PELCO SALES & SERVICE
1550 PARK AVENUE • EMERYVILLE, CALIFORNIA 94608
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Certified Refrigeration Contractors Lic. No. 675829

RECEIVED
10:13 am, Nov 13, 2012
Alameda County
Environmental Health

November 8, 2012

Mr. Mark Detterman, P.G.
Senior Hazardous Materials Specialist
Alameda County Environmental Health Department
1131 Harbor Bay Parkway, Suite 250
Alameda, Calif. 94502-6577

Subject: Work Plan for Soil and Groundwater Investigation
Apex Refrigeration, Inc.
1550 Park Avenue, Emeryville, California 94608
Alameda County Fuel Leak Case RO0003069
GeoTracker Global ID T100002519

Dear Mr. Detterman:

As a legally authorized representative of Apex Refrigeation, Inc. I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document titled Work Plan for Soil and Groundwater Investigation, Apex Refrigeration, Inc., 1550 Park Avenue, Emeryville, CA is true or correct to the best of my knowledge.

Sincerely,

APEX REFRIGERATION CORP.
DBA PELCO SALES & SERVICE

Pennie Barger

Pennie Barger
Secy-Treas.

Work Plan for Soil and Groundwater Investigation
Apex Refrigeration, Inc.
1550 Park Avenue
Emeryville, California

October 2012

ERRG Project No. 2012-144

Prepared for:

Apex Refrigeration, Inc.
1550 Park Avenue
Emeryville, California 94608

Prepared by:

ERRG
Engineering/Remediation Resources Group, Inc.
4585 Pacheco Boulevard, Suite 200
Martinez, California 94553
(925) 969-0750

Work Plan for Soil and Groundwater Investigation
Apex Refrigeration, Inc.
1550 Park Avenue
Emeryville, California

Submitted by:
Engineering/Remediation Resources Group, Inc.

Signature	October 31, 2012
	Date
Erik Brown	Project Manager
Name	Title
Signature	October 31, 2012
	Date
Phil Skorge	Project Geologist
Name	Title

PROFESSIONAL GEOLOGIST
AASMUND PHILIP SKORGE
No. 8706
Exp. 6/30/14
STATE OF CALIFORNIA

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Acronyms and Abbreviations

ACEH	Alameda County Environmental Health Department
Apex	Apex Refrigeration, Inc.
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	Code of Federal Regulations
1,2-DCA	1,2-dichloroethane
DPT	direct-push technology
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group, Inc.
IDW	investigation-derived waste
LUFT	leaking underground fuel tank
mg/kg	milligrams per kilogram
SOP	standard operating procedure
SSHP	Site-Specific Health and Safety Plan
STLC	Soluble Threshold Limit Concentration
TPH	total petroleum hydrocarbons
TPH-d	TPH as diesel
USA North	Underground Service Alert North
UST	underground storage tank
Water Board	San Francisco Regional Water Quality Control Board

Section 1. Introduction

Engineering/Remediation Resources Group, Inc. (ERRG) has prepared this work plan to conduct a soil and groundwater investigation at Apex Refrigeration, Inc. (Apex), located at 1550 Park Avenue in Emeryville, California (Figures 1 and 2). This work plan was prepared in response to Alameda County Environmental Health Department (ACEH) directives dated June 29, 2011 and March 14, 2012, which requested the submittal of a work plan to define the lateral and vertical extent of any potential soil and groundwater contamination from a former 1,400-gallon underground storage tank (UST).

1.1. SITE BACKGROUND

On or about November 6, 2009, a UST was discovered adjacent to the building located at 1550 Park Avenue in Emeryville, California during street improvements (P&D Environmental, Inc. 2010). The street, curb, and gutter adjacent to the south side of the UST were excavated to a depth of approximately 4 feet below ground surface (bgs). The top of the UST was encountered at a depth of approximately 1 foot bgs and was measured to be approximately 10 feet long and 5 feet in diameter. No holes were reported in the tank; however, an opening at the top of the tank allowed access to the interior of the UST. The UST contained water and a floating layer of black, viscous fluid with a strong petroleum odor.

On December 9, 2009, approximately 700 gallons of oily water was pumped from the UST and transported off site for disposal at the Clearwater Environmental disposal facility in Silver Springs, Nevada. One water sample collected from the UST was submitted to McCampbell Analytical, Inc. in Pittsburg, California for fuel fingerprint laboratory analysis using U.S. Environmental Protection Agency (EPA) Methods 3550C/8015B. The laboratory analysis identified fuel oil and possibly bunker oil in the sample. During January and February 2010, approximately 1,500 gallons of additional water was pumped from the UST and the adjacent excavated area and transported for disposal at the Alviso Independent Oil facility in Alviso, California.

After consulting with Apex, the City of Emeryville removed the UST on February 8, 2010. The soil excavated around the UST displayed a blue-gray discoloration and exhibited a strong oily odor. The UST was visually inspected following removal from the excavation pit. The UST appeared to be in good condition and had a calculated capacity of approximately 1,500 gallons. No evidence of holes, cracks, or pitting from significant corrosion was observed; however, a hole was observed at the west end of the UST where a rivet was missing. It is not clear if the rivet was dislodged during UST removal activities. Following removal of the UST from the excavation pit, a layer of black oil was observed floating on the water in the UST excavation pit at approximately 6 feet bgs. However, water samples could not be collected for chemical analysis because an inadequate amount of water was present in the UST pit.

After removal of the UST, two soil samples (T1 and T2) were collected from the bottom of the excavation pit using a backhoe bucket. The samples were collected from the western and eastern ends of the former UST and submitted for laboratory analysis. A four-point composite sample was also collected from the excavated soil for waste characterization purposes (SP1). The samples were analyzed for total petroleum hydrocarbons (TPH) as diesel (TPH-d) using EPA Method 3550C in conjunction with modified EPA Method 8015C; benzene toluene, ethylbenzene, and xylenes (BTEX) and the lead scavengers ethylene dibromide (EDB) and 1,2-dichloroethane (1,2-DCA) by EPA Method 5030B in conjunction with EPA Method 8260B. In addition, sample SP1 was analyzed for Leaking Underground Fuel Tank (LUFT) 5 metals (cadmium, total chromium, lead, nickel, and zinc) using EPA Method 3050B in conjunction with EPA Method 6010B, and for Soluble Threshold Limit Concentration (STLC) total chromium using California 22 Waste Extraction Test extraction methods and EPA Method 6010B for disposal characterization purposes. Approximately 20.29 tons of soil was transported for offsite disposal at the Republic Services Vasco Road Landfill in Livermore, California.

BTEX, EDB, and 1,2-DCA were not detected above laboratory reporting limits in the tank pit bottom samples (Table 1). TPH-d was detected in samples T1, T2, and SP1 at concentrations of 15, 5.8, and 830 milligrams per kilogram (mg/kg), respectively (Table 1). Cadmium was not detected above laboratory reporting limits in sample SP1. Total chromium, lead, nickel, and zinc were reported at concentrations of 54, 26, 57, and 110 mg/kg, respectively. The STLC total chromium result for sample SP1 was 0.23 milligrams per liter.

Section 2. Scope of Work

ACEH requested this work plan to define the extent of any soil and groundwater contamination because oily water was observed in the UST pit and the sample collected from the excavated soil confirmed the presence of TPH-d. ERRG proposes to collected soil and groundwater samples from four direct-push technology (DPT) soil borings at the locations shown on Figure 2 to delineate the lateral and vertical extent of petroleum hydrocarbons in soil and groundwater in the vicinity of the former UST. Specific tasks proposed to perform the scope of work are outlined in the following sections.

2.1. HEALTH AND SAFETY

ERRG has prepared a Site-Specific Health and Safety Plan (SSHP) as required by the Occupational Health and Safety Administration Standard "Hazardous Waste Operations and Emergency Response" guidelines (29 Code of Federal Regulations [CFR] 1910.120 (29 CFR 1910.120) (Appendix A). All ERRG personnel and subcontractors entering the work area will be required to read and understand the SSHP.

2.2. PERMITTING AND UTILITY CLEARANCE

Prior to mobilization, ERRG will obtain soil boring permits from Alameda County Public Works Agency. An encroachment permit will be obtained from the City of Emeryville for the drilling of soil borings on Park Avenue or along the sidewalk.

ERRG will mark the proposed boring locations in white paint and notify Underground Service Alert North (USA North) a minimum of 5 working days prior to the drilling. USA North will notify public and private utility companies to mark the locations of underground utilities owned and maintained by each company. ERRG will also contract with a private utility locator to mark and clear any locations within the work area where borings are proposed.

2.3. DIRECT-PUSH SOIL BORINGS

ERRG will oversee a California-licensed driller to advance four DPT borings to depths of 10 feet bgs in the vicinity of the former UST (Figure 2). The proposed boring locations shown on Figure 2 may be adjusted in the field based on the presence of utilities or sidewalk improvements such as concrete planters. Two soil samples will be collected from each boring at and below the observed groundwater level, anticipated to be at approximately 4 to 6 feet bgs. The sampling depths will be determined by visual observation of potential contamination. Drilling and sampling operations will be conducted in accordance with ERRG Standard Operating Procedure (SOP) GEO-014 for direct-push drilling and soil sampling (Appendix B).

Each sample will be screened for hydrocarbon vapors using a portable photoionization detector. Soil borings will be continuously cored and will be logged using the United Soil Classification System by a field geologist, working under the supervision of a California-registered geologist.

One direct-push groundwater sample will be collected from each of the borings using a Hydropunch sampler in accordance with ERRG SOP GEO-004 for direct-push groundwater sampling and SOP FS-023 for low-flow well sampling (Appendix B). Groundwater will be collected in a Hydropunch sampler and transferred to 40-milliliter volatile organic analysis vials using a 0.5-inch-diameter bladder pump with dedicated polyethylene tubing. Samples will be collected after environmental parameters (e.g., pH, specific conductance, temperature, turbidity, salinity, oxidation-reduction potential, and dissolved oxygen) have stabilized, as indicated by three consecutive readings differing by less than 10 percent.

Soil and groundwater samples will be submitted to a California-certified laboratory for analysis of the following analytes:

- TPH-purgeables by EPA Method 8015B with silica gel cleanup
- TPH-extractables by EPA Method 8015B
- BTEX by EPA Method 8260B
- Priority pollutant polycyclic aromatic hydrocarbons by EPA Method 8270 SIM

In addition, one four-point soil composite sample will be analyzed for LUFT 5 metals (cadmium, chromium, nickel, lead, and zinc) for waste disposal characterization purposes using EPA Method 6010B.

All borings will be tremie grouted from the bottom up with neat cement upon completion.

2.4. INVESTIGATION-DERIVED WASTE DISPOSAL

Investigation-derived waste (IDW) is anticipated to consist of soil cuttings, decontamination water, and groundwater. IDW will be stored in U.S. Department of Transportation-approved 55-gallon drums, pending analysis and waste characterization. ERRG will obtain permission to temporarily store the drums in a secure location at the site. Any personal protective equipment will be disposed of as nonhazardous waste in the municipal trash. Waste soil generated from soil boring activities will be placed in a drum, sealed, and transported for disposal at a California-certified facility.

2.5. REPORTING AND SCHEDULE

ERRG will prepare a Soil and Groundwater Investigation Report for submittal to ACEH within 60 days following ACEH approval of this work plan. The report will include a description of field procedures and methods, figures indicating boring and sample locations and site features, tabulated analytical results, soil boring logs, conclusions, and recommendations for additional investigation or remedial action, if necessary.

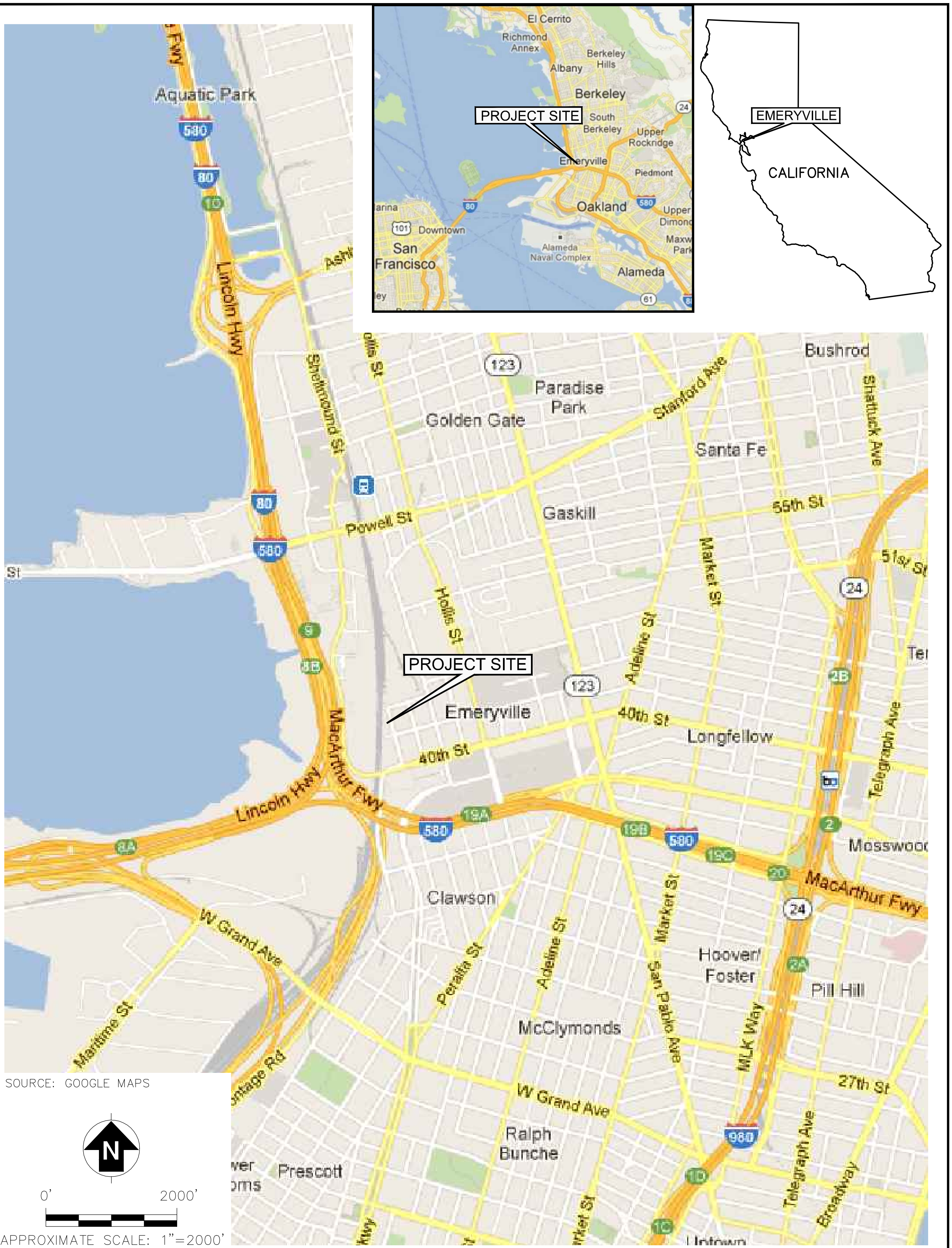
Sampling analytical results will be compared to San Francisco Regional Water Quality Control Board (Water Board) Environmental Screening Levels (Water Board, 2008). If the data suggests that no further action is required, case closure will be recommended.

Section 3. References

P&D Environmental, Inc. (P&D). "Underground Storage Tank Removal Report, 1550 Park Avenue, Emeryville, CA." March 12.

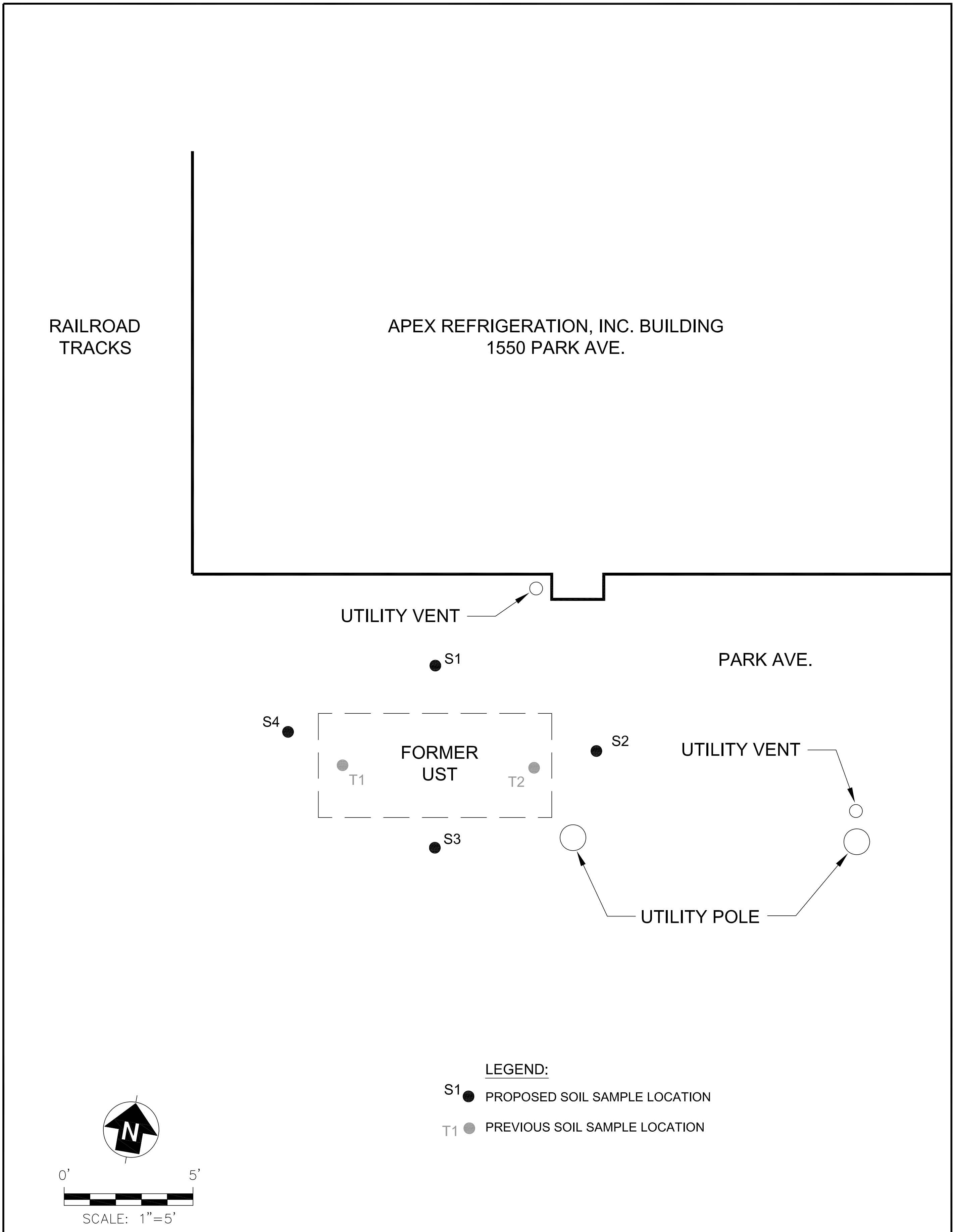
San Francisco Regional Water Quality Control Board, 2008. "Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater." Interim Final. May. Available Online at: <http://www.swrcb.ca.gov/rwqcb2/esl.shtml>.

Figures



Engineering/Remediation Resources Group, Inc. 4585 Pacheco Blvd., Suite 200 Martinez, California 94553 (925) 969-0750 ERRG	CLIENT: APEX REFRIGERATION, INC. EMERYVILLE, CALIFORNIA	SITE LOCATION MAP		
	LOCATION: 1550 PARK AVENUE EMERYVILLE, CALIFORNIA	DRAWN BY: RDB 10/8/12	CHECKED BY: ERB 10/9/12	PROJECT NO. 2012-144 / FIG NO. 1

FILE NAME: N:\Graphics\2012\2012-144 APEX Emeryville\Site Location Map.dwg LAYOUT NAME: 1 PLOTTED: Tuesday, October 09, 2012 - 11:13am



ERRG
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4585 Pacheco Blvd., Suite 200
Martinez, California 94553
(925) 969-0750

CLIENT: APEX REFRIGERATION, INC. EMERYVILLE, CALIFORNIA		SITE PLAN		
LOCATION: 1550 PARK AVENUE EMERYVILLE, CALIFORNIA	DRAWN BY: RDB 10/8/12	CHECKED BY: ERB 10/9/12	PROJECT NO. 2012–144	FIG NO. 2

FILE NAME: N:\Graphics\2012\2012-144 APEX Emeryville\Site Plan.dwg LAYOUT NAME: 2 PLOTTED: Thursday, October 11, 2012 - 12:10pm

Tables

Table 1. Historical Soil Sampling Hydrocarbon Analytical Results

Soil Sample ID	Location	Date	Petroleum Hydrocarbons					Lead Scavengers	
			TPH-d	Benzene	Toluene	Ethylbenzene	Total Xylenes	EDB	1,2-DCA
T1-7.0	West end of tank pit	2/8/2010	**15**[a]	<0.005	<0.005	<0.005	<0.005	<0.004	<0.004
T2-6.0	East end of tank pit	2/8/2010	**5.8**[b]	<0.005	<0.005	<0.005	<0.005	<0.004	<0.004
SP1	4-point composite from excavated soil	2/8/2010	**830**[c,d]	<0.005	<0.005	<0.005	<0.005	<0.004	<0.004

Notes:

a = Laboratory analytical report indicates diesel range compounds are significant with no recognizable pattern.

b = Laboratory analytical report indicates aged diesel is significant.

c = Laboratory analytical report indicates unmodified or weakly modified diesel range compounds are present.

d = Laboratory analytical report indicates stoddard solvent or mineral spirits.

All results reported in milligram per kilogram (mg/kg)

Detected concentrations are highlighted in bolded text

TPH-d = total petroleum hydrocarbons in the diesel range

EDB = 1,2-dibromomethane

1,2-DCA = 1,2-dichloroethane

Table 2. Historical Soil Sampling Metal Analytical Results

Soil Sample ID	Location	Date	Metals					
			Cadmium	Chromium (total)	Lead	Nickel	Zinc	STLC Total Chromium
SP1	4-point composite from excavated soil	2/8/2010	<1.5	**54**	**26**	**57**	**110**	**0.23**[a]

Notes:

a = Results reported in milligrams per liter (mg/L).

All results reported in milligrams per kilogram (mg/kg) unless otherwise noted

Detected concentrations are highlighted in bolded text

Appendix A. ERRG SSHP

ERRG

SITE HEALTH & SAFETY PLAN

(Short Form)

A. INTRODUCTION

This plan has been prepared solely for implementation by ERRG employees, using operating procedures for which they are specifically trained. Any use of this plan by other parties is at their own risk.

B. GENERAL INFORMATION

Project No.: 2012-144 **Date:** 10/9/12

Prepared by: Erik Brown

Approved by:

Site Location: 1550 Park Avenue, Emeryville, CA

Description: Soil and groundwater investigation of former UST site

Hazard Summary:

Overall Chemical Hazard: ☐ Serious ☐ Moderate ☒ Low ☐ Unknown

Overall Physical Hazard: ☐ Serious ☐ Moderate ☒ Low ☐ Unknown

C. Project Team

Personnel	Responsibilities
Kirk Martin	Subcontractor observation and sample collection

D. CHEMICAL/SITE CHARACTERISTICS

Contaminants(s) of Concern:

Physical State: ☒ Liquid ☒ Solid ☐ Sludge ☐ Gas/Vapor

Characteristics:

☒ Flammable ☒ Combustible ☐ Corrosive ☐ Poison ☐ Explosive

☐ Reactive ☒ Volatile ☐ Biological ☐ Radioactive ☐ Carcinogen

Other:

Physical Hazards of Site:

☐ Overhead ☐ Confined Space ☐ Below Grade ☒ Trip/Fall ☐ Burn

☐ Puncture ☒ Noise ☐ Cut ☒ Splash ☐ Heat Stress

Other:

E. HAZARD EVALUATION

Physical Hazards:

NO.	TASK	PHYSICAL HAZARDS
1	Oversight of DPT drill rig and collection of soil and groundwater samples	Heavy equipment and vehicles

Chemical Hazard Evaluation: See attached Hazard Evaluation Sheets for data on individual chemicals.

Chemical Hazards:

NO.	TASK	CHEMICAL HAZARDS	PEL	ACTION LEVEL	AIR MONITORING	REQUIRED PPE
1	Drilling oversight and sample collection	TPH-d	100	100	PID	Level D

All entries into an exclusion zone require the Buddy System. All ERRG field staff participates in a medical monitoring program and has completed applicable training per 29 CFR 1910.120. ERRG's respiratory protection program meets the requirements of 29 CFR 1910.134.

Action levels for evacuation of work zone pending reassessment of conditions:

- Level D: O_2 <19.5% or >23.5%; explosive atmosphere >10% LEL; organic vapors above background levels; particulates >___ mg/m^3; other
- Level C: O_2 <19.5% or >23.5%; explosive atmosphere >10% LEL; unknown organic vapor (in breathing zone) >5 ppm; particulates >________ mg/m^3; other
- Level B: explosive atmosphere >10% LEL; unknown organic vapor (in breathing zone) >500 ppm; particulates > mg/m^3; other
- Level A: explosive atmosphere >10% LEL; unknown organic vapor (in breathing zone) >500 ppm; particulates > mg/m^3; other

Air Monitoring:

Contaminant	Type of Sample (Area/Personal)	Monitoring Equipment	Test Method	Frequency of Sampling	Odor Threshold
TPH-d	Area	PID	PID	During drilling operations	N/A

Decontamination Procedure/Solutions:

Personnel: Soap and water wash and clean water rinse. Remove disposable PPE and place it in a designated container.

Equipment: Decontaminate with Alconox (or equivalent) and clean water rinse or steam clean.

Instruments: N/A

F. EQUIPMENT CHECKLIST

Item	Number
PID (Hnu or other)	1

Activity Hazard Analysis (AHA)

Activity/Work Task: Drilling Oversight and Sample Collection	Overall Risk Assessment Code (RAC) (Use highest code)					L
Project Location: 1550 Park Avenue, Emeryville, CA	**Risk Assessment Code (RAC) Matrix**					
Contract Number: 2012-144	**Severity**	**Probability**				
Date Prepared: 10/9/12		Frequent	Likely	Occasional	Seldom	Unlikely
Prepared by (Name/Title): Erik Brown/Project Manager	Catastrophic	E	E	H	H	M
	Critical	E	H	H	M	L
Reviewed by (Name/Title): Tim Woodson/H&S Coordinator	Marginal	H	M	M	L	L
	Negligible	M	L	L	L	L

Notes: (Field Notes, Review Comments, etc.)	Step 1: Review each **"Hazard"** with identified safety **"Controls"** and determine RAC (See above)	
	"Probability" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.	**RAC Chart**
	"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible	**E = Extremely High Risk**
		H = High Risk
	Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.	**M = Moderate Risk**
		L = Low Risk

Job Steps	Hazards	Controls	RAC
General requirements for all work elements: 1. Mark proposed soil borings 2. Collect soil and groundwater samples using a DPT rig 3. Monitor air levels 4. Properly label samples and store appropriately	▪ Heat and cold stress	▪ Keep hydrated (drink at least 0.5 liter of water per hour) ▪ Wear appropriate clothing for hot and cold weather by layering ▪ Wear waterproof clothing to keep dry while working in wet weather ▪ Wear sunblock (minimum SPF 30)	L
	▪ Biological	▪ Remain alert to the presence of insects and animals, such as rodents or birds ▪ If bitten by an animal, immediately seek medical assistance	L
	▪ Slip, trip, and fall	▪ Be aware of surroundings (e.g., footing, equipment, personnel, tools, etc.) ▪ Avoid areas of unstable ground ▪ Use good housekeeping techniques to keep the workplace clear of slip, trip, and fall hazards	L
	▪ Lifting	▪ Use proper lifting techniques (use a buddy if the object weighs more than 50 pounds, bend with the knees and not the back, and do not twist from side to side while lifting heavy objects)	L
	▪ Noise	▪ Hearing protection within a minimum noise reduction rating of 29 decibels will be used at all times when personnel are within 20 feet of active heavy equipment	L

Activity/Work Task: Drilling Oversight and Sample Collection		Overall Risk Assessment Code (RAC) (Use highest code)	**L**
Job Steps	**Hazards**	**Controls**	**RAC**
General requirements for all work elements: 1. Mark proposed soil borings 2. Collect soil and groundwater samples using a DPT rig 3. Monitor air levels 4. Properly label samples and store appropriately *(continued)*	▪ Heavy equipment operation	▪ Keep a safe distance from and do not walk behind moving equipment ▪ Use eye contact and hand signals to maintain awareness and communication with the equipment operator ▪ Use engineered traffic controls and safe driving practices to minimize hazards; use a flagger and traffic control if necessary	**L**
	▪ Vehicle traffic; driving to and from the site and crossing streets	▪ Be aware of vehicle traffic ▪ Stay in designated crosswalks ▪ Look both ways before crossing streets ▪ Drive defensively and safely to and from the site ▪ Do not use a cell phone while driving ▪ Obey all traffic laws	**L**
	▪ Chemical hazards during sample collection	▪ Wear nitrile gloves under cut-resistant gloves ▪ Discard all disposable PPE into designated containers ▪ Wash hands and face before eating and drinking ▪ Avoid contact with contaminated soil or water by wearing appropriate PPE	**L**

Equipment to be Used	**Training Requirements/Competent or Qualified Personnel name(s)**	**Inspection Requirements**
▪ Steel-toed boots (ANSI Z41) ▪ Hardhat (ANSI Z89.1) ▪ Safety glasses with side shields (ANSI Z87.1) ▪ Safety vest – Class II ▪ Hearing protection (if necessary) ▪ Leather work gloves, as needed ▪ First-aid kit ▪ Fire extinguisher	▪ Current HAZWOPER training ▪ All site crew must review the SSHP ▪ All site crew must attend onsite safety briefings and daily tailgate safety meetings ▪ Subcontracted driller must be properly trained and experienced in the use of a drill rig ▪ At least one person onsite at all times should have current first aid/CPR training certification	▪ Attend daily tailgate meetings ▪ Weekly inspection of the first-aid kit ▪ Inspect the fire extinguisher/certification ▪ Inspect hand tools and equipment daily before use

H. EMERGENCY INFORMATION

EMERGENCY CONTACTS	TELEPHONE NUMBER
Ed Grooman – ERRG Corporate Health and Safety Manager	925-838-2235 (office) 925-234-1333 (cellular)
Kirk Martin – Site Safety and Health Officer	510-409-1854 (cellular)
Erik Brown – Project Manager	925-839-2276 (office) 925-305-5337 (cellular)

I. SITE RESOURCES
(To Be Completed Prior To Start Of Field Work)

	NAME/CONTACT	TELEPHONE NUMBER
Ambulance		911
Hospital	Alta Bates Summit Medical Center 350 Hawthorne Avenue Oakland, CA 94690	510-869-6600
Poison Control Center	California Poison Control System	800-876-4766
Police	Emeryville Police Department 2449 Powell Avenue Emeryville, CA 94608	911 (emergency) 510-596-3700 (non-emergency)
Fire Department	Emeryville Fire Department 2333 Powell Street Emeryville, CA 94608	911 (emergency) 510-596-3750 (non-emergency)
Client	Apex Refrigeration, Inc. 1550 Park Avenue Emeryville, CA 94608	510-653-9850
Site	1550 Park Avenue Emeryville, CA 94608	
Occupational Healthcare Clinic	Concentra Medical Center Oakland 384 Embarcadero West Oakland, CA 94607	510-465-9565

Appendix B. ERRG SOPs

Title: **Low-Flow or Micro-Purge Well Sampling**

Document Number: **FS-023**

Revision Number: **0**

Reason for Revision:

Reviewed: ______________________ 9/9/2009
QC Manager Date

Approved: ______________________ 9/9/2009
Program Manager Date

1. Purpose

This standard operating procedure (SOP) is intended to provide methods for low-flow sampling of groundwater from monitoring wells. Low-flow or micro-purge sampling is a method of collecting samples from a well that does not require the removal of large volumes of water from the well and therefore does not overly agitate the water and suspended particles or potentially aspirate volatile organic compounds (VOCs). The method entails the removal of water directly from the screened interval without disturbing any stagnant water above the screen by pumping the well at low enough flow rates to maintain minimal drawdown of the water column followed by in-line sample collection. Typical flow rates for low-flow sampling range from 0.1 liter per minute (L/min) to 0.5 L/min depending on site characteristics.

2. Scope

This SOP is applicable to all ERRG projects where groundwater samples will be collected from a monitoring well using low-flow or micro-purge methods and where no project- and program-specific procedure is in use.

3. References

- ASTM International, 1998. ASTM D6771-02, "Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations."
- ASTM International, 2007. ASTM D4448-01, "Standard Guide for Sampling Ground-Water Monitoring Wells."
- U.S. Environmental Protection Agency, Region 1, 1996. "Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, SOP GW0001, Revision 2." July 30.
- U.S. Army Corps of Engineers, 2001. "Requirements for the Preparation of Sampling and Analysis Plans, Appendix C, Section C.2, EM200-1-3." Washington, DC.

4. Definitions

Low Flow—Refers to the velocity that is imparted during pumping to the formation adjacent to the well screen, not necessarily the flow rate of the water discharged by the pump at the surface.

Micro-purge—Another term for low-flow sampling referred to as such because pre-sampling groundwater removal (purging) is performed at flow rates two to three orders of magnitude less than typical bailer or pump methods.

Pump—An electric, compressed air, or inert gas driven device that raises liquids by means of pressure or suction. The types of pumps used for well purging should be chosen based on the well size and depth, the type of contaminants, and the specific factors affecting the overall performance of the sampling effort.

Low-flow and micro-purge sampling is performed using specially constructed pumps, usually of centrifugal, peristaltic, or centrifugal submersible design, with low draw rates (<1.0 L/min).

Well Purging—The action of removing groundwater using mechanical means from a monitoring well prior to collecting groundwater samples. Purging removes stagnant groundwater from the column allowing the groundwater surrounding the well screen to enter the collection zone.

5. Responsibilities

5.1. PROCEDURE RESPONSIBILITY

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this SOP. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2. PROJECT RESPONSIBILITY

ERRG employees performing this task, or any portion thereof, are responsible for meeting the requirements of this SOP and using materials of a construction specified in the project plans or applicable to the contaminants of concern and other aspects of the sampling effort. These may include well diameter, well construction materials, depth to water, and the presence of dense nonaqueous-phase liquid (DNAPL) or light nonaqueous-phase liquid (LNAPL) contaminants. ERRG employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate SOPs. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. Procedure

Low-flow and micro-purge sampling involves removing water directly from the screened interval without disturbing any stagnant water above the screen or without lowering the water table. Since it is not based upon the removal of well volumes, it requires in-line monitoring of water quality parameters (i.e., pH, specific conductivity, temperature, dissolved oxygen, redox potential) to determine when the groundwater sample zone has stabilized. The sample is then collected using the same pump directly from the discharge tubing.

6.1. CONSIDERATIONS

The following variables should be considered in planning for low-flow purging and sampling:

- **Recharge capacity of each well:** The recharge capacity of a well will determine how fast the well should be purged. The purge rate should be no greater than the recharge rate of the groundwater zone to prevent water table drawdown.
- **Well construction details, including well depth, diameter, screened interval, screen size, material of construction, and depth to water table:** The diameter and well depth will determine the size of the pump and the location from which the pump will operate. Peristaltic and suction draw pumps are only viable at depths of less than 25 feet. The pump intake should be placed within the well screen.
- **Pump:** Low-flow purging and sampling can be used in any well that can be pumped at a constant rate of not more than 1.0 L/min. Continuous discharge and cycle discharge pumps with adjustable flow rate controls should be used to avoid causing continuous drawdown. Whenever possible, dedicated pumps should be installed to avoid disturbing the water column.
- **Groundwater quality, including type and concentration of chemical compounds present:** Low-flow methods can be used for all types of aqueous-phase contamination, including VOCs, semivolatile organic compounds, metals, pesticides, polychlorinated biphenyls, radionuclides, and microbiological constituents. Pump parts and tubing should be made of materials that are compatible with the chemicals of interest.

6.2. EQUIPMENT

The following equipment is recommended for use in conducting well purging:

- Pump and discharge hose and line constructed of compatible materials capable of <1.0 L/min draw rates
- Water level indicator
- Swabbing materials
- Flow-through water quality meter (pH, specific conductance, temperature, optional dissolved oxygen, redox potential)–calibrated
- Nephelometer–calibrated (if required)
- Photoionization detector (PID)–calibrated (if screening for VOCs is required)
- Drums or tanks to contain the purge water
- Field logbook
- Calculator
- Plastic sheeting
- Sample containers and preservatives
- Ice and Ziploc-type bags

6.3. PRE-SAMPLING

To prevent cross contamination of other wells on site, upgradient and background wells should be sampled first. The procedure for pre-sampling is as follows:

- Prepare the area surrounding the well by placing plastic sheeting on the ground surface to prevent potential cross-contamination of the pump and discharge hose or sample equipment and materials.
- Place and secure the drum, tank, or suitable purge water container in close proximity to the well for collection and storage of purge water. Purge water must be containerized and disposed of in the manner specified in the project and program plan or as the client directs. Never return purge water to the well. If in doubt or where requirements are not specified, handle all purge water as waste and dispose of it accordingly.
- If performing VOC screening, measure and record the background organic vapors in the ambient air using a PID, in accordance with manufacturer recommendations.
- Open the well casing, remove the well cap, and immediately measure and record the organic vapor levels from the head space within the well casing using a PID, in accordance with manufacturer recommendations.
- Measure the depth to the static water level using the water level indicator in accordance with ERRG SOP FS-020, Water Level Measurements.

6.4. WELL PURGING

The procedure for well purging is as follows:

- Review and understand the proper operating and maintenance instruction for each type of pump that is used prior to placing the pump in the well. Each pump type has specific operating procedures.
- Some wells may include a dedicated pump that is already placed in the well along the well screen. If this is the case, review well construction data to verify the proper placement of the pump intake. Inspect the location where the discharge line and pump support cable exit the well to determine that they are in the proper position (markings should be present at the well head to show this).
- Assemble the pump and discharge line in accordance with manufacturer instructions. Ensure the pump discharge line is long enough so that the pump intake can be located within the well screen area and the discharge end can reach the purge water container.
- Slowly lower the pump into the well until it is submerged and at the desired pumping depth.
- Connect the pump discharge to the flow-through water quality meter system in accordance with the manufacturer's procedure.
- Start the pump and begin monitoring discharge rates and volume collected. Adjust flows if necessary to remain in a range of 0.1 to 0.5 L/min without exceeding the well discharge rate.
- Monitor and record the pH, conductivity, temperature, dissolved oxygen, redox potential, and turbidity at set intervals (2 to 10 minutes).
- Collect the sample following the procedure below when all water monitored water quality parameters are stable, as indicated by three consecutive readings differing by less than 10 percent.

6.5. SAMPLE COLLECTION

The procedure for sample collection is as follows:

- Prepare the sample bottles and preservatives required for the sampling.
- Don a pair of clean gloves.
- Collect the sample immediately after purging through the pump discharge line.
- Fill volatile organic analysis (VOA) vials first (reduce the flow rate of the pump discharge) allowing the liquid to slowly fill the container without agitation and obtain a meniscus slightly above the top of the vial.
- Cap and check all VOA vials for entrained air by slowly tipping and observing for bubbles. If any are present, discard the sample and collect again as above.
- Continue filling all required sample bottles.
- Add preservatives to the samples as needed, and place the sample bottles on ice. Note that most sample bottles come with preservatives already added. If such is the case, do not overfill the bottles.
- Replace the well cap, if required, and lock the cover.
- Record the sampling information.
- Secure the area by removing equipment and materials, properly dispose of plastic sheeting and other disposable sampling materials, and close the purge water container(s).
- Decontaminate the pumping equipment and sampling equipment. The pumping equipment should not be decontaminated if it is dedicated to the well.

7. Attachments

None.

8. Forms

None.

Title: **Direct-Push Groundwater Sampling**

Document Number: **GEO-004**

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Reason for Revision:

Reviewed: ______________________ 9/9/2009
QC Manager Date

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Procedure No:	GEO-004
Revision No:	0
Date of Revision:	05/12/2007
Review Date:	00/00/00

Direct-Push Groundwater Sampling

1. Purpose

This standard operating procedure (SOP) provides the standard practice for direct-push groundwater sampling. This SOP provides the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This SOP may also contain guidance for recommended or suggested practices that are based upon collective professional experience. Recommended or suggested practices go beyond the minimum requirements of this SOP and should be implemented when appropriate.

2. Scope

This SOP describes standards for direct-push groundwater sampling and discusses how such sampling will be conducted and documented for projects executed by Engineering/Remediation Resources Group, Inc. (ERRG). Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for direct-push groundwater sampling may be developed, as necessary, to supplement this SOP and to address project-specific conditions and objectives.

This SOP covers requirements for basic collection of groundwater samples from direct-push temporary installations (such as the Hydropunch® system). It describes equipment, procedures, and aspects of quality control (QC). The following are some manners of collecting groundwater samples that are not covered specifically in this SOP:

- The use of driven-point well systems that do not protect (enclose) the well screen during installation.
- The use of specialized closed-chamber devices such as the BAT® system (www.bat-gms.com) or SimulProbe® (www.besstinc.com)
- The use of driven devices that contain built-in pumping or testing systems.

Individuals needing assistance planning or conducting direct-push groundwater sampling or these other types of sampling may consult internal ERRG technical listings for experts or may contact the Geosciences Discipline Lead (see Section 5.1).

3. References

The following references are useful for the planning and implementing direct-push groundwater sampling activities:

- ASTM D 6001-96, "Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations"
- ASTM D 5730-98, "Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water"
- ASTM D 4448-01, "Guide for Sampling Groundwater Monitoring Wells"

- ASTM D 4750-87, "Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
- QED Environmental Systems, Inc. (http://www.qedenv.com/sales/hydropunch.html)
- Geoprobe Systems, Inc. (http://www.geoprobe.com)
- USEPA Clu-in (http://fate.clu-in.org/direct_push/dpgroundwater.asp)

4. Definitions

The following definitions are applicable to direct-push groundwater sampling and this SOP:

Direct Push—The creation of a boring by the displacement of soil without cutting or grinding, and without the production of mechanically altered soil (cuttings) at the ground surface. In direct-push methods, soil is displaced, primarily laterally, as a pipe or rod is forced vertically downward, creating a cylindrical space (i.e., a boring). Energy to create the boring is generated by a "direct-push rig" and may use constant pressure (e.g., hydraulically powered), vibration, or other means.

Geoprobe—Geoprobe® is a registered trademark of Geoprobe Systems, Inc. (www.geoprobe.com). The term geoprobe is informally used to refer to any small-diameter, pushcoring tool that is operated from a small vehicle and is used for site characterization (typically soils). Geoprobe Screen Point 15 and Screen Point 16 Systems are similar to the Hydropunch® II system (see below) and are considered suitable for use by this SOP.

Hydropunch—Hydropunch® I and II are registered products of QED Environmental Systems, Inc. (www.qedenv.com). The term hydropunch is informally used to refer to any short to medium length small-diameter, protected well screen system that is driven (pushed) to depth and then exposed to soil material and pore fluids by retraction of a protective sleeve, without regard to manufacturer, trademark, or registered name. The Hydropunch® I and Hydropunch® II systems are considered suitable for use by this SOP.

Well Screen—A filtering device that is designed to retain soil, earthen material, or artificial sand pack on one side and permit the flow of water or other subsurface fluid into a void space on the other side (inside). A well screen is nearly always rigid and cylindrical.

Protected Screen—A well screen that is encased within another material or system as it is emplaced, and becomes exposed to soil materials and pore fluids only when a target depth has been reached and the protective device has been retracted or removed. The Hydropunch® and Geoprobe® Screen Point systems use protective covers, which are left in place until the target depth has been reached, and are then lifted upward, exposing the well screen to adjacent soil material and pore fluids.

Unprotected Screen—A well screen that is in contact at all times during use with soil materials and pore fluids. The most common unprotected screen is a driven well point.

5. Responsibilities

5.1. PROCEDURE RESPONSIBILITY

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this SOP. Any questions, comments, or suggestions on this technical SOP should be sent to the Geosciences Discipline Lead.

5.2. PROJECT RESPONSIBILITY

ERRG employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. ERRG employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate SOPs. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. Procedure

This section presents information on design issues, planning and preparation, basic procedures, documentation requirements, and technical review requirements for direct-push groundwater sampling. Contract vendors generally conduct the pushing or driving of the sampling equipment to the desired sampling depth and associated collection of groundwater samples on ERRG projects is performed by contract vendors. A rig geologist is also present at each sampling event to oversee sampling activities and to ensure that samples are collected from the proper depths and placed in the correct containers following appropriate protocols. Contract vendors will require a detailed scope of work and adequate oversight.

6.1. DESIGN ISSUES LIKELY TO AFFECT SAMPLE QUALITY OR COLLECTION

Sample quality is easily compromised by poorly selected or applied sampling techniques. Common and avoidable problems include the following:

- Use of Unprotected Screens. Use of an unprotected screen creates a likelihood that pore fluid and possibly soil particles that are not from the target depth (final depth) of the screen will pass through the well screen and into the well chamber and be included in the sample. This creates uncertainty as to how representative the sample is of the target horizon. This SOP recommends against the use of unprotected screens.
- Excessive Sediment or Particulate Matter within Well Screen. The presence of sediment within samples may bias analytical result, hamper laboratory QC, or have other deleterious effects. The presence of sediment from an aquifer that is contaminated with an organic contaminant may positively bias (i.e., increase) the concentration results from analysis of organic chemicals, as

organic chemicals are typically sorbed onto sediment. The presence of sediment or other particulate matter may also positively bias the concentration results from analysis of metals. This SOP recommends that entrainment of sediment into water within the well screen and the sample be avoided as much as reasonably possible.

- Collection of Samples at a Uniform Depth Interval (e.g., every 5 feet or every 10 feet of depth) Instead of Collection at Targeted Hydrostratigraphic Horizons. Many programs have been designed for sample collection at uniform pre-set depth intervals. Although this methodology may provide useful data, a more efficient and technically sound methodology involves targeting specific hydrostratigraphic units and boundaries (interfaces) between the units that may significantly affect the transport and distribution of contaminants. Such methodology involves constructing suitable cross sections and interpreting the distribution of hydrostratigraphic units from boring logs, cone penetrometer test curves, and borehole geophysical logs, and then selecting sampling locations and depths appropriately.

Direct-push groundwater sampling is commonly used in unconsolidated fine-grained and sandy soils. Problems are encountered when trying to push and drive the sampler through consolidated soils, cemented soils, coble or boulder beds, rubble fill, etc. In addition, some fine-grained beds may not yield water in sufficient volumes to allow sample collection in a timely manner. Evaluation of subsurface data (e.g., boring logs, cross-sections, reports, cone penetrometer tests, borehole geophysical logs, etc.) from the site or adjacent areas may provide information relative to potential problems with direct push sampling, including if the method is viable at the site. This should be done as part of the planning phase.

6.2. PLANNING AND PREPARATION

Planning and preparation for direct-push groundwater sampling activities involves the following:

- Identifying sample collection objectives and exact methodologies and equipment to be used for sample collection.
- Identifying specific locations, targeted depths, and specific identification numbers for groundwater samples to be collected.
- Identifying numbers and volumes of samples to be collected.
- Specifying types of chemical analyses to be conducted for the samples.
- Listing specific QC procedures and sampling required.
- Describing any detailed project-specific sampling requirements or procedures beyond those covered in this SOP, as necessary.
- Listing expected soil types, hydrostratigraphy, and formations to be encountered.
- Identifying and listing all pertinent health and safety issues and requirements, including those contained in the project-specific health and safety plan(s), relative to work activities, including site utility clearance.
- Compiling main subcontractor requirements for direct-push groundwater sampling and generating the statement of work to procure subcontractor services.

The specific sampling methods to be used and detailed procedures for collecting the groundwater samples should be developed to minimize disturbance or alteration of the samples. For example, the procedures for collecting groundwater samples for analysis of volatile organic compounds should prescribe a methodology that minimizes the contact of the sample with air. The methods and procedures should also allow appropriate or successful sample collection with respect to the expected depth to water, total depth, and inside diameter of the temporary screen system. For example, specified pumps should have sufficient power to lift water, and any downhole equipment should be narrow enough to operate without fouling or sticking in the direct-push sample tubes.

All of the above information and items should be compiled as part of a sampling plan contained within the project-specific work plans. The work plans should include detailed, project-specific direct-push groundwater sampling procedures beyond the basic procedures and requirements in this SOP.

Preparation for direct-push groundwater sampling activities includes the following:

- Securing all necessary site access, permitting, and plan approvals.
- Procuring the appropriate direct push sampling subcontractor.
- Completing all necessary underground utility clearance activities at each of the sampling locations; each location should be cleared according to requirements in appropriate ERRG technical SOPs and the project work plans.
- Briefing the rig geologist and other site personnel on specific information is necessary for effective implementation of the sampling effort (e.g., sampling objectives, locations and depths, project-specific sampling requirements and procedures, pertinent health and safety requirements, etc.).
- Verifying that project personnel have proper health and safety training. The project manager, or designee, is responsible for appropriately briefing field personnel, as described above.

6.3. BASIC PROCEDURE

The basic procedure for direct-push groundwater sample collection is described below. More detailed project-specific procedures, based on sampling and QC requirements and other aspects of the actual project, should be compiled to supplement this SOP and should be presented in the project work plans.

1. Decontaminate the direct push sampling rig and associated sampling equipment, in accordance with applicable ERRG technical SOPs and project-specific requirements and procedures, before mobilizing to the first sample location.
2. The driller and rig geologist should inspect the direct-push rig to verify that the equipment is properly maintained, adequately decontaminated, and capable of achieving the objectives for sampling equipment advancement, groundwater sample collection, and abandonment of the boring.

3. Calibrate all field analytical and health and safety monitoring equipment in accordance with the instrument manufacturer's specifications and project work plans. Calibration results must be recorded on the appropriate form(s), as specified by the project work plans or health and safety plan.
4. Wear the appropriate personal protective equipment as specified in the project work plans or health and safety plan. Personal protection will typically include the following, at a minimum: hardhat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.
5. Once the direct-push rig is sited at the sampling location, make sure the location is reasonably free of underground utilities in accordance with the project work plans. Manually probe or excavate near-surface soils (as required) as an additional step to avoid underground utilities or structures.
6. Between each sampling location and prior to each sampling run, decontaminate the sampling equipment in accordance with applicable ERRG technical SOPs and project-specific procedures.
7. Push or advance the sampling device until it is at the target depth or horizon where the sample is to be collected.
8. Retract the protective sleeve upward until the length of well screen is exposed, allowing water to flow into the sampler.
9. During advancement of the sampling device and collecting of the sample, conduct appropriate health and safety measurements and monitoring, as required and specified in the project work plans or health and safety plan.
10. Evaluate for the presence and sufficiency of water within the well screen. This step is usually done with a small-diameter electric water-level indicator.
11. If sufficient water is present, perform any purging that is part of the required sampling protocol.
12. Collect the water sample from inside the well screen and transfer into appropriate containers in accordance with appropriate ERRG technical SOPs and project-specific requirements. Label and number each sample container in accordance with applicable ERRG SOPs and the project work plans.
13. Document the sampling event on the appropriate form(s), as specified in the project work plans. The information listed on the form(s) should, at a minimum, include the following:
    - Project name and number
    - Date and time of the sampling event
    - Sampling methods used (specify sample type)
    - Sample number
    - Sample location
    - Sample depth interval
    - Sample description (type of matrix)
    - Weather conditions
    - Unusual events, including lack of water or insufficient water volume in sampler
    - Signature or initials of sampler

14. Appropriately preserve, package, handle, and ship the sample in accordance with applicable ERRG technical SOPs and project-specific procedures. The samples shall also be maintained under custody. Samples stored on site will be subject to the provisions of applicable ERRG procedures and project requirements. All reasonable attempts should be made to ship samples on the date they are collected.
15. Perform any other downhole operations that are required prior to abandoning the hole, including removing the direct-push sampling equipment from the boring.
16. Fill the boring with grout in accordance with applicable ERRG technical SOPs and project-specific requirements and procedures.

6.4. DOCUMENTATION

Accurate documentation of the sampling event (e.g., emplacement of the temporary screen system, development of the temporary installation, sample collection, etc.) and the sample condition are important for interpreting the quality of the analyte concentrations found within the sample, and for ensuring various project and QC requirements are met. Such documentation should be compiled on the appropriate forms, as specified in the project work plans. In addition, some regulatory agencies may require that any boring that penetrates the water table be reported in the same manner as a monitoring well. This may necessitate generation of a well construction diagram and boring log. Such documentation requirements should be specified in the project work plans.

6.5. TECHNICAL REVIEW

Direct-push groundwater sampling specifications, procedures, and results (e.g., reports, logs, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review and oversight of the actual field implementation of the sampling activities, which may include aiding in troubleshooting sampling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising direct-push groundwater sampling programs. Individuals needing assistance in finding qualified technical reviewers may consult internal ERRG technical listings for experts in direct-push sampling.

Any issues raised during the technical review shall be resolved between the reviewer and staff planning, conducting, or preparing results of direct-push groundwater sampling activities as follows:

- Comments and issues raised relative to planning and developing detailed procedures for sampling should be resolved before mobilization and sampling commences.
- Comments and issues raised relative to results of sampling activities should be resolved before external (i.e., outside of ERRG) use or submission of the results.

The technical review comments and issues and corresponding resolution shall be documented and filed with the project records. The records should be maintained until project closeout.

7. Attachments

None.

8. Forms

None.

Title: **Direct-Push Drilling and Soil Sampling**

Document Number: **GEO-014**

Revision Number: **0**

Reason for Revision:

Reviewed: ______________________ 9/9/2009
QC Manager Date

Approved: ______________________ 9/9/2009
Program Manager Date

Direct-Push Drilling and Soil Sampling

1. Purpose

This standard operating procedure (SOP) provides the standard practice for direct-push drilling and soil sampling. The SOP provides the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This SOP may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended or suggested practice goes beyond the minimum requirements of the SOP and should be implemented when appropriate.

2. Scope

This SOP describes standards for direct-push drilling and soil sampling, and discusses how such drilling and sampling will be conducted and documented for projects executed by ERRG. Responsibilities of individuals performing the work are also detailed. Additional project-specific requirements for direct-push drilling and soil sampling may be developed, as necessary, to supplement this procedure and to address project-specific conditions and objectives.

This SOP covers requirements for collection of soil and unconsolidated materials by direct push methods primarily for laboratory or other testing and for lithologic description or analysis (logging). It describes basic equipment and procedures and addresses aspects of the process where quality must be maintained. It does not address procedures for specific brands of equipment, or for uncommon purposes of boring or sampling. Other types of soil and rock sampling while drilling are addressed in other ERRG technical SOPs.

3. References

The methodology for direct-push drilling and soil sampling should follow industry standard practices. The following references are relevant and useful for planning and conducting direct-push drilling and soil sampling:

- ASTM D 6282-98, "Direct Push Soil Sampling for Environmental Site Characterizations."
- ASTM D 6286-98, "Standard Guide for Selection of Drilling Methods for Environmental Site Characterization."

4. Definitions

The following definitions are applicable to direct-push drilling and soil sampling and this SOP.

Direct-push drilling—The creation of a boring by the displacement of soil without cutting or grinding and without the production of mechanically altered soil (cuttings) at the ground surface. In direct-push drilling, soil is displaced, primarily laterally, as a pipe or rod is forced vertically downward, creating a cylindric space (i.e., a boring). Energy to create the boring may be generated from constant pressure (e.g., hydraulically powered), vibration, or other means.

Slough—Slough is soil or other earth material that has been dislodged from its original location within the boring and displaced elsewhere within the boring (usually to the bottom). The creation and sampling of slough should be avoided, because slough has disturbed properties and is typically of uncertain origin with respect to depth. The presence of slough also impedes proper abandonment of borings.

Conductor Casing—Conductor casing is drill pipe that is extended down into the ground as a boring is advanced, to prevent sidewall material from falling into the borehole and covering the in-place soil material that constitutes the bottom of the boring. Conductor casing is usually removed when a borehole is being abandoned.

Sample—A mass of soil or earthen material that has been removed from the boring from a known depth, has had little internal disturbance, and may be considered representative of the in-situ earthen material from a known depth and representative with respect to the intended tests or properties of interest.

5. Responsibilities

5.1. PROCEDURE RESPONSIBILITY

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this SOP. Any questions, comments, or suggestions regarding this technical SOP should be sent to the Geosciences Discipline Lead.

5.2. PROJECT RESPONSIBILITY

ERRG employees performing this task, or any portion thereof, are responsible for meeting the requirements of this SOP. ERRG employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. Procedure

This section addresses basic requirements and procedures involved with direct-push drilling and soil sampling. This section includes information on selection of methods and equipment, planning and preparation requirements, health and safety requirements, drilling and sampling procedures, and key practices for ensuring quality.

Proper drilling and subsurface soil sampling procedures are necessary to ensure the quality and integrity of the samples. The details within this SOP should be used in conjunction with project-specific work plans. The project work plans should generally provide the following information:

- Specific direct-push drilling and soil sampling methodologies and equipment to be employed
- Sample collection objectives
- Anticipated locations and total depths of soil borings and target horizons or depths of soil samples to be collected
- Numbers and volumes of samples to be collected
- Types of chemical analyses to be conducted for the samples
- Specific quality control (QC) procedures and sampling requirements
- Detailed direct-push drilling and subsurface soil sampling requirements or procedures based upon site-specific conditions and project-specific objectives and requirements

6.1. SELECTION OF METHODS AND EQUIPMENT

The practice of direct-push drilling and soil sampling involves numerous variations in methodology and types of equipment. There are few industry-wide standards for direct-push drilling and soil boring. Key aspects of the variations in direct-push drilling and sampling are as follows:

- **The use of single-wall or dual-wall sampling systems.** Single-wall systems generally provide lower-quality sampling and higher rates of production than dual-wall systems. Single-wall systems can typically be advanced with lower energy sources (i.e., to greater depth) than dual-wall systems because they have smaller area and hence encounter less sidewall friction and tip resistance during advance.
- **Open-hole or cased boring.** This SOP recommends that borings always be advanced through or with a conductor casing.
- **Open-barrel or closed (sealed)-barrel sampler.** Open-barrel samplers are open at the bottom at all times, and may fill with slough, lose sample material as they are retrieved, or contribute or be subject to cross-contamination. Closed-barrel samplers are closed at the bottom until being mechanically opened at a target depth. Closed-barrel samplers reduce the potential for sampling of slough or cross-contamination of the sample.

- **Liner or inner-barrel material.** Inner barrel and sampler tubes should be selected based on the need to see or access samples for lithologic evaluation and the need to perform chemical or other analytical testing. Use of lexan or other see-through materials can be beneficial in identifying soil type or visual indications of contamination (such as petroleum saturation). Some liners, such as lexan, can be quickly cut to select certain sample intervals for testing, and the sample may be retained, shipped and stored directly in the liner. Liners or sample barrel material should generally not be made of materials that include any of the chemical species that are sought during analysis.
- **Energy source for making the boring.** Energy sources may be static or dynamic, and may include vibratory or sonic systems, hydraulic systems, percussion (hammer) systems, or even rotational systems.
- **Energy source for removing the sampler.** Energy sources may be static or dynamic, and are generally one of the following: hydraulically-lifted rod systems, winch and wire rope systems, or percussive systems (back-pounding). This SOP recommends against back-pounding as a means of removing samplers, as it tends to disturb samples.
- **Use of checkball or open-top tubes for collection of soil.** Checkball systems prevent fluids that are within the sampling barrel, above the sample, from flowing down into the barrel as the sampler is retrieved. Checkball systems are mostly used when sampling granular soils beneath the water table, to minimize the potential for water to dislodge or alter sample material as the barrel is retrieved.
- **Use of catchers or retainers.** Catchers are used to help retain loose soils within the sampling barrel as it is retrieved. Catchers are most commonly used when sampling granular soils beneath the water table, with variable success.

6.2. PLANNING AND PREPARATION

Planning for direct-push drilling and soil sampling activities involves the following:

- Identifying drilling and sample collection objectives and exact methodologies and equipment to be used for sample collection.
- Identifying specific drilling and sampling locations, targeted depths, and specific identification numbers of soil samples to be collected.
- Identifying numbers and volumes of samples to be collected.
- Specifying types of chemical analyses to be conducted for the samples.
- Listing specific quality control (QC) procedures and sampling requirements.
- Describing any detailed project-specific sampling requirements or procedures beyond those covered in this SOP, as necessary.
- Listing expected soil types, hydrostratigraphy, and formations to be encountered (if known).

- Identifying and listing all pertinent health and safety issues and requirements, including those contained in the project-specific health and safety plan(s), relative to work activities (including site utility clearance).
- Compiling main subcontractor requirements for direct-push drilling and soil sampling and generating of the statement of work to procure subcontractor services.

All of the above information and items should be compiled as part of a sampling plan contained within the project work plans. This plan includes detailed, project-specific direct-push drilling and soil sampling procedures beyond the basic procedures and requirements in this SOP.

Preparation for direct-push drilling and soil sampling activities includes the following:

- Securing all necessary site access, permitting, and plan approvals.
- Procuring the appropriate direct-push drilling and sampling subcontractor.
- Completing all necessary underground utility clearance activities at each of the sampling locations; each location should be cleared according to requirements in appropriate ERRG technical SOPs and the project work plans.
- Briefing the rig geologist, subcontractor personnel, and other site personnel on specific information necessary for effective implementation of the sampling effort (e.g., sampling objectives, locations and depths, project-specific sampling requirements and procedures, pertinent health and safety requirements, etc.).
- Verifying that job personnel have proper health and safety training.

The project manager, or designee, is responsible for appropriately briefing field personnel, as described above.

6.3. HEALTH AND SAFETY REQUIREMENTS

Prior to initiating drilling and sampling activities, applicable ERRG and project-specific safety requirements must be reviewed by ERRG site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan and other applicable ERRG policies and procedures. Additional health and safety requirements include the following:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All ERRG and subcontractor personnel at the site should have appropriate training and qualifications as per the project health and safety plan. Documentation should be kept readily available in the project files on site.
- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Pushed or driven drill tools can catch or snag loose clothing, causing serious injury.

- Clear communication signals must be established with the drilling crew, since verbal communication may not be heard during the drilling process.
- The entire crew should be made aware to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

6.4. DRILLING AND SAMPLING REQUIREMENTS AND PROCEDURES

This SOP cannot present a single, detailed and specific procedure that is applicable to all methods and equipment that are available (Section 6.1) or to the specific sampling objectives of a specific project. An example procedure for direct-push drilling and soil sample collection is shown in Attachment 1 (Section 7). The example procedure may be supplemented or customized to provide project-specific requirements and procedures.

Sample quality is easily compromised by poorly selected or haphazard drilling and sampling technique. Common problems and suggested solutions include the following:

- Generation of excess slough. Excess sloughing occurs when conductor casing is not used, when soil materials fall out of the sample barrel as it is retrieved, and when soil at or near the ground surface falls into the boring. Slough is excess when the amount that is present hinders the collection of sufficient representative sample volume or mass for the required testing or lithologic analysis.
- Collection of slough for testing or logging. This occurs when a large volume of slough is present in the boring bottom at the time the sampler is emplaced and driven into soil. Because slough is disturbed and from unknown depth, it is unsuitable for logging or testing.
- Disturbance (negatively-biasing) of samples for analysis of volatile organic compounds (VOCs). The act of driving a sampling tube into soil causes compression and some heating of the soil, and can create macroscopic void space, i.e., a micro-annulus between the soil and sampling tube. Heating, compression of soil, and creation of void space contribute to the migration of gaseous fluids as well as the partitioning of VOCs, such as gasoline or solvent vapors. Although some heating, compression, and formation of microannular space are unavoidable, care should be taken to minimize these phenomena to the extent that is reasonably possible. Some sampling devices and methods are more suitable for analysis of samples for VOCs than others.
- Improper abandonment of borings. Excess slough or caving (the dislodgement and falling of a significant volume of sidewall material) hinders the proper abandonment of a boring. Where this occurs, the borehole should be cleaned out prior to grouting. A tremmie pipe should be used to conduct grout to the bottom of the borehole if a conductor casing is not in place prior to and during grouting.

Additional key practices that will ensure the quality of the samples collected and proper/efficient abandonment of the borings, include the following:

- Drill with a Conductor Casing. Various equipment, systems, and methods exist for direct-push drilling and soil sampling. Some systems are open-hole (i.e., do not use conductor casing), hence borings made with these systems are at high risk for slough-related difficulties in logging, sampling, and abandonment. Most systems have provisions for driving down a conductor casing, to keep the boring open and relatively free of slough when the sampler or a plug or drive-point is not present at the bottom of the casing system. This SOP recommends the use of a method of direct-push drilling that integrally includes the advancement of conductor casing as the boring is made, and further recommends that the conductor casing remain in place during sampling and into the abandonment process.
- Measure the Boring Depth. A weighted tape should be used to verify the depth of the boring within the conductor casing. Measurement should be made with reference to the ground surface. It is important to measure depth at the start of sampling intervals and at total depth (TD) of the boring.
- Clean-Out Excessive Slough. If slough is present, it should be removed by forcing a sampler into it and retrieving and emptying the sampler of slough.
- Identify Slough and Avoid Sampling it or Logging It as In Situ Material. Slough is generally easy to identify based on jumbled internal textures, lighter density, macroscopic and unmineralized void spaces, greater softness and malleability, and decreased cohesion, as compared to in situ material that has not been dislodged prior to the sampling process.
- Grout Through a Conductor Casing. Grouting through a conductor casing prevents any significant accumulation of slough in the boring and ensures that grout will be the predominant material in the borehole, thereby minimizing any potential for vertical migration of fluids in the filled bore-space. This minimizes potential liability.

6.5. DOCUMENTATION

Accurate documentation of the boring, sampling, and abandonment activities is important for interpreting sample results, interpreting boring conditions and lithologic information, and conceptually reconstructing events. Appropriate forms (including boring logs) should be completed as per appropriate ERRG technical SOPs and project-specific requirements and procedures.

6.6. TECHNICAL REVIEW

All direct-push drilling and soil sampling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review and oversight of the actual field implementation of direct-push drilling and soil sampling activities. This should include aiding in troubleshooting drilling and sampling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising direct-push drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal ERRG technical listings for experts in drilling or direct-push drilling and sampling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of direct-push drilling and soil sampling activities, as follows:

- Comments and issues raised relative to planning and developing detailed procedures for direct-push drilling and soil sampling should be resolved before mobilization and drilling commences.
- Comments and issues raised relative to the results of drilling and sampling activities should be resolved before external (i.e., outside of ERRG) use or submission of the results.

The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

7. Attachments

- Attachment 1, Example Direct-Push Drilling and Soil Sampling Procedure.

8. Forms

None

Attachment 1

Example Direct-push drilling and Soil Sampling Procedure

The following procedure is provided as an example. It should be customized based on project- and site-specific equipment, methodology, and sampling and QC requirements. This procedure is written for a direct-push drilling rig that uses a small diameter conductor casing with a 3-foot-long inner wireline sample barrel (with a 3-foot-long acrylic liner) connected to the bottom of the casing. The casing and associated sample barrel are driven, pushed, or vibrated into the ground in three-foot increments. Soil samples are collected into the acrylic sample tubes as the conductor casing and sample barrel are advanced into the formation. The samples inside the liner and sample barrel are then retrieved with a wireline, leaving the conductor casing in place. Soil samples are thus continuously collected until the total depth of the boring is reached. The example procedure consists of the following:

1. Decontaminate the direct push sampling rig and associated sampling equipment before mobilizing to the first sample location, in accordance with applicable ERRG technical SOPs and project-specific requirements and procedures.
2. Inspect the direct-push rig to make sure the equipment is properly maintained, adequately decontaminated, and determined capable of achieving the objectives for drilling (equipment advancement), sample collection, and abandonment of the boring (to be done by the driller and rig geologist).
3. Calibrate all field analytical and health and safety monitoring equipment according to the instrument manufacturer's specifications and project work plans. Calibration results must be recorded on the appropriate form(s) as specified by the project work plans or health and safety plan.
4. Wear the appropriate personal protective equipment, as specified in the project work plans or health and safety plan. Personal protection will typically include, at a minimum, a hardhat, safety glasses, gloves, steel-toed boots, hearing protection, and coveralls.
5. Remove the surface cover (e.g., concrete, asphalt, etc.) at the drilling and sampling location according to the project work plans.
6. Once the direct-push rig is sited at the sampling location, make sure the location is reasonably free of underground utilities, as per the project work plans. Manually probe or excavate near-surface soils (as required) as an additional step to avoid underground utilities or structures.
7. Learn the drilling equipment heights and dimensions necessary to independently determine the boring or sampler depth while observing the work (to be done by the rig geologist). Such information includes lengths of rods, casing, barrels, and other in-ground equipment; the length of strokes or advances; and the height from ground surface to "full down" stroke of the direct-push rig.

8. Between each sampling location and prior to each sampling run, decontaminate the sampling equipment according to applicable ERRG technical SOPs and project-specific procedures.

9. Inform the driller of the expected total depth, the first and expected additional sampling depths, the likelihood of encountering groundwater or NAPL, and any contingency or opportunistic decisions that are anticipated (such as contingency-sampling or increased total depth).

10. Record the type of sampler assembly on the appropriate form(s) as specified in appropriate ERRG technical SOPs or the project work plans. To minimize off-gassing of volatiles, the sampler should not be advanced and pushed until the sampling team is ready to process the sample.

11. Commence drilling and sample collection by advancing the conductor casing and associated sample barrel (with liner) for the first three-foot increment.

12. Pull the wireline sampling string up from the bottom of the borehole and remove the sample barrel. Make sure that each sample barrel is retrieved as quickly and smoothly as possible. Record the depth interval for each sample drive as the sample barrel is being retrieved.

13. Remove the acrylic liner containing the soil sample from the sample barrel.

14. Observe and record the amount of sample recovery on the appropriate form(s), according to applicable ERRG procedures and the project work plans. Any observed field problems associated with the sampling attempt (e.g., refusal) or lack of recovery should be noted on the appropriate form.

15. Select the appropriate portion of the liner containing the sample to be cut and be submitted for laboratory analysis. Such selection should be based on the following factors: (1) judgment that the sample represents relatively undisturbed intact material, not slough; (2) volume and length of sample required for analysis; (3) minimal exposure to air; (4) lithology; and (5) obvious evidence of contamination. The project work plans should specify the volume and length of sample to be submitted for specific analyses and confirm the selection factor(s).

16. Place Teflon™ film over each end of the liner containing the samples to be submitted for chemical analysis and seal each end with plastic end caps. Do not use any type of tape to seal the cap because tape causes a toluene interference. All samples should be individually stored in resealable plastic bags. Note: Additional project-specific sample preparation steps or modifications may be required as stated in the project work plans.

17. Appropriately label and number each sample to be submitted for analysis as per applicable ERRG technical SOPs and the project work plans. The label will be filled out using waterproof ink and may contain, at a minimum, the following information:

    - Project number
    - Boring number

- Sample number
- Bottom depth of sleeve
- Date and time of sample collection
- Parameters of analysis
- Sampler's initials

18. Document the sampling event on the appropriate form(s), as specified in the project work plans. The information listed on the form(s) should, at a minimum, include the following:

    - Project name and number
    - Date and time of the sampling event
    - Sampling methods used – specify sample type
    - Sample number
    - Sample location
    - Sample depth interval
    - Sample description (type of matrix)
    - Weather conditions
    - Unusual events, including lack of water or insufficient water volume in sampler
    - Signature or initials of sampler

19. Appropriately preserve, package, handle, and ship the sample in accordance with applicable ERRG technical SOPs and project-specific procedures. The samples shall also be maintained under custody. Samples stored on site will be subject to the provisions of applicable ERRG procedures and project requirements. All reasonable attempts should be made to ship samples on the date they are collected.

20. Cut and split the remaining acrylic liner to expose the remaining soils for logging. The descriptions of the soil and preparation of a boring log should follow applicable ERRG technical SOPs and project-specific requirements and procedures. The soil boring log should include the following information:

    - Borehole location
    - Name of the drilling company and driller
    - Dates and times when drilling began and when it was completed
    - Lithologic data and descriptions from soil samples
    - Sampling depths and recovery of soil samples

21. Continue to advance the borehole in three-foot increments and collect soil samples to the total depth. As the borehole is advanced, the rig geologist will generally do the following:

- Observe and monitor rig operations
- Conduct all health and safety monitoring and sampling and supervise health and safety compliance
- Prepare a boring log from cuttings or soil samples as per applicable ERRG technical SOPs and project-specific requirements
- Document drilling progress and other appropriate observations on appropriate forms
- Supervise the collection and preparation of any soil, soil vapor, or groundwater samples

The rig geologist should not leave the drill site while drilling operations are being conducted and the borehole is being advanced.

22. As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration, flowing sands, drilling refusal, changes in equipment, etc. These conditions should be recorded on the appropriate logs and forms as per applicable ERRG technical SOPs and the project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

23. The rig geologist should also observe the makeup and tightening of connections as additional conductor casing joints are added to the drill string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

24. Cuttings (i.e., left over soil samples) and fluid containment during drilling should be observed and supervised by the rig geologist as per the project work plans.

25. Periodically measure the boring depth with a weighted tape to verify its depth. If it cannot be directly measured, then count rods or pipe lengths that have been inserted into the ground or take other action to verify depth (in a manner that is independent of asking the driller the boring depth).

26. If the borehole is to be abandoned once drilling and sampling is completed, follow procedures outlined in applicable ERRG technical SOPs and the project work plans. The abandonment will be supervised by the rig geologist. If the borehole contains slough, the slough should be removed prior to abandonment.

27. If a monitoring well is to be installed in the borehole, follow appropriate ERRG technical SOPs and project-specific requirements and procedures. The well installation will be supervised by the rig geologist.

28. After drilling, sampling, and well installation or borehole abandonment is completed, lay the conductor casing down and move the rig off of the location. The rig geologist or appropriate designee will supervise demobilization and site restoration. Additional demobilization requirements and procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans.
- All abandoned borings should be topped off and completed as per the project work plans. All wells should also have their surface completions finished as per the project work plans.
- Any hazards remaining as a result of drilling activities should be identified and appropriate barriers and markers put in place, as per the project health and safety plan.
- All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans and/or other applicable requirements.

29. Complete all appropriate forms and documentation as required in the project work plans.