information regarding sampling changes, scheduling modifications and change orders,
- Information regarding drilling decisions (also recorded on the boring log),
- Information regarding sampling decisions,
- Information regarding access agreements, if applicable,
- Details of the sampling location, including a sketch map illustrating the sampling location (if not on the boring log),
- Equipment used,
- Date and time of sample collection and name of collector,
- Sample identification number(s),
- Information from containers, labels of reagents used, deionized and organic-free water used, etc.,
- Field analyses, conducted by whom, using what instruments or test kits,
- Field observations,
- All calculations and results,
- Extraordinary occurrences,
- Types of field instruments used and purpose of use, including calibration methods and results (if not on instrument calibration log),
- Investigative Derived Waste (IDW) documentation information including:
    - types of containers/drums,
    - contents, type, and approximate volume of waste,
    - type of contamination and predicted level of contamination based on available information,
- Shipping information, and
- Diagonal line with signature at end of logbook entry.

The last four pages of the logbook will be reserved for compiling a "List of Contents" for the logbook. Information recorded will include the project name and number, duration of involvement, brief description of activities, the page numbers in the logbook, the last page number copied to file, and date copied. The personnel assigned the logbook should update the "List of Contents" on a weekly basis.

1.5 Site Safety and Health Logbook

A separate Site Safety and Health (SSH) logbook may be maintained by the Site Safety and Health Officer (SSHO) to document all daily safety and health activities. If a separate SSH logbook is not required for a project, then the health and safety information should be recorded in the field logbook. The SSHO will be responsible for ensuring the following information is entered into the logbook:

- When the daily health and safety meeting/briefing was conducted (use daily form to record meeting topics and attendees),
- Daily health and safety site inspections,
- Daily inspection of field equipment,
- Weather, including general weather conditions, temperature, wind and direction,
- Major changes in weather conditions,
- Problems associated with field monitoring equipment,
- Detailed record of any health and safety incidents at the site, including any subcontractor incidents,
- Medical problems with any field team member, including anyone taking special medications, and
- Any visitors introduced at the site along with health and/or training records, as appropriate.

1.6 FIELD FORMS

As appropriate, some or all of the field forms listed below will be distributed by the Field Team Leader (FTL) or designate team member to field personnel. The Field Team Leader will ensure that the forms are filled out correctly by the field team members:

FORMS:

Drilling Log

Well Construction Log

Well Development Log

Well/Boring Abandonment Log

Groundwater Sampling Log

Groundwater Level Measurement Log

Surface Water Sampling Log

Soil Gas Sampling Log

Decontamination Form

Chain-of-Custody Form

Field Equipment Calibration Form

Site Safety Health Plan (SSHP) Forms:

Air Monitoring Log

Daily Site Safety Briefing Form

Contractor SSHP Acceptance Form

Employee SSHP Acceptance Form

Visitor Sign-In

Project-specific forms should be listed in the project work plan or sampling and analysis plan.

1.7 Tracking of Field Records

Field records (logbooks and forms) tracking is the responsibility of the Field Team Leader during field operations. Following completion of the field event, the FTL will deliver the field records to the TN&A Project Manager.

The FTL shall compile the original field forms in a 3-ring notebook or secure file box during field operations. At the end of the fieldwork or phases of fieldwork, the FTL will send or deliver the field forms to the TN&A Project Manager at the project office. The on-site project personnel throughout the duration of the field program will maintain copies of the field forms.

1.8 Filing of Field Records

When an individual logbook is full or the activity is completed, the logbook will be submitted to the TN&A Project Manager within two working days for final cataloging and filing. The logbooks will be stored in the project file and will only be accessible to the Project Manager.

All non-bound field records (e.g., field forms, drilling logs) will be completed on the day the associated activity occurs and will be turned in to the FTL by the end of the day. The unbound daily field forms should be sent on at least a weekly basis to the Project Manager.

All field data collected using electronic data loggers or computer entry forms will be downloaded to a computer. If possible, the data will be downloaded on a daily basis by the person collecting the data. The Field Team Leader will be responsible for ensuring that all data collected are adequately represented in electronic media and in the project file. A hard copy of the data, and any graphical representation produced by logging software, will also be printed out and filed in the project file.

2.0 DAILY QUALITY CONTROL REPORTS

Daily Quality Control Reports (DQCRs) are an U.S. Army Corps of Engineers (USACE) requirement and may be used on other projects as well. DQCRs are completed daily by each field team. The purpose of these reports is to provide a written log of daily field activities to the TN&A Project Manager and client. Information on the DQCRs should be in a bulleted format (concise and brief). The information will include:

- Project, contract, and delivery order/task order numbers,
- Date (on each page of DQCR),
- Project name and location,
- Temperature range,
- Wind conditions,
- Personnel and subcontractors on-site,
- Equipment on-site,
- Summary of site activities,
- Level of health and safety protection,

- Field instruments used,
- Calibrations performed,
- Problems encountered,
- Corrective actions taken,
- Samples collected and collection methods (including sample IDs),
- QC samples collected (including sample IDs),
- Additional remarks, and
- Signature of person filling out DQCR.

DQCRs will be completed and faxed on a daily basis to the TN&A Project Manager. DQCRs are provided to the on-site USACE representative on a daily basis.

STANDARD OPERATING PRACTICE TNFLD001A

Site Access and Clearance

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 2
2.0 UTILITY CLEARANCE/PERMITS 2
3.0 SITE ACCESS 3

STANDARD OPERATING PRACTICE TNFLD001A

Site Access and Clearance

1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) document is to provide guidance to all field personnel for obtaining digging clearance and access to sites.

2.0 UTILITY CLEARANCE/PERMITS

All underground utilities in the vicinity of each drilling location will be identified, located, and marked prior to any drilling, digging, or other subsurface field work. TN&A will coordinate the receipt of any required drilling or digging (or other) permits needed for completing the field work. The officially designated utility marking service in the state where the site is located will be contacted for locating buried utilities. The names (and other pertinent information) for all persons involved during this effort will be documented. Copies of the permits obtained will be included in an appendix to the remedial investigation report.

Prior to conducting any subsurface work at the site, all private utilities (those not covered by the public utility marking service) will be identified by TN&A field personnel. Private utility marking services may be available to locate on-site buried utilities. The TN&A Project Manager (or designee), in conjunction with client PM, will coordinate with off-site property owners or representatives to identify and mark any public or private utilities at off-site drilling locations, if applicable.

Utilities to be identified and marked prior to subsurface work may include but are not limited to the following:

- Underground storage tanks (USTs) and related distribution piping,
- Electrical lines,
- Water mains and laterals,
- Sewer mains and laterals,
- Communication lines such as telephone, cable, and fiber optic lines,
- Natural gas and petroleum pipelines, and
- Any privately installed utilities for facilities that are not public utilities.

Buried utilities are identified according to color coded paint markings and flags, as identified below:

- **Red**

  -Electric power lines, cables, conduits, and lighting cables

- **Yellow**

  -Gas, oil, steam, petroleum, or gaseous materials

- **Orange**

  -Communication, alarm, signal lines, cables, or conduits

- **Blue**

  -Water, irrigation, and slurry lines

- **Green**

  -Sewer drain lines

White may be used to designate proposed excavation boundaries.

3.0 SITE ACCESS AGREEMENTS

No subsurface work will be conducted on properties without current written access agreements in place.

STANDARD OPERATING PRACTICE TNFLD007D

Subsurface Soil Sampling

1.0 OBJECTIVE 2
2.0 BACKGROUND 2
3.0 REQUIRED EQUIPMENT 3
3.1 GENERAL 3
3.2 HAND AUGERING 3
3.3 TEST PITS/TRENCHES 4
3.4 SPLIT-SPOON SAMPLING (BASED ON ASTM METHOD D1586) 4
3.5 THIN-WALLED SAMPLING (BASED ON ASTM METHOD D1587) 4
3.6 DIRECT PUSH TECHNOLOGIES 5
3.7 CONTINUOUS CORE SAMPLER 5
4.0 PROCEDURES 6
4.1 GENERAL 6
4.2 HAND AUGERING 7
4.2.1 Methodology 7
4.3 TEST PITS/TRENCHES 8
4.3.1 Methodology 8
4.4 SPLIT-SPOON SAMPLING 9
4.4.1 Methodology 9
4.5 THIN-WALLED SAMPLING 11
4.5.1 Methodology 11
4.6 DPT SUBSURFACE SOIL SAMPLING 12
4.6.1 Methodology 12
4.7 CONTINUOUS CORE SAMPLER 13
4.7.1 Methodology 13
4.8 COLLECTION AND HOMOGENIZATION OF COMPOSITE SAMPLES 14
5.0 RESTRICTIONS/LIMITATIONS 15
6.0 REFERENCES 16

STANDARD OPERATING PRACTICE TNFLD007D

Subsurface Soil Sampling

1.0 OBJECTIVE

The objective of this procedure is to define the requirements for collecting subsurface soil samples.

2.0 BACKGROUND

For the purpose of this document, subsurface soil samples are those samples collected in the unconsolidated zone at a depth of 1-foot (ft) or greater below ground surface. Samples collected from ground surface down to 1 ft below ground surface are addressed in Standard Operating Practice (SOP) FLD006B, "Surface Soil Sampling." All operations at hazardous waste sites must be conducted in compliance with the provisions of Occupational Safety and Health Act (OSHA) 29 Code of Federal Regulations (CFR) 1910.120 and all other state, local, and federal regulations.

Various methods are available to collect subsurface soil samples. Hand augers are advanced manually into the soil and may be used to collect samples to depths of 10 ft or less. The hand auger may be used to collect field screening samples for all analytes, including volatile organic compounds (VOCs), without sample liners. However, for those projects requiring definitive VOC analyses, liners must be used in the hand auger or a slide hammer.

Test pits/trenches are open excavations that can be used to collect subsurface soil samples and geotechnical/engineering information. All test pits/trenches must be constructed in accordance with all state, local, and federal regulations governing excavations including OSHA 29 CFR 1926.650, Sect. P. If possible, samples should be collected without entering the excavation. If it becomes necessary to enter excavations greater than 3.5 feet (ft) in depth, all requirements of the OSHA regulations governing confined space entry must be followed. Extreme caution should always be used when sampling in excavations. For excavations greater than 3.5 ft in depth, a ladder, extending from the base of the excavation to above the ground surface, must always be in place while personnel are in the excavation.

Split-spoon [American Society for Testing and Materials (ASTM) Method D1586] samplers, including the California-modified split-spoon sampler (3-inch-OD, 2-3/8-inch ID),thin-walled samplers (ASTM Method D1587), continuous soil core samplers, and direct-push (e.g., Geoprobe®) samplers are mechanically pushed, driven, or vibrated into undisturbed soil. The samplers collect the soil sample in an enclosed tube, which prevents mixing and contamination of the samples by uphole soils. Soil samples may be collected for geotechnical information and/or chemical analyses. Field screening samples for VOC analyses may be collected directly from the sampler. For those projects requiring definitive VOC analyses, liners should be used.

3.0 REQUIRED EQUIPMENT

3.1 GENERAL

The following general equipment is required:

- approved site Work Plan,
- approved site Sampling and Analysis Plan (SAP),
- approved site Health and Safety Plan,
- field logbook,
- camera and film,
- indelible (waterproof) ink pen, blue or black,
- indelible markers,
- sample tags/labels and appropriate forms/documentation,
- appropriate sample containers as specified in the site SAP,
- insulated cooler(s),
- latex inner gloves,
- outer gloves (as needed) of material resistant to suspected contaminants,
- plastic resealable bags and waterproof sealing tape,
- rinse bottles and ASTM Type II deionized water,
- decontamination equipment and supplies (see SOP 011A),
- personal protective equipment (PPE) as required by the site Health and Safety Plan,
- plastic sheeting,
- chain-of-custody forms and security seals,
- appropriate equipment and meters for obtaining field measurements specified in the SAP and the Health and Safety Plan,
- ice for cooling samples, and
- aluminum foil.

3.2 HAND AUGERING

The following equipment is needed for hand augering:

- hand auger (i.e., flighted-, bucket-, or tube-type augers) and/or slide hammer sampler,
- extension rods as needed,
- wrench(es),
- stainless steel hand trowel or sampling spoon,
- large [minimum 12-inch (in.) diameter] stainless steel, glass, or Pyrex® mixing bowl,
- sufficient sampler liners for collecting definitive VOC samples,
- stainless steel blade to trim excess soil from end of liners (if used),

- Teflon® or silicon tape,
- sufficient end caps to cover both ends of sampler liners (if used), and
- sufficient plastic sheeting to contain all cuttings.

3.3 TEST PITS/TRENCHES

The following equipment is needed for test pits or trenches:

- backhoe or other excavation equipment (as specified in the site Work Plan),
- extension ladder (capable of extending from bottom of excavation to above ground surface),
- trench/pit shoring and bracing equipment (as needed),
- stainless steel hand trowel or sampling spoon,
- large (minimum 12-in.-diameter) stainless steel mixing bowl,
- sampler to be used to collect VOC samples for definitive analyses (as needed),
- sufficient sampler liners for collecting definitive VOC samples (as needed),
- Teflon or silicon tape, and
- sufficient end caps to cover both ends of sampler liners (if used).

3.4 SPLIT-SPOON SAMPLING (BASED ON ASTM METHOD D1586)

The following equipment is needed for split-spoon sampling (including California-modified):

- drilling rig equipped with a 140-pound (lb) drop hammer and sufficient hollow-stem augers to drill to the depths required by the site Work Plan,
- sufficient numbers and type of split-spoon samplers so that at least one is always decontaminated and available for use; three split-spoon samplers are generally the minimum necessary,
- sufficient numbers and types of sampler liners,
- sufficient plastic sheeting to contain all cuttings and cover the ground surface under the drill rig,
- sufficient waste containers (e.g., 55-gallon (gal) steel drums) as specified in the site Work Plan to containerize all cuttings and investigation-derived waste (IDW),
- Teflon or silicon tape,
- stainless steel blade to trim excess soil from end of liners (if used), and
- sufficient number and types of plastic end caps to cover both ends of all sampler liners (if used).

3.5 THIN-WALLED SAMPLING (BASED ON ASTM METHOD D1587)

The following equipment is needed for thin-walled sampling:

- drilling rig equipped with a 140-lb drop hammer and sufficient hollow-stem augers to drill to the depths required by the site Work Plan;

- sufficient numbers and type of thin-walled samplers so that at least one is always decontaminated and available for use; thin-walled samplers generally are used only once;
- sufficient plastic sheeting to contain all cuttings and cover the ground surface under the drill rig;
- sufficient waste containers (e.g., 55-gal steel drums) as specified in the site Work Plan to containerize all cuttings and IDW;
- sufficient number and types of plastic end caps to cover both ends of all thin-walled samplers;
- Allen wrenches; and
- Teflon® or silicon tape.

3.6 DIRECT PUSH TECHNOLOGIES

The following equipment is needed for use with direct push technologies (DPT), such as the Geoprobe™ system:

- DPT truck capable of pushing sampler to depths required by the site Work Plan;
- assembled DPT sampler (standard or large bore as described in the site SAP);
- sufficient extension rods to reach the depths required by the site Work Plan;
- extension rod couplers;
- extension rod handle;
- stop pin;
- sampler liners (as needed) in accordance with the site SAP (e.g., stainless steel, acetate, or brass);
- stainless steel blade to trim excess soil from end of liners (if used);
- Teflon or silicon tape; and
- sufficient plastic end caps to cover both ends of sampler liners (if used).

3.7 CONTINUOUS CORE SAMPLER

The following equipment is needed for continuous core sampling:

- drilling rig with continuous coring capability (i.e., hollow-stem auger or rotasonic drill),
- sufficient plastic sheeting to contain all cuttings and cover the ground surface under the drill rig,
- sufficient clear plastic sleeving to hold rotasonic drill cores; sufficient waste containers (e.g., 55-gal steel drums), as specified in the site Work Plan, to containerize all cuttings and IDW,
- drive sleeves (if used to collect samples for off-site laboratory VOC analyses) in accordance with the site SAP,
- stainless steel blade to trim excess soil from end of drive sleeves (if used),
- Teflon or silicon tape, and
- sufficient vinyl end caps to cover both ends of the drive sleeves (if used).

4.0 PROCEDURES

4.1 GENERAL

The collection of subsurface soil samples is an intrusive event and requires knowledge of the site and careful planning before commencing. Several standard steps should be taken before beginning any subsurface sampling activity.

1. Obtain all site clearances (including utility clearances) and digging permits (SOP 001A).
2. Verify that all logbooks are on the site, up to date, and ready to be used. (See SOP 002A).
3. Photograph the site before commencing work (only with approval of the Sponsor and the facility).
4. Verify (in writing) that all personnel have read and understood the approved site Health and Safety Plan. (All personnel must sign off on the Health and Safety Plan.)
5. Verify that all personnel involved in the sampling activity have the proper training and certifications required under OSHA 29 CFR 1910.120 and 29 CFR 1910.134.
6. Verify the site location by existing maps and surface features. Check for surface features or artifacts (e.g., manhole covers and overhead power lines) that could impede movement on the site or indicate a previously unidentified hazard.
7. Mark off the boundaries of the work site with flagging or other means to prohibit access to unauthorized personnel. All sites should have a single, clearly marked entrance through which all personnel should enter and exit. Sites having a high contamination level or where activities may unearth highly contaminated materials must also have an exclusion zone, contamination reduction zone, and support zone clearly marked and properly maintained. All personnel exiting the work area should pass through a decontamination procedure for their own protection and to prevent the spread of contamination. The extensiveness of the personnel decontamination procedure will be outlined in the approved site Health and Safety Plan.
8. Set up a decontamination line for equipment and personnel. (See SOP 011A.)
9. Check to see that all the necessary equipment (including PPE and samplers) is available at the site, is in good working condition, and has been properly decontaminated.
10. Check that all monitoring equipment is properly calibrated and operating.
11. Set up the IDW management system (e.g., spread plastic, position drums, etc.) as outlined in the site Work Plan. (See SOP 012A.)

At no time should samples, decontaminated sample sleeves, or decontaminated samplers be touched by unprotected (i.e., ungloved) hands. A fresh or decontaminated pair of gloves must be used for each sample collection. Great care should be exercised to ensure that no contaminated tool or device is inserted into the borehole. All downhole tools and samplers must be kept off the

ground and/or free from contamination between the time they pass through the decontamination procedure until they are used in the boring.

4.2 HAND AUGERING

Hand augering consists of manually advancing the auger into the soil to collect subsurface soil samples, generally at depths of 10 ft or less. There are several types of hand augers available (e.g., Iwan, ship, closed spiral, and open spiral). All these devices are used in much the same way. The auger is attached to the bottom of a length of steel rods that have a crossbar (handle) at the top. The operator advances the auger by rotating the crossbar while pressing the auger into the ground. As the auger advances, it fills with soil. When the auger is filled with soil, the unit is removed from the hole, cleared, and reinserted. Additional rods are added until the desired depth is reached. Upon reaching the sampling depth, the auger is removed. A decontaminated auger is then used to collect the sample. The same auger may be used in drilling and sampling, but it must pass through the decontamination process between drilling and sampling. When done properly, this method will result in samples for definitive analysis for all analytes except VOCs; however, this method will yield screening data for VOCs. To obtain definitive levels for VOCs, a liner must be used in the auger or in a slide-hammer sampler.

4.2.1 Methodology

The steps for hand-auger sampling are:

1. Complete the standard general steps for subsurface sampling (Section 4.1).
2. Don PPE as required by the site Health and Safety Plan.
3. Using a decontaminated auger, auger to the desired depth.
4. Place drill cuttings on plastic sheeting spread beside boring. Cuttings should be placed in stratigraphic order to show changes as the boring progresses.
5. After reaching the desired sampling depth, remove the auger from the boring and decontaminate. Alternatively, a different auger (decontaminated) may be used to collect the sample.
6. Insert the decontaminated auger into the boring and advance until full. If definitive samples are required for VOC analyses, an auger or slide hammer sampler with a properly positioned sampling sleeve will be used. The type and material of the sleeve will be specified in the SAP.
7. Remove auger from borehole and field screen with the method and equipment specified in the site SAP. Extract sample and place in appropriate containers as specified in the site SAP. If a liner was used, remove liner from auger/slide hammer and place aluminum foil on ends (shiny side away from sample), cap and seal both ends of the liner with Teflon or silicon tape, and place appropriate label on the liner.

8. Place sample container (e.g., liner and jar) in resealable plastic bag and place bag containing sample into an insulated cooler with ice. Samples should be maintained at 4°± 2°C from the time of collection until received at the laboratory. (See SOP 010A.)

9. Draw a sketch of the sampling location in the field logbook. Note the sample identification number, depth, time of collection, field screening result, and laboratory analysis requested for the sample in the site sampling logbook. (See SOP 002A)

10. Doff contaminated gloves and don fresh or decontaminated gloves.

11. Repeat steps 1 through 10 until sampling is completed.

12. Dispose of cuttings and nonsalvageable equipment as outlined in the site Work Plan.

13. Plug and abandon borehole as specified in the site Work Plan. (See SOP 008I.)

14. Decontaminate all equipment and personnel. (See SOP 011A.)

4.3 TEST PITS/TRENCHES

Test pits/trenches are open excavations that are generally dug by earth moving machinery (e.g., backhoes and bulldozers) that can be used to collect subsurface soil samples and geotechnical/engineering information. All test pits/trenches must be constructed in accordance with state, local, and federal regulations governing excavations. This includes but is not limited to OSHA 29 CFR 1926.650 Sect. P.

Samples should be collected without entering the excavation, if a collapse hazard is present and/or the excavation would be defined as a confined space. A long-handled sampling tool (if available) should be used in pits/trenches greater than 3.5 ft in depth. Should it become necessary for personnel to enter excavations greater than 3.5 ft in depth, all requirements of the regulations governing confined space entry must be followed. Extreme caution should always be used when sampling in excavations. For excavations greater than 3.5 ft in depth, a ladder extending from the base of the excavation to above the ground surface must always be in place while personnel are in the excavation.

4.3.1 Methodology

The steps for test pit/trench sampling are:

1. Complete the standard steps for subsurface sampling in Section 4.1.

2. Don PPE as required by the site Health and Safety Plan.

3. Excavate the pit/trench to the required depth and width. The location and depth of the required samples will be outlined in the SAP. If dewatering of the trench is required, all water should be handled in accordance with the methodology for managing IDW as outlined in the site Work Plan.

4. Place the soil removed from the excavation on plastic sheeting spread in line with, but a minimum of 5 ft back from, the wall of the trench.

5. Using a decontaminated stainless steel spoon or trowel (or other sampling device specified in the site SAP), scoop out a portion of soil from the bottom or walls of the trench (as specified in the site SAP) sufficient to fill the required sampling containers. If definitive samples are required for VOC analyses, a sampling device capable of using liner sleeves must be used. The type and material of the sleeve will be specified in the SAP.

6. Remove the sample from the pit/trench and field screen with the method(s) and equipment specified in the site SAP. Place the sample in the appropriate containers as specified in the site SAP. If a device with a liner sleeve was used, remove liner from sampler, place aluminum foil on ends (shiny side away from sample), cap and seal both ends of the liner with Teflon or silicon tape, and place appropriate label on the liner.

7. Place sample container (e.g., liner and jar) in resealable plastic bag and place bag containing sample into an insulated cooler with ice. Samples should be maintained at 4°± 2° Celsius (C) ±2°C from the time of collection until received at the laboratory. (See SOP 010A.)

8. Draw a sketch of the pit/trench and indicate the location of the sample in the field logbook. Note the sample identification number, depth, time of collection, field screening result, and laboratory analysis requested for the sample in the site sampling logbook. (See SOP 002A.)

9. Doff contaminated gloves and don fresh or decontaminated gloves.

10. Repeat steps 3 through 9 until sampling is completed.

11. Reclaim the pit/trench as outlined in the site Work Plan. At a minimum, soil should be placed in the excavation so that the final permeability is less than or equal to the original condition of the soil.

12. Decontaminate all equipment and personnel. (See 011A.)

4.4 SPLIT-SPOON SAMPLING

The split-spoon sampler consists of a threaded steel pipe that is split in two pieces along the axis of the pipe. A hardened steel driving shoe is screwed onto the downhole end and a threaded "head" with a check valve is screwed onto the top. The sampler is driven (ASTM Method D1586) into undisturbed soil. The sampler collects the soil sample in the enclosed tube, which prevents mixing and contamination of the sample by uphole soils. Soil samples may be collected for geotechnical information and/or chemical analyses. When done properly, this method will result in samples for screening and definitive data for all analytes except VOCs. Screening samples for VOC analyses may be collected directly from the sampler. To obtain definitive samples for VOCs, liner sleeves must be used in the sampler.

4.4.1 Methodology

The steps for split-spoon sampling are:

1. Complete the standard steps for subsurface sampling in Section 4.1.

2. Don PPE as required by the site Health and Safety Plan.

3. Using decontaminated augers, auger to the desired depth.
4. Place drill cuttings on plastic sheeting spread beside boring or handle as specified in the site Work Plan.
5. Upon reaching the desired sampling depth, attach a decontaminated split spoon to the sampling rods and insert into boring. If definitive analyses are required for VOCs, a split spoon with properly positioned sampling liners will be used. The type and material of the liners will be specified in the SAP.
6. Position the drive hammer on the sampling rods and lightly tap the rods to seat the sampler.
7. Drive the sampler in accordance with ASTM Method D1586 (i.e., a 140-lb hammer is repeatedly dropped 30 in. while counting the number of blows required to drive the sampler each 6-in. interval). Cease driving when the sampler is full, or when 50 blows of the hammer have moved the sampler less than 1 in.
8. Remove the split spoon from the boring. Carefully open the split spoon and immediately field screen the sample with the equipment specified in the site SAP. Extract the sample and place it in appropriate containers, as specified in the site SAP. If liners were used, separate the liners and immediately field screen between each liner. Immediately after field screening, remove the liner designated for VOC analyses from the split spoon. Place aluminum foil, cap, and seal both ends of the liner with Teflon or silicon tape. Place appropriate label on the liner. Proceed to remove, cap, seal, and label the other liners as necessary.
9. Immediately after collection, place sample containers (e.g., liners and jars) in resealable plastic bags and place bags containing samples into an insulated cooler. Samples should be maintained at 4° ± 2°C from the time of collection until received at the laboratory.
10. Note the sample identification number, depth, time of collection, field screening result, lithologic description, and laboratory analyses requested for the samples in the site sampling logbook. (See SOP 002A.)
11. Doff contaminated gloves and don fresh or decontaminated gloves.
12. Repeat steps 3 through 11 until total required depth is reached.
13. Remove the augers from the boring. Note: When the boring is completed and the augers have been removed, it is sometimes advisable to leave the borehole open for several hours to check for groundwater inflow. This information can be valuable later in the project.
14. Dispose of cuttings and nonsalvageable equipment as outlined in the site Work Plan.
15. Plug and abandon borehole as specified in the site Work Plan. (See SOP 12.)
16. Decontaminate all equipment and personnel. (See SOP 011A.)

4.5 THIN-WALLED SAMPLING

The thin-walled sampler (also known as a Shelby tube) consists of a one-piece hollow steel tube that is usually 2 to 5 in. in diameter and from 1 to 3 ft in length. The thin-walled sampler is mechanically pushed or driven (ASTM Method D1587) into undisturbed soil. The sampler collects a column of relatively undisturbed soil in the tube. This method generally is used to collect samples for geotechnical information, but it can also be used to collect soil for chemical analyses. When done properly, this method will result in samples for screening and definitive analyses for all analytes. Screening samples for VOC analyses may be collected directly from the sampler in the field. For definitive VOC samples, the entire sampler must be properly sealed and sent to the laboratory.

4.5.1 Methodology

The steps for using the thin wall sampler are:

1. Complete the standard steps for subsurface sampling in Section 4.1.
2. Don PPE as required by the site Health and Safety Plan.
3. Using decontaminated augers, auger to the desired depth.
4. Place drill cuttings on plastic sheeting spread beside boring or handle as specified in the site Work Plan.
5. After reaching the desired sampling depth, attach a decontaminated thin wall sampler to the sampling head and screw onto the sampling rods. Insert the sampler into the boring.
6. Position the drill head (ram) on the sampling rods and, using the rig hydraulics, push the sampler to the required depth (i.e., fill the tube) or until refusal. A smooth, sustained push will generally yield the best sample. If the rig hydraulics cannot push the tube, it can be driven using the drive hammer. The weight of the hammer, height of drop, and number of blows should be recorded in the field logbook. (See SOP 002A.)
7. Twist the drill rods clockwise to break loose the sample. Withdraw the sampler from the boring.
8. Detach the sampler from the sample rods and remove the tube from the sampling head.
9. For geotechnical analyses and/or definitive VOC analyses, trim off excess soil from either end of the tube until it is at least flush with the rim of the tube. Cap and seal both ends of the tube and mark the "up" end. The sealed tube should be handled carefully to minimize vibration or impacts and should be transported to the laboratory in the upright position. If geotechnical analyses are not desired, the sample may be extruded from the tube on-site, field screened, and placed in appropriate containers. The VOC screening sample must be collected first and as soon after extruding the soil from the container as possible. Proceed to fill the other containers as necessary. Immediately after collection, place sample containers in resealable plastic bags and place bags containing samples into an insulated cooler. Samples should be maintained at 4°± 2°C from the time of collection until received at the laboratory. (See SOP 010A.)

10. Note the sample identification number, depth, time of collection, field screening result, lithologic description (if known), and laboratory analyses requested for the samples in the site sampling logbook. (See SOP 002A.)

11. Doff contaminated gloves and don fresh or decontaminated gloves.

12. Repeat steps 3 through 11 until total required depth is reached.

13. Remove the augers from the boring. Note: When the boring is completed and the augers have been removed, it is sometimes advisable to leave the borehole open for several hours to check for groundwater inflow. This information can be valuable later in the project.

14. Dispose of cuttings and nonsalvageable equipment as outlined in the site Work Plan.

15. Plug and abandon borehole as specified in the site Work Plan. (See SOP 008I.)

16. Decontaminate all equipment and personnel. (See SOP 011A.)

4.6 DPT Subsurface Soil Sampling

Direct Push Technology (DPT) rigs advance a hollow sampling probe, usually with a plastic liner, using hydraulic methods. The Geoprobe unit uses the Probe-Drive sampler to retrieve a soil sample at the working depth of the Geoprobe. Unlike split-spoon samplers, the Probe-Drive sampler remains completely sealed by a piston tip at the end of the sample tube while it is pushed or driven to the desired sampling depth. A piston stop-pin at the opposite end of the sampler is removed by means of extension rods inserted down the inside diameter of the probe rods after the sampler has been driven to depth. This enables the piston to retract into the sample tube while the sample is taken. The large-bore sampler permits the use of internal liners during sampling. The small size of Geoprobe rigs allows access to locations that would preclude using larger rigs.

4.6.1 Methodology

The steps for DPT (Geoprobe) sampling are:

1. Complete the standard steps for subsurface sampling (Section 4.1.)

2. Don PPE as required by the site Health and Safety Plan.

3. Attach a decontaminated sampler to the lead probe rod. For definitive samples for VOC analyses, the large-bore sampler must be used (the large-bore sampler allows the use of liner sleeves). A 12-in. probe rod is recommended to start the standard 24-in. and large-bore samplers.

4. Drive/push the sampler to the desired depth. Some soil conditions may warrant using a retractable or solid drive point to preprobe the hole to the desired depth. Note: Do not attempt to drive the sampler into bedrock or other impenetrable layer.

5. After reaching the desired sampling depth, remove the drive cap and lower extension rods into the inside diameter of the probe rods using couplers to join the rods.

6. Disengage the stop-pin from the drive head with the extension rods.

7. Remove the extension rods and attached stop-pin from the probe rods.
8. If the top of the probe rod is already in the lowest driving position, attach another probe rod before driving. Replace the drive cap onto the top probe rod.
9. Mark the top probe rod with a marker or tape at the appropriate distance above the ground surface (allow 24 in. for the large-bore sampler). Drive the probe rods and sampler the designated distance. Be careful not to over-drive the sampler, which would compact the soil sample in the tube and make sample extrusion difficult.
10. Extract the probe rods from the hole and recover the sampler. Examine the sampler to confirm that a sample has been recovered.
11. When using the standard sampler, extrude the soil from the sampler, field screen as specified in the site SAP, and place in appropriate, labeled containers. This method yields both screening and definitive samples for all analytes except VOCs. This method yields screening samples for VOCs. When using the large-bore sampler, remove the cutting shoe and withdraw the sample sleeves. Immediately field screen the sleeves as specified in the site SAP. Place aluminum foil on ends of sample, cap and seal both ends of the sleeves with Teflon or silicon tape (the sleeve for VOC analyses first) and label appropriately. This method yields screening and definitive samples for all analytes.
12. Place sample containers (e.g., liners and jars) in resealable plastic bags and place bags containing samples into an insulated cooler with ice. Samples should be maintained at 4°± 2°C from the time of collection until received at the laboratory. (See SOP 010A.)
13. Note the sample identification number, depth, time of collection, field screening result, and laboratory analysis requested for the sample in the site sampling logbook. (See SOP 002A.)
14. Doff contaminated gloves and don fresh or decontaminated gloves.
15. Repeat steps 1 through 14 until sampling is completed.
16. Plug and abandon borehole as specified in the site Work Plan. (See SOP 008I.)
17. Dispose of non-salvageable equipment as outlined in the site Work Plan.
18. Decontaminate all equipment and personnel. (See SOP 011A.)

4.7 Continuous Core Sampler

The continuous core sampler is a steel tube that may be split in half and held together by threaded collars or may be in one piece. The sampler is usually 5 or 10 ft in length with a 3- to 5-in. diameter. The device may be driven ahead of hollow-stem augers or advanced into the soil by vibrational and/or rotary action.

4.7.1 Methodology

The steps for continuous core sampling are:

1. Complete the standard steps for subsurface sampling in Section 4.1.

2. Don PPE as required by the site Health and Safety Plan.
3. Using the approved drilling method and a decontaminated continuous core sampler, advance to the desired depth.
4. After reaching the desired sampling depth, remove the sampler from the boring and extrude the sample into a holding tray. It may also be desirable to extrude the sample into a clear, resealable plastic bag as it is being placed in the holding tray.
5. Select the desired sampling point on the core. Lightly scrape the core with a decontaminated stainless steel scoop or spoon to remove surface soil and place samples into the appropriate containers. This method yields screening and definitive samples for all analytes except VOCs. This method yields screening samples for VOCs. If definitive samples are required for VOC analyses, a 2-in.-diameter, 4-in.-long stainless-steel or brass sleeves should be driven into the core at the desired sampling point. The length of the sampling sleeve should be equal to or smaller than the diameter of the core to ensure that no headspace exists in the VOC sample. The sleeve can then be extracted and immediately capped and sealed.
6. Place sample containers (e.g., liners and jars) in resealable plastic bags and place bags containing samples into an insulated cooler with ice. Samples should be maintained at 4°± 2°C from the time of collection until received at the laboratory. (See SOP 010A.)
7. Note the sample identification number, depth, time of collection, field screening result, and laboratory analysis requested for the sample in the site sampling logbook. (See SOP 002A.)
8. Doff contaminated gloves and don fresh or decontaminated gloves.
9. Repeat steps 3 through 8 until sampling is completed.
10. Plug and abandon borehole as specified in the site Work Plan. (See SOP 008I.)
11. Dispose of cuttings and non-salvageable equipment as outlined in the site Work Plan.
12. Decontaminate all equipment and personnel. (See SOP 011A.)

4.8 Collection and Homogenization of Composite Samples

Composite samples consist of a series of discrete grab samples that are mixed together to characterize the average composition of a given material. The discrete samples used to make up a composite sample are of equal volume and are collected in an identical fashion. There are two basic types of composite soil samples: areal and vertical. Areal composites are collected from individual grab samples from the same horizontal strata or depth; vertical composites are collected from individual grab samples from within a single vertical profile (i.e., one borehole).

It is important that a composite sample be truly representative if the various sample locations or intervals making up the composite. Therefore, proper homogenization techniques should be followed to generate a composite sample. In addition, the equipment used to composite the sample must not affect the sample quality. A stainless steel bowl and stainless steel or Teflon® or PFTE spoon, properly decontaminated (SOP 011A), are typically used for field compositing of soil samples.

The following steps must be followed when compositing soil samples.

1. Determine where composite sample(s) will be obtained as indicated in the site-specific SAP or comparable plan document.
2. VOC and, in some cases, SVOC samples must be collected and contained immediately as discrete samples and, therefore, cannot be composited.
3. Obtain samples by the methods outlined in this SOP.
4. For split-spoon or Shelby-tube or other cores methods from a specified depth or range of depths, extract or extrude the sample from the split spoon or Shelby tube onto a stainless steel tray or bowl.
5. For hand-auger samples: The sample is acquired directly from the withdrawn auger by using a clean stainless steel or PFTE spatula or spoon. Extract or extrude the sample from the hand auger onto a clean stainless steel tray or bowl.
6. Divide the soil in the sample tray or bowl into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. Follow this procedure several times until the sample is adequately mixed. If a round bowl is used, stir the material in a circular fashion and occasionally turn the material over. The extent of mixing will depend on the nature of the material and should be done to achieve a consistent physical appearance prior to filling sample containers.
7. Once mixing is completed, divide the sample material in half and fill containers by scooping sample material alternately from each half. Transfer subsamples of the composited sample into the appropriate sample containers. Seal, wipe clean, and label sample containers. Use the same care in handling these samples as that used for other samples from the site.

5.0 RESTRICTIONS/LIMITATIONS

The restrictions and limitations for hand augering are:

- The strength of the operator and the quality of the samples required generally limit the use of hand augers to a depth of less than 10 ft.
- Dense, tightly compacted soils or soils with high clay content and/or abundant cobbles will significantly increase the difficulty of hand augering. Loose dry, sandy, uncompacted soils will be easier to auger through but are more likely to slough into the hole and may not be retained in the auger.
- Hand-augured samples should only be collected above (or slightly below) the water table to avoid mixed samples and to reduce the likelihood of borehole collapse.

The restrictions and limitations of test pits are:

- The depths that can be economically reached by test pits/trenches are limited. For sample depths greater than 15 ft, soil borings are recommended over trenches.

- Large volumes of potentially contaminated material must be handled in excavating and reclaiming the test pit/trench. All fluids removed from the excavation must be assumed to be contaminated and must be tested before disposal.
- There is always the possibility of catastrophic failure of a wall and the collapse of the trench.

The restrictions and limitations for split-spoon sampling are:

- Loose, dry, uncompacted, and/or highly saturated materials may not be retained in the sampler. This condition may require the use of a basket (sand catcher) or spring retainer in the cutting shoe of the sampler.
- Soils with a high cobble or rock fragment content may clog the sampler and prevent adequate collection of sample or layers of well-lithified rock will cause refusal of sampler.

The restrictions and limitations for thin-walled sampling are:

- Loose, dry, uncompacted, and/or highly saturated materials may not be retained in the sampler.
- Soils with a high cobble or rock fragment content may clog or damage the sampler and prevent adequate sample collection or layers of lithified rock will cause refusal of sampler.
- It can be difficult or impossible to properly extrude soils from the sampler on-site. When samples are needed for chemical analyses, another sampling device should be used.

The restrictions and limitations for DPT (Geoprobe) sampling are:

- The standard Geoprobe soil sampler can collect only 100 grams of soil.
- The Geoprobe system is limited to sampling depths of approximately 50 ft in unconsolidated, sandy soils, and to shallower depths in compacted gravelly soils and tills.
- If larger sample volumes are required, two (or more) holes may have to be drilled and sampled.

The restrictions and limitations for using the continuous core sampler are:

- Loose dry, uncompacted and/or highly saturated materials may not be retained in the sampler or may break apart when extruded from the sampler, thus inhibiting proper sampling procedures.
- Soils with a high cobble or rock fragment content may clog the sampler and prevent adequate collection of sample.
- Dense and/or highly compacted soils may be difficult to extrude from the sampler. A split-spoon sampler with sleeves is a better choice if highly compact soils may be encountered and VOC samples are needed.

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STANDARD OPERATING PRACTICE TNFLD007E

Direct Push Technologies (Geoprobe®)

TABLE OF CONTENTS

Page

1.0 SCOPE AND OBJECTIVES 2
2.0 BACKGROUND 2
3.0 REQUIRED EQUIPMENT 4
3.1 DECONTAMINATION EQUIPMENT 4
3.2 PROBING EQUIPMENT 4
3.3 SMALL DIAMETER MONITORING WELL EQUIPMENT 5
3.4 SAMPLING EQUIPMENT 5
4.0 PROCEDURES 6
4.1 MOBILIZATION 6
4.2 DECONTAMINATION 6
4.3 SOIL GAS SAMPLING 6
4.3.1 Post-Run Tubing Soil Gas Sampling Procedure 6
4.3.2 Vertical Profiling 8
4.4 SOIL SAMPLING 8
4.4.1 Large Bore and Macro-Core Sampler Use and Specifications 8
4.4.2 Soil Sampling Procedures 9
4.4.3 Documentation 10
4.5 GROUNDWATER SAMPLING 10
4.5.1 Screen Point Sampler Procedure 11
4.5.2 Small Diameter Wells 12
4.5.3 Small Diameter Wells Using Prepacked Well Screens 12
4.5.4 Two-Inch Diameter PVC Wells 14
4.5.5 Sampling Small Diameter and Two-Inch Diameter PVC Wells 14
4.5.5 Documentation 14
4.6 PLUGGING AND ABANDONMENT 14
4.7 QUALITY CONTROL 15
5.0 RESTRICTIONS/LIMITATIONS 15
6.0 REFERENCES 15

STANDARD OPERATING PRACTICE TNFLD007E

Direct Push Technologies (Geoprobe®)

1.0 SCOPE AND OBJECTIVES

The objective of this procedure is to define the techniques and requirements for the use and operation of direct push technologies (DPT) for the collection of subsurface soil, groundwater and soil gas samples and data. DPT refers to tools and sensors that are "pushed" into the ground without the use of drilling to collect soil or to make a path for the tool.

While other manufacturers make similar equipment, Geoprobe® is considered by some to be the industry-standard for soil probing and is the focus of this Standard Operating Practice (SOP).

2.0 BACKGROUND

DPT can be used in nearly any conditions amenable to hollow-stem-auger drilling and provides a cost-effective alternative to traditional subsurface investigative methods. Depending on site conditions, up to 15 to 25 soil gas, soil, or groundwater samples can be collected in a day.

DPT is particularly suited to the site characterization process. The samples collected using this technique are commonly analyzed using on-site gas chromatography for rapid analytical turnaround time and in-field decision making. By using DPT in combination with appropriate on-site analytical equipment (gas chromatograph/mass spectrometer, atomic absorption, X-ray fluorescence, immunoassay, etc.), the sampling plan can be adjusted in the field to ensure the vertical and lateral extent of soil and/or groundwater contamination is determined before demobilization. DPT is also used for a wide range of other environmental applications such as remedial action installation (e.g., injection of bioremediation materials), remediation system monitoring, cleanup confirmation sampling, hydrologic studies, and geotechnical studies.

The Geoprobe® is a vehicle-mounted, hydraulically powered, percussion/probing machine manufactured by Geoprobe Systems, Inc. of Salina, Kansas. A Geoprobe® relies on a relatively small amount of static (vehicle) weight combined with percussion as the energy for advancement of a tool string to collect soil gas, soil, and/or groundwater samples. Static forces are used to push the probe to depths of more than 40 feet (ft) in some soils. With the addition of percussion to the static force, probes can be driven to depths in excess of 100 ft. Geoprobe Systems also offers the following tools and add-ons for sample and data collection (listed to provide information, not endorsement of any particular tool or product):

- Large Bore Soil Sampler. A closed piston sampler for soil sampling at discrete depths. The design allows the sampler to remain completely sealed while driven to depth. It recovers 22-inch long x 1.0625-inch diameter (559 mm x 27 mm) core to depths of over 60 feet (depending on soil conditions).
- Macro-Core® Soil Sampler. Uses a variety of liner materials in a hollow steel corer. It is typically used to depths of 30 to 60 feet. Can be used as an open sampler (continuous core) or fitted with a closed piston (discrete sampler).

- Dual Tube Sampling Systems. Uses two sets of probe rods to collect continuous soil cores. One set of rods is driven into the ground as an outer casing, providing a sealed hole from which soil samples may be recovered without the threat of cross-contamination. The second, smaller set of rods are placed inside the outer casing, hold a sampler liner in place as the out casing is driven one sampling interval. The small rods are then retracted to retrieve the filled liner. (Not covered in this SOP.)
- Membrane Interface Probe. Provides near real-time total volatiles data from subsurface soil probe to on-board PID or FID or both detectors in series. (Not covered in this SOP.)
- GeoTech Cone Penetrometer. Cordless cone penetration testing (CPT) technology that uses acoustic transmission of soil resistance data for real-time assessment of subsurface soil conditions. (Not covered in this SOP.)
- Small diameter monitoring wells, which are prepacked well screens in two sizes (0.5-inch ID x 1.375-inch OD or 1.0-inch ID x 2.5-inch OD).
- Screen Point 15 Groundwater Sampler. The "Screen Point 15" is a 1.0-inch OD steel groundwater sampling point with an exposed screen length of 41 inch (longer screens may be custom ordered). This commonly referred to as a "Hydropunch".
- Groundwater Profiler. Discrete interval sampling using a 6-inch or 12-inch screen lengths. The tool is advanced through Geoprobe's 2.125-inch probe rods. Large screen openings allow pre-sample development and hydraulic conductivity testing as well as discrete zone sampling.

Variations and customizations of the tools listed above are also available for Geoprobe Systems Inc. and other vendors.

The advantages of DPT systems are:

- Lower cost;
- Ease of mobilization, versatility of use, can be used in limited access areas where larger and taller drilling equipment will not fit,
- Rapid sample collection;
- Absence of borehole cuttings, thus minimizing investigation-derived waste and risk to workers associated with contaminated soils or vapors;
- Ability to collect undisturbed soil and groundwater samples without constructing permanent monitoring wells;
- Access to much greater depths than those achieved with hand-driven probing equipment; and
- Ability to rapidly obtain a continuous record of stratigraphy using the soil conductivity logging system.

Disadvantages of DPT systems are:

- Depth limitations and difficulty or inability to drive probes through larger size gravels or boulders, semi-consolidated soils, and hard rock;
- Smaller diameter probes and wells can limit options for purging/sampling equipment and methodology; and

- Small diameter cores limit the amount of sample material produced for extensive laboratory analyses.

3.0 REQUIRED EQUIPMENT

3.1 DECONTAMINATION EQUIPMENT

The following decontamination equipment is required:

- plastic buckets and/or troughs;
- laboratory-grade detergent (phosphate free);
- high-pressure hot water cleaner;
- stiff bristle brushes capable of cleaning the inside and outside of equipment;
- Teflon® sprayers or wash bottles, or 2- to 5-gallon (gal) Teflon configuration manual pump sprayer;
- plastic sheeting;
- disposable wipes or rags;
- aluminum foil;
- potable water;
- deionized, organic-free water [American Society for Testing and Materials (ASTM) Type II or equivalent];
- pesticide-grade or better methanol, or pesticide-grade or better isopropanol if required by the state or region (Note: the use of methanol is preferred to isopropanol because of the potential for generation of acetone as a photodegradation product of isopropanol); and
- latex gloves, goggles, and other protective clothing as specified in the site-specific Health and Safety Plan.

3.2 PROBING EQUIPMENT

The following equipment is required:

- heavy-duty, four-wheel-drive pickup, van, or all-terrain vehicle (ATV);
- rear-mounted hydraulic probe driving and removal system;
- rotary impact drill for asphalt/concrete penetration;
- vacuum volume pump system for soil gas sampling and groundwater purging;
- hardened steel sampling probes and accessories; and
- decontamination equipment.

3.3 SMALL DIAMETER MONITORING WELL EQUIPMENT

The following equipment is required:

- casing drive seat,
- expendable drive point,
- drive-point O-ring (per manufacturer specification),
- prepacked screen,
- polyvinyl chloride protective casing,
- service cap,
- stainless steel casing, and
- casing O-ring (per manufacturer specification).

3.4 SAMPLING EQUIPMENT

The following equipment is required:

- retractable soil gas points for vertical profiling;
- expendable soil gas points for discrete depth-interval sampling;
- 3/16-inch (in.) Teflon®, polyethylene, or polypropylene tubing and soil gas points;
- appropriate sample containers, ice, cooler, and sample labels;
- glass soil gas bulbs with Teflon stopcocks and replaceable septa, stainless steel canister, or sample syringes;
- Tedlar® bags for gas samples;
- screen point samplers or mill-slotted well points for shallow groundwater sampling;
- water trap for vacuum pump purging or semivolatile sampling;
- for groundwater purging and sampling: small-diameter inertial foot-valve pumps, peristaltic pumps, minibailers, or tubing bottom check valve; and small-diameter, flexible water level indicator;
- granular or powdered bentonite;
- plastic sheeting, garbage bags, caution tape and posts;
- Geoprobe® operator's manual;
- permanent implants for soil gas sampling, air sparging, or performance monitoring;
- soil conductivity tools for stratigraphic definition;
- field analytical equipment (gas chromatograph/mass spectrometer, atomic absorption, x-ray fluorescence, and immunoassay);
- closed-piston Large-bore and/or Macro-Core soil samplers for discrete depth soil sampling with liners, extruders and dowels for discharging soil, and other soil sampling accessories;
- small diameter well materials; and

- probing tools including sufficient numbers of probe rods to avoid extensive decontamination, drive caps, pull caps, drive points, extension rods, cleaning accessories, subassemblies, and adapters.

4.0 PROCEDURES

4.1 MOBILIZATION

Before initiating any Geoprobe® survey, the following items must be completed:

- each location will be field checked for accessibility;
- all initial and optional/potential sampling locations will be staked;
- utility clearance will be completed on each location (SOP 001A);
- depth to groundwater (vadose zone thickness) will be estimated for each location; and
- sampling location and other information, such as approximate surface elevation and estimated depth to groundwater, will be plotted on a map for field use.

4.2 DECONTAMINATION

All downhole Geoprobe® sampling equipment and all equipment directly contacting the samples will be decontaminated (following SOP 011A) before reuse and between drilling locations.

4.3 SOIL GAS SAMPLING

There are three types of Geoprobe® sampling tools that can be used for sampling soil gas: (1) sampling through probe rods using an expendable point, (2) sampling through probe rods using a retractable point, and (3) sampling through inner tubing using the post-run tubing (PRT) system. The PRT system is the preferred sampling method for the following reasons:

- increases speed and accuracy of soil gas sampling,
- eliminates problems associated with rod leakage and sample carryover (preserves sample integrity),
- reduces the probe rod decontamination time,
- uses a simple design for ease of use and vacuum-tight sealing, and
- requires no management of inner tubing during probing.

4.3.1 Post-Run Tubing Soil Gas Sampling Procedure

The following section describes the primary steps that must be followed when sampling soil gas using the PRT method. Field staff should carefully review Appendix D (and any subsequent updates/revisions) of the Geoprobe® Tools and Equipment Catalog (Geoprobe Systems, 1999)

for additional details regarding operation and procedures for soil gas sampling with the PRT system.

Preparation

1. Decontaminate all parts before use following the decontamination procedures outlined in SOP 011A.
2. Install O-rings on the expendable point holder and the PRT adapter.
3. Check the probe rods for any obstructions and test fit the adapter with the PRT fittings on the expendable point holder.
4. Connect the adapter to the end of the tubing; secure with Teflon tape, if necessary.

Probing

1. Drive the PRT tip configuration into the ground. Connect probe rods as necessary to reach the desired depth.
2. Disengage the expendable point by pulling the probe rods up about 1 foot (ft) when the desired depth is reached. Remove the push cap from the top probe rod.

Connection

3. Insert the adapter end of the tubing inside the probe rods.
4. Push the evacuation tubing down the probe rods until it reaches the bottom. Leave 2 feet (ft) of tubing extending out of the top of the probe rods.
5. Twist the tubing in a counterclockwise direction until the adapter threads have threaded into the expendable point holder.
6. Check the connection by pulling up lightly on the tubing.

Sampling

7. Connect the evacuation tubing and the in-line glass bulb or stainless steel canister to the vacuum pump system.
8. Purge the tubing and glass soil gas bulb or stainless steel canister by pumping at least three probe rod and canister volumes before collecting a sample.
9. The gas flow rates will be monitored with a ball-type flow meter attached to the exit port of the vacuum pump.
10. Close the stopcocks in the glass bulb or stainless steel canister.
11. If the soil gas sample is collected with a syringe, puncture a silicon rubber segment in the evacuation line.
12. If the soil does not yield vapor to the applied vacuum, either pull the probe rod back farther from the tip or apply a greater vacuum pressure.

Removal

13. After collecting a sample, pull up firmly on the tubing until it releases from the PRT adapter.

14. Remove the tubing from the probe rods. Dispose of the tubing.
15. Retrieve the probe rods from the ground.
16. Visually inspect the O-ring at the base of the PRT to verify a proper seal was achieved.
17. Plug the hole as specified in Section 5.7 of this procedure.

Documentation

The following information, as a minimum, will be recorded in the field logbook or on a Soil Gas Sample Log (if used): date and time, site and sample location, sample collection personnel, probe/sample depth, flow rate, purge, and sample volume. SOP 002A describes field documentation practices and requirements.

4.3.2 Vertical Profiling

Vertical profiling consists of collecting soil gas samples from various depths at a single location. The depth of the soil gas sample with the most significant response will indicate the optimum soil sampling depth. Vertical profiling should generally be done at a number of locations during the soil gas survey to assess the variability of contaminants in the vadose zone. Knowledge of the subsurface lithology can also assist in determining the optimum depth to collect soil gas samples. (New tubing must be used for each sample.)

4.4 Soil Sampling

The Geoprobe system has two different types of soil-sampling tools: (1) the Large Bore soil sampler—a closed piston (discrete interval) sampler and (2) the Macro-Core soil sampler—a longer and larger-diameter sampler that can be used in an open tube mode for ground surface sampling and in a closed piston mode for depth discrete subsurface sampling. Both types of samplers are pushed or driven and do not generate any cuttings.

4.4.1 Large Bore and Macro-Core Sampler Use and Specifications

The Large Bore sampler is generally more applicable to intermittent depth-discrete sampling while the Macro-Core with its greater length and volume is more appropriate for shallower continuous coring and/or when greater sample volume is needed for extensive laboratory analysis. The Macro-Core sampler is now equipped with a closed-piston tip for discrete sample collection. Except for surface coring (i.e., 0 to 4 ft depth), the Macro-Core sampler must always be used in the closed piston mode to ensure depth discrete sample integrity. Equipment specifications are provided in the following table for each of these soil-sampling devices.

GEOPROBE® PROBE DRIVE SOIL SAMPLERS (1999)

Name of sampler	Sample tube dimensions (in.)	Core dimensions (in.)	Volume [milliliters (mL)]	Liners	Depth capability (ft)[a]
Large Bore	24 by 1.375	22 by 1.0625	320	Yes	60+
Macro-Core	48 by 2	45 by 1.5	1303	Yes	30+

Liners are available for the Large Bore sampler in clear plastic (CAB), brass, stainless steel, and PTFE (Teflon®). Liners are available for the Macro-Core sampler in clear plastic (PVC and PETG), stainless steel, and PTFE. When cores are retrieved, the plastic liners can be cut longitudinally to screen soils for contaminants and lithologic logging and to remove soils for laboratory analysis. In addition, the plastic liners can be cut circumferentially to isolate and cap segments for later analysis of volatile organic compounds (VOCs).

4.4.2 Soil Sampling Procedures

The following steps must be followed when sampling soil with the Geoprobe® system. Field staff should carefully review Appendix A and B (and any subsequent updates/revisions) of the Geoprobe® Tools and Equipment Catalog (Geoprobe Systems, 1999) for additional details regarding operation and procedures for soil sampling using the Large Bore and Macro-Core samplers, respectively.

Assembly

1. Decontaminate all parts before use following the decontamination procedures outlined in SOP 011A.
2. Assemble all of the parts as shown in the Geoprobe® operator's manual.
3. Replace the O-ring on the piston stop-pin each time the sampler is assembled. Make sure the pin is tightened down with a wrench.

Probing

4. Attach the assembled sampler onto the leading Geoprobe® probe rod.
5. Drive the sampler into the ground and retighten the stop-pin.
6. Drive the sampler to the top of the desired sampling interval. Note: A 12-in.-diameter drive rod for initial drilling is often helpful in placing the sampler below the surface.

Stop-Pin Removal

7. Remove the drive cap and lower the extension rods down the inside diameter of the probe rods; use couplers to join rods together.
8. Attach the extension rod handle to the top extension rod and rotate the handle clockwise to remove the stop-pin.

9. Remove the extension rods from the probe rods. The stop-pin should be attached to the last extension rod.

Sampling

10. Replace the drive cap onto the top probe rod.
11. Mark the length of the sampler used on the top probe rod.
12. Drive the sampler the marked distance. Do not over-drive the sampler.
13. Remove the probe rods from the hole to recover the sampler.
14. Remove the soil core from the sampler sheath. Samples may require a machine extruder to separate soils from liners or sampling sheaths.
15. If contaminants of concern include VOCs, then the soil core should immediately be screened for VOCs by a hand-held organic vapor analyzer (OVA; either PID or FID) across the entire length of core. Instrument readings should be recorded in the field book and/or soil boring log. Samples should then be quickly containerized for OVA headspace analysis of VOCs, and for on-site and/or off-site analysis of VOCs per specifications in site-specific Work Plans. Sample liner section ends should be immediately capped for off-site VOC laboratory samples. Sampling for other analytes (e.g., inorganics and SVOCs) should follow VOC sampling.
16. Label all samples completely immediately upon sampling.

4.4.3 Documentation

The soil sampling process must be fully documented using a soil boring log form and related requirements of SOP 002A. Soil lithology should be logged according to the requirements of SOP 007B. All screening measurements, sample identification numbers, and other relevant information identified on the soil boring log must be recorded for each boring.

4.5 GROUNDWATER SAMPLING

There are three types of well point configurations that can be used with the Geoprobe® to collect groundwater samples. All three types of well points are driven into the saturated zone with the Geoprobe®, and a sample of the groundwater is collected through the hollow probe rods.

The different well points available are:

- An expendable point (which is disconnected by pulling up on the probe rods to expose the open bore of the probe rod),
- A mill-slotted well point, and
- A screen point sampler.

The expendable point is generally not recommended because sand and silt can flow up the probe rod and clog the sampling apparatus. The mill-slotted well point is recommended for relatively clean unconsolidated sand aquifers where silts and clays are minor or nonexistent. The screen point sampler, which contains a fine screen within a perforated steel sheath, is recommended for

most hydrogeological settings. To avoid potential cross-contamination and mixing, multiple groundwater samples should never be taken vertically at different depths from within the same borehole. The lateral swing lever allows groundwater sampling from separate, adjacent probes without moving the vehicle. This mode should be used to preserve sample integrity from each depth during vertical profiling of groundwater contamination.

4.5.1 Screen Point Sampler Procedure

The Geoprobe® screen point sampler consists of an expendable stainless steel probe point, a 1.0-inch OD screen and riser attached to the probe point, a stainless steel sheath that covers the screen during probing, and a head assembly. The 41-inch long screens are wire-wound stainless steel or slotted PVC. Screens can be custom fabricated up to a length of 48 in. The screen section remains totally enclosed in the sheath until it is pushed out into the formation at the desired depth. Groundwater samples can be bailed using minibailers and/or pumped from the probing rods or pumped directly from the screen section using flexible tubing, a PRT adapter, and a peristaltic pump. The following steps must be followed when using the screen point sampler. Field staff should carefully review Appendix C (and any subsequent updates/revisions) of the Geoprobe® Tools and Equipment Catalog (Geoprobe® Systems, 1999) for additional details regarding operation and procedures for groundwater sampling with the Screen Point 15 Groundwater Sampler.

Assembly

1. Decontaminate all parts before use following the decontamination procedures in SOP 011A.
2. An uncontaminated screen insert should be used for each new sample.
3. New O-rings must be installed at each O-ring location before each sample is taken.
4. Follow the assembly procedures outlined in the Geoprobe® operator's manual.

Probing

5. Place a drive cap on the assembled sampler and drive into the ground.
6. Continue to drive the sampler with probe rods until the sampler tip has been driven about 1 ft below the target sampling depth.
7. Disengage the expendable drive point by pulling the rods back a distance of about 2 ft.

Exposing Screen

8. The 3/8-in. tubing affixed with a PRT adapter is lowered to the top end of the screen assembly.
9. The threads on the PRT adapter are engaged with the threads on the screen connector by pushing gently downward on the tubing and rotating it counterclockwise.
10. In a stable formation, it should be possible to push the screen assembly out into the open borehole by pushing down on the tubing.
11. If the screen cannot be pushed into the open borehole with the tubing, remove the tubing and push the screen—with the extension rods inserted—down the inside of the probe rods. Care should be taken to prevent damage to the sample and probe rods.

Sampling

12. Attach a peristaltic or bladder pump (or a vacuum pump with an in-line trap) to the 3/8-in. tubing and collect a water sample. This method of sampling can be used at depths of 25 ft or less. Do not use a vacuum or peristaltic pump if sampling for VOCs. A bailer should be used in this case.
13. At depths greater than 25 ft, lower the 3/8-in. tubing equipped with a bottom check valve to the water level. By oscillating the tubing up and down, water will be pushed upward into the tubing. Remove the tubing from the probe rods and collect the sample. The 3/8-in. O.D. by 1/4-in.-I.D. well tubing recovers 9.64 mL/ft. Discard tubing after each sample.
14. A stainless steel bailer attached to clean nylon line can also be used to collect water samples. The bailer is lowered down the hollow drive rods to the water table.

Removal

15. Remove the tubing if the PRT system was used.
16. Remove the probe rods and sampler.

4.5.2 Small Diameter Wells

A permanent groundwater sampling point, known as a small-diameter well or microwell, can be installed using the Geoprobe®. The well is installed using an expendable drive point attached to stainless steel casing. After driving conventional probe rods to the desired screen depth, the casing is driven around the probe rods to total depth. The probe rods are then removed and a prepacked stainless steel screen is placed at the base of the hole while the casing is retracted, leaving the screen exposed to the aquifer in the lower section of the hole. An alternative approach is to use an expendable point with the Macro Core Sampler and install a 2-inch PVC well in the hole. These methods are further described below.

The advantages of small-diameter wells are:

- No drill cuttings or other investigation-derived wastes are generated during the installation of a small diameter well.
- A small diameter well is less expensive to install than a conventional well, and requires no seals and grout above the screen.
- The small diameter well can be developed, purged, and sampled just like a conventional monitoring well.
- The water produced during development and purging is minimal because of the small diameter (volume) of the small diameter well.

4.5.3 Small Diameter Wells Using Prepacked Well Screens

This method uses a prepacked stainless steel screen that is placed at the base of the hole while the casing is retracted to up above the top of screen. Prepacked screens come in two sizes: 0.5-inch ID x 1.375-inch OD x 36-inch length and 1.0-inch ID x 2.5-inch OD x 5-foot length.

The following steps must be followed when installing the prepacked screen small diameter well. Field staff should obtain and carefully review the Geoprobe® Technical Bulletin 95-1000

(Geoprobe® Systems, October 1995, and any subsequent updates/revisions) for additional details regarding operation and procedures for small diameter well installation.

Decontamination

Decontaminate all parts before use following the decontamination procedures in SOP 011A.

Pilot Hole

A pilot hole is made by probing with a retractable pilot point threaded onto the end of the probe rod. The pilot hole should be pushed to within 2 to 4 ft of the planned total depth of the well.

Initial Assembly and Insertion

1. Ensure that an O-ring is in the proper slot on the expendable drive point and insert the expendable drive point into the drive shoe.
2. Thread the point driver into a section of probe rod and insert the probe rod (driver end first) into the casing assembly.
3. Thread the drive collar into the casing and the skirted drive cap onto the probe rod.
4. Insert the casing assembly into the pilot hole. Do not retract the assembly before the sampling depth has been reached.

Driving

5. Drive the assembly to the planned total depth.
6. When adding probe rods and casing joints, ensure the threads are tight and the shoulder of the probe rod threads is even with, or above, the top of the drive collar. Ensure that each casing joint is equipped with O-rings.

Prepacked Screen Installation

7. Remove all probe rods from the inside of the installed casing. Reinstall the casing drive collar.
8. Attach the prepacked screen to a section of extension rod using a screen connector.
9. Lower the screen/rod assembly down the casing until the screen reaches the bottom of the casing. Leave at least 25 in. of extension rod above the casing.

Casing Retraction

10. Retract the casing using the casing puller on the hammer of the Geoprobe®.
11. As the casing rises, press the extension rod handle down so that the prepacked screen remains stationary.
12. After the casing has been pulled up the length of the screen (3 or 5 feet), rotate the handle of the extension rod clockwise at least six turns. Remove the extension rods from the casing.
13. Install a service cap on the top of the casing and install a protective casing with a locking cap and lock to prevent tampering.

4.5.4 Two-Inch Diameter PVC Wells

The basic installation procedure is similar to above, except that an expendable point is used and the well is installed through a 2 5/8-inch ID Macro Core Sampler. The Macro Core is used to advance a continuous core boring to the desired depth. A two-inch ID Schedule-40 PVC well screen is placed into the inner diameter of the Macro Core which is fitted with an expendable endpoint. As the Macro Core is pulled up, the expendable point and the PVC well screen stay at depth. As the expendable point is only slightly larger than the two-inch PVC, it creates a very small annulus around the PVC. It may be possible to install a sand filter pack and a granulated bentonite seal with a small diameter tremie pipe after the Macro Core casing is pulled up, although some bridging should be anticipated. Once installed, the two-inch PVC can be used for groundwater sampling, air sparging, or SVE systems. Because this well installation is non-standard, check with local well installation regulations regarding use of data from these wells.

This application performs best in sandy soil conditions where there is relatively little resistance to DPT advancement of the sampler and formation collapse will occur around the screen. Depth limitations are site specific, but are generally 30 feet or less. Once installed, the two-inch PVC can be used for groundwater sampling, air sparging, or SVE systems. Because this well installation is non-standard, check with local well installation regulations regarding use of data from these wells. The well should be completed at the surface using standard wellhead completion procedures (see SOP 008D).

4.5.5 Sampling Small Diameter and Two-Inch Diameter PVC Wells

The small diameter wells can be developed, purged, and sampled by using a peristaltic bladder, tubing with bottom check valve, or a bailer. The two-inch PVC wells can be developed, purged and samples using standard monitoring well techniques. SOP 008D provides information regarding the methods and requirements for development/purging. SOP 008F provides information regarding the methods and requirements for groundwater sampling.

4.5.5 Documentation

The small diameter or microwell installation process must be fully documented in the field logbook and (if used) the appropriate field forms, in accordance with SOP 002A. Development, purging, and sampling of small diameter or microwells should be completely documented. The locations and elevations of each well should be accurately surveyed.

4.6 Plugging And Abandonment

All probed holes - whether soil gas, soil, or groundwater test holes - must be plugged and abandoned. Holes should be filled with bentonite slurry, granular bentonite, or 3% bentonite cement from total depth to the surface. The plugging material can be poured into shallow holes less than 5 ft in depth. Deeper holes will require tremie placement of the plugging material. When plugging a small diameter well, the casing is retracted a few inches and extension rods are used to push out the grout plug and expendable point. A grout tube is then inserted out of the grout hole at the end of the screen, and a high-pressure grout pump is used to pump grout into the boring as the casing rods and screen are withdrawn using the Casing Puller Assembly.

4.7 QUALITY CONTROL

Any departure from the specified SOPs must be submitted and approved before deviating from the requirements. Deviations shall be sufficiently documented to allow repetition of the activity as actually performed.

5.0 RESTRICTIONS/LIMITATIONS

The following restrictions/limitations apply to the procedures described in this SOP:

- Soil gas results are a secondary indicator of other media (soil and water) contamination. The results are semiquantitative. Soil gas release is affected by many variables including the chemical and physical properties of the contaminant, soil permeability, temperature, barometric pressure, precipitation, and fluctuating water table. Actual soil and/or groundwater samples are required for definitive confirmation.
- DPT is limited to sampling depths up to approximately 100 ft in unconsolidated, sandy soils and to shallower depths in compacted clayey or gravelly soils and tills.
- Small diameter well installations may not meet well installation requirements in some states and, therefore, groundwater data collected from this type of well are not accepted as definitive data. Always check with your local regulatory agency for well installation requirements.

6.0 REFERENCES

Christy, T. M. and Spradlin, S.C., *The Use of Small Diameter Probing Equipment for Contaminated Site Investigation*, Geoprobe® Systems Brochure, 1993.

Geoprobe® Systems, 1999-2000 Equipment and Tools Catalog, 1999.

Geoprobe® Systems, *A Guide to Geoprobe® Tools for Groundwater Samplers and Permanent Monitoring Devices*; Technical Bulletin 95-1000, October 1995.

Tuttle, J. C. and Chapman, G. H., *Site Characterization Alternative: Hydraulic Probe Sampling and Mobile Laboratory Analysis*, HMC Superfund '92, HMCRI's 13th Annual Conference and Exhibition, 1992.

STANDARD OPERATING PRACTICE TNFLD010C

Sample Labeling, Control and Shipping

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 2

2.0 SAMPLE LABELING PROCEDURES 2

2.1 Procedures 2

3.0 SAMPLE NOMENCLATURE 3

4.0 CHAIN OF CUSTODY PROCEDURES 3

5.0 SAMPLE HANDLING PROCEDURES 5

5.1 General 5
5.2 Sample Packaging for Shipment 5
5.3 Sample Shipment Considerations (DOT Regulations) 6

6.0 REFERENCES 7

STANDARD OPERATING PRACTICE TNFLD010C

Sample Labeling, Control and Shipping

1.0 INTRODUCTION

The general objective of this SOP is to present procedures for sample identification (ID), sample control and chain-of-custody, and sample handling.

2.0 SAMPLE LABELING PROCEDURES

All sample identification, field records, and chain-of-custody records will be recorded in black waterproof, ballpoint non-erasable ink. Under no circumstances will "Sharpie" markers be used on field forms or chain-of-custody forms. If errors are made on any of these documents, personnel will cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the person performing the correction. If possible, all corrections should be made by the individual who made the error.

If information is entered using stick-on labels on sample tags, logbooks, or sample containers, subsequent removal of these labels should not be possible without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information. Corrections to information recorded on stick-on labels should be made as stated in the previous paragraph.

2.1 PROCEDURES

All soil, sediment, surface water, groundwater, waste, ambient air, and vapor emission samples collected will be labeled according to the following procedures.

1. Label each sample container with the following information:
   - Date and time,
   - Sample ID number,
   - Project number ,
   - Sampler (name), and
   - Preservative .
2. Enter sample collection information in the field logbook. Begin the sample collection entry with the time at which the sample is collected (or collection is begun). Make the entry chronologically in the logbook (SOP No. 002A).
3. If no map of sampling locations is available prior to sampling, sketch a drawing of the site (not to scale) in the field logbook to provide an illustration of all sampling points. Provide

measured distances from sampling points to a fixed reference point to allow accurate placement of sample locations on figures or maps.

3.0 SAMPLE NOMENCLATURE

The sample numbering scheme used for field samples and quality control (QC) samples is defined in the project-specific Sampling and Analysis Plan, Field Sampling Plan or comparable document.

4.0 CHAIN OF CUSTODY PROCEDURES

Chain-of-custody (COC) is a continuous possession of samples from their origin to completion of analysis and archiving/disposal in the laboratory. This uninterrupted possession is required to maintain integrity of samples. The chain-of-custody record is the documentation of this uninterrupted possession of the samples. The following procedures are recommended for ensuring preservation of chain-of-custody in the field:

- To simplify the chain-of-custody record and eliminate potential litigation problems, as few people as possible should handle the samples during the investigation.
- Each field team member is responsible for the proper handling and custody of the samples collected until they are properly and formally transferred to another person or facility. If the project has a Field Sample Coordinator (FSC), the field team will deliver all samples to the FSC as soon as possible, who then assumes responsibility for completing the chain-of-custody record.
- Prior to or immediately following sample collection, sample labels shall be completed for each sample container, using black waterproof, non-erasable ink, and affixed to the sample container. Labels should be affixed to each sample container and completely covered with a clear waterproof tape to prevent the labels from separating from the sample containers or water damage to the labels.
- Sample containers should be placed in resealable plastic bags before placement on ice to prevent moisture from contacting the sample jars, which could affect the legibility of the sample container labels.
- All samples collected (date, time of collection, sample ID, location and other information as necessary) must be documented in bound field logbook at the time of sample collection.

To complete the chain-of-custody and to maintain an accurate record of sample collection, transport, analysis and disposal, the following methodology will be used:

1. Samples will be accompanied by a chain-of-custody form at all times. A chain-of-custody record will be completed for all samples or materials collected. A separate chain-of-custody record will be utilized for each final destination or laboratory utilized during the inspection or investigation.

2. The chain-of-custody form will be used by personnel responsible for ensuring the integrity of samples from the time of collection until shipment to the laboratory.

3. The chain-of-custody record shall accompany all samples to the final destination. The original of the record will be placed in a sealed plastic bag taped to the inside top cover of the cooler. One copy of the record will be retained by the Field Sample Coordinator, and faxed to the Project Chemist and Project Manager. The original record will be transmitted to the Project Manager after samples are accepted by the laboratory. This copy will become a part of the project file.

4. The chain-of-custody form will be signed by each individual who has the samples in his or her possession.

5. The chain-of-custody form will be initialed in the field by the person collecting the sample, for every sample. If needed, several COC forms or COC continuation forms can be used to group samples under one COC. The continuation forms will reference the original COC number and all pages will be numbered.

6. The chain-of-custody will be completed in the field to indicate project, date, location, sampler, client, etc.

7. If the person collecting the sample does not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished by" and "Received by" will be completed in the field by the sampler and transporter, respectively.

8. The person transporting the samples to the laboratory or delivering them for shipment will sign the record form as "Relinquished by" at the time the samples are handed off to the laboratory (which will sign the "Received by" section).

9. If the samples are transported directly to the laboratory, the chain-of-custody form will be kept in the possession of the person delivering the samples.

10. If the samples are shipped to the laboratory by commercial carrier, the chain-of-custody form will be sealed in a watertight container, taped on the inside lid, and the shipping container sealed with custody seals (two on each shipping container) and tape prior to being given to the carrier.

    a. For samples shipped by commercial carrier, the waybill or air bill will serve as an extension of the chain-of-custody record between the final field custodian and receipt in the laboratory. The sender's copy of the waybill must be stapled to the sender's copy of the chain-of-custody form and filed with the original. The waybill tracking number must be entered into the logbook. Sample sender must sign with date and time as "Relinquished by" just before sealing coolers.

    b. Upon receipt in the laboratory, the sample recipient will open the shipping containers, compare the contents with the chain-of-custody record, ensure that document control

information is accurate and complete, and sign and date the record as "Received by". Any discrepancies will be noted on the chain-of-custody form.

c. In the event of the discrepancies, the samples in question will be segregated from normal sample storage and the Project Chemist immediately notified.

d. The chain-of-custody form is completed upon receipt of the samples by the analytical service laboratory. The completed chain-of-custody form will be returned to the Project Manager and maintained in the project file.

5.0 SAMPLE HANDLING PROCEDURES

5.1 GENERAL

Upon collection, all samples will be immediately placed on ice and taken to a proper location for packing, re-icing, and shipment. At all times, sufficient ice must be in the coolers to maintain a temperature of 4° C. All void spaces in the cooler should be filled with ice. Estimate no more than two to one ratio of samples to ice, except during hot weather when a one to one ratio should be used (e.g., one pound of ice per one pound of sample). This will insure samples are stored at the proper temperature.

5.2 SAMPLE PACKAGING FOR SHIPMENT

When preparing the samples for shipment to the laboratory, the following procedures will be employed:

1. Proper packing is necessary to ensure that samples arrive at the laboratory in good condition. The following protocol will be used for packaging of samples:

    a. Only waterproof metal or equivalent strength plastic ice chests and coolers will be used. Tapes that may emit VOCs will not be used within the container.

    b. Two large garbage bags or drum liners will be placed in the cooler to prevent leakage.

    c. Approximately 2 inches of inert cushioning material (vermiculite or similar absorbent material) will be placed in the bottom of the inner drum liner.

    d. All sample containers will be placed in clear, plastic, resealable (e.g. Ziploc ™) bags. Glass containers should be wrapped in bubble wrap or cushioning material to prevent breakage.

    e. Samples will be packed properly for shipment so that the bottles will not move around and/or break during shipment.

    f. Sufficient ice to maintain 4° C during shipment will be placed beneath, around, and on top of the sample containers. Additional cushioning materials will be added to prevent movement of samples during shipment.

g. The chain-of-custody form will be placed in a resealable plastic bag and attached to the lid of the cooler with clear plastic packing tape. Laboratory name and contact, courier name(s), and other pertinent information will be recorded on the form.

h. If the cooler is equipped with a drain plug, it will be taped shut.

i. The completed shipping label will be attached to the cooler.

j. "This Side Up" arrow labels will be placed on two sides of the cooler, and "Fragile" labels will be placed on all four sides.

k. Numbered and signed custody seals will be placed on the front right and back left of each cooler. These seals will be covered with clear plastic packing tape.

1. Samples will be transported by courier in an approved, cooled shipping container, ensuring that the maximum holding times between sample collection and analysis will not be violated. In general, all samples should be shipped priority overnight.

2. The weight limit of the shipper will be observed.

3. All records pertaining to the shipment of a sample will be retained in the project file (e.g., freight bills, post office receipts, and bills of lading).

5.3 Sample Shipment Considerations (DOT Regulations)

Samples in general can be classified in to hazardous materials/dangerous goods for shipment per DOT regulations. If we believe that the sample does not contain hazardous materials above reportable quantities or above TCLP hazardous characteristics, or above listed concentrations in the 40 CFR hazardous waste table including pH, corrosivity, and ignitability criteria, we can ship them regular, i.e. not under DOT requirements.

If the shipper believes that the sample contains a hazardous substance, for example chromium, then he/she should check reportable quantity (RQ) for chromium, TCLP for chromium, and sample pH (for liquid) and make a simple estimate of actual chromium content in the sample. Then add up all the chromium per cooler and see the requirements under DOT regulations for shipment of hazardous/dangerous goods shipment.

IF YOU ARE NOT DOT-TRAINING CERTIFIED, YOU CANNOT SHIP HAZARDOUS MATERIAL/DANGEROUS GOODS. To do so risks <u>large fines against the individual who signs the shipping bill.</u>

For some chemicals and compressed gases, the quantity, limitations, shipment requirements are all given in 49 CFR 172.101, especially in the Hazardous Materials Table 172.101. <u>Field personnel cannot classify samples based on the source or origin according to these regulations</u>. The shipper is supposed to know something about actual or expected chemical concentrations of the material in the shipping container. Field personnel who are unsure about shipping anything from the field should call a qualified person in the office and have the regulations reviewed for each situation.

6.0 REFERENCES

Department of Transportation, Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples, March 1981.

United States Environmental Protection Agency Region 4, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, May 1996.

STANDARD OPERATING PRACTICE FLD010B

Soil Sample Preservation

TABLE OF CONTENTS

Page

1.0 SCOPE AND LIMITATIONS 1

2.0 METHANOL PRESERVATION 1

2.1 FIELD EQUIPMENT LIST 2
2.2 PROCEDURES 2

3.0 SODIUM BISULFATE PRESERVATION 3

4.0 NON-PRESERVATION SAMPLERS AND OTHER SAMPLING TOOLS 3

4.1 ENCORE™ SAMPLERS 3
4.2 TERRA CORE™ SAMPLERS 4

5.0 FIELD BALANCE CALIBRATION 4

6.0 REFERENCES 5

1.0 SCOPE AND LIMITATIONS

This Standard Operating Practice (SOP) presents chemicals and procedures for soil sample preservation and sample handling. This SOP is limited to the collection and preservation of unconsolidated soil samples for laboratory analysis of volatile organic compounds (VOCs) by the specified methods (section 2.0).

2.0 METHANOL PRESERVATION

This method is applicable to soils to be analyzed for VOCs by methanol extraction in the vial, followed by purge and trap analysis (SW-846 8015, 8021, 8260, or CLP SOW). Soil core samples are collected in wide mouth VOC vials and preserved with methanol. This method is based in part on: ASTM D4547-91; SW846 Methods 5030, 5035, 8000, 8015, and 8260; a single laboratory method evaluation study conducted by the America Petroleum Institute; and work by the EPA Total Petroleum Hydrocarbons Committee.

2.1 FIELD EQUIPMENT LIST

The following is a minimum required equipment list for implementation of the methanol preservation method:

- Digital field scale sensitive to 0.1 grams, with calibration weight;
- Extra batteries for field scale
- Laboratory- or vendor-supplied pre-preserved sample vials
- Dry weight sample baggie or container with cap.
- Soil sample collection equipment (disposable plastic syringe, stainless steel or disposable plastic scoops, etc.)
- Decontamination equipment and supplies, if using re-usable sampling equipment
- Proper personal protective equipment, as specified in site-specific safety and health plan (SSHP)
- Proper air monitoring equipment, as specified in SSHP.

2.2 PROCEDURES

The following methods are prescribed for soil preservation with methanol:

- Prior to sampling, the field balance will be properly calibrated as described in Section 5.0. Calibration will be recorded in the field logbook or appropriate field form.
- VOA vials will be obtained from a third-party vendor. Vials will be pre-weighed and will include the weight of methanol (5 ± 0.1 grams). Vials will be re-weighed before use to verify minimal loss (<0.1 grams) of methanol during shipment.
- Use a tared plastic open-end syringe to collect soil sample. Sample and syringe must weigh within the acceptable limits (4-6 grams).
- Plunge soil sample from syringe into weighed VOC vial. Sample should not cause methanol to splash, causing loss of preservative.
- Close vial tightly, weigh, and record weight in logbook or appropriate form. Copies of the recorded sample and tare weight are to be attached to the chain-of-custody forms and sent with the samples to the laboratory.
- Label, place in bag, and place on ice until packed for shipping.

- An additional volume (~4 oz) will be collected for dry weight analysis. Dry weight sample can be placed in a resealable plastic bag or sample container with cap. Properly label dry weight sample.
- Record sample time, location, interval depth, number, and preservation method in log book or appropriate field form and COC form.
- Samples should be packed upright for shipment to the laboratory.

If the laboratory requires soil weight other than 5 grams, ratio of soil weight to methanol volume should remain 1:1.

3.0 SODIUM BISULFATE PRESERVATION

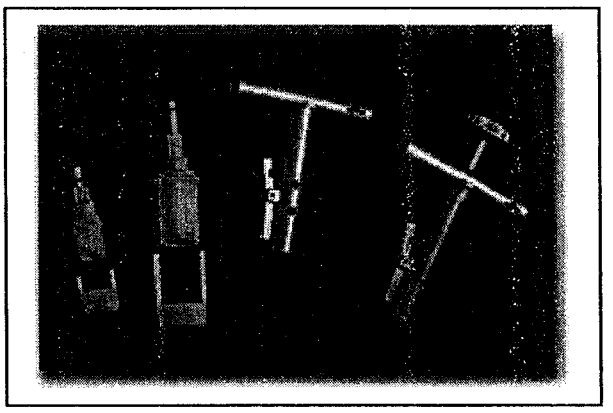
This procedure is the same as the methanol preservation, except sodium bisulfate is used rather than methanol. The sodium bisulfate preservation is used for low-concentration level protocols.

4.0 NON-PRESERVATION SAMPLERS AND OTHER SAMPLING TOOLS

Inclusion of a specific product or vendor in this SOP does not imply TN&A endorsement of the product or vendor. The sampling tool to be used should be specified in the project work plan. Additionally, different states have different regulations or guidelines regarding preservation requirements and use of non-preservation tools for VOC samples.

4.1 ENCORE™ SAMPLERS

The EnCore™ Sampler[1] is a disposable volumetric sampling device that collects, stores, and delivers soil samples for VOC and TPH-gasoline (gasoline-range organics or GRO) sampling. The Sampler is designed for a one-time use only and prevents minimal handling by the field personnel. The EnCore Sampler is made of a high-tech inert composite polymer. Seals are provided by three Viton® o-rings. The three components include the coring body, the plunger, and the cap. The Sampler is available in five and 25 grams; however only 5 gram samplers will be used. An attachable and reusable T-handle is used



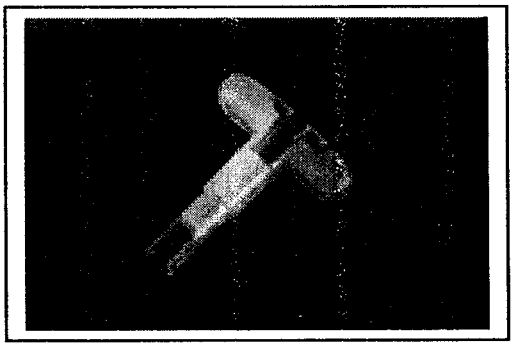
[1] Developed and marketed by En Novative Technologies, a subsidiary of En Chem, Inc., Greenbay, WI.

to assist in pushing the sampler into the soil. The airtight sealing cap prevents the transfer of volatiles as the Sampler becomes a self-contained package. No chemicals are involved in the field. At least two, preferably three, Samplers will be used per sample.

To use, attach an empty Sampler to the T-handle with the plunger in the down position and remove the cap. Push the Sampler into the soil by use of the T-handle. The plunger is pressed up during sample collection to minimize headspace. Place the cap on the Sampler until the cap is in the locked position. Replace in the envelope; label the envelope, bag, and place on ice until packed for shipment.

4.2 TERRA CORE™ SAMPLERS

The Terra Core™ Sampler[2] is a disposable transfer tool designed to take samples from hard packed soils and transfer them to the appropriate containers for in-field chemical preservation as described within USEPA Method 5035 (see Section 2.0 or 3.0).



The Terra Core™ Sampler's design eliminates the need for a field balance or separate handle while delivering an approximate five-gram soil sample.

5.0 FIELD BALANCE CALIBRATION

The following procedure is prescribed for calibrating field balances such as the Acculab PP-150B or equivalent:

- Prior to use, allow the balance to warm up and stabilize for at least two minutes. Recalibrate daily at a minimum and more often if balance is to be actively weighing for prolonged periods.
- Press and hold the "CAL" key until the calibration weight appears and flashes on the display.
- With the calibration weight value still flashing, press the tare key, and the display will read "AL 0." After pausing for at least two seconds, place the 100-gram calibration weight gently on the center of the tray top.
- The display will momentarily show "AL F" and then return to active weighing. The calibration is complete when the display correctly shows the calibration weight, and the display has stabilized. If "AL E" appears instead of "AL F," this indicates a

[2] En Novative Technologies, Inc.

calibration error has occurred and the calibration process should be repeated. "AL E" can occur if the calibration steps are not followed in the correct order or if an incorrect calibration weight was applied.

- Remove the calibration weight and press the tare key to reset the zero point.
- Record the calibration information in the field logbook.

6.0 REFERENCES

United States Environmental Protection Agency Region 4, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, May 1996.

STANDARD OPERATING PRACTICE TNFLD011A

Decontamination Procedures

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 2

2.0 GENERAL REQUIREMENTS 2

2.1 CLEANING MATERIALS 2
2.2 SAFETY PROCEDURES TO BE USED DURING CLEANING OPERATIONS 3
2.3 STORAGE OF FIELD EQUIPMENT 3

3.0 QUALITY CONTROL PROCEDURES FOR CLEANING OPERATIONS 3

3.1 EQUIPMENT BLANK SAMPLES 4

4.0 CLEANING REUSABLE SAMPLE-CONTACTING EQUIPMENT 4

4.1 GENERAL 4
4.2 EQUIPMENT USED TO COLLECT SAMPLE FOR ORGANIC ANALYSES 4
4.3 SAMPLING EQUIPMENT USED TO COLLECT SAMPLES FOR INORGANIC ANALYSES 5
4.4 CLEANING PROCEDURES FOR TUBING 5
4.5 SAMPLING EQUIPMENT CONTAMINATED WITH GUMMY OR OILY MATERIALS 5

5.0 SPECIFIC EQUIPMENT CLEANING PROCEDURES 6

5.1 WATER LEVEL INDICATORS 6
5.2 BLADDER PUMPS 6
5.3 PORTABLE POWER AUGERS 7
5.4 DRILLING RIGS 7
5.5 FLOW-THROUGH CELL 8
5.6 FIELD ANALYTICAL EQUIPMENT AND OTHER FIELD INSTRUMENTATION 8
5.7 ICE CHESTS AND SHIPPING CONTAINERS 8

6.0 DECONTAMINATION FLUID CONTAINMENT 9

7.0 REFERENCES 9

STANDARD OPERATING PRACTICE TNFLD011A

Decontamination Procedures

1.0 INTRODUCTION

The cleaning procedures outlined in this SOP represent standard decontamination procedures to be used by TN&A for all sampling equipment that may come into contact with contaminated media. Disposable sampling equipment will be used as much as possible to minimize the need for decontamination.

Alternative field decontamination procedures must be approved by the TN&A project manager ore designee and recorded in the field logbooks.

Cleaning procedures are described for two types of equipment:

- **Non-sample contacting equipment** - related equipment associated with the sampling effort, but that does not directly contact the sample (for example, drilling bits, soil field-screening jars, and flow-through cell).
- **Sample-contacting equipment** - equipment that comes in direct contact with the sample or portion of sample that will undergo chemical analyses or physical testing (for example, split-spoon or pond dipper).

2.0 GENERAL REQUIREMENTS

2.1 CLEANING MATERIALS

Detergent: The laboratory detergent will be a standard brand of phosphate-free laboratory detergent such as Liquinox®. The use of any other detergent must be justified and documented in the field logbooks. This detergent must be kept in a clean plastic, metal, or glass container until used.

Tap Water: A potable water source (tap water) will be identified and tested for use for equipment decontamination procedures as part of the field pre-planning activities. The use of tap water for cleaning equipment is not acceptable unless it has been tested and found to be non-contaminated for all project target analytes. Tap water may be from an on-site or off-site source and is typically the project site municipal water supply source. Tap water can be stored in clean tanks, sprayers, or squeeze bottles or may be applied directly from a tap water source.

Deionized Water: Deionized water is defined as tap water that has been treated by passing through a standard deionizing resin column. ASTM Type II deionized water will be laboratory-certified to contain no heavy metals or other inorganic compounds (i.e., at or above analytical

detection limits) as defined by a standard Inductively Coupled Plasma (ICP) scan. Deionized water must be stored in clean glass, stainless steel, or plastic containers.

During cleaning operations, the substitution of a higher grade water (e.g., deionized or organic-free water for tap water) is permitted and need not be noted as a variation of this SOP.

Alcohol, Acids and Solvents: Isopropanol, nitric acid, hexane are typical additional cleaning fluids that may be used to clean field equipment. The project-specific Sampling and Analysis Plan (SAP or comparable document) should specify if these materials are to be used. Observe all DOT shipping requirements for these materials.

2.2 Safety Procedures to be Used During Cleaning Operations

The materials used to decontaminate equipment can be dangerous if improperly handled. Caution must be exercised by all personnel and all applicable safety procedures shall be followed. At a minimum, the following precautions shall be taken in the decon area and in the field during cleaning operations:

- Safety glasses with side shields or goggles and nitrile or latex inner gloves will be worn at all times during all cleaning operations. All other site-specific health and safety requirements must be met for workers in contact with contaminated or potentially contaminated equipment.
- Steam cleaning will generally be performed by a TN&A subcontractor who is responsible for compliance with their own health and safety requirements for this task.
- Eating, smoking, drinking, chewing, or any hand-to-mouth contact shall not be permitted during cleaning operations.

2.3 Storage of Field Equipment

All field equipment shall be stored in a contaminant-free environment after being decontaminated. For example, clean field equipment will not be stored near fuel sources or within in the exclusion zone. Equipment will be moved upwind of the decontamination area and allowed to air dry. The dry equipment will then be wrapped in plastic or aluminum foil. Larger equipment will be wrapped in plastic sheeting until used. Cleaning solutions must be stored as described in Section 2.1.

3.0 QUALITY CONTROL PROCEDURES FOR CLEANING OPERATIONS

This section establishes guidelines for specific QC procedures to monitor the effectiveness of the sampling equipment cleaning procedures. All QC procedures will be recorded in the field log books.

3.1 EQUIPMENT BLANK SAMPLES

The effectiveness of the equipment cleaning procedures shall be evaluated by rinsing cleaned, non-dedicated sampling equipment (e.g., submersible pumps, pond dipper) with ASTM Type II or equivalent laboratory grade organic-free water. The rinsate samples will be collected and submitted for laboratory analysis in accordance with the project-specific SAP. Select different pieces of equipment for this procedure each time equipment is washed, so that a representative sampling of all equipment is obtained during field activities.

The following procedures will be used to collect an equipment rinsate blank:

1. Complete the cleaning procedures listed in Section 4.0 of this SOP. If the rinsate blank is collected from a submersible pump, be sure to rinse the sample contact portion of the disassembled pump with deionized water.
2. Fill laboratory-supplied containers with laboratory-grade water rinsate. Refer to the project-specific SAP for sample analyses to be performed on the rinsate blank. The project-specific QAPP will provide the number of sample containers and preservatives needed.
3. Follow the project-specific SAP for sample nomenclature for QC samples.

4.0 CLEANING REUSABLE SAMPLE-CONTACTING EQUIPMENT

As noted in Section 1.0 of this SOP, efforts will be made to use disposable sampling equipment to minimize the potential for cross contamination. However, when sample-contacting equipment is reused, such as the pond dipper, the procedures outlined in this section shall be followed.

4.1 GENERAL

Equipment decontamination will take place in designated "decon" area within the Contamination Reduction Zone (see project-specific health & safety plan) that is lined with plastic. All equipment decon waters will be retained and containerized as specified in the project-specific SAP. The detergent and rinse water baths may be reused but new solutions must be prepared periodically, depending on the amount of equipment requiring decontamination.

4.2 EQUIPMENT USED TO COLLECT SAMPLE FOR ORGANIC ANALYSES

The following procedure will be used when cleaning metallic, Teflon®, plastic, or glass field sampling equipment:

1. Wash equipment thoroughly with laboratory detergent (e.g., Liquinox®) and water using a brush to remove any particulate matter or surface film. When cleaning plastic sampling equipment, care should be taken to avoid scratching the equipment.
2. Rinse equipment thoroughly with tap water.

3. Rinse equipment thoroughly twice with deionized water.
4. Allow equipment to air dry as much as possible.
5. Wrap equipment in plastic or aluminum foil.

4.3 Sampling Equipment Used to Collect Samples for Inorganic Analyses

The following procedure will be used when cleaning field equipment used for the collection of samples for metals and other inorganic analyses:

1. Wash equipment thoroughly with laboratory detergent (e.g., Liquinox®) and water using a brush to remove any particulate matter or surface film. When cleaning plastic sampling equipment, care should be taken to avoid scratching the equipment.
2. Rinse equipment thoroughly with tap water.
3. Rinse equipment using a 0.1 N nitric acid.
4. Rinse equipment using distilled water.
5. Rinse equipment using a pesticide-grade solvent (hexane).
6. Rinse equipment thoroughly twice with deionized water.
7. Wrap equipment in plastic.

4.4 Cleaning Procedures for Tubing

If tubing is not dedicated to a specific well during well development and/or sampling activities, the following tubing cleaning procedures will be used to clean tubing in between sampling locations. The tubing must be of an inert material such as Teflon or may be bonded poly Teflon-line tubing for this procedure. Note: this procedure is cumbersome and time-consuming and may not be practicable for long-lengths of tubing.

Set up three large tubs for the detergent wash, tap-water rinse and deionized water rinse of the tubing. Place all of the tubing in the detergent bath. Using a pump (down-hole pump or peristaltic pump may be used for this procedure), pump the detergent-wash water through the tubing for several minutes. Remove tubing and pump and place in rinse bath and repeat pumping procedure. Change rinse water in between cleaning tubing from different wells. Remove tubing and pump and place in deionized water rinse tub and repeat pumping procedure. Collect rinsate samples at this time (Section 3.1). Place clean tubing in a large plastic bag (e.g., a 55-gallon drum liner) and wrap pump in plastic or aluminum foil.

4.5 Sampling Equipment Contaminated with Gummy or Oily Materials

In cases where reusable-sampling equipment (such as an oil-water interface probe) is used and contaminated with highly adhesive, gummy or oily materials, additional decontamination

procedures using special solvents may be required. If this is required, special decontamination steps will be implemented between Steps 2 and 3 of Section 4.2.

If sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with isopropanol to remove the materials before proceeding with Step 1 of Section 4.2.

In extreme cases, when equipment is painted, badly rusted, or coated with materials that are difficult to remove, it may be necessary to steam clean, wire brush, or sandblast equipment before proceeding with Step 1. Any sampling equipment that cannot be cleaned using these procedures will be discarded as investigation-derived waste (IDW) and will be managed in accordance with SOP No. 012A.

5.0 SPECIFIC EQUIPMENT CLEANING PROCEDURES

5.1 WATER LEVEL INDICATORS

The following procedures apply to cleaning water level indicators and other sounding equipment. Because a water level indicator may be in contact with groundwater that will be sampled, it is considered sample-contacting equipment. Personnel shall clean water level indicators in accordance with these procedures between each well.

1. Wash equipment thoroughly with laboratory detergent and water using a brush to remove any particulate matter or surface film.
2. Rinse equipment thoroughly with deionized water.
3. Allow equipment to air dry as much as possible.
4. Wrap equipment in one layer of aluminum foil (at the end of the day).

5.2 BLADDER PUMPS

Decontamination procedures, which are described in the manufacturer's literature, should be followed as much as is practicable. Because a pump is in contact with groundwater that will be sampled, it is considered sample-contacting equipment. The following steps provide generalized decontamination procedures for bladder pumps:

1. Pump a sufficient amount of soapy water through the pump to flush out any residual purge water.
2. Using a brush, scrub the exterior of the contaminated electrical supply/control cables, air hose, and pump with hot soapy water. Rinse the soap from the outside of each with tap water. Next, rinse each with deionized water and recoil onto the spool.
3. Pump a sufficient amount of tap water through the pump to flush out soapy water. Disassemble the bladder pump by unscrewing the screened portion of the pump

casing, and removing the bladder. Rinse the outside of the bladder and the inside of the pump casing with soapy water, then rinse with tap water.

4. Rinse the outside of the bladder and the inside of the pump casing with deionized water. Reassemble the pump and pump a sufficient amount of deionized water through the pump to flush out the tap water.
5. Rinse the outside of the pump, air hose, and electrical supply control cables with deionized water.
6. Place the equipment in a polyethylene bag or wrapped with polyethylene film to prevent contamination during storage or transit.

5.3 Portable Power Augers

Portable power augers may be used during installation of passive soil gas sampling devices. Soil samples will not be collected for chemical analysis from the soil gas survey sampling points, therefore the augers are considered to be non-sample contacting equipment.

1. The engine and power head will be cleaned with a power washer, steam jenny, or hand washed with a brush using detergent (does not have to be laboratory detergent but will not be a degreaser) to remove oil, grease, and hydraulic fluid from the exterior of the unit. These units will be rinsed thoroughly with tap water followed by deionized water.
2. All auger flights and bits shall be cleaned by a pressure washer capable of producing water at 200°F and 1,500 psi before borehole entry and will remain clean until installed in the borehole.

5.4 Drilling Rigs

A decontamination pad will be constructed on-site prior to beginning any drilling rig or drilling equipment decontamination procedures.

Drilling equipment will be decontaminated prior to the commencement of drilling activities. Drilling rig will be decontaminated between boreholes and care should be taken to reduce mud tracking.

The drilling subcontractor will be responsible for conducting proper decontamination of drilling equipment. Drilling equipment in contact with the subsurface will be placed on racks or saw horses at least 2 feet above the floor of the decontamination pad and steam cleaned with high pressure hot water. Persistent particulate matter or surface films will be removed with tap water and phosphate-free detergent, scrubbing, and a tap water rinse. Drill rods that are hollow or have holes that transmit water or drilling fluids will be cleaned on the inside with vigorous brushing, detergent, and steam cleaning, followed by a tap water rinse.

After completion of decontamination, the equipment will be removed from the decontamination pad and covered with clean new plastic until the equipment is used again. If stored overnight, the plastic will be secured to ensure that it stays in place.

Water used during the decontamination process will be pumped into 55-gallon drums and stored on-site until proper disposal procedures can be conducted.

Upon completion of all drilling activities, any drilling equipment that contacted subsurface materials will be decontaminated prior to the departure of the drilling equipment from the site.

5.5 Flow-Through Cell

The water quality meter and flow-through cell are non-sample contacting equipment. The sonde will be removed from the flow-through cell prior to decontamination. The flow-through cell will be disconnected from the associated sample tubing. The flow-through cell will be submerged in soapy water, while samplers use their hands to cap the ends of the cell. (Note: samplers must wear disposable latex or nitrile gloves during decontamination). The soapy water should be agitated in the cell; samplers should use their fingers to dislodge any remaining sediment (stiff brushes should not be used in the flow-through cell to prevent scratches). This procedure will be repeated with tap water. The flow-through cell will be rinsed thoroughly with deionized water, and stored in a resealable gallon-sized plastic bag.

5.6 Field Analytical Equipment and Other Field Instrumentation

Decontamination of field analytical equipment and other field instrumentation will follow the respective manufacturer's recommendations.

The exterior of sealed, watertight equipment will be washed with a Liquinox® solution and rinsed with tap water before storage. The interior of such equipment may be wiped with a damp cloth if necessary. Other field instrumentation will be wiped with a clean, damp cloth. Conductivity probes, pH meter probes, DO meter probes, etc., will be rinsed with deionized water before storage.

The turbidity meter sample cuvette will be cleaned and dried with a soft cloth, to prevent scratching of the sample cuvette. The desiccant in flow meters and other equipment will be checked and replaced if necessary each time the equipment is cleaned.

5.7 Ice Chests and Shipping Containers

All ice chests and reusable containers shall be washed with laboratory detergent (interior and exterior) and rinsed with tap water and air dried before use. In the event that an ice chest becomes severely contaminated, in the opinion of field personnel, it shall be cleaned as thoroughly as possible, rendered unusable, and properly disposed as IDW.

6.0 DECONTAMINATION FLUID CONTAINMENT

All decontamination liquids will be containerized in DOT-approved 55-gallon drums. Drums will be labeled according to the procedures specified in the project-specific SAP and TN&A SOP No. 012A and stored in the designation IDW container storage location at the site.

7.0 REFERENCES

ASTM, September 1990. *Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites*, D 5088-90

U.S. Environmental Protection Agency Region IV. May 1996. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, Environmental Services Division

STANDARD OPERATING PRACTICE TNFLD012A

Investigative Derived Materials Management Procedures

TABLE OF CONTENTS

1.0 OBJECTIVE **2**

2.0 BACKGROUND **2**

3.0 RESPONSIBILITIES **3**

4.0 REQUIRED EQUIPMENT **4**

5.0 PROCEDURES **4**

5.1 INVESTIGATION-DERIVED WASTE CHARACTERIZATION 4
5.1.1 Placement of Wastes *5*
5.2 GENERATION AND HANDLING OF INVESTIGATIVE-DERIVED WASTE 5
5.2.1 Non-RCRA Regulated Materials *6*
5.2.2 RCRA Regulated Materials *8*
5.3 INVESTIGATIVE-DERIVED WASTE DISPOSAL OPTIONS 10
5.3.1 On-Site Disposal *10*
5.3.2 On-Site Treatment *11*

6.0 RESTRICTIONS/LIMITATIONS **12**

7.0 REFERENCES **12**

STANDARD OPERATING PRACTICE TNFLD012A

Investigative Derived Materials Management Procedures

1.0 OBJECTIVE

The objective of this Standard Operating Practice (SOP) is to define the procedural requirements for managing and sampling investigative-derived waste (IDW) generated during the site investigation process while striving for three goals:

- **Minimization** All site investigations shall be conducted in such a way as to generate the least amount of IDW. Every effort will be made to return as much material to the site of generation as is permitted by law and is protective of personnel and the environment.
- **Management** The IDW that cannot be disposed of on-site shall be managed in a manner consistent with the final method of remediation of the site, if known. If the final remediation method for the site is not known, the IDW generated will be managed, stored, transported, and disposed of in a manner consistent with all appropriate laws and regulatory requirements.
- **Mediation** Each site and each sponsor is unique. The most important goal is to assist each sponsor in successfully negotiating with the controlling regulatory agencies. This negotiation should result in an IDW handling method that is the most time efficient, cost-effective, and appropriate. The IDW handling method must also be in accordance with all regulations and cause the least adverse impact to the facility, the community surrounding the facility, and the environment.

2.0 BACKGROUND

In the process of conducting field operations in the pre-remedial and remedial phases of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) investigations, IDW are often generated. IDWs consist of fluids from well development, purging, and pump tests; drilling fluids and cuttings from well installations; soil cuttings from borings; soils from test pits; residues from testing treatment technologies; personal protective equipment (PPE); decontamination solutions used to clean nondisposable equipment; and any other material or equipment that may be contaminated to the point it cannot be sufficiently cleaned to permit further safe use.

The National Contingency Plan (NCP) states "the field investigation team should, when handling, treating or disposing of investigation-derived waste on-site, conduct such activities in compliance with applicable or relevant and appropriate requirements (ARARs) to the extent practicable, considering the exigencies of the situation" (NCP, 55 FR 8756). In addition,

operations should, at all times, be conducted with the central idea of maximum protection for the workers at the site, the population around the site, and the environment in general.

Ten major concerns control the disposition of IDW at a site:

- types and concentrations of contaminants,
- volume of IDW,
- media affected by the contaminants (e.g., groundwater and for soil),
- location of the site (e.g., residential versus unpopulated area),
- public access to the site (e.g., will children play in the area),
- prior knowledge of conditions at the site (e.g., known as opposed to suspected contamination),
- potential worker exposure,
- potential environmental impact from disposal,
- state and federal regulatory requirements, and
- cost.

3.0 RESPONSIBILITIES

T N & Associates (TN&A): TN&A is responsible for the identification of potential contaminants and for the characterization of IDW. The ultimate responsibility for proper determination of IDW waste status and proper disposal lies with TN&A's client.

Site Manager: The Site Manager, or Field Team Leader, is responsible for ensuring that field activities are completed to meet the project objectives, are conducted in accordance with the project plans and requirements, and all activities are performed according to the respective procedures. The Site Manager is responsible for ensuring all site personnel are trained in the procedures, the procedures are adhered to, and all activities are documented.

Field Team: All members of the field team (samplers, technicians, field geologists, engineers, etc.) are responsible for understanding and implementing this field procedure as well as ensuring all team members also perform work in accordance with this procedure.

Client: The client (e.g., USACE, USEPA) is responsible for establishing the status of the waste material as it relates to federal, state, and local regulations. Designated representatives of the client are responsible for signing all invoices, manifests, and bills of lading to transport and for dispose of waste material.

It is the responsibility of all field personnel to identify, document, and submit recommendations to improve the quality, usability, and implementability of this procedure.

4.0 REQUIRED EQUIPMENT

Equipment required for characterizing and handling the material includes:

- Field screening equipment such as a photoionization detector, organic vapor analyzer (OVA), and/or an on-site gas chromatograph (GC).
- Personal protective equipment. Level of protection is based on the type and expected concentration of contaminants. The minimum protective equipment includes Occupational Safety and Health Act-approved hard hat, safety glasses, protective gloves, and hard-toed boots or shoes.
- Sample collection equipment. The type required is dependent on the waste type as well as the container type.

5.0 PROCEDURES

5.1 INVESTIGATION-DERIVED WASTE CHARACTERIZATION

The first step in selecting the method of material handling to use at a site is to determine the potential contaminants of concern by reviewing site records, information gathered during the Preliminary Assessment/Site Inspection, Hazard Ranking System scoring, and interviews with persons knowledgeable about activities at the site. Early sampling results also can be used to indicate whether the wastes generated will exhibit hazardous characteristics. Published Environmental Protection Agency (EPA) guidance [EPA, Office of Solid Waste and Emergency Response (OSWER) Directive 9345.3-02, *Management of Investigation-Derived Waste During Site Investigations,* May 1991] discourages the containerizing and sampling of IDW just to establish hazardous components because of the resulting increase in investigation costs.

The next step in selecting the material handling method is to establish which federal, state, or local regulations apply to the material and which are the corresponding ARARs. Establishing the status of the IDW with regard to RCRA is critical. A waste material is hazardous under RCRA if it exhibits one of four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 *Code of Federal Regulations* (CFR) 261.20 through 261.24. Identified contaminants may also be considered hazardous under RCRA if they are listed in 40 CFR 261.30 through 261.33. EPA guidance [EPA, Office of Solid Waste and Emergency Response Directive 9345.3-02FS, *Management of Investigation-Derived Waste,* February 1991] states it is permissible to handle a material as nonhazardous with regard to RCRA until it is proved to be a RCRA hazardous waste material. Nevertheless, if available information and best professional judgement indicate that, to maximize protection, a material should be managed as RCRA hazardous waste, regardless of known status, RCRA Subtitle C requirements should be followed.

Even if a material is not considered hazardous waste under RCRA, it may still contain hazardous contaminants regulated by federal, state, and local laws and regulations. It is the responsibility of the sponsor to determine the status of the material as it relates to RCRA and other statutes. Other potential ARARs include the Clean Water Act, which contains the requirements for the

discharge of aqueous IDW to surface water and treatment facilities, and the Toxic Substance Control Act, which contains the requirements for handling IDW contaminated with polychlorinated biphenyls (PCBs) in concentrations of 50 parts per million (ppm) or greater.

After the potential contaminants are identified, it is the responsibility of the client to consult the appropriate state and federal regulatory agencies to ensure all local, state, and federal laws and regulations are followed. The IDW issue must be addressed and resolved for each project before initiating field activities.

5.1.1 Placement of Wastes

If there is any possibility of the waste material containing a RCRA hazardous substance and being restricted under the Land Disposal Restrictions (LDRs), the material must not be "placed." To assist in defining "placement" at CERCLA sites, EPA uses the concept of Areas of Contamination (AOC). EPA Superfund LDR Guide 5 states, "An AOC is delineated by the areal extent (or boundary) of contiguous contamination. Such contamination must be continuous, but may contain varying types and concentrations of hazardous substances." *[Determining When LDRs Are Applicable to CERCLA Response Actions,* Office of Solid Waste and Emergency Response (OSWER) Directive No.9347.3-05FS, June 1989].

Placement as defined by EPA occurs when waste material:

- is moved off-site,
- is moved out of an AOC for treatment or storage then returned to the same or a different AOC and returned to the environment,
- is stored in a container within the AOC then returned to the same AOC and returned to the environment, or
- is consolidated from several AOCs into a single AOC and returned to the environment.

If placement does not occur, the LDRs are not applicable to the CERCLA action regardless of the contaminants in the material. Therefore, before containerizing material or moving it outside an AOC, the status of the material, as it relates to RCRA and the LDRs, must be determined.

5.2 Generation And Handling Of Investigative-Derived Waste

All the IDW will fall into one of four categories:

- non-RCRA regulated (nonhazardous),
- non-RCRA regulated (hazardous),
- RCRA regulated (nonhazardous), or
- RCRA regulated (hazardous).

5.2.1 Non-RCRA Regulated Materials

Waste materials that do not exhibit one of the four characteristics (ignitability, corrosivity, reactivity, or toxicity) as defined in 40 CFR 261.20 through 261.24 or do not contain contaminants listed in 40 CFR 261.30 through 261.33 are not regulated under RCRA.

Provision should be made for those cases in which it is logistically more convenient for TN&A to move the waste material to a central collection point for storage before determination of disposal method. Should this be necessary, extreme care must be exercised to segregate those materials that field screen "clean" from those that show contamination.

Any and all containers in which IDW is stored must be clearly labeled as to the contents, the locations at which the material was generated, the date, and a person to contact including the telephone number. There may also be facility-specific labeling requirements. At no time shall a container be labeled as containing hazardous material until a determination is made as to whether the material is hazardous.

In any case, the material must be removed from public access and stored in clean, sealed containers at a single, secure collection point at the facility until a final disposal method is determined. No IDW shall be removed from the facility or released to the environment without permission from the client and the controlling regulatory agencies.

5.2.1.1 Soils

Soils include drill cuttings, surface soils, and sediments. For drilling operations, drilling cuttings will be contained in 55-gallon drums, on plastic sheeting, or in other suitable containers pending characterization and disposal. Alternatively, permission may be sought from the controlling regulatory agencies to bury drill cuttings in shallow pits lined with plastic sheeting and installed directly adjacent to the borings. If waste characterization indicates the soil is not contaminated, it may be spread on the ground. At the conclusion of drilling operations, these pits will be covered by surface soils and reseeded either by the drilling contractor or the facility. The location and size of the pits will be included in the field logbook and in the report of the investigation for future reference. Surface soils and sediments, in excess of sampling requirements, will be returned directly to their source point. For test pits, the soil will be stockpiled on-site (on plastic sheeting, covered by plastic sheeting) adjacent to the excavations and used to refill the pits when sampling is completed. Test pits can then be covered with surface soils and reseeded. These procedures are in accordance with published EPA guidance (EPA, OSWER Directive No.9345.3-02, May 1991; *Management of Investigation-Derived Waste During Site Inspections).* The logic for using this method is threefold: (1) it eliminates the moving and costly sampling of soils; (2) the problem of what to do with drums or stockpiles of soils is eliminated; and (3) if contamination is subsequently identified in the soil samples from the boring, the pit of drill cuttings can be addressed during the remediation process for the overall site.

Soils containing only volatile contaminants for which on-site burial is not allowed or is logistically inconvenient will be field screened with an OVA or comparable field-screening instrument. It is preferred that representative samples also be analyzed by an on-site GC if

possible. Before initiating the field effort, it will be necessary to negotiate a field screening action level with the controlling regulatory agencies.

Soils that field screen less than the established field screening limit can (with the approval of the controlling regulatory agencies) either be spread back on the site or taken to a central collection point for disposal at the facility. Soils that screen higher than the established field screening limit will be collected and segregated either at the site or at a central collection point. These soils will be stockpiled in an area lined with, and covered by, plastic sheeting (preferably black to resist breakdown of the plastic from exposure to sunlight) or placed in sealed, labeled containers.

Soils in which the contaminants of concern are such that they would not register on the field screening equipment (e.g., metals, semivolatiles) must be stockpiled either on-site or at a central collection point in a plastic-lined and plastic-covered area and held until the results of the sample analyses have been received. The results of these analyses can be used to indicate the status of the soils.

If no soil samples are collected when drilling (e.g., while installing monitoring wells) and screening indicates possible contamination or is inconclusive, a representative sample will be collected from the cuttings and analyzed for the contaminants of concern. While awaiting the results of these analyses, the material should be stockpiled on-site in a plastic-lined and plastic-covered area, placed in labeled containers or, if moved to a central collection point, kept segregated from other material until contaminant levels are established. Labels should include a contact name and telephone number. If analytical results are below established ARARs, the soils can be spread back on the site or used by the client as fill material with the regulatory agencies' permission. If analytical results show levels of contamination exceeding established ARARs, the on-site treatment facility should be used, if available, or the material shall be containerized and disposed of as directed by the client.

5.2.1.2 Fluids

Fluids include drilling fluids, development/purge water, and decontamination fluids. For areas in which there is no indication of contaminants that are RCRA regulated, permission will be sought from the controlling regulatory agencies to allow the development and purge waters generated in the well installation and sampling process to be released into the sewer system of the facility. If the controlling agencies will not allow this action, or if there is any possibility of the fluids' being contaminated, all fluids will be containerized in labeled containers and stored at the site or at a central collection point. Labels should include a contact name and telephone number. Purged groundwater must always be containerized separately from decontamination fluids.

If no samples of the fluid have been collected for analyses at the end of the generation process, a representative sample of the fluid will be collected and analyzed for contaminants of concern. If analytical samples were collected (such as from a monitoring well), the results of these analyses can be used to indicate the status of the fluids. The object of these analyses is to gather enough data to obtain written permission from the controlling regulatory agencies to release the fluids into the storm water collection or sanitary sewer systems at the facility. If analytical results show levels of contamination exceeding established ARARs, the fluid can be treated by using the

on-site water treatment facility (if available), or the IDW shall be disposed of as directed by the client.

5.2.1.3 Personal Protective Equipment

Personal protective equipment (PPE) includes all gloves, Tyvek® suits, and other disposable equipment. All PPE that cannot be adequately decontaminated to permit safe reuse will be double plastic-bagged, collected, and placed in an approved industrial waste bin.

5.2.2 RCRA Regulated Materials

A waste material is regulated under RCRA if it exhibits one of four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.20 through 261.24 or the identified contaminants are listed in 40 CFR 261.30 through 261.33.

5.2.2.1 Soils

Soils include drill cuttings, surface soils, and sediments. For areas in which there are known or suspected RCRA-regulated contaminants, permission will be sought from the controlling regulatory agencies to bury disturbed soils in shallow, plastic-lined pits on-site, cover them with surface soils, and reseed. The location and size of the pits will be included in the field logbook and project reports for future reference. This procedure is in accordance with published Environmental Protection Agency (EPA) guidance (EPA, OSWER Directive 3945.3-02, May 1991, *Management of Investigation-Derived Waste During Site Inspections).*

If on-site burial is not permitted or is logistically inconvenient, soils will be field screened for volatile contaminants as described above and stockpiled at the site in an area lined with, and covered by, plastic sheeting, preferably black to resist breakdown of the plastic from exposure to sunlight. Stockpiling the soil at the site without containerization will prevent placement (as defined by EPA) from occurring and thus avoid activating potential land disposal restrictions. Soils that field screen less than the established field screening limit can be spread back on the site with the approval of the controlling regulatory agencies.

If it is logistically impossible to stockpile the material at the site, or if contaminants are such that field screening would be inconclusive, the material shall be collected in approved containers, preferably a steel roll-offbox. These containers must be labeled as to the contents, the date(s) of collection, and the location at which the material was generated. If the IDW will be submitted to a disposal facility, representative samples will be collected and submitted to an approved laboratory to be analyzed for ignitability, corrosivity, reactivity, and for Toxicity Characteristic Leachate Procedure, as well as any other contaminants requested by the controlling regulatory agencies.

If the results of the analyses are below established ARARs, the soils can be spread back on the site or used by the client as fill material with the regulatory agencies' permission. If analytical results indicate the IDWs are RCRA regulated, the approved on-site treatment facility should be used (if available), or the containers shall be disposed at an RCRA-permitted disposal/treatment

facility (TSD). RCRA regulated IDW may remain stored on-site for the time period allowed by the client's generator status. State time requirements may be slightly different so be sure to check with the state regulatory agency.

- **Large Quantity Generator** (>1,000 kg hazardous waste per month): 90 days.
- **Small Quantity Generator** (100-1,000 kg hazardous waste per month): 180 days or 270 days if TSD is greater than 200 miles away.
- **Conditionally Exempt Small Quantity Generator** (<100 kg hazardous waste per month): no time restrictions.

5.2.2.2 Fluids

Fluids include drilling fluids, development/purge water, and decontamination fluids. For areas in which known or suspected RCRA-regulated contaminants exist, all fluids will be containerized in properly labeled containers (i.e., drums or tanks) and stored at the site. At the end of the generation process, if no samples of the fluids have been collected, a representative sample will be collected and analyzed for contaminants of concern. If analytical samples were collected (such as from a monitoring well), the results of these analyses can be used in place of collecting and analyzing additional samples to indicate the status of the fluids. If analytical results show levels of contamination below established ARARs, the fluids can be released to the storm water or sanitary sewer system of the facility with the controlling regulatory agencies' approval. If analytical results indicate the IDW is RCRA regulated or other contaminants are present at levels exceeding established ARARs, the on-site treatment facility should be used (if available), or the containers shall be disposed of at a RCRA TSD Facility.

RCRA regulated IDW may remain stored on-site for the time period allowed by the client's generator status. State time requirements may be slightly different so be sure to check with the state regulatory agency.

- **Large Quantity Generator** (>1,000 kg hazardous waste per month): 90 days.
- **Small Quantity Generator** (100-1,000 kg **hazardous waste** per month): 180 days or 270 days if TSD is greater than 200 miles away.
- **Conditionally Exempt Small Quantity Generator** (<100 kg hazardous waste per month): no time restrictions.

5.2.2.3 Personal Protective Equipment

PPE includes all gloves, Tyvek® suits, and other disposable equipment. All PPE that cannot be adequately decontaminated to permit safe reuse will be double plastic-bagged, collected, and placed in approved containers at a central collection point. These containers will then be disposed of at a RCRA TSD Facility.

5.3 INVESTIGATIVE-DERIVED WASTE DISPOSAL OPTIONS

Table 5.1 presents various disposal options for the five most common types of IDW.

Table 5.1. Investigative-Derived Waste Disposal Options

Type of IDW	Generation process	Disposal options
Soil	Borehole drilling Test pits Surface soil sampling	Consolidate in a pit (within the Area of Contamination) Return to pit immediately after generation Spread around boring/pit Send to an existing on-site treatment/disposal unit (TDU) Containerize and dispose of appropriately Store for future disposal
Sludges/sediments	Sludge pit Sediment sampling	Return to pit immediately after generation Containerize and dispose of appropriately Store for future disposal
Aqueous liquids	Well installation Well purging during sampling/development and pump/treat tests	Pour onto ground Send to Publicly Owned Treatment Works (POTW) or facility treatment works Send to existing TDU Store for future disposal
Disposal personal protective equipment (PPE)	Sampling procedures	Send to on-site TDU Place in on-site industrial dumpster Containerize and dispose of appropriately Store for future disposal
Decontamination fluids	Decontamination of PPE and other equipment	Send to on-site TDU Containerize and dispose of appropriately Store for future disposal

5.3.1 On-Site Disposal

This option should never be used when the release of IDW to the surface of the site could degrade surface conditions (e.g., contaminated well water poured on clean surface soil or contaminated soils from depth spread on an uncontaminated surface).

Two questions must be answered before using this option:

- Is returning the waste to the generation site the safest and most protective method for personnel and the environment?

For example, returning potentially contaminated soil excavated from sampling pits may not be protective if the site is in a residential area or if access to the site cannot be tightly controlled. If wastes contain highly toxic constituents or high concentrations of constituents, they may endanger workers or the environment if returned to their source without access restrictions or a cover (e.g., exposure to air could volatilize certain chemicals).

- Is returning the waste to the generation site allowed by the controlling regulatory agencies?

  Written permission should be obtained from both state and federal regulatory agencies before releasing the material back to the environment. Releasing this material without the permission of the controlling regulatory agencies could be construed as an uncontrolled release of a regulated waste and cause the client and the person or persons releasing the material to spend a great deal of time and money re-collecting it and paying fines. This permission should be obtained by developing sampling criteria and critical contaminant levels with the regulators before initiating the field effort. Unfortunately, there are currently no standard contaminant concentration levels applicable for all contaminants everywhere, so sampling criteria and critical contaminant levels must be negotiated with the controlling regulatory agencies on a case-by-case basis.

If both of these considerations are met, the preferred method of waste disposal is to return the waste to the site of generation through burying cuttings adjacent to borings, spreading cuttings on-site, returning sludges and residues to holding pits, releasing purged well waters to surface of site, or other methods. This method reduces the volume of waste to be moved and at the same time helps to limit the spread of contamination off-site.

5.3.2 On-Site Treatment

If on-site disposal of the material is not permitted, a method of treating the material on-site, or at a central location at the facility, should be selected. It should be recognized that the effectiveness of a treatment method is a function of the suite of contaminants involved and, therefore, must be chosen on a case-by-case basis. In addition, approved treatment methods will vary from state to state, and a list of approved methods should be obtained from the controlling regulatory agencies. In any case, a preferred treatment option should be established before initiating field operations.

5.3.2.1 Off-Site Disposal

If on-site disposal is prohibited and no treatment method is viable or permitted, the alternative would be to have the material handled under the waste disposal contracts in place at the facility. Because this would likely mean the use of either sanitary or hazardous waste landfills for disposal, it is the least attractive option on the basis of cost, environmental stewardship, and future potential liability for the sponsor. In addition, in the case of RCRA hazardous materials, the client's RCRA waste-generating status must be kept in mind and the permitted amounts of RCRA waste must not be exceeded as a result of an influx of IDW from site investigations.

6.0 RESTRICTIONS/LIMITATIONS

This Standard Operating Practice does not address those areas in which material contains radionuclide contamination. Should this be suspected, a health physicist must be involved to develop waste-handling procedures and on-site to monitor activities at all times.

7.0 REFERENCES

U.S. Environmental Protection Agency, Memorandum, *Discharge of Wastewater from CERCLA Sites into POTWs,* OSWER Directive 9330.2-04, April 15, 1986.

U.S. Environmental Protection Agency, *Guidance on Remedial Actions for Superfund Sites with PCB Contamination,* Office of Emergency and Remedial Response, EPA/540/G-90/007, August 1990.

U.S. Environmental Protection Agency, *CERCLA Compliance with the CWA and SDWA,* Fact Sheet 9234.2-06/FS, Office of Solid Waste and Emergency Response, February 1990.

U.S. Environmental Protection Agency, *Management of Investigation-Derived Waste,* Superfund Publication 9345.3-02FS, Office of Solid Waste and Emergency Response, February 1991.

U.S. Environmental Protection Agency, *Management of Investigation-Derived Waste During Site Inspections,* OSWER Directive 9345.3-02, Office of Solid Waste and Emergency Response, May 1991.

U.S. Environmental Protection Agency, Superfund LDR Guide 5, *Determining When LDRs Are Applicable to CERCLA Response Actions,* OSWER Directive 9347.3-05FS, June 1989.

U.S. Environmental Protection Agency, 40 CFR, Parts 261.20 through 261.33.

APPENDIX D

Site Safety and Health Plan

SITE SAFETY AND HEALTH PLAN T N & Associates Safety and Health Program	*This document is for the exclusive use of TN & Associates and its subcontractors*	TN & ASSOCIATES PROJECT DOCUMENT #: 2002189

PROJECT NAME	Cannon AFB (FTA-4)	**PROJECT#**	2002189	**REGION**	Southwest
JOBSITE ADDRESS	Cannon AFB near Clovis, NM	**CLIENT** **CLIENT CONTACT** **CLIENT CONTACT PHONE #**		USACE-Omaha District Jane Davey 402-221-7645	

( ) **AMENDMENT TO EXISTING APPROVED H&SP**
( ) **H&SP AMENDMENT NUMBER?** _____ ( ) **DATE EXISTING APPROVED H&SP** _____

OBJECTIVES OF FIELD WORK:
(e.g. collect surface soil samples):

DPT Subsurface Investigation to confirm the concentration of total petroleum hydrocarbons (TPH) in soil at Fire Training Area 4 (FTA-4).

TYPE *Check as many as applicable*

Active	(X)	Landfill	( )	Unknown	( )
Inactive	( )	Uncontrolled	( )	Military	(X)
Secure	(X)	Industrial	( )	Other (specify)	
Unsecure	( )	Recovery	( )		
Enclosed space	( )	Well Field	( )		

DESCRIPTION AND FEATURES: *Include principal operations and unusual features (containers, buildings, dikes, power lines, hillslopes, rivers, etc.)*

SWMU 109 was used as a fuel truck cleaning area between 1961 and 1974. An estimated 3,000 to 4,000 gallons of fuel percolated into the ground as a result of these activities. In 1974 the site was activated as a fire training area. Commingled waste oils, solvents, and recovered jet propellant 4 (JP-4) were burned during fire training excercises conducted from 1974 to 1975. The underground waste oil tank (SWMU 110) was installed in 1975, and only recovered JP-4 was burned during excercises conducted from 1975 to 1995. After that time, the SWMU was no longer used as a fire training area.

ACTIVITIES HAZARD ANALYSIS IS ATTACHED.

SURROUNDING POPULATION: ( ) Residential ( ) Industrial ( ) Commercial ( ) Rural (X) Urban (X) OTHER: Military Use

HISTORY: *Summarize conditions that relate to hazard. Include citizen complaints, spills, previous investigations or agency actions, known injuries, etc.*

SWMU 109 was used as a fuel truck cleaning area between 1961 and 1974. An estimated 3,000 to 4,000 gallons of fuel percolated into the ground as a result of these activities. In 1974 the site was activated as a fire training area where commingled waste oils, solvents, and recovered Jet Propellant (JP-4) were burned during fire training excercises through 1975. In 1975, an underground waste oil tank was installed, and only recovered JP-4 was burned during excercises until 1995. After that time, the SWMU was no longer used for fire training.

WASTE TYPES: ( ) Liquid (X) Solid ( ) Sludge ( ) Gas ( ) Unknown ( ) Other, specify:

WASTE CHARACTERISTICS: *Check as many as applicable.*

( ) Corrosive ( ) Flammable ( ) Radioactive
( ) Toxic (X) Volatile ( ) Reactive
( ) Inert Gas ( ) Unknown ( ) Other, specify:

WORK ZONES: *Describe the Exclusion, Contamination Reduction, and Support Zones in terms on-site personnel will recognize*

Since work zone is mobile (drill rig), exclusion zone will be a 30 ft. radius around the drill rig. The contamination reduction zone will be limited to just outside the exclusion zone. The support zone will be the area outside the contamination reduction zone. Gross Decontamniation of drill equipment will take place at the designated decon pad where all IDW will be contained

HAZARDS OF CONCERN:

( ) Heat Stress *attach guidelines*
( ) Cold Stress *attach guidelines*
( ) Explosive/Flammable
( ) Oxygen Deficient
( ) Radiological
( ) Biological
(X) Other - specify: Buried Lines
(X) Noise
( ) Inorganic Chemicals
( ) Organic Chemicals
(X) Motorized Traffic
(X) Heavy Machinery
(X) Slips, Trips, & Falls

FACILITY'S PAST AND PRESENT DISPOSAL METHODS AND PRACTICES:

Several thousand gallons of fuel percolated into the ground as a result of fuel truck cleaning activities. While the site was used as a fire training area, commingled waste oils, solvents and recovered JP-4 were burned as part of the training exercises. In 1975, an underground storage tank was installed to store the recovered JP-4 until it could be used in training.

HAZARDOUS MATERIAL SUMMARY *Circle waste type and estimate amounts by category.*

CHEMICALS: *Amount/Units:*	**SOLIDS:** *Amount/Units:*	**SLUDGES:** *Amount/Units:*	**SOLVENTS:** *Amount/Units:*	**OILS:** *Amount/Units:*	**OTHER:** *Amount/Units:*
Acids	Flyash	Paints	Halogenated (chloro, bromo) Solvents	Oily Wastes	Laboratory
Pickling Liquors	Mill or Mine Tailings	Pigments	Hydrocarbons	Gasoline	Pharmaceutical
Caustics	Asbestos	Metals Sludges	Alcohols	Diesel Oil	Hospital
Pesticides	Ferrous Smelter	POTW Sludge	Ketones	Lubricants	Radiological
Dyes/Inks	Non-Ferrous Smelter	Aluminum	Esters	PCBs	Municipal
Cyanides	Metals	Distillation Bottoms	Ethers	Polynuclear Aromatics	Construction
Phenols	Other *specify:*	Other *specify:*	Other *specify:*	Other *specify: TPH*	Munitions
Halogens					Other *specify:*
Dioxins					
Other *specify:*					

OVERALL HAZARD EVALUATION: ( ) High ( ) Medium (X) Low ( ) Unknown *(Where tasks have different hazards, evaluate each.)*

JUSTIFICATION:

Potential for inhalation of airborne COCs is low, dermal contact potential protected via use of gloves.

FIRE/EXPLOSION POTENTIAL: ( ) High ( ) Medium (X) Low ( ) Unknown

BACKGROUND REVIEW: (X) Complete ( ) Incomplete

KNOWN CONTAMINANTS	HIGHEST OBSERVED CONCENTRATION *(specify units and media)*	PEL/TLV *ppm or mg/m3 (specify)*	IDLH *ppm or mg/m3 (specify)*	WARNING CONCENTRATION *(in ppm)*	SYMPTOMS & EFFECTS OF ACUTE EXPOSURE	PHOTO IONIZATION POTENTIAL
TPH (or Petroleum Distillates, n.o.s., or Petroleum products, n.o.s.)	38500 mg/kg - S	OSHA PEL 500 ppm ACGIH TLV 300 ppm (Gasoline) 100 ppm (Studdard Solvent)	IDLH 1100 ppm	**Broad Range** Caution should be used when relying on odor alone as a warning of potentially hazardous exposures		
Diesel Range Organics		OSHA PEL Naphthalene 10 ppm ACGIH TLV Naphthalene 10 ppm Hydrosulfurized Kerosene C9-16 200 mg/m^3 (skin) ACGIH STEL Naphthalene 15 ppm	IDLH 250 ppm	**Broad Range** Caution should be used when relying on odor alone as a warning of potentially hazardous exposures		

S = Soil	SW = Surface Water	T = Tailings	W = Waste	TK = Tanks	SD = Sediment
A = Air	GW = Ground Water	SL = Sludge	D = Drums	L = Lagoons	OFF = Off-Site

Date October 2004

TASK DESCRIPTION/SPECIFIC TECHNIQUE/SITE LOCATION *(attach additional sheets as necessary)*	Type	Primary PPE	Contingency	HAZARD & SCHEDULE
1 Conduct DPT Subsurface Investigation	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low Oct-04
2	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low
3	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low
4	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low
5	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low
6	Intrusive Non-intrusive	A B C D Modified	A B C D Exit Area	Hi Med Low

PERSONNEL AND RESPONSIBILITIES

NAME (MODIFY LIST)	FIRM/DIVISION	RESPONSIBILITIES	On Site?
Nova Clite		Site Project Manager	No
John Bruskewitz		Site Health & Safety Coordinator	Yes
Subcontracted Driller*		Driller	Yes

* Drilling Contractor must demonstrate current 40-hr OSHA HAZWOPER and 8-hr refresher training and acceptable medical clearance documentation to project manager.

PROTECTIVE EQUIPMENT: *Specify by task. Indicate type and/or material, as necessary. Group tasks if possible. Use copies of this sheet if needed.*

BLOCK A

TASKS: DPT Subsurface Investigation
LEVEL: D

Respiratory: (X) Not Needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge: Benzene
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not needed
(X) Safety Glasses:
( ) Face Shield:
( ) Goggles:
(X) Hard Hat:
( ) Other:

Boots: ( ) Not needed
(X) Steel-Toe (X) Steel Shank
( ) Rubber (X) Leather
( ) Overboots:

Prot. Clothing: (X)
( ) Encapsulated Suit:
( ) Splash Suit
( ) Apron:
( ) Tyvek Coverall or
( ) Saranex Coverall
(X) Cloth Coverall:
( ) Other:

Gloves: ( ) Not needed
( ) Undergloves: PVC or
(X) Gloves: Nitrile
( ) Overgloves:

Other: specify below
( ) Tick Spray
( ) Flotation Device If Over Water
(X) Hearing Protection: Optional
( ) Sun Screen

BLOCK B

TASKS: DPT Subsurface Investigation
LEVEL: Exit Area Contingency

Respiratory: (X) Not needed
( ) SCBA, Airline:
( ) APR: MSA Full Face
( ) Cartridge: Benzene-H
( ) Escape Mask:
( ) Other:

Head and Eye: (X) Not needed
( ) Safety Glasses:
( ) Face Shield:
( ) Goggles:
( ) Hard Hat:
( ) Other:

Boots: (X) Not needed
( ) Steel-Toe ( ) Steel Shank
( ) Rubber ( ) Leather
( ) Overboots: Latex

Prot. Clothing: (X) Not needed
( ) Encapsulated Suit:
( ) Splash Suit
( ) Apron:
( ) Tyvek Coverall or
( ) Saranex Coverall
( ) Cloth Coverall:
( ) Other:

Gloves: (X) Not needed
( ) Undergloves: PVC
( ) Gloves:
( ) Overgloves: Nitrile

Other: specify below
( ) Tick Spray
( ) Flotation Device If Over Water
( ) Heating Protection
( ) Sun Screen

Exit Area

BLOCK C

TASKS: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9
LEVEL: A - B - C - D - Modified
( ) Primary ( ) Contingency

Respiratory: ( ) Not needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge:
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not needed
( ) Safety Glasses:
( ) Face Shield:
( ) Goggles:
( ) Hard Hat:
( ) Other:

Boots: ( ) Not needed
( ) Steel-Toe ( ) Steel Shank
( ) Rubber ( ) Leather
( ) Overboots:

Prot. Clothing: ( ) Not needed
( ) Encapsulated Suit:
( ) Splash Suit
( ) Apron:
( ) Tyvek Coverall
( ) Saranex Coverall
( ) Cloth Coverall:
( ) Other:

Gloves: ( ) Not needed
( ) Undergloves:
( ) Gloves:
( ) Overgloves:

Other: specify below
( ) Tick Spray
( ) Flotation Device
( ) Heating Protection
( ) Sun Screen

BLOCK D

TASKS: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9
LEVEL: A - B - C - D - Modified
( ) Primary ( ) Contingency

Respiratory: ( ) Not needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge:
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not needed
( ) Safety Glasses:
( ) Face Shield:
( ) Goggles:
( ) Hard Hat:
( ) Other:

Boots: ( ) Not needed
( ) Steel-Toe ( ) Steel Shank
( ) Rubber ( ) Leather
( ) Overboots:

Prot. Clothing: ( ) Not needed
( ) Encapsulated Suit:
( ) Splash Suit
( ) Apron:
( ) Tyvek Coverall
( ) Saranex Coverall
( ) Cloth Coverall:
( ) Other:

Gloves: ( ) Not needed
( ) Undergloves:
( ) Gloves:
( ) Overgloves:

Other: specify below
( ) Tick Spray
( ) Flotation Device
( ) Heating Protection
( ) Sun Screen

SITE SAFETY AND HEALTH PLAN T N & Associates Safety and Health Program	*This document is for the exclusive use of TN & Associates and its subcontractors*	TN & ASSOCIATES PROJECT DOCUMENT #: 2002189

MONITORING EQUIPMENT: *Specify by task. Indicate type as necessary. Attach additional sheets if needed.*

INSTRUMENT	TASK	ACTION GUIDELINES	COMMENTS *(When and how will you use the monitor?)*
Combustible Gas Indicator	(1)-2-3-4-5-6-7-8		(X) Not Needed
Radiation Survey Meter	1-2-3-4-5-6-7-8		(X) Not Needed
Photoionization Detector 10.6eV Lamp Type OVM HNU P1-101 (or equivalent)	(1)-2-3-4-5-6-7-8	*Specify:* Total Petroleum Hydrocarbons have a TWA of 100mg/m^3, but there is no STEL.	( ) Not Needed Soil samples will be screened for VOCs in the field at the time of sample collection.
Flame Ionization Detector Type_____	1-2-3-4-5-6-7-8	*Specify:*	(X) Not Needed
Detector Tubes/ Monitox Type_____ Type_____	1-2-3-4-5-6-7-8	*Specify:*	(X) Not Needed
Respirable Dust Monitor Type_____ Type_____	1-2-3-4-5-6-7-8	*Specify:*	(X) Not Needed
Other *Specify:*	1-2-3-4-5-6-7-8	*Specify:* If team notices unusual odors or irritation of the eye or throat, they will leave the area.	

Date October 2004

DECONTAMINATION PROCEDURES

ATTACH SITE MAP INDICATING EXCLUSION, DECONTAMINATION, AND SUPPORT ZONES AS PAGE TWO

Personnel Decontamination *Summarize below or attach diagram;*	**Sampling Equipment Decontamination** *Summarize below or attach diagram;*	**Heavy Equipment Decontamination** *Summarize below or attach diagram;*
1. Equipment Drop 2. Surgical glove removal 3. Removal of hard hat and safety glasses. ( ) Not Needed	1. Alconox rinse 2. Rinse with distilled water 3. Air dry ( ) Not Needed	Drillers will decontaminate their equipment before it leaves the site and between boreholes. ( ) Not Needed
Containment and Disposal Method Solid wastes will be collected in drums and disposed of by others.	**Containment and Disposal Method** Liquid and solid wastes will be collected in drums and disposed of by others.	**Containment and Disposal Method** Liquid wastes will be collected in drums and disposed of by others.

EMERGENCY CONTACTS

Water Supply	505-784-1092	Pete Zamie
Site Telephone	505-784-1092	Pete Zamie
EPA Release Report #:		
TN&Associates 24-Hour Emergency #:	1-888-662-5705	(Wm Fink pager)
Facility Management	505-784-1092	Pete Zamie
Other (specify)		
CHEMTREC Emergency #:	1-800-424-9300	

EMERGENCY CONTACTS	NAME	PHONE
Health and Safety Manager	William Fink	414-607-6779
Project Manager	Nova Clite	414-607-6727
Site Safety Coordinator	John Bruskewitz	414-607-6776
Client Contact	Jane Davey	402-221-7645
Other *(specify)*	Rich Baldino	312-220-7000
State Spill Number	Region 6 Emergency Response Center	1-866-372-7745
Fire Department		911
Police Department		911
State Police		911
Poison Control Center		1-800-222-1222
Occupational Physician	Health Resources, Inc.	1-800-350-4511

CONTINGENCY PLANS: *Summarize below*

If work team observes hazards for which they are not prepared, they will withdraw from the area and call the Corperate Health and Safety Manager (William Fink), the Base POC (Pete Zamie), and the USACE PM (Jane Davey). No team member will enter or remain on this site unless accompanied by another.

MEDICAL EMERGENCY **PHONE**

Hospital Name: Plains Regional Medical Center 505-769-2141
Hospital Address: 2100 N. Mrtn Lthr King Jr Blvd, Clovis, NM 88101
Name of Contact at Hospital: Emergency Room Physician
Name of 24-Hour Ambulance: 911
Route to Hospital: (see attached sheet)

HEALTH AND SAFETY PLAN APPROVALS

Prepared by _____ Date _____
DHSC Signature _____ Date _____
HSM Signature _____ Date _____

Distance to Hospital 10 miles

SAFETY AND HEALTH PLAN SIGNATURE FORM

T N & Associates Safety and Health Program

All site personnel must sign this form indicating receipt of the H&SP. Keep this original on site. It becomes part of the permanent project files. Send a copy to the Corporate Safety and Health Manager.

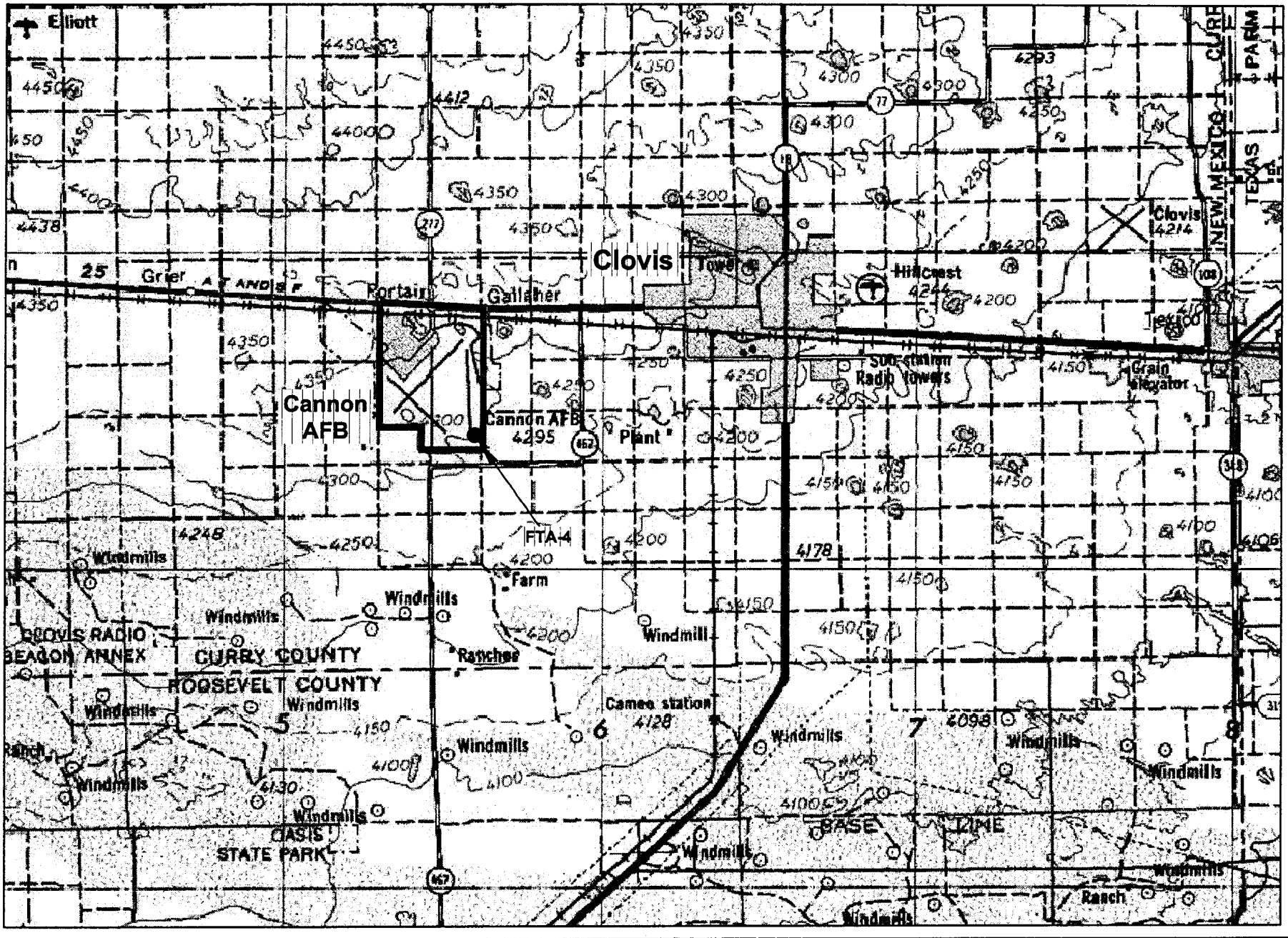
SITE NAME/NUMBER: Cannon Air Force Base (FTA-4), near Clovis New Mexico

DIVISION/LOCATION: T N & Associates, Milwaukee, WI 414-257-4200

CERTIFICATION:

I understand, and agree to comply with, the provisions of the above referenced H&SP for work activities on this project. I agree to report any injuries, illnesses or exposure incidents to the site Health and Safety Coordinator (SHSC). I agree to inform the SHSC about any drugs (legal and illegal) that I take within three days of site work.

PRINTED NAME	SIGNATURE	DATE



TN&A T N & Associates, Inc. Engineering and Science

Figure was adapted from USGS Quads:
Midway, NM (1985)
Clovis, NM (1978)
Clovis, NM, TX (1972)

0 2.5 5

1 Inch = 2.5 Miles (approximately)

N

Figure 1
Cannon Air Force Base Site Location Map

MAPQUEST.

Send To Printer Back To Directions

Start: Cannon Afb, NM
US

End: 2100 N Dr Martin Luther King Jr Blvd
Clovis, NM
88101-9412 US

Distance: 8.73 miles

Total Estimated Time: 21 minutes

Mexico Hotels
Visit **Mexico** - Your Resource for Info on Great Mexican Destinations
www.visitmexico.com

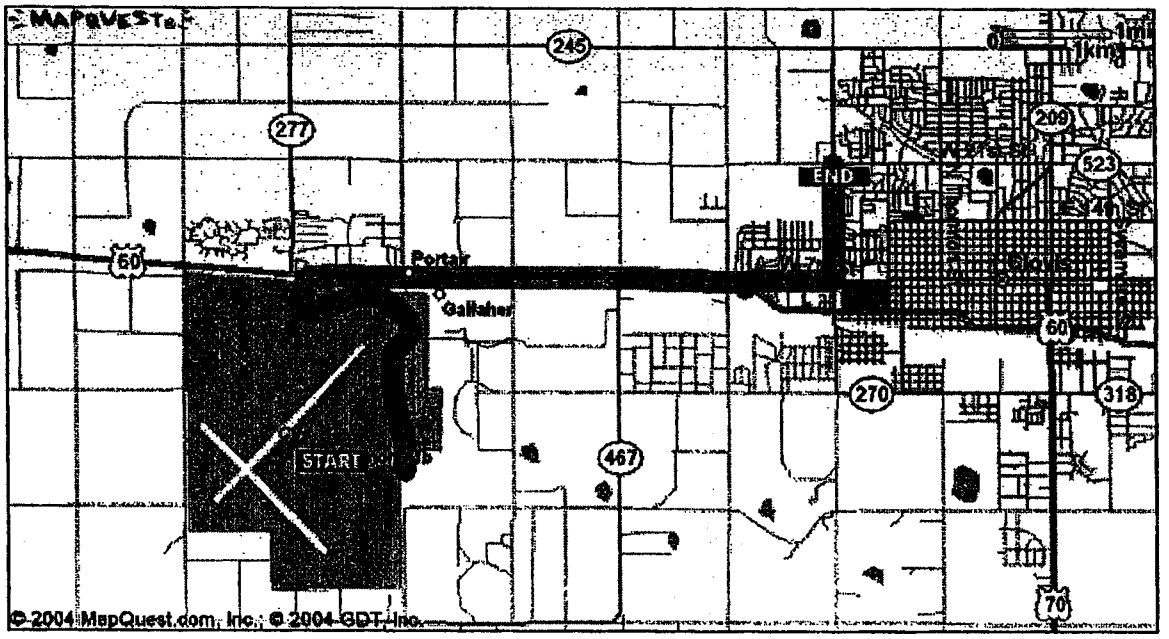
Clovis Hotels
Search 1000's of **Hotels** on ORBITZ. Great Rooms for Less. Book Online!
www.ORBITZ.com

Clovis Hotels
Travelocity Great Rates for Fall Great Rooms. Guaranteed!
www.travelocity.com

Clovis Hotels
Compare prices and find great hotel deals for your trip
www.tripadvisor.com

About these results

Directions	Distance
START **1.** Start out going North on S PERIMETER RD toward NO PERIMETER RD.	2.0 miles
2. S PERIMETER RD becomes NO PERIMETER RD.	0.4 miles
3. Turn RIGHT onto N TORCH BLVD.	0.2 miles
4. Merge onto US-84 S/US-60 E.	4.1 miles
5. Turn LEFT onto W 7TH ST.	0.8 miles
6. Turn LEFT onto N MARTIN LUTHER KING JR BLVD.	1.0 miles
END **End at 2100 N Dr Martin Luther King Jr Blvd, Clovis, NM 88101-9412 US**	



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Other (specify)		
CHEMTREC Emergency #:	1-800-424-9300	

CONTINGENCY PLANS: *Summarize below*

If work team observes hazards for which they are not prepared, they will withdraw from the area and call the Corperate Health and Safety Manager (William Fink), the Base POC (Pete Zamie), and the USACE PM (Jane Davey). No team member will enter or remain on this site unless accompanied by another.

HEALTH AND SAFETY PLAN APPROVALS

Prepared by _____ Date _____

DHSC Signature _____ Date _____

HSM Signature _____ Date _____

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Project Manager	Nova Clite	414-607-6727
Site Safety Coordinator	John Bruskewitz	414-607-6776
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Hospital Address: 2100 N. Mrtn Lthr King Jr Blvd, Clovis, NM 88101

Name of Contact at Hospital: Emergency Room Physician

Name of 24-Hour Ambulance: 911

Route to Hospital: (see attached sheet)

Distance to Hospital 10 miles

T N & Associates, Inc.
Engineering and Science

Cannon AFB (FTA-4)

Activity Hazard Analysis (AHA) Summary

Prepared by: William Fink, CIH, CSP, CHMM, Safety and Health Manager

Approved by: Nova Clite, Project Manager

Task/Activity	Hazard	Consequence	Procedure/Prevention
AHA 1 DPT Subsurface Investigation	Chemical Exposure During Sampling Activities	Chemical Exposure: Inhalation; Ingestion; Skin Absorption	ENSURE field crew has gone through HAZARD COMMUNICATION TRAINING Wear appropriate PPE – cloth coveralls, gloves, boots, and eye protection.
	Heat Stress	Heat Cramps Heat Exhaustion Heat Stroke Death	Implement a heat stress control program when necessary due to environmental conditions. Use of PPE. Program to include monitoring, training, acclimatization, scheduling, work rest regimens, personal protective devices, shaded areas and cool rest areas, electrolyte and water replacement fluids, and biological monitoring when necessary.
	Head, Eye, and Foot Injuries	Injury	Hard hats, steel toe boots, and safety glasses with side shields are required at all times.
	Cold Stress	Frostbite Hypothermia	Implement a cold stress control program including environmental monitoring, training, heavy winter clothing, and heated rest areas.
	Slip/Trip/ Fall Hazards	Injury, Death	Safety training to stress the fundamentals, such as the cause and prevention of slip/trip/fall hazards, lifting techniques, and incident prevention. Secure positions in and around drums and tanks to be sampled.
	Biological Hazards	Injury due to insects, poison plants and animals	Biological hazards, poisonous plants, insects and animals are to be addressed during daily safety meeting. Proper PPE will include skin protection designed to keep biological hazard exposure to a minimum.

T N & Associates, Inc.
Engineering and Science

Cannon AFB (FTA-4)

Activity Hazard Analysis (AHA) Summary (continued)

Task/Activity	Hazard	Consequence	Protection/Prevention
AHA 1 DPT Subsurface Investigation	Chemical Decon-tamination of Sampling Equipment	Chemical Exposure: Inhalation; Ingestion; Skin Absorption	ENSURE field crew has gone through HAZARD COMMUNICATION TRAINING Wear appropriate PPE – cloth coveralls, gloves, boots, respiratory protection (if necessary), eye protection
	Manual Lifting	Back Muscle Strain/ Musculoskeletal trauma and injury	Employing proper lifting and handling techniques and prevent back strain. Two or three personnel shall lift heavy equipment. Footgear shall have good treads. Personnel shall be alert of where they are walking.
	Noise	Damage to hearing, miscommunication	Implement hearing conservation program to comply with OSHA standards including exposure monitoring, employee training, engineering/ administrative controls, personal hearing protection, and audiometric testing.
	Heavy Equipment Operation In Vicinity	Struck-by Hazard: Injury, Death	Field personnel will alert all operators of their presence when in vicinity of equipment. Backup alarms, safe work practices for operator and field technicians. Establishment of traffic patterns.
	Radiation from PID (non-ionizing)	Low level non-ionizing radiation exposure	Ensure that field personnel operating PID have been thoroughly trained in operation, storage, handling, and all safety procedures of the equipment and calibration gases
	Slicing open acetate or plastic liners	Cuts to hands or arms	Use safety knife (box cutter type) with hooked blade; practice and review safe cutting procedures before fieldwork ; do not cut toward your hand; have experienced personnel perform liner cutting.
	Fire and Explosion	Injury/Burns/Death	Store calibration gases in secure storage area or locked flammable storage cabinet. Segregate non-compatible chemicals – ENSURE field crew has gone through HAZARD COMMUNICATION TRAINING.

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Activity Hazard Analysis (AHA) Summary (continued)

Equipment Used	Inspection Requirements	Training Requirements
PPE - Modified Level D - Level C - Level B - Water Resistant Coveralls/Rainsuit Air Monitoring Equipment - AIM Logic 600 Series 4 Gas Monitor - HNU PI-101 Photoionization Detector (or equivalent) Hand Tools and Power Tools Appropriate Sampling Equipment	Daily Safety Inspection of: Work Area and Staging Area Inspect hand tools and power equipment before use. Calibrate air monitoring equipment before/after use. Inspect PPE before use. Inspect and clean Heavy Equipment before and after use.	40-hr. OSHA HAZWOPER trng 3-day supervised field trng 8-hr. OSHA HAZWOPER Site-Specific Training First Aid/CPR/AED training (as necessary)

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Cannon AFB (FTA-4)

Activity Hazard Analysis (AHA) Summary

Prepared by: William Fink, CIH, CSP, CHMM, Safety and Health Manager

Approved by: Nova Clite, Project Manager

Task/Activity	Hazard	Consequence	Control/Mitigation
AHA 2 All On-Site Field Activities: Severe Weather Alert	Severe Weather	Injury/Death Property damage	Monitor local weather through available media or a weather radio. During daily safety meetings address inclement weather procedures: Lightning and/or Thunder: Equipment shutdown Proceed to support zone Await further instruction from Project Manager or SSHO Heavy Rain/Wind: If visibility is affected, shut down equip Proceed to support zone Await further instructions from the SSHO Tornado: Equipment shut down Proceed to support zone Await further instructions from the SSHO **NOTE: A 30-min. STAND DOWN period is required after encountering Lightning, Thunder, Heavy Rain or Wind in order to allow the storm to pass. Verification from the National Weather Service for an ALL Clear is also advised prior to re-commencing work.**