Response to Comments for the 322 Landfill Well Placement/Development Plan

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

Jared Morrison

Digitally signed by Jared Morrison
Date: 2024.02.13 14:32:24 -06'00'

02/13/2024

Jared Morrison
Director Environmental Services
Evergy, Inc.

Date

February 13, 2024
File No. 0129778

U.S. Environmental Protection Agency – Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Subject: Response to Comments for the 322 Landfill Well Placement / Development Plan dated March 6, 2023
322 Landfill, Tecumseh Energy Center, Tecumseh, Kansas

The Tecumseh Energy Center (TEC) 322 Landfill Well Placement/Development Plan (Well Development Plan), dated March 6, 2023, was prepared pursuant to Paragraph 10.d. of the Consent Agreement and Final Order (CAFO) between the U.S. Environmental Protection Agency (USEPA) and Evergy Kansas Central, Inc. (Evergy) In the Matter of Evergy Kansas Central, Inc.: Docket No. RCRA-07-2023-0001 dated November 7, 2022. Paragraph 10.f. of the CAFO requires that Evergy provide USEPA a plan for the installation of additional wells at the 322 Landfill. Evergy provided the required plan on March 6, 2023.

This letter was prepared in response to the USEPA's November 16, 2023 email from Ms. Cynthia Sans (Email) containing an attachment with USEPA comments regarding the March 6, 2023 Well Development Plan for the 322 Landfill. This letter presents each individual comment from the Email in italics followed by the specific Evergy response to the comment.

Evergy Comment Responses

USEPA Comment #1: Section 2.1, Monitoring Well Locations, Page 2
Recommend 24 hours after well completion prior to development rather than 12 hours.

Response to Comment #1:
The Well Development Plan has been revised to provide 24 hours before monitoring well development. These revisions are included in Section 2.1.1.4 (Monitoring Well Development) of the revised Well Development Plan.

USEPA Comment #2: Section 2.1, Monitoring Well Locations, Page 2
A Kansas licensed driller should be utilized for well construction and development and well installation should be consistent with Kansas Department of Health and Environment (KDHE) regulations.

Response to Comment #2:
The Well Development Plan has been revised to state that monitoring wells will be installed and developed in accordance with Kansas Administrative Regulations (K.A.R.) Article 30. This revision is included in Section 2.1.1 (Well Drilling and Installation) of the revised Well Development Plan.

USEPA Comment #3: Section 2.1, Monitoring Well Locations, Page 2
A Kansas licensed surveyor should be utilized to survey all completed well locations.

Response to Comment #3:
The Well Development Plan has been revised to provide details for surveying of the new monitoring wells. These revisions are included in Section 2.1.3 (Survey) of the revised Well Development Plan.

USEPA Comment # 4: Section 2.1, Monitoring Well Locations, Page 2
The precision of water level measurements (usually 0.01 feet) should be included.

Response to Comment #4:
The Sampling and Analysis Plan (SAP) was revised in June 2023 to include water level measurement procedures for the TEC specifying that the distance from the water surface to the referenced measuring point will be recorded to the nearest 0.01 foot. These revisions are included in Paragraph 3 of Section 4.4.2 (Water Level Measurements) of the revised SAP.

USEPA Comment #5: Section 2.1, Monitoring Well Locations, Page 2
Please clarify if any aquifer testing such as slug testing will be performed on the newly installed monitoring wells.

Response to Comment #5:
The Well Development Plan has been revised to provide details for aquifer testing of the new monitoring wells. These revisions are included in Section 2.2 (Aquifer Testing) of the revised Well Development Plan.

USEPA Comment #6: Section 2.2, Baseline Sampling, Page 3
A statistical analysis of groundwater data must be conducted consistent with §257.93 for all samples collected.

Response to Comment #6:
The Well Development Plan has been revised to provide clarification that statistical analyses will be performed according to the methods specified in the TEC Statistical Data Analysis Plan consistent with the provisions of Title 40 Code of Federal Regulations (40 CFR) § 257.93. These revisions are included in Section 3.1 (Assessment Monitoring) of the revised Well Development Plan.

USEPA Comment #7: Section 3.1, Assessment Monitoring, Page 4
Only monitoring wells with statistically significant increases as described in §257.94 need to advance to assessment monitoring as described in §257.95.

Response to Comment #7:
The Well Development Plan has been revised to clarify that the entire groundwater network system will transition into assessment monitoring following a statistically significant increase as described in 40 CFR § 257.94. Evergy confirmed the intent of this comment with USEPA Region 7 staff via phone conference on January 29, 2024.

USEPA Comment #8: Figures
The second figure with the proposed new monitoring well locations appears to be mislabeled as Figure 1 and should be Figure 2.

Response to Comment #8:
The Well Development Plan has been revised to correct the figure number for the proposed new monitoring well locations figure. These revisions are included in Figure 2 of the revised Well Development Plan.

USEPA Comment 9: Figures
Given the distance between MW-4 and proposed monitoring well MW-11, an additional upgradient monitoring well location is recommended between these two locations which would also be more directly upgradient in the prevailing uppermost aquifer flow direction.

Response to Comment #9:
The Well Development Plan has been revised to include an additional proposed upgradient monitoring well in the southwest region of the 322 Landfill. The approximate area of proposed monitoring well MW-9 has also been revised to address access concerns for the well placement. These revisions are included in Figure 2 of the revised Well Development Plan.

As outlined in Paragraph 4 in Section 2.1 (Monitoring Well Locations) of the Well Development Plan, one upgradient monitoring well was installed in the area of proposed monitoring well MW-11 as part of the original 322 Landfill groundwater monitoring system but was found to be dry and not in communication with the uppermost aquifer. If these conditions are found to extend along the western edge of the landfill, the additional upgradient monitoring well may not contain sufficient groundwater to support groundwater sampling.

USEPA Comment #10: General Comment
The standard operating procedures for monitoring well drilling, development, management of investigative-derived waste including development and purge water, drill cuttings, etc. should be included or referenced as to location of the supporting documents.

Response to Comment #10:
The Well Development Plan has been revised to include the Standard Operating Procedures for monitoring well drilling, completion, installation, and development. These revisions are included in Section 2.1.1 (Monitoring Well Drilling and Installation) of the revised Well Development Plan. The Well Development Plan has been revised to provide a discussion of handling development and purge water.

These revisions are included in Section 2.1.2 (Development and Purge Water Management) of the revised Well Development Plan.

USEPA Comment #11: General Comment
The Sampling and Analysis Plan should be referenced as to location of the supporting document or included.

Response to Comment #11:
The Well Development Plan has been revised to reference the SAP for the TEC. This change is included in Paragraph 1 of Section 2.3 (Baseline Sampling) of the revised Well Development Plan.

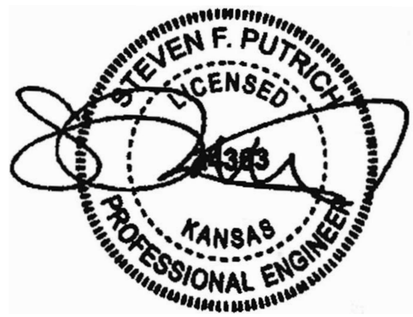
USEPA Comment #12: General Comment
An updated schedule should be included when revised and available.

Response to Comment #12:
Upon approval of the Well Development Plan for the 322 Landfill by USEPA, Evergy will provide an updated schedule to USEPA when revised and available.

Please contact Jared Morrison (jared.morrison@evergy.com) with any questions that you may have regarding the information contained in this letter.

www.haleyaldrich.com

322 LANDFILL WELL PLACEMENT/DEVELOPMENT PLAN
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS



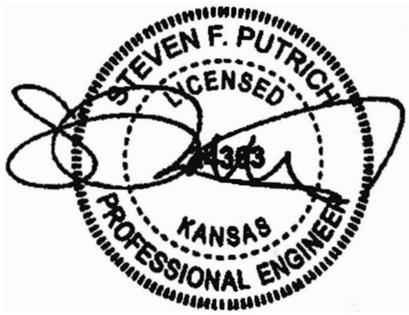
by
Haley & Aldrich, Inc.
Phoenix, Arizona

for
Evergy Kansas Central, Inc.

File No. 0129778-052
March 2023

Rev 1: February 2024

Table of Contents



Page

List of Tables

List of Figures

List of Appendices

1. Introduction

This document is the 322 Landfill Well Placement/Development Plan (Plan) prepared pursuant to Paragraph 10.f. of the Consent Agreement and Final Order (CAFO) between the U.S. Environmental Protection Agency (USEPA) and Evergy Kansas Central, Inc. (Evergy) In the Matter of Evergy Kansas Central, Inc.: Docket No. RCRA-07-2023-0001 dated November 7, 2022. Paragraph 10.f. of the CAFO requires that Evergy provide USEPA a plan for the installation of additional wells at the 322 Landfill.

1.1 BACKGROUND

Evergy Tecumseh Energy Center (TEC) is a closed coal fired power generation facility. Evergy operated a permitted solid waste disposal area referred to as the 322 Landfill. This landfill was permitted through the Bureau of Waste Management of the Kansas Department of Health and Environment (KDHE) under Permit No.322. Prior to, and during, plant decommissioning, the landfill received coal combustion residuals (CCR) and other permitted industrial waste streams. The 322 Landfill was closed in accordance with the CCR Rule and KDHE regulatory requirements. CCR Rule Closure of the unit was certified in accordance with Title 40 Code of Federal Regulations (40 CFR) § 257.102 on April 30, 2021. The unit is currently being managed in accordance with the post-closure care requirements.

Pursuant to Paragraph 10.f. of the CAFO, this Plan has been prepared for the installation of additional monitoring wells at the 322 Landfill. The items requested by USEPA in Paragraphs 10.f.i. through 10.f.v. of the CAFO are provided in the following sections.

1.1.1 Monitoring Network

Consistent with 40 CFR §§ 257.90 through 257.95, Evergy installed and certified a groundwater monitoring network for the 322 Landfill at TEC and collected eight rounds of groundwater samples for the analysis of Appendix III and Appendix IV baseline constituents. The groundwater monitoring network at the 322 Landfill includes one upgradient monitoring well (MW-4) and three downgradient monitoring wells (MW-1, MW-5, and MW-6); and one cross gradient well (MW-2) is used to monitor groundwater elevations for the purpose of establishing groundwater flow direction at each sampling event.

Monitoring well MW-4 was sited at a location considered to be representative of background groundwater conditions. Groundwater in the uppermost aquifer beneath the 322 Landfill consistently flows in a northeast direction. The downgradient monitoring wells were sited based on site-specific conditions at locations considered sufficient to detect groundwater constituents in the uppermost aquifer passing the waste boundary of the unit. The locations of the monitoring wells are shown on Figure 1, and well construction details are provided in Table 1.

1.2 PURPOSE AND SCOPE

This Plan addresses requirements set forth in Paragraph 10.f. of the CAFO and is consistent with requirements outlined in 40 CFR §§ 257.90(b)(1) and 257.91 for groundwater monitoring and system, and applicable requirements outlined in 40 CFR § 257.95(d). The specific requirements for this Plan listed in the CAFO are provided in Sections 2 through 4 of this Plan and are in bold italic font, followed by a narrative describing how each requirement has been met.

2. Groundwater Monitoring Well Installation

2.1 MONITORING WELL LOCATIONS

Paragraph 10.f.i. of the CAFO requires:
"A discussion of how the proposed wells will comply with 40 CFR §§ 257.90(b)(1) and 257.91."

In accordance with CAFO Paragraph 10.f.i., the installation of three (3) new monitoring wells at potential upgradient locations and four (4) new monitoring wells at downgradient or cross gradient locations at the TEC 322 Landfill is proposed to monitor groundwater quality passing the waste boundary of the 322 Landfill (Figure 2) pursuant to 40 CFR § 257.90(b)(1)(i) and the performance standard of 40 CFR § 257.91(a).

Pursuant to 40 CFR § 257.91(b), the number, spacing, and depths of proposed monitoring wells were determined based upon site-specific technical information obtained during drilling, installation, and testing of the original monitoring wells at the 322 Landfill, including stratigraphy, lithology, hydraulic conductivity, porosity, and site-specific data developed during previous characterization activities. The proposed wells include wells in known upgradient and downgradient locations, and additional wells that will further support characterization of the groundwater flow field. Several of the proposed wells may be cross gradient and may be monitored for piezometric observation only.

As directed in 40 CFR § 257.91(c), following installation of the proposed monitoring wells to the current monitoring system, the 322 Landfill monitoring system will now include as many as three (3) upgradient monitoring wells and at least five (5) downgradient monitoring wells, which exceeds the minimum well requirements identified under the CCR Rule. Downgradient monitoring wells will be at a horizontal spacing of approximately 350 to 400 feet similar to the current spacing of downgradient monitoring wells MW-5 and MW-6. The additional wells, including cross gradient wells, will serve to demonstrate that the groundwater flow direction is consistently toward the northeast.

During previous drilling programs, shallow bedrock was observed, and dry formation conditions were encountered southwest of the 322 Landfill. One (1) additional upgradient monitoring well was installed in this area as part of the 322 Landfill groundwater monitoring system but was found to be dry and not in communication with the uppermost aquifer. If these conditions are found to extend along the western edge of the landfill, the proposed upgradient monitoring wells may not contain sufficient groundwater to collect groundwater samples.

The proposed schedule for installation of the new 322 Landfill monitoring wells is provided in Table 2.

2.1.1 Monitoring Well Drilling and Installation

Monitoring wells will be drilled and installed by a KDHE-licensed water well driller in accordance with Kansas Administrative Regulations (K.A.R.) Article 30.[1] Procedures for monitoring well drilling, completion, installation, and development are summarized below and will be completed in accordance with Article 30 and the standard operating procedures (SOP) provided in Appendix A.

[1] Kansas Department of Health and Environment, 2013. Kansas Administrative Regulations, Article 30, Water Well Contractor's License; Water Well Construction. June.

Prior to any subsurface work, federal and state laws require excavators to notify appropriate utility companies before digging. Kansas 811 will be contacted at least 72 hours in advance of any subsurface work to mark public utilities. Evergy will clear site utilities by reviewing facility as-built drawings and potential drilling locations for the presence of underground utility hazards (utility lines, subsurface structures, etc.). Each proposed monitoring well location will be cleared by hand auguring the top 5 feet below ground surface (bgs).

2.1.1.1 Monitoring Well Drilling

Based on existing groundwater elevation data, the groundwater flow direction is consistently toward the northeast, and the water bearing geologic formation nearest the natural ground surface at the 322 Landfill is composed of poorly sorted glacial till material that includes clay, sand, and gravel. The proposed monitoring wells will be installed to a depth of approximately 15 feet bgs and will be screened within the glacial till material directly above the shale confining unit that underlies the 322 Landfill (Figure 3). A lithologic log will be created for each boring, which will note depth of groundwater, characterize soil samples in accordance with the Unified Soil Classification System, and describe each bedrock core, if applicable. Split spoon soil samples will be collected every 5 feet, to the top of bedrock, to support continued lithologic logging.

2.1.1.2 Monitoring Well Installation

The proposed monitoring wells will be installed to a depth of approximately 10 to 15 feet bgs and will be screened within the glacial till material directly above the underlying shale. The proposed monitoring wells will be designed and installed in accordance with 40 CFR § 257.91(e), and K.A.R. 28-30-6. The planned well design is provided in Figure 3.

2.1.1.3 Monitoring Well Completion

Monitoring wells will be completed with 2-inch inside diameter flush threaded, 2-inch polyvinyl chloride (PVC) plug, well screen, and riser. The well screen will be up to 10 feet long and have 0.020-inch slots. The annular space between the borehole walls and the PVC materials will be filled with appropriately sized sand pack (No. 8-12 silica sand) to approximately 1 foot above the well screen. A bentonite seal of fine chips or pellets will be placed above the filter pack to ground surface. The top of the riser will be secured with a locking watertight cap. Each well will be completed with an above ground protective casing that will be locked once installation is complete. Monitoring well construction may be adjusted based on field observations. The planned well design is provided in Figure 3.

2.1.1.4 Monitoring Well Development

The newly installed monitoring wells will be allowed to set for a minimum of 24 hours prior to well development. The wells will be developed by swabbing, bailing, airlifting, and/or pumping methods in accordance with the SOP in Appendix A. Monitoring well development will be complete once the monitoring well is visibly clear and sediment free, turbidity is reduced to less than 10 Nephelometric Turbidity Units or has stabilized, and when pH, temperature, and conductivity have stabilized. Water level elevations will be measured with a decontaminated water level indicator throughout the well development.

2.1.2 Development and Purge Water Management

Development and purge water will be discharged to the ground at the site following drilling activities. The drilling subcontractor will be responsible for ensuring that no development or purge water will enter any on-site surface water pathways.

2.1.3 Survey

Following monitoring well drilling, installation, and development, a surveyor licensed in the state of Kansas will be contracted to establish final well locations and the vertical elevation (surface and casing) at each monitoring well.

2.2 AQUIFER TESTING

Slug testing will be completed at each newly installed monitoring well to characterize hydraulic properties of the uppermost aquifer. Each well will be allowed to set for a minimum of 48 hours following monitoring well development prior to slug testing. The slug tests will be performed in accordance with the SOP provided in Appendix A. Data obtained during testing will be evaluated using commercially available software to estimate hydraulic conductivity.

2.3 BASELINE SAMPLING

Paragraph 10.f.ii. of the CAFO requires:
"A proposed sampling schedule to meet the requirements of 40 CFR § 257.90(b)(1)(iii)."

A detection monitoring program will be initiated at the newly installed monitoring wells in accordance with 40 CFR § 257.90(b)(1)(iii) within 30 days of monitoring well development. The program will include a minimum of eight independent baseline groundwater samples collected from each new monitoring well and analyzed for the constituents listed in Appendix III and Appendix IV. The samples will be collected bi-monthly from the newly installed monitoring wells over a period of 16 months to ensure collection of data describing seasonal variability. Groundwater samples will be collected in accordance with the site-specific Sampling and Analysis Plan.[2]

All samples will be analyzed by a laboratory certified by the State of Kansas. Data validation and usability assessment will be performed in accordance with guidance and requirements established in the documents titled *USEPA National Functional Guidelines for Inorganic Data Review (USEPA, 2020)*[3] and *the Evaluation of Radiochemical Data Usability* (Paar, 1997).[4]

The baseline sampling schedule for the new 322 Landfill monitoring wells is provided in Table 2.

---

[2] Haley & Aldrich, Inc., 2023. Groundwater Sampling and Analysis Plan, Tecumseh Energy Center, Tecumseh, Kansas. June 6.

[3] U.S. Environmental Protection Agency, 2020. National Functional Guidelines for Inorganic Superfund Methods Data Review. EPA-540-R-2017-001. January.

[4] Paar, J.G., 19978. Evaluation of Radiochemical Data Usability. April.

3. Assessment Monitoring Groundwater Sampling Program

3.1 ASSESSMENT MONITORING

Paragraph 10.f.iii. of the of the CAFO requires:
"A proposed schedule for incorporating the new wells into the assessment monitoring sampling program when viable."

The current assessment monitoring program includes sampling and analysis of Appendix III and Appendix IV constituents followed by statistical analysis in accordance with the sampling and analysis program (40 CFR § 257.90(b)(1)(ii) and (iv)) and the TEC Statistical Data Analysis Plan (40 CFR *§* 257.93). The annual assessment monitoring sampling event consists of all Appendix IV constituents pursuant to 40 CFR § 257.95(b). Upon completion of eight baseline sampling events at the newly installed 322 Landfill monitoring wells, the new monitoring wells will be sampled along with existing wells pursuant to the detection monitoring requirements of 40 CFR § 257.94. Following a statistically significant increase at any new or existing well, the new wells will transition into the assessment monitoring program together with MW-1, MW-4, MW-5, and MW-6 and be certified as part of the network in accordance with 40 CFR § 257.91(f).

The schedule for incorporation of the new wells into the assessment monitoring program at 322 Landfill is provided in Table 2.

3.2 SEMI-ANNUAL ASSESSMENT MONITORING SAMPLING

Paragraph 10.f.iv. of the CAFO requires:
"A proposed sampling schedule for semi-annual assessment monitoring for any Appendix III and Appendix IV constituents identified in the annual assessment monitoring event pursuant to 40 CFR § 257.95(d)."

In accordance with 40 CFR § 257.95(d)(1), assessment monitoring sampling will be completed at monitoring wells MW-1, MW-4, MW-5, and MW-6 on a semiannual basis beginning within 90 days of obtaining validated results from the annual assessment monitoring sampling event. Upon completion of eight baseline sampling events at the new monitoring wells, the wells will be incorporated into the assessment monitoring program. The assessment monitoring sampling schedule is provided in Table 2.

4. Reporting

Paragraph 10.f.v. of the CAFO requires:
"Identification of any potential updates and/or modifications to reports/notifications in Respondent's operating record and on Respondent's publicly available CCR compliance webpage and a schedule for making the updates and/or modifications."

In accordance with CAFO Paragraph 10.f.v., the following reports/notifications will be updated or modified to reflect the additional groundwater monitoring wells. The schedule for document updates is presented in Table 3:

- Groundwater System Certification – 40 CFR § 257.91(f)
- Sampling and Analysis Plan – 40 CFR § 257.90(b)(1)(ii) and 40 CFR § 257.93(a)

TABLES

TABLE 1
MONITORING WELL CONSTRUCTION INFORMATION
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

Location	Well Identification	Well Installation Date	Casing Diameter (inches)	Blank Casing Type	Screened Casing Type	Slot Size (inch)	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Well Depth (feet bgs)	Depth to Water[a] (feet btoc)	Water Level Elevation (feet amsl)	Water Column Depth (feet)	Northing[b]	Easting[b]	Ground Surface Elevation (feet amsl)[c]	Top of Casing Elevation (feet amsl)
322 Landfill																
Downgradient	MW-1	6/7/1978	4	Schd 40 PVC	Schd 40 PVC	0.500	5.5	25.5	25.5	6.08	898.57	19.42	270840.4168	2004708.9116	902.65[c]	904.65
	MW-2	7/8/2009	2	Schd 40 PVC	Schd 40 PVC	0.010	11.5	16.5	16.5	13.31	917.06	3.19	270802.1534	2004122.3714	928.37[c]	930.37
	MW-5	4/8/2016	2	Schd 40 PVC	Schd 40 PVC	0.020	6	16	16	8.26	907.92	7.74	270381.5513	2004921.3410	913.3	916.18
	MW-6	4/8/2016	2	Schd 40 PVC	Schd 40 PVC	0.020	8.7	18.7	18.7	9.63	901.65	9.07	270804.2617	2004929.8163	908.04	911.28
Upgradient	MW-4	4/13/2012	2	Schd 40 PVC	Schd 40 PVC	0.020	7	12	12	6.32	930.16	5.68	268353.7298	2004187.4333	934.48[c]	936.48

Notes:
Monitoring Well Used for Piezometric Observation Only
[a] Depth to water from groundwater elevation survey on September 9, 2022.
[b] Data Source: Westar Energy Tecumseh Energy Center, August 2016.
[c] Surface elevation estimated based on 2-foot casing stick up
amsl - above mean sea level
bgs - below ground surface
btoc - below top of casing
Schd 40 PVC - Schedule 40 polyvinyl chloride

TABLE 2
PROPOSED SCHEDULE FOR CONSENT AGREEMENT PARAGRAPH 10.f.
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

Schedule Item[1]	CAFO Item	CCR Rule Regulation	Estimated Start Date
Install new wells	*Paragraph 10.f.i.*	*40 CFR § 257.90(b)(1)(i)* *40 CFR § 257.91*	Within 180 days of USEPA approval of this Plan[2]
Initiate baseline sampling of new wells	*Paragraph 10.f.ii.*	*40 CFR § 257.90(b)(1)(iii)*	Within 30 days of monitoring well development
Incorporation of new wells into network	*Paragraph 10.f.iii.*	*40 CFR § 257.90(b)(1)(iv)*	Within 30 days of obtaining validated results from eight independent baseline sampling events
Semi-annual assessment monitoring sampling	*Paragraph 10.f.iv.*	*40 CFR § 257.95(d)(1)*	Within 90 days of obtaining validated results from the annual assessment monitoring sampling event

Notes:
1. Proposed schedule address the requirements in Paragraph 10.f. of a consent agreement between the U.S. Environmental Protection Agency and Evergy dated November 7, 2022
2. 322 Landfill Well Placement / Development Plan (Plan)
CAFO = Consent Agreement and Final Order
CCR = Coal Combustion Residual
CFR = Code of Federal Regulation
SSL = statistically significant level
USEPA = U.S. Environmental Protection Agency

TABLE 3
PROPOSED SCHEDULE FOR REPORTING UPDATES / MODIFICATIONS
EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

Report Item[1]	CCR Rule Regulation	Estimated Completion Date
Groundwater System Certification	*40 CFR § 257.91(f)*	Within 60 days of incorporating new monitoring wells into the monitoring well network
Sampling and Analysis Plan	*40 CFR § 257.90(b)(1)(ii)* *40 CFR § 257.93(a)*	Within 60 days of incorporating new monitoring wells into the monitoring well network

Notes:

1. Proposed schedule address the requirements in Paragraph 10.f.v. of a consent agreement between the U.S. Environmental Protection Agency (EPA) and Evergy dated November 7, 2022

CCR = Coal Combustion Residual

CFR = Code of Federal Regulation

FIGURES

LEGEND

- MONITORING WELL
- PIEZOMETER OBSERVATION ONLY
- 322 LANDFILL BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, NOVEMBER 7, 2019

N

0 300 600
SCALE IN FEET

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

322 LANDFILL MONITORING
WELL LOCATION MAP

evergy

FEBRUARY 2024

FIGURE 1

GIS FILE PATH: \\haleyaldrich.com\share\phx_common\Projects\Westar\Tecumseh Energy Center (TEC)\GIS\MXDs\2023_01\129778_039_0001_322_LANDFILL_MONITORING_WELL_LOCATION_MAP.mxd — USER: khensen — LAST SAVED: 2/3/2023 6:48:01 AM

LEGEND

- PROPOSED UPGRADIENT MONITORING WELL
- PROPOSED DOWNGRADIENT MONITORING WELL
- MONITORING WELL
- PIEZOMETER OBSERVATION ONLY
- GROUNDWATER FLOW DIRECTION
- APPROXIMATE AREA FOR PROPOSED MONITORING WELL
- 322 LANDFILL BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, NOVEMBER 7, 2019

N

0 300 600

SCALE IN FEET

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

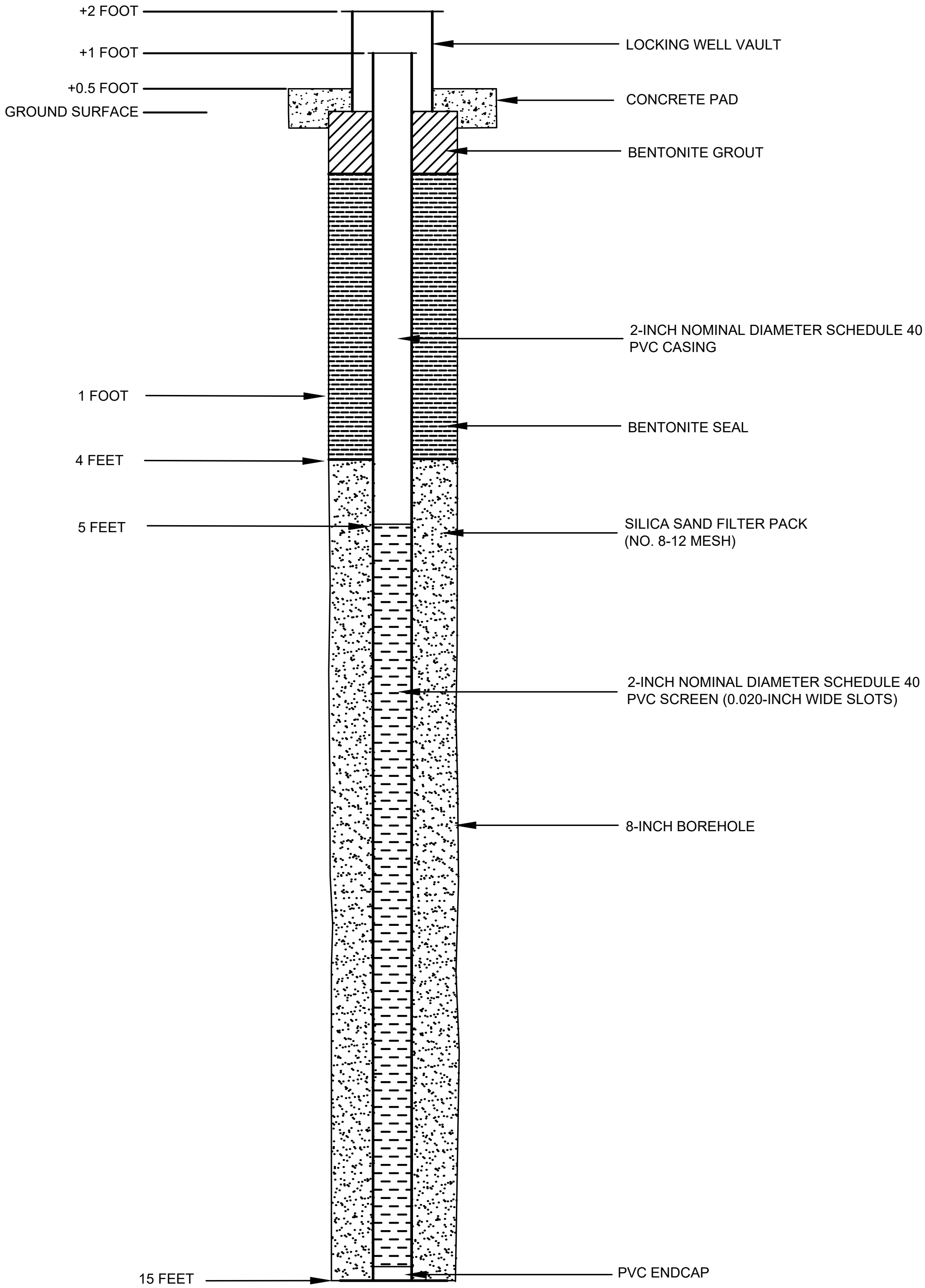
PROPOSED GROUNDWATER MONITORING WELLS

evergy

FEBRUARY 2024

FIGURE 2

GIS FILE PATH: \\haleyaldrich.com\share\phx_common\Projects\Westar\GIS\Tecumseh_Energy_Center\Maps\2023_12\129778_039_0002_322_PROPOSED_GROUNDWATER_MONITORING_WELLS.mxd — USER: khensen — LAST SAVED: 12/7/2023 8:48:20 AM



HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER
TECUMSEH, KANSAS

PROPOSED MONITORING WELL DESIGN

evergy

NOT TO SCALE
FEBRUARY 2024

FIGURE 3

G:\PROJECTS\WESTAR\TECUMSEH ENERGY CENTER (TEC)\CAD\PROPOSED MONITORING WELL DESIGN.DWG

APPENDIX A
Standard Operating Procedures

OPERATING PROCEDURE: OP2000

MONITORING FIELD EXPLORATIONS

PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	CSO/ 12-02	JAM/ 01-03		STP/6-1-03	SRK/7-1-03

Total Pages: 56

TABLE OF CONTENTS

OPERATING PROCEDURE: OP2000

MONITORING FIELD EXPLORATIONS

1. PURPOSE

Exploratory test borings, probes and test pits represent important sources of subsurface information relating to geologic conditions and site suitability fundamental to environmental site assessment and geotechnical engineering design recommendations. The following procedure is an outline of the field staff responsibilities while monitoring subsurface exploration methods utilized by Haley & Aldrich Inc. (H&A) to obtain the best possible data for geologic characterization, laboratory testing and subsequent engineering evaluations and environmental assessment.

2. EQUIPMENT & MATERIALS

2.1 Standard Required Equipment

	Required		Additional as Required
1.	Proposal (signed by Client)	20.	First Aid Kit
2.	Site Plan	21.	Cellular Phone
3.	Contract with Subcontractor (pay items)	22.	Health & Safety Plan
4.	Exploration Criteria/Specifications	23.	Respirator & Tyvek Suit
5.	Field Book	24.	Laptop Computer
6.	Clipboard	25.	Camera & Film
7.	Logs & Forms	26.	Field Procedures
8.	Office Supplies (pencils & markers)	27.	Maps and References
9.	Engineer's Scale	28.	Sample Bags & Jars with Labels
10.	6 ft. Ruler	29.	Survey Stakes/Paint/Flagging
11.	100 ft. Measuring Tape	30.	Shovel
12.	Hand Lens, magnifying	31.	Geologist's Pick
13.	Pocket Knife	32.	Flashlight
14.	Hard Hat	33.	Roadway Box Key/Socket Wrench
15.	Safety Glasses	34.	Water Level Indicator
16.	Sound Dampeners	35.	Hand Level
17.	Steel Toe Boots	36.	Brunton Compass
18.	Protective Gloves	37.	Pocket Penetrometer
19.	Rain Gear	38.	Torvane

2.2 Required Environmental Equipment

Most environmental fieldwork will have extensive equipment requirements and supplies specifically related to the project needs. The following list is a representative list of equipment classed as type-specific groups. A comprehensive list of equipment and materials must be developed for each project in coordination with the Project Manager (PM) and Health & Safety (H&S) Coordinator prior to the start of the field program.

1. Personal Protection Equipment (PPE)
   - Air Purifying Respirator & Cartridges (Type GMC-Type H)
   - Latex/Nitrile Inner Gloves/Boot Covers
   - Tyvek/Saranex Coveralls/Sleeves/Apron

2. Decontamination Equipment and Supplies
   - Decontamination Kit
     - 5 gallon bucket
     - 5 gallon water jug
     - alconox detergent
     - brushes & paper towels
     - methanol/hexane/deionized water
   - Decontamination Tub
   - Absorption Pads
   - Polyethylene Sheeting
   - Polyethylene Trash Bags

3. Air Quality/Headspace Monitoring Equipment
   - Photo-Ionization Detector (PID)
   - Flame Ionization Detector (FID)
   - Organic Vapor Analyzer (OVA)
   - Combustible Gas Meter-LEL/O2
   - Dust Monitor
   - Multigas Meter-HCn/Methane/H2S
   - Gas Pointer
   - Draeger Tube Sampling Kit
   - Radiation Survey Meter

4. Soil Sampling Equipment and Supplies
   - Hand Auger
   - Soil Core Sampler
   - Shovel/Trowel/Remote Sampler
   - Stainless Steel Bowl
   - Aluminum Foil
   - Tongue Depressors
   - Sample Bags/Laboratory Glassware & Labels
   - Cooler & Ice Blocks

5. Water Sampling Equipment and Supplies
   - Water Level Indicator
   - Oil/Water Interface Probe
   - Centrifugal Pump-Volume
   - Submersible Pump-Low Flow
   - Peristaltic Pump & Silicone Tubing
   - Purge Pump & DC Supply
   - Waterra® Tubing/Foot Valves/Filters
   - Stainless Steel/Teflon Bailers & Rope
   - Remote Sampler
   - Water Testing Equipment
     - Flow Cell (pH, temperature, conductivity, DO, turbidity, ORP and salinity)
     - Dissolved Oxygen (DO) Meter
     - Oxidation-Reduction Potential (ORP) Meter
     - Turbidity Meter
     - Downhole Temperature/Resistivity/Conductivity/Salinity Meter
     - pH/ Turbidity/DO/ Temperature/Resistivity/Conductivity/Salinity Meter
   - Laboratory Glassware & Labels
   - Cooler & Ice Blocks

2.3 Additional Equipment, Specialized Instrumentation, Materials & Company Vehicles

Company-wide, Haley & Aldrich maintains an array of equipment, vehicles and specialized instrumentation for a broad variety of uses in addition to the selected equipment listed above. Additional equipment, vehicles and materials may be rented or purchased as needed with the approval of the project manager. Project equipment needs should be addressed proactively so that interoffice allocation can take place. It is recommended that the field staff familiarize themselves with the use, function and availability of all types of equipment standard to the industry. The following list is representative of the additional equipment currently available but is not intended to be a comprehensive list.

1. Survey Instrumentation
   - Theodolite/Transit/ Level & Rod
   - Global Positioning System (GPS)

2. Subsurface Locating Equipment
   - Ground Penetrating Radar (GPR)
   - Metal Detector
   - Magnetometer

3. Air-Soil-Water Quality/Analytical Equipment
   - Gas Chromatograph (GC)
   - TPH Analyzer
   - Infrared Oil Analyzer
   - Radiation Survey Meter
   - Oxidation-Reduction Potential Meter (ORP)

4. Geotechnical Equipment & Instrumentation
   - Vane Shear Test Equipment
   - Vibrating Wire Piezometer Equipment
   - Pressuremeter Testing Equipment
   - Seismograph Equipment
   - Inclinometer Equipment
   - Nuclear Moisture-Density Gauge
   - Sound Level Meter

5. Hydrogeologic Equipment & Instrumentation
   - Datalogger/Levelogger Hardware & Software
   - Stream Flow Gauge & Equipment

6. Photographic Equipment
   - Video Camera
   - Digital Camera
   - 35mm Camera

7. Communication Equipment
   - Cellular Telephone
   - Satellite Telephone
   - Two-Way Radio

8. Computer Hardware & Software

2.4 Billing Equipment & Materials

Equipment and materials are billed to the project as used on a daily or per item basis. Completion of equipment usage and billing forms and submission of original receipts for items purchased or rented is required in order to charge the project for reimbursement.

3. PROCEDURE

3.1 Preliminary Preparations

3.1.1 Project Briefing

Prior to the beginning of an exploration program all field staff should attend a project briefing with the project manager and office staff involved in the proposed project. At this time a file folder for the field activities should be created for the purpose of containing all relevant project information including: copies of the original proposal, site and utility plans, contract documents and drawings, applicable regulations, exploration and sampling criteria, site contacts, phone numbers of team members, health and safety (H&S) plans, log and report forms and any other related documents or references. The field folder should be organized and maintained such that all documents likely to be useful for the completion of field activities by others are readily available in the event of personnel changes.

During the project briefing each team member should become thoroughly familiar with the overall scope of the project in addition to the task items and individual requirements of the work plan. Development of an outline of the specific activities envisioned and a review of the details concerning each task may facilitate the formulation of alternate approaches to field methods as well as the creation of action, materials and equipment lists.

Field staff should review all existing applicable information that relates to site geology and possess detailed familiarity and understanding of the contract specifications in order that knowledgeable field decisions can be made. Field staff should be experienced in all of the various field exploration procedures, instrumentation installation and sampling techniques required for the project. Requests for training, guidance or assistance should be made by the field staff as needed. Haley & Aldrich, Inc. fosters a supportive environment where all staff are encouraged to share knowledge and experiences with each other.

3.1.2 Health & Safety

Safety in the workplace is a prime concern of Haley & Aldrich, Inc. on all projects. It is essential that field personnel understand and comply with all regulations governing worker safety in the field including applicable OSHA guidelines. Certain projects will require the field staff to attend a Health & Safety briefing due to specific occupational safety concerns. The nature of these concerns will be addressed by a site specific Health & Safety Plan. It is the responsibility of the project manager to notify the field staff of the existence of the Health & Safety Plan, however all field staff are encouraged to inquire with the Project Manager and with the Health & Safety Coordinator directly to avoid any possible oversight. Safety awareness and safe work practices are the responsibility of the field staff at all times and on all projects whether or not site or task specific guidelines are in existence. In the event of an accident, exposure or if unexpected contamination is encountered, the Project Manager and the Health & Safety Coordinator must be contacted immediately. Standard H&A safety recommendations for subsurface explorations are provided OP1001 Excavation and Trenching Safety and OP1002 Drilling Safety.

3.2 Duties and Responsibilities

3.2.1 General

The principal reason for providing Haley & Aldrich field representation is to assure that the field data being collected is accurate and of the type necessary to properly evaluate the site geologic conditions for use in the subsequent engineering analyses and environmental assessment.

3.2.2 Supervision of Subsurface Exploration Programs

Each subsurface exploration program carried out under H&A supervision is designed to accommodate the specific requirements of a given project. Subsurface exploration programs routinely include the excavation of test pits and the drilling of test borings with associated instrumentation installation, special testing and sampling requirements. Modifications to the fieldwork criteria, sampling and testing are often made during the execution of the subsurface exploration program as the accumulated geologic data and test results are interpreted. For this reason it is essential that all records are current and complete and that uncertainties are identified for resolution. Field staff are responsible for maintaining communication with the project manager and logistical coordination of the field effort within the workscope and budgetary limits.

3.2.3 Verification of Subsurface Exploration Techniques and Services

It is the role of H&A field staff to verify that instrumentation installation, subsurface sampling and testing methods are in conformance with applicable approved standards and specifications and to document conditions and results. Performance of sampling and testing is commonly conducted with subcontractor support and equipment. It is the responsibility of the H&A field staff to verify that proper equipment and techniques are employed and to obtain measurements and make observations independently. H&A field staff are responsible for complete field logging of groundwater, soil and bedrock conditions, the maintenance of accurate test records and field exploration location sketches, and ensuring proper instrumentation installation, sample preservation and handling. In addition, payment for services rendered on behalf of the client is commonly handled with H&A providing a daily field report (DFR) including an accurate breakdown of the work activities and itemized costs on a daily basis. Subcontractor pay items and method of payment are defined in their contract.

3.2.4 Right of Access

Prior to site entry, Haley & Aldrich staff members must ensure that permission has been gained from the property owner to access the property.

3.2.5 Layout and Utility Clearance

Prior to the start of any subsurface exploration all proposed locations must have utility clearance from all appropriate agencies and utility owners. Utility owners typically do not enter private properties. If there are particular concerns regarding utilities on private property, arrangements can be made with a private utility locating service. Prior to contacting any utility agency or service all proposed exploration locations must first be clearly marked in the field either with white paint or staked and white flagged. Additional colors can be used to highlight the location if the ground is snow covered. Alternate locations should be laid out in areas of suspected utilities. H&A requires the subsurface exploration subcontractor to obtain the utility clearance within the terms of the contract or services agreement. H&A field staff should verify with the driller/test pit contractor that the utilities have been cleared and obtain the clearance number prior to the start of subsurface explorations. Pre-excavation may be necessary in areas of closely spaced utilities either by hand, vacuum, or other means. Additional guidance is provided in OP1003 Utility Clearance.

3.2.6 Site Safety and Subcontractor Briefing

At the start of fieldwork, H&A field staff should coordinate a site briefing to review the schedule and workscope with all subcontractors involved with the project. This briefing should include a review of the equipment and material needs, exploration criteria and priority, testing and sampling specifics, pay items, site conditions, environmental concerns, known or suspected contamination, H&S information, decontamination requirements, site restoration and waste disposal issues, a site walkover and utility check. While it is the subcontractor's responsibility to obtain the utility clearance, the field representative should pay attention to the utility plans as well as surface manifestations of utilities involving manholes or catch basin grates, and gate or roadway boxes. Distance to overhead utilities must be considered as well. Observations of potential conflicts with utilities should be addressed with the subcontractor for their consideration.

3.2.7 Exploration Monitoring

3.2.7.1 General

Haley & Aldrich field staff should become familiar with the technical details and suitability of all exploration equipment and methods. Test borings are the most common method employed by H&A to obtain high quality data on subsurface conditions. Unsampled probes can be used in a limited capacity to document overburden thickness. Specialty equipment is routinely used in sampled probes for environmental sampling. Test pits are preferred for surficial geological mapping and to document fill or overburden thickness. In addition to these typical exploration methods a variety of special testing techniques and instrumentation installations may supplement the subsurface exploration program. Specific H&A procedures must be consulted for details relating to special testing, sampling and instrumentation installation.

3.2.7.2 Exploration Equipment and Use

Exploration equipment selection is based upon a detailed understanding of the capabilities of the equipment with regard to the anticipated site geological conditions. In addition, the particular project needs may necessitate or preclude certain techniques and equipment. During the initial site walkover or layout, equipment access is considered and the type of exploration method is determined. Relatively small drill rigs are routinely used for overburden sampling, bedrock coring and groundwater monitoring well installations on a variety of projects. Larger pneumatic-percussive well rigs are used for drilling aquifer test and production wells. Excavation equipment may be preferred for initial surficial geologic mapping and to provide access prior to drilling. Various probe equipment may be considered for preliminary estimation of overburden thickness. Access to a water supply must be arranged for cased test borings and rock coring. Shallow water conditions and potentially liquefaction-susceptible soils preclude the use of augers. Bedrock monitoring wells must be cored in sufficient diameter to allow sand pack and seals. Enclosed areas may necessitate alternate fuels or low overhead equipment. Ecologically sensitive areas may require non-petroleum-based hydraulics or lightweight equipment. Many factors affect the equipment selection resulting in some trade-off in performance, cost and reliability of data.

3.2.7.3 Test Boring Techniques

A. *Cased Borings* - Cased borings are the primary method of obtaining high quality overburden samples and for penetration to bedrock prior to rock coring. The drill casing (pipe) is typically advanced in 5 ft. increments either by driving or spinning and then is washed out with an axially discharging tricone rollerbit pumping water or drill slurry from the recirculation tub. Upon flushing, the rollerbit is removed and a splitspoon sampler is fixed to the drill string (rods), lowered to the bottom of the borehole and driven into the undisturbed soils below the bottom of the casing. The procedure is repeated until the termination depth criterion is reached or bedrock is encountered. Common casing inside diameter (I.D.) ranges from 3 inch to 6 inch depending upon conditions and criteria. Rollerbits are sized to fit inside the casing with approximately 1/16 to 1/8 in. clearance. Typically boreholes are started with 5 or 6 in. I.D. casing fitted with a hard-shoe or drive-shoe in the lead (bottom) section. The casing is driven and splitspoon sampling is conducted at 5 ft. intervals (standard sampling) until an obstruction is encountered or the casing is seated into material such as clay that will maintain itself uncased. In the event of an obstruction the rollerbit or a buttonbit may be used to advance through the obstruction. In some cases the obstruction may break or a boulder-buster may be successfully employed and the casing is advanced. In other cases the next smaller diameter casing will be telescoped down the borehole and advanced through the hole in the obstruction created by the buttonbit. In the event that material such as clay that will maintain itself uncased is encountered, the open hole is extended as deep as possible. The borehole may be maintained by a bentonite or polymer slurry (mud rotary drilling). Casing fitted with a spin-shoe (econoshoe) is advanced by drilling in a similar manner to rollerbit advancement. Slurry or water is pumped down the casing to cool the bit and flush away the drill solids. Prior to splitspoon sampling the rollerbit must be lowered down the borehole and the spun casing must be drilled out in the same fashion as with driven casing. Spun or driven casing must be seated into the top of the bedrock in order to achieve an effective seal prior to rock coring.

B. *Mud Rotary Drilling* - Mud rotary drilling typically is conducted in deeper overburden borings and on projects where there are special concerns for soil sample integrity or particularly soft soils. Various products are used to make drill mud depending upon conditions and project requirements. Some mud is bentonite-silica based (heavy mud), some are compatible with saline conditions for ocean drilling, and some polymers are biodegradable for use in boreholes intended for environmental groundwater monitoring well installation. In all cases, mud drilling requires that a positive head be maintained in the casing at all times to stabilize the borehole. The practice is to fit a bypass line to the recirculation circuit that can be easily used to fill the casing as the rollerbit is being withdrawn. Use of a mud balance is required under certain circumstances to ensure sample integrity at the bottom of the borehole. The specific gravity to maintain in the drill mud will be specified on these projects.

C. *Auger Borings* - Hollow stem augers (HSA) are an effective and fast method for drilling shallow borings in softer soils above the water table without introducing water or drill slurry. Hollow stem augers are preferred for environmental studies where continuous soil sampling and minimization of potential cross contamination due to the use of drilling fluids is desired. Hollow stem augers and solid stem augers are also used as shallow probes. Auger flights are typically 5 ft. in length and are commonly 3.5 to 4.25 in. I.D. The lead section is fitted with a cutter head upon which are fixed several hardened, replaceable teeth. Using a center plug fixed to the bottom of the rods, hollow stem augers are typically advanced by drilling to the desired depth whereupon the center plug is replaced by the splitspoon and driven below the bottom of the lead section. Disturbance below the bottom of the augers due to the cutter head is typically substantial and heave is common at the bottom of the borehole due to the piston like effect of the center plug during removal. As such, augers are not favored for test borings on many geotechnical projects where high quality samples and penetration resistance data are required.

D. *Splitspoon Sampling and the Standard Penetration Test (SPT)* - The typical method for obtaining representative samples and a measure of the penetrative resistance of soils in test borings is by means of the Standard Penetration Test (SPT). This is accomplished utilizing a hollow tube splitspoon sampler assembly attached to the drill rods and driven into the soils at the bottom of the borehole at regular intervals. Splitspoon samplers are manufactured in various sizes with the most commonly used being 1 3/8 in. I.D. (2 in. O.D.) and having an interior sample chamber length of 24 in. (approximately 36 in. overall length). Once lowered to the sampling depth, the sampler is typically driven 24 in. into the soils with a 140 lb. hammer freely-falling over a 30 in. drop and the number of blows (SPT blowcount) required for each 6 in. of penetration is recorded. The penetrative resistance in blows per foot obtained from the summation of the blowcounts from 6 in. to 18 in. is referred to as the “N-value”. Terminology for density of granular soils and consistency of cohesive soils has been correlated to N-values. When performed properly the SPT provides useful data for determination of the geotechnical behavior of soils and engineering design in addition to representative remolded soil samples for geological interpretation.

E. *Bedrock Coring* - Bedrock coring is conducted in cased borings to obtain accurate detail of the bedrock properties and high quality samples for laboratory testing. A wide variety of rock core equipment is available and rock coring techniques vary greatly depending upon the driller, rock type, equipment and many other factors. Observations related to drilling activities are a primary focus during rock coring including bit weight, feed restriction, head speed, engine speed and gear, pump volume, water loss and fluid return, core rate, drilling halts, jamming, rapid advances, equipment defects, bit type, bit wear, core barrel type, core barrel adjustment. For all projects it is essential that accurate measurements be made when determining the depth of the bedrock surface from drill action or SPT and that detailed observations are recorded concerning the effects noted and the procedures executed upon encountering bedrock. Coring should begin at the minimum depth below the bedrock surface required to seat the casing in order to document the bedrock condition in the uppermost zone where typically fracturing and weathering transitions are greatest. Core hole depth must be verified following each run to account for lost core. When necessary, logging should be broken down into a two step process beginning with sample preservation, labeling and recording of a simple description including recovery and RQD measurements followed by detailed logging of individual features and properties as time and conditions permit.

F. *Observation Well Installation* - Groundwater observation or monitoring wells are commonly installed in completed test borings as a means obtaining accurate stabilized groundwater readings essential to engineering design, and hydrogeologic modeling. In addition, permanent observation or monitoring well installations provide for continual long-term sampling for environmental analyses. A wide variety of material types and sizes are employed depending upon the intended use. Typical observation or monitoring wells installations consist of 2 in. I.D. PVC pipe with a machine slotted screen section backfilled with filter sand and sealed with bentonite within the desired stratum or zone. Solid riser sections above the sealed zone may be grouted or backfilled with a variety of materials depending upon the project needs and finished at the ground surface with either a flush-mount roadway box or with a protective casing such as a guard pipe and padlock for undeveloped sites. Careful attention to the placement of screens, backfill and seals is required and accurate depth measurements must be recorded during installation. Initial well development may occur immediately upon completion in order set the sand pack and remove the effects of drill fluids from the formation waters.

3.2.7.4 Probes

A. *Unsampled Probes* - The term probe has historically referred to the advancement of a solid drill bit or rod by various means without sampling in order to estimate potential soft sediment thickness and refusal or obstruction depths. Small diameter rods advanced by hand have been useful in determining minimum peat and organic thickness in wetlands. Mechanical advancement of solid stem augers with conventional drilling equipment and pneumatic-percussive air track drilling are routinely used to supplement or replace test borings in areas of known shallow bedrock. Direct-push methods include simple rod assemblies to sophisticated electro-piezocone mechanisms. The principle advantage to conducting probes is that a great deal of data points can be rapidly obtained to create detailed contours of the desired surface or stratum. Implicit in the conduct of non-instrumented unsampled probes is that variations in drill action or rod advance is used to estimate strata changes. Acoustic listening devices placed within a saturated bedrock well near an air track rig will enhance the listener's ability to hear the pneumatic-percussive bit encounter bedrock. Primary among the disadvantages to conducting probes is the uncertainty resulting from relying strictly upon drill action without a hard data sample. Close proximity probes in zones of shallow refusal and repeated probes adjacent to those terminated on suspected obstructions help boost confidence and define aberrations. Secondary among the disadvantages to conducting probes is the inaccuracy inherent in the measurement of an often rapidly moving reference point as the drill advances through obstructions or variable zones into progressively more competent bedrock. Solid stem augers with conventional drilling equipment are slow to progress through dense soils and may be defeated by boulders but can be advanced below the water table without problems. Pneumatic-percussive air track drilling will rapidly advance through dense soils, boulders and bedrock but is inhibited below the groundwater table by borehole collapse and particularly when the air evacuation is suspended as rods are added to the drill string. Depending upon site conditions and termination depth, dozens of probes may be conducted in a single day. As such, horizontal and vertical control should be established at each probe location separate from the probe effort in order to obtain the most use from the rig time and to maximize the accuracy of the data.

B. *Sampled Probes* - Small diameter hand augers, soil plugs and manual soil cores are routinely used for surface soil sampling for rudimentary site reconnaissance, environmental sampling and hydric soils mapping. Direct-push and percussive or vibration driven soil core equipment preferred for shallow environmental sampling ranges in size from small diameter hand held units to vehicle mounted machinery capable of obtaining soil cores within polycarbonate liners 3.6 in. I.D. by 8 ft. length. As with any uncased borehole, additional soil cores may be obtained until the termination depth criterion is reached or sample integrity is compromised due to borehole collapse. Care must be exercised in establishing collapsed or resampled zones when documenting direct-push samples or soil cores.

3.2.7.5 Test Pits

Test pits are an extremely economical and effective way to rapidly characterize shallow subsurface conditions. Test pits are particularly useful for surficial geologic mapping, determining fill thickness and content, contouring shallow bedrock conditions and in determining oversized (cobble and boulder) percentages. Small backhoes with an approximately ¼ cubic yard bucket capacity are capable of excavating test pits up to 12 ft. depth in most materials and can be used with minimal site damage. Larger excavators with an approximately ¾ cubic yard bucket capacity are capable of excavating test pits up to 16 to 20 ft. depth and can be used to construct access for drill rigs on difficult sites. Given sufficient area, excavators can safely enter the excavation and extend the test pit indefinitely. During test pit excavation careful consideration must be given to potential bearing surface disturbance within proposed structures. In addition, care must be taken to minimize other site impacts requiring costly restoration including damage to trees, pavement, curbing, landscaping and utilities.

3.2.7.6 Environmental Sampling & Monitoring

Environmental sampling combined with discrete field screening of soil and groundwater for contaminants is routinely conducted during the performance of subsurface explorations. In addition, continuous monitoring of air quality within the work zone or at the project site may be required to address H&S concerns. Potential contaminants and sources may be identified in the initial stage of project planning and prior arrangements made for PPE, monitoring, sampling and laboratory analysis.

To minimize the risk of cross-contamination typical environmental sampling programs work from known or suspected clean areas toward areas of known or suspected contamination. Contamination encountered unexpectedly may present serious exposure risks to field personnel without proper PPE and monitoring instrumentation, particularly if the contamination is gross or unidentified. In the event unexpected contamination is encountered, all fieldwork should be suspended and the area evacuated immediately until the Project Manager and the Health & Safety Coordinator can be contacted so that H&S and sampling guidelines can be developed.

A. *Decontamination Procedures & Waste Management* - Standard equipment decontamination practices may include the establishment of a decontamination area such that decontamination fluids are collected and properly stored for disposal. Typically a location within the site is chosen away from sensitive or occupied zones and a decontamination pad is created within a bermed area using polyethylene sheeting. A high-pressure steam cleaner is used to wash all equipment prior to each exploration and wastewater is pumped into adjacent drums. Splitspoons and hand sampling tools are scrubbed between samples at the exploration location using a detergent (water and alconox) solution rinsed with control (tap) water followed by a solvent (methanol) rinse, wiped with a paper towel and rinsed with deionized water before being allowed to air dry. Hexane may be needed for removal of heavy petroleum, grease and coal tar. Decontamination waste, sample residue and drill cuttings are typically drummed, labeled and staged onsite for proper disposal.

B. *Environmental Soil Sampling* - Environmental soil samples obtained for chemical analyses are collected in surface samples and by using many of the techniques employed in typical subsurface explorations with special attention given to decontamination procedures. Preservation, handling and glassware for environmental soil samples varies considerably depending upon several factors including the type and degree of contamination, the analytical method to be conducted, the analytical laboratory being used and the governing regulations. In addition, the depth and location of samples may be strictly controlled under agency guidelines. Documentation of volatile organic compounds (VOC) in the soil through headspace screening is required in order to provide real-time guidance in the field to direct the sampling.

Clean 8 oz. jars are partially filled with newly obtained soils and covered with aluminum foil and allowed to stabilized prior to screening with a photoionization detector (PID). The presence of metals in soils is not associated with odors, while coal tar, fuels and solvents are often easily distinguished. Particular attention is given to discoloration or odors noted, however it is company policy to avoid fumes and odors at all times. Soils collected from a discrete zone should be homogenized and a representative portion placed into laboratory glassware and labeled. Analytical samples are kept in a cooler with ice blocks and a Chain of Custody form is maintained until transfer to the analytical laboratory.

C. *Environmental Water Sampling* - Groundwater monitoring (observation) wells must undergo an initial well development following installation and prior to sampling. This is intended optimize well function and to produce formation-derived groundwater samples and valid analytical testing results. Groundwater sampling from existing monitoring wells for chemical analyses involves initially gauging the static groundwater level and the well depth in order to determine the well volume. Waterra® footvalves and tubing, bailers, submersible pumps or peristaltic pumps may be used to purge a minimum of three well volumes in order to minimize well effects. Turbidity, conductivity, resistivity, salinity, dissolved oxygen, oxidation-reduction potential, temperature and pH are recorded periodically after purging and groundwater parameters must be stable prior to sampling. Low-flow groundwater sampling is required for certain analyses to be valid. In such cases, variable speed submersible pumps are used at extremely slow rates to minimize drawdown and turbidity. Sampling of surface waters or open-body water at depth may be done with remote or variable depth, bottle-type samplers. Preservation, handling and glassware for environmental water samples varies considerably depending upon several factors including the type and degree of contamination, the analytical method to be conducted, the analytical laboratory being used and the governing regulations.

4.2.7.7 Special Testing, Sampling and Instrumentation

H&A utilizes a wide variety of well established and state-of-the-art soil, rock and groundwater testing procedures and instrumentation to supplement many subsurface exploration programs. Among the methods and techniques routinely used are fixed-piston tube sampling, vane shear testing, pressuremeter testing, permeability testing, water pressure (packer) testing in rock, inclinometer installation, multiposition borehole extensometers (MPBX) installation and aquifer (pump) testing. Prior to attempting an unfamiliar technique H&A field staff must review all related procedures and consult experienced personnel. Outside support or training that may be necessary to perform new procedures shall be sought with project manager approval. Notes and references obtained should be retained for potential development into new operating procedure.

APPENDIX A
REFERENCES

A.1 References

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D420-98, "Standard Guide to Site Characterization for Engineering Design and Construction Purposes."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D653-01, "Standard Terminology Relating to Soil, Rock and Contained Fluids."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D1452-80, "Standard Practice for Soil Investigation and Sampling by Auger Borings."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6151-97, "Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D1586-99, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D3550-01, "Standard Test Method for Thick Wall, Ring-Lined, Split Barrel Drive Sampling of Soils."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D1587-00, "Standard Practice for Thin-Walled Tube Sampling of Soils."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D2113-99, "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D2488-93, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D4220-95, "Standard Practices for Preserving and Transporting Soil Samples."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5079-90, "Standard Practices for Preserving and Transporting Rock Core Samples."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5092-90, “Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5434-97, “Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock.”

- American Society of Civil Engineers, 1976," Subsurface Investigations for Design and Construction of Foundations of Buildings", Manual and Report on Engineering Practice, No. 56, 61 p.

- Hvorslev, M.J., 1949, "Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes", U.S. Army Engineer Waterways Experiment Station, Vicksburg, MI, 521 p.

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.11.04, E1527-00, “Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.11.04, E1528-00, “Standard Practice for Environmental Site Assessments: Transaction Screen Process.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.11.04, E1903-97, “Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5730-98, “Standard Guide for Site Characteristics for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone and Ground Water.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5088-90, “Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6286-98, “Standard Guide for Selection of Drilling Methods for Environmental Site Characterization.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6169-98, “Standard Guide for Selection of Soil and Rock Sampling Devices for Environmental Investigations.”

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D5781-95, "Standard Guide for the Use of Dual-Wall Reverse Circulation Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D5782-95, "Standard Guide for the Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D5783-95, "Standard Guide for the Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D5784-95, "Standard Guide for the Use of Hollow-Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6001-96, "Standard Guide Direct Push Water Sampling for Geoenvironmental Investigations."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D4700-91, "Standard Guide for Soil Sampling from the Vadose Zone."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.11.04, D4547-98, "Standard Guide for Sampling Waste and Soils for Volatile Organics."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D5903-96, "Standard Guide for Planning and Preparing for a Ground-Water Sampling Event."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6089-97, "Standard Guide for Documenting a Ground-Water Sampling Event."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D4750-87, "Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.11.04, D4448-01, "Standard Guide for Sampling Groundwater Monitoring Wells."
- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6452-99, "Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.09, D6517-00, “Standard Guide for Field Preservation of Ground-Water Samples.”

APPENDIX B
RELATED HALEY & ALDRICH PROCEDURES

- OP1001 Excavation and Trenching Safety
- OP1002 Drilling Safety
- OP1003 Utility Clearance
- OP2001 Identification & Description of Soils in the Field Using Visual-Manual Methods
- OP2002 Identification & Description of Rock in the Field Using Visual-Manual Methods
- OP2003 Surficial Geologic Mapping
- OP2005 Test Borings, Sampling, Standard Penetration Testing (STP) and Borehole Abandonment
- OP2017 Rock Coring
- OP2020 Groundwater Monitoring (Observation) Well Installation, Development and Abandonment
- OP2026 Exploratory Test Pits
- OP2028 Exploratory Probes
- OP2030 Direct Push Borings (Percussion-Vibration Driven Probes)

APPENDIX C
FORMS AND EXAMPLES

C.1 Forms

All Haley & Aldrich field forms are maintained on the server at K:\techproc\sop\Forms. The following is a list of selected current forms available for use in routine field exploration programs.

Site Investigations

- Form 2024 Site Investigation Form

Test Borings

- Form 2004 Subcontractor Quantities For Test Borings
- Form 2029 Sampling Labels - Geotechnical
- Form 2003 Test Boring Daily Field Report
- Form 2001 Test Boring Reports
- Form 2002 Core Boring Reports
- Form 2028 Geotechnical Sample Receiving Form

Observation (Monitoring) Wells

- Form 2007 Observation Well Installation Form
- Form 2013 Well Decommissioning Report
- Form 3006 Monitoring Well Development Report
- Form 2021 Groundwater Monitoring Report

Test Pits

- Form 2006 Test Pit Logs
- Form 2028 Geotechnical Sample Receiving Form

Test Probes

- Form 2022 Test Probe Report
- Form 2023 Test Probe Summary
- Form 2025 Vibracore Report

Environmental Sampling

- Form 1010 Headspace Screening Report
- Form 3001 Sampling Labels – Environmental
- Form 3002 Chain of Custody Electronic
- Form 3003 Chain of Custody Field
- Form 3004 Sampling Record
- Form 3005 Groundwater Sampling Record

C.2 Examples

The following examples of selected completed forms are intended to provide guidance in the standard documentation conventions practiced by H&A.

HALEY & ALDRICH

SITE INVESTIGATION FORM

PROJECT ____________________ **H&A FILE NO.** ____________
LOCATION ____________________ **PROJECT MGR.** ____________
CLIENT ____________________ **FIELD REP** ____________
CONTRACTOR ____________________ **DATE** ____________

SITE ACCESS
☐ Paved ☐ Gravel ☐ Trails ☐ None ☐ Water ☐ Inside ☐ Other ________

ENTRANCE
☐ Enclosed ☐ Gate/Keys Comments: ____________

EXPLORATION EQUIPMENT
☐ Truck Rig ☐ ATV Rig ☐ Skid Rig ☐ Tripod ☐ Geoprobe ☐ Other ________
☐ Backhoe ☐ Bobcat ☐ Excavator ☐ Sm Excavator ☐ Barge ☐ Other ________
☐ Chainsaw ☐ Haybales ☐ Plywood ☐ 4WD Vehicle ☐ Other ________

WATER SUPPLY AVAILABLE
☐ Hydrant ☐ Tap ☐ River/Lake ☐ None

ELECTRIC AVAILABLE:
☐ Yes ☐ No

TOPOGRAPHY
☐ Low Lying ☐ Level ☐ Sloping ☐ Cliffs ☐ Mountains ☐ Other ________

PHYSIOGRAPHY
☐ Bedrock ☐ Till Upland ☐ Valley Floor ☐ Flood Plain ☐ Coastal Plain ☐ Other ________
☐ Wetlands ☐ Tidal Marsh ☐ Estuarine ☐ Lakes/Ponds ☐ Outwash Plain ☐ Other ________
☐ Developed ☐ Filled Land ☐ Paved ☐ Landscaped ☐ Other ________

DRAINAGE
☐ Rivers ☐ Streams ☐ Rills ☐ Canals ☐ Ditches ☐ Culverts ☐ Other ________

ESTIMATED GROUNDSURFACE ELEVATION: ________ ft

ESTIMATED GROUNDWATER DEPTH/ELEVATION: ________ ft

WOODED
☐ Heavily ☐ Partially ☐ Sparsely ☐ Comments: ____________

VEGETATION
☐ Brush ☐ Grass ☐ None ☐ Comments: ____________

BEDROCK OUTCROPS
LOCATION: ____________
TYPE: ____________

SOIL EXPOSURES
LOCATION: ____________
TYPE: ____________

EXISTING STRUCTURES
☐ Buildings ☐ Warehouse ☐ Slabs ☐ Bridges ☐ Foundations ☐ Other ________

UNDERGROUND STORAGE TANKS
☐ Yes ☐ No

VISIBLE EVIDENCE OF CONTAMINATION
☐ Drums ☐ Staining ☐ Site history ☐ Unauthorized dumping ☐ Other ________

OVERHEAD UTILITIES
LOCATION: ____________
TYPE: ____________

UNDERGROUND UTILITIES
LOCATION: ____________
TYPE: ____________

COMMENTS: ____________

SITE INVESTIGATION FORM

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP	
CONTRACTOR		DATE	

SITE SKETCH

North Arrow

OVERALL DESCRIPTION AND REMARKS:	LEGEND
	Scale: 0

HALEY & ALDRICH

SUBCONTRACTOR QUANTITIES FOR TEST BORINGS

Form #2005

Project	**File No.**
Location	**Date**
Contractor	**Project Manager**

No.	Description	Unit	Quantity
I	**MOBILIZATION/DEMOBILIZATION**		
1	Mob/Demob of Truck rig w/ OSHA-trained crew within 100 miles of contractor yard*	ea	
2	Mob/Demob of Skid rig with OSHA-trained crew within 100 miles of contractor yard*	ea	
3	Mob/Demob of Bomb/ATV rig with OSHA-trained crew within 100 miles of contractor yard*	ea	
4	Mob/Demob of Geoprobe rig w/ OSHA-trained crew within 100 miles of contractor yard*	ea	
II	**DRILLING - FOOTAGE RATE**		
5	3-in. dia. cased overburden drilling (0-100 ft.) with no sampling	lf	
6	cased overburden drilling (0-100 ft.) with standard 5-ft. interval sampling	lf	
7	cased overburden drilling (0-100 ft.) continuous sampling	lf	
8	4-in. dia. cased overburden drilling (0-100 ft.) with no sampling	lf	
9	cased overburden drilling (0-100 ft.) with standard 5-ft. interval sampling	lf	
10	cased overburden drilling (0-100 ft.) continuous sampling	lf	
11	4-¼ in. dia. hollow stem auger overburden drilling (0-100 ft.) with no sampling	lf	
12	hollow stem auger overburden drilling (0-100 ft.) w/ standard 5-ft. interval sampling	lf	
13	hollow stem auger overburden drilling (0-100 ft.) continuous sampling	lf	
14	NX rock core via double-tube core barrel (includes bit wear)	lf	
15	HX rock core via double-tube core barrel (includes bit wear)	lf	
16	Extra split spoon samples (for footage rates only)	ea	
17	3-in. undisturbed tube samples	ea	
18	Standby Time for rig and crew/Decon of equipment	hr	
III	**DRILLING - DAY RATE**		
19	Truck mounted drill rig with OSHA-trained crew	day	
20	Truck mounted drill rig with OSHA-trained crew (overtime rate)	hr	
21	Skid rig with OSHA-trained crew	day	
22	Skid rig with OSHA-trained crew (overtime rate)	hr	
23	Bomb/ATV drill rig with OSHA-trained crew	day	
24	Bomb/ATV drill rig with OSHA-trained crew (overtime rate)	hr	
25	Geoprobe rig with OSHA-trained crew	day	
26	Geoprobe rig with OSHA-trained crew (overtime rate)	hr	
27	NX rock core via double-tube core barrel (includes bit wear for day rates)	lf	
28	HX rock core via double-tube core barrel (includes bit wear for day rates)	lf	
29	Geoprobe push samples liners (4' section)	ea	
IV	**OBSERVATION WELL INSTALLATION**		
30	1-in. dia. piezometer (Sch 40 PVC) installed	lf	
31	2-in. dia. well (Sch 40 PVC) installed (slotted and screened)	lf	
32	4-in. dia. well (Sch 40 PVC) installed (slotted and screened)	lf	
33	Standard 4-in. dia. roadway box	ea	
34	Standard 8-in. dia. roadway box	ea	
35	5 ft. protective guard pipe with padlock (4-in. diameter)	ea	
V	**ADDITIONAL ITEMS**		
36	Utility Clearance	ea	
37	Permits - Determined on a job to job basis	ls	
38	State Police Detail	hr	
39	Laborer	hr	
40	Chain Saw	day	
41	Steam Cleaner with Generator	day	
42	Upgrade Crew Personnel Protection to Level "C"	hr	
43	55 gal. soil/water drum	ea	
44	Borehole Grouting (4-in. diameter)	lf	
45	Sand	bag	
46	Concrete	bag	
47	Cold Patch	bag	
48			
49			
VI	**COMMENTS**		

Driller Signature ______________________ **Date** ________

Geologist Signature ______________________ **Date** ________

WHITE - FIELD SERVICE MANAGER **CANARY** - CONTRACTOR **PINK** - PROJECT MANAGER

Form 2004

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Boring ID:	**File Number:**
Sample Interval:	**Project:**
Depth:	**PM:**
Recovery:	**Blow Counts:**
Collected By:	/ / /
Comments:	

HALEY & ALDRICH

TEST BORING DAILY REPORT

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MANAGER	
CLIENT		FIELD REPRESENTATIVE	
CONTRACTOR		DATE	
DRILLER		DFR NUMBER	
TYPE OF RIG(S)		NUMBER OF RIGS	

SUBCONTRACTOR'S TIME ON SITE

Rig Type	Arrived	Left Site	Lunch/Other	Downtime	Standby Time	Total Billable Hours

HALEY & ALDRICH'S TIME ON SITE

Field Representive(s)	Arrived	Left Site	Lunch/Other	Paperwork	Travel Time	Total Billable Hours

WORK PRODUCTION TO DATE

Boring No.	Type of Drilling	Over Burden (lf)	Rock Core (lf)	Obstr. Drilling	Total Footage (lf)	Tubes Samples	Extra Split Spoons*	Misc. (Wells etc.)	Materials Encountered (Type and Depth Range)

STATUS OF TOTAL PRODUCTION

Unsampled	Continuos	Standard	Inside Dia.	Boring Footages: Item	Today	Total to Date	Estimate	% Complete	Additional pay Items	Today	Total to Date
									Observation Wells I.D. (ft)		
									Roadway Boxes (ea)		
				H.S.A.					Guard Pipes (ea)		
				Casing					Steamer and Generator (day)		
				Casing					Grout (lf)		
				Casing					Undisturbed Tube Samples (ea)		
				Uncased					Extra Split Spoons (ea)*		
				Rock Core					55 Gallon Drums (ea)		
				Geoprobe					Police Details (hr)		
									Stand by Time (hr)		

No. of Borings Completed	Remaining	Rig-Days to Date	Remaining

SYMBOLS

B 2-1/2 inch Standard	**A** 4 inch Hollow Stem Auger	**Z** Probes of Soundings	**T** 2 inch Shelby Tube	**Y** Pressure Test
N 3 inch Standard	**W** Water Borings	**C** Rock Core	**V** Vane Shear Test	**S** Observation Well
H 4 inch Standard	**X** Continuous Sampling	**U** 3 inch Piston Tube	**P** Permeability Test	

* Extra split spoon samples are for footage contracts only.

HALEY & ALDRICH

TEST BORING DAILY REPORT

REMARKS

TEST BORING REPORT

HALEY & ALDRICH

BORING NO.

Page 1 of

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE STARTED	
DRILLER		DATE FINISHED	

Elevation ft. | Datum | Boring Location

Item	Casing	Sampler	Core Barrel	Rig Make & Model			Hammer Type	Drilling Mud	Casing Advance
Type				☐ Truck	☐ Tripod	☐ Cat-Head	☐ Safety	☐ Bentonite	Type Method Depth
Inside Diameter (in.)				☐ ATV	☐ Geoprobe	☐ Winch	☐ Doughnut	☐ Polymer	
Hammer Weight (lb.)				☐ Track	☐ Air Track	☐ Roller Bit	☐ Automatic	☐ None	
Hammer Fall (in.)				☐ Skid	☐ ________	☐ Cutting Head	Drilling Notes:		

Depth (ft.)	Sampler Blows per 6 in.	Sample No. & Recovery (in.)	Sample Depth (ft.)	Well Diagram	Stratum Change (ft.)	USCS Symbol	Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0																	

Water Level Data					
			Depth in feet to:		
Date	Time	Elapsed Time (hr.)	Bottom of Casing	Bottom of Hole	Water

Sample ID

O	Open End Rod
T	Thin Wall Tube
U	Undisturbed Sample
S	Split Spoon Sample
G	Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (Linear ft.) ________
Rock Cored (Linear ft.) ________
Number of Samples ________

BORING NO.

Field Tests Dilatancy: R - Rapid S - Slow N - None Plasticity: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High Dry Strength: N - None L - Low M - Meduim H - High V - Very High

***NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.**

NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

J:forms\final\3700.xls

HALEY & ALDRICH

TEST BORING REPORT

BORING NO.

Page of

Depth (ft.)	Sampler Blows per 6 in.	Sample No. & Recovery (in.)	Sample Depth (ft.)	Well Diagram	Stratum Change (ft.)	USCS Symbol	Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel		Sand				Field Test			
								% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength

NOTES: FILE NO. BORING NO.

*NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

J:forms\final\3701.xls

HALEY & ALDRICH

CORE BORING REPORT

BORING NO.

Page 1 of

PROJECT
LOCATION
CLIENT
CONTRACTOR
DRILLER

H&A FILE NO.
PROJECT MGR.
FIELD REP.
DATE STARTED
DATE FINISHED

Elevation ft	Datum	Boring Location		
Item	Casing	Sampler	Core Barrel	Rig Make & Model
Type				☐ Truck ☐ Tripod ☐ Cat-Head
Inside Diameter (in)				☐ ATV ☐ Geoprobe ☐ Winch
Hammer Weight (lb)				☐ Track ☐ Air Track ☐ Roller Bit
Hammer Fall (in)				☐ Skid ☐ ________ ☐ Cutting Head

Hammer Type: ☐ Safety ☐ Doughnut

Drill Mud: ☐ Bentonite ☐ Polymer ☐ None

Casing: ☐ Driven ☐ Spun

Depth (ft)	Drilling Rate (min/ft)	Core No. Depth (ft)	Recovery (in)	RQD (%)	Weath-ering	Well Diagram	Stratum Change (ft)	Visual Classification and Remarks

Water Level Data					
Date	Time	Elapsed Time (hr.)	Depth in feet to: Bottom of Casing	Bottom of Hole	Water

Sample ID
- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon Sample
- G Geoprobe

Well Diagram
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (Linear ft.)
Rock Cored (Linear ft.)
Number of Samples

BORING NO.

J:forms\final\Frm_3702.xls

HALEY & ALDRICH

CORE BORING REPORT

BORING NO.	
Page	of

Depth (ft)	Drilling Rate (min/ft)	Core No. Depth (ft)	Recovery	RQD	Weath-ering	Well Diagram	Stratum Change (ft)	Visual Classification and Remarks
			(in)	(%)				

FILE NO.	BORING NO.

I:\forms\final\Frm_3702

GEOTECHNICAL SAMPLE RECEIVING REPORT

HALEY & ALDRICH

Page ____ of ____

PROJECT ____________________ H&A FILE NO. ____________
LOCATION ____________________ PROJECT MGR. ____________
CLIENT ____________________ PROJECT ENGR. ____________
DELIVERED BY ____________________ DATE ____________

TYPE OF SAMPLE

SOIL:

Jar Samples ________ box(es)

Undisturbed Tube Samples:
Outside Diameter: ☐ 3-in. ☐ 2-in. ________ tube(s)

*** Bag Samples ________ bag(s)
*** 5-gal. Bucket Samples ________ bucket(s)

ROCK CORE:

Boxes: ________ box(es)

Other: ________ sample(s)

OTHER: ____________________

HAZARDOUS MATERIALS? ☐ Yes ☐ No

CONTAMINANTS (please list major contaminants)

If geology/pre-construction project, fill out Section A - If Con-Mon project, fill out Section B.

A:

Box No.	Exploration No.	Sample No.(s) From - To	Depth From - To	Remarks {if multiple types of samples, list type, (e.g., jars, tube, bag, rock)}

B:

Explor. No.	Sample No.	Depth Range (ft)	Sample Description (USCS or geologic unit)	Sample Source (on-site, Contractor Pit, etc.)	Proposed Use (see below)

For "Proposed Use" try to use the term from the specifications (e.g., structural fill, common fill, dense graded, State Highway Spec. No., etc.)

Notes: ____________________

*** ANY BAG/BUCKET SAMPLE WHICH HAS NOT HAD TESTING ASSIGNED AFTER 3 WEEKS OF RECEIVING WILL BE AUTOMATICALLY DISPOSED OF UNLESS THE LABORATORY MANAGER IS GIVEN PRIOR WRITTEN NOTIFICATION OF THE NEED TO RETAIN THE SAMPLE.

To be completed by lab personnel:

Sample received by: ____________________ Boxes Labeled? ☐ Yes ☐ No

STORAGE LOCATION:

☐ Geotechnical Laboratory
☐ Humid Room
☐ Storage Room / Shelf Location: ____________________
☐ Other: ____________________

HALEY & ALDRICH

GEOTECHNICAL SAMPLE RECEIVING REPORT

PROJECT	MAXIM OFFICE PARK	**H&A FILE NO.**	11111-030
LOCATION	BOSTON, MASSACHUSETTS	**PROJECT MGR.**	S. KRAEMER
CLIENT	BOSTON ARCHITECTS, INC.	**PROJECT ENGR.**	M. LALLY
DELIVERED BY	JOE SAND	**DATE**	03/14/02

TYPE OF SAMPLE

SOIL:

Jar Samples 2 box(es)

Undisturbed Tube Samples:

Outside Diameter: ☐ 3-in. ☐ 2-in. 2 tube(s)

*** Bag Samples 3 bag(s)

*** 5-gal. Bucket Samples ____ bucket(s)

ROCK CORE:

Boxes: 2 box(es)

Other: ____ sample(s)

OTHER: ____

HAZARDOUS MATERIALS? ☐ Yes ☑ No

CONTAMINANTS (please list major contaminants)

If geology/pre-construction project, fill out Section A - If Con-Mon project, fill out Section B.

A:

Box No.	Exploration No.	Sample No.(s) From - To	Depth From - To	Remarks {if multiple types of samples, list type, (e.g., jars, tube, bag, rock)}
1	B-01	S01 - S19	-	jars
1	B-02	S01 - S04	-	jars
2	B-02	S05 - S14	-	jars
-	B-01	U1	58.0 - 60.0	tube R=24
-	B-02	U1	68.0 - 70.	tube R=22
1	B-01	C01 - C03	-	rock core
-	TP-01	B01	5.0 - 9.0	ziplock bag

B:

Explor. No.	Sample No.	Depth Range (ft)	Sample Description (USCS or geologic unit)	Sample Source (on-site, Contractor Pit, etc.)	Proposed Use (see below)
TP-04	B01	8.5 - 10.7	Glacial Till	on-site	Common Fill
-	S12	n/a	Brown silty sand	Joe's Borrow Pit, Stoughton, MA	Structural Fill

For "Proposed Use" try to use the term from the specifications (e.g., structural fill, common fill, dense graded, State Highway Spec. No., etc.)

Notes:

*** ANY BAG/BUCKET SAMPLE WHICH HAS NOT HAD TESTING ASSIGNED AFTER 3 WEEKS OF RECEIVING WILL BE AUTOMATICALLY DISPOSED OF UNLESS THE LABORATORY MANAGER IS GIVEN PRIOR WRITTEN NOTIFICATION OF THE NEED TO RETAIN THE SAMPLE.

To be completed by lab personnel:

Sample received by: ____ Boxes Labeled? ☐ Yes ☐ No

STORAGE LOCATION:

☐ Geotechnical Laboratory ☐ Storage Room / Shelf Location: ____

☐ Humid Room ☐ Other: ____

OBSERVATION WELL INSTALLATION REPORT

HALEY & ALDRICH

Well No.

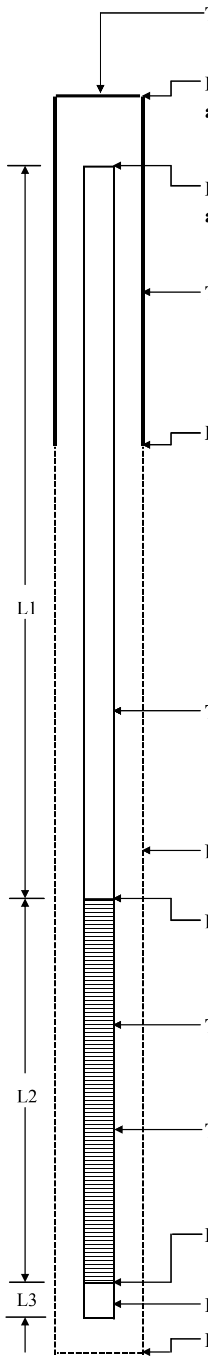
Boring No.

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE INSTALLED	
DRILLER		WATER LEVEL	

Ground El. ______ ft
El. Datum ______
Location ______
☐ Guard Pipe
☐ Roadway Box

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)



Type of protective cover/lock ______

Height/Depth of top of guard pipe/roadway box above/below ground surface ______ ft

Height/Depth of top of riser pipe above/below ground surface ______ ft

Type of protective casing: ______
Length ______ ft
Inside Diameter ______ in

Depth of bottom of guard pipe/roadway box ______ ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete		
Bentonite Seal		

Type of riser pipe: ______
Inside diameter of riser pipe ______ in
Type of backfill around riser ______

Diameter of borehole ______ in

Depth to top of well screen ______ ft

Type of screen ______
Screen gauge or size of openings ______ in
Diameter of screen ______ in
Type of backfill around screen ______

Depth of bottom of well screen ______ ft

Bottom of Silt trap ______ ft

Depth of bottom of borehole ______ ft

(Not to Scale)

______ ft +	______ ft +	______ ft =	______ ft
Riser Pay Length (L1)	Length of screen (L2)	Length of silt trap (L3)	Pay length

COMMENTS: ______

Form 2007

HALEY & ALDRICH

MONITORING WELL DEVELOPMENT REPORT

Well No.

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE	
ELEVATION SUBTRAHEND			

Estimated Volume of Water Lost During Drilling: ____________ gallons

Comments: ____________

Depth to Water Before Development: ____________ feet

Comments: ____________

Depth to Well Bottom Before Development: ____________ feet

Comments: ____________

Turubitiy of Water Before Development: ____________ NTU

Comments: ____________

Volume of Water Removed: ____________ gallons

Comments: ____________

Method of Removal (bailing, pumping): ____________

Comments: ____________

Depth to Well Bottom After Development: ____________ feet

Comments: ____________

Depth to Water After Development: ____________ feet

Comments: ____________

Turubitiy of Water After Development: ____________ NTU

Comments: ____________

HALEY & ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER

Page of

PROJECT ____________________ H&A FILE NO. ____________
LOCATION ____________________ PROJECT MGR. ____________
CLIENT ____________________ FIELD REP. ____________
CONTRACTOR ____________________ DATE ____________
ELEVATION SUBTRAHEND ____________________

Date	Time	Elapsed Time (days)	Depth of Water from Ground Surface	Elevation of Water	Remarks	Read By

HALEY & ALDRICH

TEST PIT LOG

Test Pit No.	
Page 1	of

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP	
CONTRACTOR		DATE	
EQUIPMENT		WEATHER	

Ground El. ___ ft. El. Datum ___	Location ___	Groundwater depths/entry rates (in./min.):

Depth (ft.)	Sample ID	Stratum Change Depth (ft.)	USCS Symbol	Visual Identification (Color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel		Sand				Field Test			
					% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength

Obstructions:	Remarks:	Field Tests	
		Dilatancy:	R - Rapid S - Slow N- None
		Toughness:	L - Low M - Medium H - High
		Plasticity:	N - Nonplastic L - Low M - Medium H - High
		Dry Strength:	N - None L - Low M - Medium H - High V - Very High

Standing water in completed pit:
at depth ___ ft.
measured after ___ hrs. elapsed

Boulders:

Diameter (in.)	Number		Approx. vol. (cu. ft.)
12 to 24		=	
over 24		=	

Test Pit Dimensions (ft.):
Pit Depth ___
Pit Length X Width ___

NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

J:\forms\final\Frm_3708

HALEY & ALDRICH

ENVIRONMENTAL TEST PIT LOG

Test Pit No.

Page of

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP	
CONTRACTOR		DATE	
EQUIPMENT		WEATHER	

Ground El. ______ ft.	Location	Groundwater depths/entry rates (in./min.):
El. Datum		

Depth (ft.)	Sample ID	PID Reading (ppm.)	Stratum Change Depth (ft.)	USCS Symbol	Visual Identification (Color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel		Sand				Field Test			
						% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength

Obstructions:	Remarks:	Field Tests
		Dilatancy: R - Rapid S - Slow N- None
		Toughness: L - Low M - Medium H - High
		Plasticity: N - Nonplastic L - Low M - Medium H - High
	Bucket Decontamination Method:	Dry Strength: N - None L - Low M - Medium H - High V - Very High

Standing water in completed pit:		Boulders: Diameter (in.)	Number	Approx. vol. (cu. ft.)	Test Pit Dimensions (ft.):	
at depth	______ ft.	12 to 24	______	= ______	Pit Depth	______
measured after	______ hrs. elapsed	over 24	______	= ______	Pit Length X Width	______

NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

J:\forms\final\Frm_3709.xls

HALEY & ALDRICH

TEST PROBE REPORT

PROBE NO.

Page 1 of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	
EQUIPMENT		**DRILLER**	

Rig Type:	**TOP OF ROCK BASED ON:**	Datum
Diameter of Hole:	☐ Rate of Penetration ☐ Acoustic Device	Ground El.
Drill Bit type:	☐ Driller's Opinion ☐ Other	Water El.
Drill Bit O.D.:	DEPTH TO TOP OF SOUND ROCK	Location:

Scale In Feet	Cutting Description and Remarks

Form 2022

HALEY & ALDRICH

TEST PROBE SUMMARY

Page   of

PROJECT ______________________ H&A FILE NO. ______________
LOCATION ______________________ PROJECT MGR. ______________
CLIENT ______________________ FIELD REP ______________
CONTRACTOR ______________________ DATE ______________
EQUIPMENT ______________________ DRILLER ______________

Probe Type ______________________

Probe No.	Location	Ground Surface Elevation	Depth to Water (ft)	Depth Probed		Soil Strata Description	Remarks
				From (ft)	To (ft)		

HALEY & ALDRICH

VIBRACORE REPORT

Probe No.	
Page 1 of 1	

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		GEOLOGIST	
CONTRACTOR		DATE	
EQUIPMENT		CHECKED BY	

Depth (ft)	Sketch	Visual Description	Recovery			
0			Section	Tube Length	Sample Length	Total Weight
1			Top:			
2			Bottom:			
3			Notes:			
4			Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.			
5			Remarks:			
6						
7						
8						
9						
10						

HALEY & ALDRICH

HEADSPACE SCREENING REPORT

PROJECT ____________ H&A FILE NO. ____________
LOCATION ____________ PROJECT MGR. ____________
CLIENT ____________ FIELD REP ____________
INSTRUMENT ____________ DATE SAMPLED ____________
DATE CALIBRATED (1) ____________ LAMP (eV) ____________ DATE SCREENED ____________
AMBIENT TEMPERATURE ____________ CALIBRATED BY ____________ SCREENING LOC. ____________

Exploration	Sample Number	Depth (ft)	Sample Description	Sample Reading (ppm)(2)	Back-Ground Reading (ppm)(2)	Remarks	GC(3)	Containers			
								Drill Jar			

1. Instrument calibrated to the manufacturer standard.
2. ppm represents concentration of detectable volatile gaseous compounds in parts per million of air.
3. Sample assigned for gas chromatograph screening.

Sampled and relinquished by:	Received by:	Relinquished by:	Received by:
Sign:	Sign:	Sign:	Sign:
Print:	Print:	Print:	Print:
Firm:	Firm:	Firm:	Firm:
Date: Time:	Date: Time:	Date: Time:	Date: Time:

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH
Haley & Aldrich, Inc.
465 Medford St.,
Suite 2200,
Boston, MA 02129-1400

CHAIN OF CUSTODY RECORD

Phone (617) 886-7400
Fax (617) 886-7700

Page of

H&A FILE NO. ______ LABORATORY ______ DELIVERY DATE ______
PROJECT NAME ______ ADDRESS ______ TURNAROUND TIMI ______
H&A CONTACT ______ PROJECT MANAGER ______ DELIVERY DATE ______

Sample No.	Date	Time	Depth	Type	Container Size	No. of Containers	Analysis Requested	Preservatives	Comments - (special instructions, precautions, additional method numbers, etc.)

Sampled and Relinquished by	Received by
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time

PRESERVATION KEY	Sampling Comments
A Sample chilled	
B Sample filtered	
C NaOH	
D HNO_3	
E H_2SO_4	
F HCL	
G Methanol	
H Sodium Bisulfate	
I	

Evidence samples were tamperd with? **YES** **NO**
If YES, please explain in section below.

WHITE - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3002

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	**File Number:**
Depth:	**Project:**
Date:	**Analysis:**
Time:	**Preservative:**
Collected By:	**Laboratory:**
Comments:	

HALEY & ALDRICH

Haley & Aldrich, Inc.
465 Medford St.,
Suite 2200,
Boston, MA 02129-1400

CHAIN OF CUSTODY RECORD

Phone (617) 886-7400
Fax (617) 886-7600

Page of

H&A FILE NO.		LABORATORY		DELIVERY DATE	
PROJECT NAME		ADDRESS		TURNAROUND TIME	
H&A CONTACT		CONTACT		PROJECT MANAGER	

Sample No.	Date	Time	Depth	Type	Analysis Requested: VOA	ABNs PAH only	Metals RCRA (8) PP(13)	Pesticides PCBs	VPH Full Suite C-ranges only	EPH Full Suite C-ranges only	TPH (specify)	TCLP (specify)	Reactivity Ignitability Corrosivity				Number of Containers	Comments (special instructions, precautions, additional method numbers, etc.)

Sampled and Relinquished by	Received by
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time

LIQUID

												VOA Vial
												Amber Glass
												Plastic Bottle
												Preservative
												Volume

SOLID

												VOA Vial
												Amber Glass
												Clear Glass
												Preservative
												Volume

PRESERVATION KEY

A Sample chilled	**C** NaOH	**E** H_2SO_4	**G** Methanol
B Sample filtered	**D** HNO_3	**F** HCL	**H** Sodium Bisulfate

Sampling Comments

Evidence samples were tampered with? YES NO

If YES, please explain in section below.

WHITE - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3003

WATER AND WASTEWATER METHODS

Analysis Description	Method No.	Preservative	Solid Sample Volume/Container	Liquid	Holding Time
Alkalinity	310	Cool 4° C	N/A	250 mL HDPE	14 days
Amenable Cyanide	Std. Mth. 412 F.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Ammonia	350	pH<2 H2SO4, Cool 4° C	N/A	1 L HDPE	28 days
Base/Neutral & Acid Extractables	625	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Biochemical Oxygen Demand (BOD)	405.1	Cool 4° C	N/A	2 L HDPE	48 hours
Chemical Oxygen Demand (COD)	410	pH<2 H2SO4, Cool 4° C	N/A	125 mL HDPE	28 days
Chloride	300.0, 325	None Required	N/A	125 mL HDPE	28 days
Chromium, Hexavalent	3500D, 218.4/5	None Required	N/A	1 L HDPE	24 hours
Fluoride	300.0, 340	None Required	N/A	500 mL HDPE	28 days
Hardness, Total (as CaCO3)	130	pH<2 H2SO4, Cool 4° C	N/A	250 mL HDPE	6 Months
Nitrate	300.0, 352.1	Cool 4° C	N/A	250 mL HDPE	48 Hours
Nitrite	300.0, 354.1	Cool 4° C	N/A	125 mL HDPE	48 Hours
Orthophosphate	300.0, 365	Filter, Cool 4° C	N/A	125 mL HDPE	48 Hours
PCBs	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Pesticides	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanide	MADEP draft	pH>12 NaOH, 4° C	N/A	1 L HDPE	14 days
Priority Pollutant Metals (13 Metals)	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Purgeable Halocarbons & Aromatics	601/602	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
RCRA Metals (8 Metals)	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Sulfate	300.0, 375	Cool 4° C	N/A	250 mL HDPE	28 days
Sulfide	376	pH>9 NaOH, Zn Acetate, Cool 4° C	N/A	1 L HDPE	7 days
Sulfite	377.1	None Required	N/A	125 mL HDPE	Analyze Immediately
Total Cyanide	335	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Total Dissolved Solids (TDS)	209	Cool 4° C	N/A	250 mL HDPE	7 days
Total Organic Carbon (TOC)	415	pH<2 HCl or H2SO4, Cool 4° C, Dark	N/A	40 mL Amber	28 days
Total Organic Halogen (TOX)	506	pH<2 HNO3, 4° C	N/A	1 L Amber	check with lab
Total Phenolics	420.1	pH<2 H2SO4, Cool 4° C	N/A	1 L Amber	28 days
Total Phosphorus	365	pH<2 H2SO4, Cool 4oC	N/A	125 mL HDPE	28 days
Total Solids (TS)	160.3	Cool 4° C	N/A	250 mL HDPE	7 days
Total Suspended Solids (TSS)	160.2	Cool 4° C	N/A	250 mL HDPE	7 days
Volatile Organics	624	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
Weak and Dissociable Cyanide	Std. Mth. 412 H.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
DRINKING WATER ANALYSIS					
Volatile Organics	502.2 or 524.2	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
MICROBIOLOGY					
Fecal Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Standard Plate Count	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Total Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Yeast and Mold	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours

SOIL/SEDIMENTS/WATER

Analysis Description	Method No.	Solids (S) / Liquids (L) Preservative	Solid Sample Volume/Container	Liquid	Holding Time
Acid Extractables/Base/Neutral Extractables	8270	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Amenable Cyanide	-	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Chromium, Hexavalent	3060A/7196	S/L: Cool 4° C	8 oz. CWM	1 L HDPE	24 hours
Extractable Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Herbicides	8150	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Non-Halogenated Organics	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
PAH (low level)	8310 or GC/MS SIM	S/L: Cool 4° C	8 oz. AWM	1 L Amber	7 days Ext/40 days Analyze
Paint Filter Liquids Test	9095	S: Cool 4° C	8 oz. CWM	1 L Amber	Analyze ASAP
PCBs	8082	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Pesticides	8081	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanide	MADEP draft	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Priority Pollutant Metals(13 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
RCRA Metals (8 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
Total Cyanide	9010	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Volatile Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
Volatile Organics	8260B, 8021	S: methanol/$NaHSO_4$, 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
RCRA HAZARDOUS WASTE CHARACTERIZATION					
Corrosivity (pH only)	SW846-7.2	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Ignitability/Flashpoint	SW846-7.1	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Reactivity (CN-/S2-)	SW846-7.3	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
TCLP (RCRA 8) Metals (check for mercury)	1311	S: Cool 4° C	16 oz. CWM	check with lab	6 mos. Ext/6 mos. Analyze
TCLP Pesticides/Herbicides	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Semivolatiles	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Volatiles	1311	S: Cool 4° C	8 oz. CWM	check with lab	14 days Ext/14 days Analyze
HYDROCARBON OIL & GREASE ANALYSIS					
MADEP EPH Method	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP EPH Method (C-Ranges only)	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP VPH Method	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP VPH Method (C-Ranges only)	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP EPH Method - with selected PAHs (including acenaphthene, naphthalene, 2-methylnaphthalene, and phenanthrene)	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
Petroleum Identification	ASTM D3328				
Quantitative (include Chromatograms)		S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days
Total Petroleum Hydrocarbons (Infrared)	418.1	S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days

AIR METHODS

Analysis Description	Method No.	Preservative	Sample Volume/Container		Holding Time
Volatile Organic Compounds	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
Volatile Organic Compounds	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours
VPH in air	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
VPH in air	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours

HALEY & ALDRICH

SAMPLING RECORD

Page ____ of ____

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

Weather ______ **Temperature** ______

Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other___________

Comments ______

SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION

Sample No.	Location	Depth (ft)	Time	Sample Description	Sampling Device	Cleaning Prodedure	Container Type

General Comments: (ie: field filtrations, persons communicated with at site, etc.)

HALEY & ALDRICH

GROUNDWATER SAMPLING RECORD

PROJECT ______________________ H&A FILE NO. ______________
LOCATION ______________________ PROJECT MGR. ______________
CLIENT ______________________ FIELD REP ______________
CONTRACTOR ______________________ DATE ______________

GROUNDWATER SAMPLING INFORMATION

Well No.							
Water Depth (ft)							
Time							
Product							
Depth Of Well (ft)							
Inside Diameter (in)							
Standing Water Depth (ft) (1)							
Volume Of Water In Well (gal)							
Purging Device							
Volume of Bailer/Pump Capacity							
Cleaning Procedure							
Bails Removed/ Volume Removed							
Time Purging Started							
Time Purging Stopped							
Sampling Device							
Cleaning Procedure							
TIME SAMPLES TAKEN: VOA							
TIME SAMPLES TAKEN: ABN							
TIME SAMPLES TAKEN: Metals							
TIME SAMPLES TAKEN:							
TIME SAMPLES TAKEN:							
TIME SAMPLES TAKEN:							
PARAMETERS: Color							
PARAMETERS: Odor							
PARAMETERS: pH							
PARAMETERS: Conductivity							
PARAMETERS: Turbidity							
PARAMETERS: Dissolved Oxygen							
PARAMETERS: Temp, ^{0} C							
PARAMETERS: Salinity							

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

HALEY & ALDRICH

TEST BORING REPORT

BORING NO. **B 7 (OW)**

Page 1 of 2

PROJECT	Greenspace Development	**H&A FILE NO.**	27921-000
LOCATION	18 Riverside Road, Boston Massachusetts	**PROJECT MGR.**	S.R. Kraemer
CLIENT	Ecologic Investments	**FIELD REP.**	C.S. Osgood
CONTRACTOR	Guild Drilling Co., Inc.	**DATE STARTED**	13-Feb-01
DRILLER	Charlie O'Donnel	**DATE FINISHED**	14-Feb-01

Elevation 23.3 ft. **Datum** Boston City **Boring Location** See sketch on reverse of form.

Item	Casing	Sampler	Core Barrel	Rig Make & Model: CME 75			Hammer Type	Drilling Mud	Casing Advance
Type	NW	S	NV2	☑ Truck	☐ Tripod	☑ Cat-Head	☑ Safety	☑ Bentonite	Type Method Depth
Inside Diameter (in.)	3	1.385	2	☐ ATV	☐ Geoprobe	☐ Winch	☐ Doughnut	☐ Polymer	NW Driven 29.0 ft.
Hammer Weight (lb.)	300	140		☐ Track	☐ Air Track	☑ Roller Bit	☐ Automatic	☐ None	
Hammer Fall (in.)	24	30		☐ Skid	☐	☐ Cutting Head	Drilling Notes: Flushed slurry prior to coring.		

Depth (ft.)	Sampler Blows per 6 in.	Sample No. & Recovery (in.)	Sample Depth (ft.)	Well Diagram	Stratum Change (ft.)	USCS Symbol	Visual-Manual Identification & Description (density/consistency, color, GROUP NAME & SYMBOL, maximum particle size*, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	10		0.0			SP-SM	Medium dense brown poorly graded SAND with silt (SP-SM),				20	70	10				
	12	S1					mps 2 mm, distinctly stratified, fines partially organic, no odor, dry.										
	15	21"															
	20		2.0		2.0		-ALLUVIUM-										
	11		2.0			SP	Dense brown poorly graded SAND (SP), mps 25 mm, no odor, dry.	5	5	20	30	35	5				
	15	S2															
	16	10"															
	17		4.0				-ALLUVIUM-										
					4.5												
5	WOR		5.0				Very soft, dark brown ORGANIC SOILS with sand (OL/OH), trace					25	75	S	M	H	VH
	WOR	S3				OL/OH	seashell fragments and particles, soil mps 0.5 mm, strong										
	WOH	24"					organic odor, moist.										
	WOH		7.0				-ORGANIC DEPOSIT-										
					8.0												
							Note: Drilling fluid returning medium to fine sand from 8.0 ft. to										
							10.0 ft. Drilling fluid color change to yellow red at 8.5 ft.										
							-PROBABLE MARINE DEPOSIT-										
					10.0												
10	3		10.0			CH	Stiff yellow brown fat CLAY (CH), trace fine sand, mps 0.5 mm,						100	N	M	H	
	6	S4					apparently laminated with frequent fine sand partings and										
	6	22"					possible organic fibers, no odor, moist.										
	6		12.0				-MARINE DEPOSIT-										
					13.5												
							Note: Drill action indicates gravel below 13.5 ft.										
15	12		15.0			CL	Very stiff yellow brown to gray sandy lean CLAY with gravel (CL),	5	10	10	10	15	50	S	M	M	
	14	S5					mps 35 mm, distinct disrupted laminae in discrete zones, coarse										
	15	17"					fraction consists of well rounded igneous and igneous and										
	19		17.0				metamorphic lithologies, no odor, moist.										
							-GLACIOMARINE DEPOSIT-										
					18.0												
							Note: Drill action and total loss of drilling fluid indicates gravel										
					19.0		and cobbles from 18.0 ft. to 19.0 ft.										
							Very dense gray silty SAND (SM), mps 15 mm, very well bonded,										
20	21	S6	20.0			SM	coarse fraction consists partly of platy argillite fragments, no odor, moist.		10	15	20	30	25	R			
	25	10"	21.0		21.0		-GLACIAL TILL-										
	33	S6A	21.0			ML	Very dense gray SILT (ML), mps <0.1 mm, no structure, no odor,						100	R		N	
	34	7"	22.0				dry.										
							-RESIDUAL SOIL-										
							Note: Drilling advanced smoothly from 21.0 ft. to 25.0 ft.										
					25.0		PROBABLE TOP OF DECOMPOSED BEDROCK 25.0 FT.										
25	53		25.0				Very dense gray highly to completely weathered ARGILLITE.										
	28	S7					Possible extremely thin relect bedding subparallel to strong										
	39	5"					low angle foliation. Sample is generally well bonded and consists										
	35		27.0				of very soft angular fragments and particles which are easily										
							crushed with finger pressure.										
							-DECOMPOSED BEDROCK-										
							Note: Drill action indicates stratum change at 28.5 ft.										
					28.5		TOP OF "SOUND" BEDROCK 28.5 FT.										
							SEE SHEET 2 FOR CORE BORING REPORT										
30																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth in feet to: Bottom of Casing	Bottom of Hole	Water
13-Feb-01	15:30	0	29.0	29.0	2.0
14-Feb-01	7:00	15.5	29.0	29.0	6.2
14-Feb-01	15:00	1.0	39.5	39.5	10.4

Sample ID
- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon Sample
- G Geoprobe

Well Diagram
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (Linear ft.)	29.5
Rock Cored (Linear ft.)	10.0
Number of Samples	S7 C2
BORING NO.	**B 7 (OW)**

Field Tests Dilatancy: R - Rapid S - Slow N - None Plasticity: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High Dry Strength: N - None L - Low M - Meduim H - High V - Very High

***NOTE: Maximum Particle Size is determined by direct observation within the limitations of sampler size.**

NOTE: Soil identifications based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

CORE BORING REPORT

Depth (ft)	Drilling Rate (min/ft)	Core No. Depth (ft)	Recovery (in)	RQD (%)	Weathering	Well Diagram	Stratum Change (ft)	Visual Classification and Remarks
								SEE SHEET 1 TEST BORING REPORT FOR OVERBURDEN DETAILS.
							21.0	TOP OF RESIDUAL SOIL 21.0 FT.
								Note: Advanced borehole with rollerbit and splitspoon and drove NW casing through residual
								soil from 21.0 ft. to 25.0 ft.
					Residual			
					Soil			-RESIDUAL SOIL-
							25.0	TOP OF DECOMPOSED BEDROCK 25.0 FT.
25								
					High			Note: Advanced borehole with rollerbit and splitspoon and drove NW casing through
					to			decomposed bedrock from 25.0 ft. to 28.5 ft.
					Complete			
								-DECOMPOSED BEDROCK-
							28.5	TOP OF "SOUND" BEDROCK 28.5 FT.
								Note: Seated NW casing at 29.0 ft. Advanced borehole with rollerbit to 29.5 ft. without sampling
								prior to coring.
		29.5	56"		Slight			C1: Moderately hard, slightly weathered, gray, aphanitic ARGILLITE. Bedding extremely thin to
30								very thin, generally low angle (30-35 degrees). Foliation low angle, commonly subparallel to
	6							bedding. Cleavage well developed along bedding/foliation planes where coincident.
					Mod.			Cleavage joints very close to close 29.5 -31.0 ft. and close below 32.5 ft. smooth-planar,
	3	C1			High			slightly oxidized, occasionally calcite-infilled, tight. High angle to vertical joints moderately
					Mod.			close, rough-undulatory, pyritized or highly oxidized and decomposed with silt infilling, open.
	5							Soft, moderately to highly weathered zone 31.0-32.5 ft. associated with extremely close,
					Slight			moderately dipping, slickensided-planar shears intersecting bedding plane and high angle features.
	6							Note: Partial water loss below 31.0 ft.
		34.5	24"	40%				Note: Lost core assumed 31.7-32.0 ft.
35	6	34.5	60"	100%				C2: Similar to bottom of run C1 except cleavage joints close to moderately close. High angle to
								vertical joints absent. Occasional thin zone of extremely close, extremely thin, moderately
	7							dipping to high angle (50-60 degrees) calcite stringers. Occasional calcite-healed low angle
								joint.
	6	C2			Slight			-CAMBRIDGE FORMATION-
	6						38.0	
								Lithology change at 38.0 ft. to hard, slightly weathered, dark gray to black, fine grained to
	8							aphanitic DIABASE. Single high angle joint at 38.7 ft. rough-stepped, slightly oxidized, tight.
		39.5	54"	90%				
40	8							BOTTOM OF EXPLORATION 39.5 FT.

HALEY & ALDRICH

TEST PIT LOG

Test Pit No. TP-1

Page 1 of 1

PROJECT	New England Hospital	**H&A FILE NO.**	10715-205
LOCATION	Boston, Massachusetts	**PROJECT MGR.**	M.X. Haley
CLIENT	PFT Associates	**FIELD REP**	C. S. Osgood
CONTRACTOR	J. Marchese & Sons Const.	**DATE**	07-Jan-02
EQUIPMENT	CAT 416 Rubber Tire Extendahoe 0.24 cu.yd. bucket capacity	**WEATHER**	Mostly Clear 20s

Ground El.	36.3 ft.	**Location**	West of Pedestrian Tunnel
El. Datum	NGVD	**Groundwater depths/entry rates (in./min.):**	7.8 ft. Steadily

Depth (ft.)	Sample ID	Stratum Change Depth (ft.)	USCS Symbol	Visual Identification (density/consistency, color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
				Dark brown silty SAND (SM), mps 5 mm, organic odor, moist.		5	5	10	45	40	R			
	0.5		SM	Fines largely organic.										
				-LOAM FILL-										
		1.3												
2	S3			Yellow brown to olive brown sandy fat CLAY (CH), trace roots, clinker fragments,	5	5	5	10	15	60	N	M	H	
			CH	cinder particles and fragments, clay pipe fragments, metal wire, asphalt fragments.										
				10% cobbles, <5% boulders, mps 30 in., no odor, moist.										
				-FILL-										
4	4.0			Note: Poured concrete foundation wall on east side of test pit from 0.0 -4.4 ft.										
	4.0													
				Note: Poured concrete foooting 4.4-5.4 ft.										
6	S2													
	8.0	8.0												
8	8.0			Yellow brown fat CLAY (CH), trace fine sand. mps 0.5 mm, no odor, dry.					5	95	N	M	H	
	S1		CH	Appartantly laminated with frequent fine sand partings and possible organic fibers.										
	9.0			-MARINE DEPOSIT-										
10														
		11.0												
				Yellow brown to gray sandy lean CLAY (CL) with gravel. mps 35 mm,	5	10	10	10	15	50	S	M	L	
			CL	Distinct disrupted laminae in discrete zones. Coarse fraction consists of well-rounded										
				igneous and metemorphic lithologies.										
12	12.0	12.0		-GLACIOMARINE DEPOSIT-										
				Note: Possible stratum change to gray lean CLAY with sand (CL) below 12.0 ft.										
				Coarse fraction apparantly less abundent.										
				-MARINE DEPOSIT-										
				BOTTOM OF EXPLORATION 13.5 FT.										
14														

Obstructions:

Remarks:
Note: Bag samples S1-S3 obtained for potential mechanical analysis from depths indicated.

Field Tests

Dilatancy:	R - Rapid S - Slow N- None
Toughness:	L - Low M - Medium H - High
Plasticity:	N - Nonplastic L - Low M - Medium H - High
Dry Strength:	N - None L - Low M - Medium H - High V - Very High

Standing water in completed pit:
at depth 13.2 ft.
measured after 0.1 hrs. elapsed

Boulders:

Diameter (in.)	Number		Approx. vol. (cu. ft.)
12 to 24	1	=	1.8
over 24	1	=	8.2

Test Pit Dimensions (ft.):
Pit Depth 13.5
Pit Length X Width 9.0 x 6.0

NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

K:\template\forms\uscstp.xls

ENVIRONMENTAL TEST PIT LOG

HALEY & ALDRICH

Test Pit No. **TP 214**

Page 1 of 1

PROJECT	Mirror Lake Watershed Study	H&A FILE NO.	28675-309
LOCATION	Essex, Massachusetts	PROJECT MGR.	D.H. Gevalt
CLIENT	Citizens Advisory Partnership	FIELD REP	C.S. Osgood
CONTRACTOR	Stanley Lynde Const. Co., Inc.	DATE	19-Jul-02
EQUIPMENT	Case 580 rubber tire backhoe - 1/4 cu. yd. bucket	WEATHER	Thunderstorms 90's

Ground El.	74.5 ft.	Location	N 2,089,041.101
El. Datum	NGVD		E 801,444.238

Groundwater depths/entry rates (in./min.): None

Depth (ft.)	Sample ID	PID Reading (ppm.)	Stratum Change Depth (ft.)	USCS Symbol	Visual Identification (density/consistency, color, GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions,	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
					Note: Ground surface strewn with boulders. Numerous depressions indicating subsurface voids noted.										
	1.5				15% coarse to fine sand, 15% cinder fragments and particles, 10% unidentifiable, white ash-like material, 10% fines (largely organic), 10% coarse to fine gravel, 10% wood (manufactured and treated), 5% glass fragments, 5% metal strips and wire, 5% charcoa										
2	S2	15.9			5% plastic sheeting (possibly polyethelene bags), 5% brick particles, 5% clay pipe fragments. Matrix generally dark brown to gray in color with pockets of white and red. 15% boulders, 15 % cobbles. Maximum particle size 36 inches.										
	2.5				Distinct decomposed gasoline odor, possible faint napthalene odor. Visible irridescen sheen on moist solids 4.6 to 5.2 ft.										
4					-FILL-										
	4.6														
	S1	140			Note: Bedrock surface smooth and flat, consisting of very hard to hard, slightly										
	5.2		5.2		weathered, light gray to pink, coarse to fine grained granite. Single high angle joint noted.										
					REFUSAL ON BEDROCK 5.2 FT.										
6															
8															

Obstructions:

Remarks:
Note: Sample S1 submitted for laboratory chemical analysis.
Note: Field monitoring of breathing zone and headspace screening conducted using an hNU 11.7 ev. PID.

Bucket Decontamination Method: Steam cleaned

Field Tests

Dilatancy:	R - Rapid S - Slow N- None
Toughness:	L - Low M - Medium H - High
Plasticity:	N - Nonplastic L - Low M - Medium H - High
Dry Strength:	N - None L - Low M - Medium H - High V - Very High

Standing water in completed pit:

at depth	NE	ft.
measured after	0.75	hrs. elapsed

Boulders:

Diameter (in.)	Number		Approx. vol. (cu. ft.)
12 to 24	6.0	=	18.0
over 24	1.0	=	33.0

Test Pit Dimensions (ft.):

Pit Depth	5.2
Pit Length X Width	10.5 x 4.3

NOTE: Soil identifications based on visual/manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

K:\Template\forms\uscstp.xls

Form #3008

APPENDIX D
CHECKLISTS

D.1 Field Monitoring Checklist

D.1.1 Preliminary Preparation

A. Project Briefing
B. Field Project File and Document Assembly
  - Proposal
  - Contract Documents
  - Locus, Site & Utility Plans
  - Exploration Criteria
  - Subcontractor Agreement
  - Site and Project Contacts
  - Forms
    - DFR
    - Subcontractor Quantities
    - Test Boring Report
    - Core Boring Report
    - Observation Well Installation Form
    - Test Pit Log
    - Special Testing / Instrumentation Forms
    - COC
    - Equipment Usage and Billing Form
    - Sample Receiving Form

C. H&S Briefing
  - H&S Plan

D. Equipment Request and Assembly

D.1.2 Onsite Duties

A. Site Walkover and Subcontractor Utility and Safety Briefing
B. Exploration Program Review
  - Exploration Layout
  - Site Conditions Sketch
  - Preliminary Surficial Geologic Map
  - Exploration Monitoring
    - Equipment Inventory
    - Exploration Layout & Utility Check
    - Field Logging Soil & Rock
    - Water Level Measurements
    - Production and Budget Quantities
    - Sample Handling & Transport
    - Instrumentation & Testing Records
    - As-Built Sketches & Exploration Locations

D.1.3 Follow Up & Summary

- Proof Logs and Test Reports
- Finalize DFR and Subcontractor Quantities
- Sample Receiving and Disposition
- Equipment Return and Billing
- Exploration Program Summary
- Final Site & Geological Conditions Summary
- Geologic Profiles

OPERATING PROCEDURE: OP3009

MONITORING WELL DEVELOPMENT PROCEDURE

PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	BAM/ 08-02	JCP/ 08-02	GJM/ 06-03		JAK/ 06-03

Total Pages: 20

HALEY & ALDRICH

TABLE OF CONTENTS

LIST OF TABLES

OPERATING PROCEDURE: OP3009

MONITORING WELL DEVELOPMENT PROCEDURE

1. PURPOSE

This procedure provides guidance on methods and techniques for groundwater monitoring well development typically performed after well installation, but prior to groundwater quality sampling, specifically for instrumentation installed in overburden or bedrock for environmental monitoring and geotechnical purposes. Groundwater well development increases the yield of the well by removing fine sediments and particles from within the well and the well filter pack, enhances the hydraulic communication between the well and the screened formation, decreases turbidity, increases precision of hydrologic measurements, and increases representativeness of groundwater quality data. Well development is an integral component of a groundwater sampling program, with the objective of obtaining high quality, reproducible groundwater quality data.

The selected method and duration of groundwater well development will be dependent on a number of factors, including: well construction method and materials, depth to groundwater, anticipated groundwater testing parameters and data quality objectives, presence of contamination (i.e., degree of contamination and presence of free-phase non-aqueous phase liquids), method of borehole advancement, and site physical setting/access.

IMPORTANT NOTES:

It is not necessary to follow all of the methods in this procedure for every monitoring well development performed. The procedures may be adapted to conform to specific local practice, site-specific geologic conditions, or to support local, municipal or state regulatory requirements.

The term "groundwater monitoring well" or "well" in the procedure is used to denote groundwater monitoring wells, groundwater observation wells, piezometers, gas monitoring wells, lysimeters or other devices constructed in similar manner to a well. Certain well constructions (i.e., large-diameter pumping test wells, injection/extraction wells, commercial, residential or industrial water supply wells) may be developed using the information contained in the procedure, but are typically installed using specialized drilling equipment and are typically developed using that equipment by specific methods that are beyond the scope and intent of this field procedure.

2. EQUIPMENT & SUPPLIES

Required

1. Water Level Indicator, Sinco or equivalent
2. Oil/Water Interface Probe
3. Thermometer
4. pH meter and buffering/calibration solutions
5. Conductivity meter and probe
6. Dissolved oxygen meter and probe
7. Turbidity meter and probe
8. Oxidation/Reduction Potential meter and probe
9. Salinity meter
10. Pump (Grundfos, peristaltic, whale etc.)
11. Pump accessories (Cables, fittings, tools)
12. ½ in. or 5/8 in. HDPE or Teflon discharge tubing; also silicon tubing for peristaltic pump
13. Power source for pump (generator with fuel; automotive battery, rechargeable battery)
14. Graduated plastic bucket (5-gallon) or flow meter
15. Stopwatch
16. Standard decontamination equipment (water jug, buckets or washtubs, brushes, Alconox, distilled water, tap water, methanol, squeeze bottles)
17. Ruler, engineer's 6 ft. folding
18. Scale, engineer's
19. Graduated tape, 100 ft. length, weighted end
20. Field Logs & Forms/Field Book
21. Site Plan, Maps, Boring and Well Installation Logs
22. Personal protective equipment
23. Calculator
24. Keys to well padlocks/covers
25. Paper towels
26. Trash bags

Optional:

1. Horiba MultiMeter (measures pH, temperature, conductivity, DO, turbidity, and salinity)
2. Horiba U-22 Flow Cell (measures pH, temperature, conductivity, DO, turbidity, ORP and salinity)
3. Inertial Pump Materials: Waterra Foot Valves, HDPE Tubing
4. Bailers; rope, knife

3. PROCEDURE

3.1 Summary of Procedure Purpose and Intent

The primary purpose of developing groundwater quality monitoring wells at sites containing, or potentially containing, solid or hazardous materials or their byproducts, is to create an effective filter pack around the well screen, rectify impact to the formation caused by drilling and the associated drilling fluid, remove fine particles from the formation near the borehole and assist in restoring the natural water quality of the aquifer in the vicinity of the well. The properly developed well ensures the reliable collection of representative ground water samples, of acceptably low turbidity.

Well development induces movement of water in two directions across the well screen and filter pack. This movement removes fines or other foreign materials from within the well, the filter pack, and the surrounding natural formation, creating a stable graded filter yielding water of relatively low turbidity.

3.2 Role of Environmental Professional or Engineer

Groundwater monitoring well development requires evaluation and consideration of a variety of site-specific characteristics, which precludes the use of one single development practice or procedure. The procedure is provided as a guide to aid the environmental professional, geologist or engineer in selecting the technical approach and methodology to effectively complete a well development program.

At the initiation of project planning, the Project Manager, Project Engineer or Scientist, and field personnel, determine any project-specific requirements for groundwater well development. Municipal, state or federal regulations, local practice, client requirements or project requirements may dictate the use of a different or modified well development method.

3.3 General Methods of Monitoring Well Development

There are three general types of well development methods typically employed on small diameter monitoring wells (equal to or less than 4 in. I.D.) installed for environmental purposes:

- Pumping and overpumping
- Bailing
- Surging with a Surge Block

Well development methods that potentially alter the chemical composition of the groundwater are not acceptable. Therefore, methods that introduce fluids (including water pumped from the well) or air, to accomplish development are generally considered unsuitable. This eliminates several methods commonly used to develop large-diameter water supply wells. These methods include backwashing, jetting, airlift pumping or air surging.

The majority of well development for environmental purposes is conducted by mechanical pumping and overpumping, use of inertial lift pumps, inertial lift pumps with surge blocks, bailers, or a combination of these methods.

3.4 Preliminary Procedures

In preparation for well development activities (and subsequent groundwater quality sampling event), the Project Manager and groundwater developer/sampler reviews project-specific requirements and considerations of the well development and groundwater sampling program.

The information reviewed may include site map or plans, drilling methods and records, well construction records, depth to groundwater data, previous groundwater quality data, data trends, earlier sampling records and field procedures used, and preferred well sampling sequence or sampling order. Identify project documentation needs and records of well development execution.

Other information to be reviewed are specific laboratory analyses to be performed on samples to be obtained from each well, sampling glassware, need for field filtration and container preservatives. Related aspects of the procedure include site health & safety plan review, evaluation of the site physical setting, availability of electrical power, property access permission and constraints, and purge water disposal.

Design the well development program to support the data quality objectives of the chemical analyses of the groundwater samples to be obtained. Based on the types of data to be collected in the field, identify the appropriate types of mechanical purging required (by pumps or other specialized equipment), likelihood of the presence of non-aqueous phase liquid (NAPL) and accommodations for measuring NAPL. Generally, a series of wells are developed starting with the least contaminated well working towards the well exhibiting the most significant contamination, if known.

Other considerations are identifying protocol for personnel protective equipment (PPE) use and specialized handling of purged water and decontamination wastewater, as generated. Recently installed monitoring wells should not be developed before well sealant materials (bentonite annular seal, cement/bentonite grout) have set or cured, typically assumed to be approximately one week.

In some cases, groundwater obtained from wells installed and sealed with a column of cement grout has exhibited artificially high pH, due to migration and influence of the calcium carbonate from the cement. The Project Manager and field representative are cautioned of this possibility, manifested during the well development procedure by inconsistent, unstable or high pH readings.

Table I presents common well development equipment, and lists advantages/disadvantages of the equipment.

3.5 Calculate Volume of Standing Water in Well

Calculate the estimated volume of standing water in the well. Some useful formulae for calculating well volumes are provided below:

- $V = L\ r^2 (0.163)$

  Where:

  V = volume of standing water in well, in gallons
  r = internal radius of well, in inches
  L = length of standing water column, in feet
  0.163 = derived constant converting well radius in inches to feet, and cubic feet to gallons

Other useful formulae:

- Gallons per 100 ft. = 4.08 * (D)2

  Where D = Inside well or borehole diameter, in inches

- Cubic feet of water per 100 ft. = 0.55 * (D)2

  Where D = Inside well or borehole diameter, in inches

- 7.48 gallons = 1 cubic foot

- 0.134 cubic feet = 1 gallon

3.6 Field Procedures

3.6.1 Locate Well

Locate the subject well in the field, using site plans, sketches, fixed references or other available documentation. Metal detectors may be useful in locating buried metal well casings; however, non-ferrous (i.e., aluminum or PVC) or missing well casings will not respond to metal detector signals.

Verify well designation, particularly individual wells located in closely spaced well clusters or well nests. If necessary, verify and document the location of the well to be decommissioned, referenced by taped distance to three fixed features, or acquire coordinates using global positioning system (GPS) methods or by instrument survey.

3.6.2 Evaluate Well Integrity and Construction

Evaluate and document condition of protective well casing and surface seal (padlock missing/broken, well cap missing, staining on well riser observed, concrete surface seal cracked, surface runoff entering well etc.). Record well construction material (stainless steel, PVC, fiberglass, galvanized steel, black carbon steel etc.).

Establish/verify monitoring well reference point (i.e., PVC rim, roadway box rim, protective guard pipe casing rim, ground surface).

3.7 Well Development Procedure – Mechanical Pump Method

Mechanical pumps include electrically powered submersible pumps (Grundfos and Whale brands), or suction lift surficial pumps, such as centrifugal or peristaltic types. Pumps may have variable speed controls to regulate discharge rate. Other types of suction lift surface pumps may be driven by internal combustion gasoline engines (not discussed in this procedure).

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details.

2. Don appropriate personnel protective equipment (PPE) as identified in project health & safety plan. Pay particular attention to splash hazards.

3. Decontaminate all downhole development equipment prior to placement within wells, between uses in either the same well, or in other wells. Clean and prepare equipment using an Alconox soapy wash, tap water rinse, methanol rinse, and distilled/deionized water rinse. Containerize decontamination rinseate, if required.

4. If warranted, measure for possible presence of non-aqueous phase liquids (NAPL), using oil/water interface probe. Modify well development program based on findings and discussion with Project Manager, including postponing/canceling well development.

5. Measure well diameter, depth to water (static water level), depth to bottom of well using water level indicator or weighted graduated tape. Calculate standing water volume (see above).

6. Verify information on the respective well record, if available, and note any discrepancies. If well logs are not available, determine screen length and depth, if possible, to determine whether the well construction will provide useful data.

7. Evaluate obstructions present within the well or material accumulated in bottom of well. The presence of substantial quantity of accumulated materials (i.e., silt $>$ 0.5 ft.) in bottom of well may warrant modifying the well development method to remove the sediment (i.e., use of peristaltic pump or hand bailer to remove sediment).

8. Remove any unsuitable dedicated groundwater sampling devices, if present (i.e., Waterra-type inertial pumps and discharge tubing, bailers, SoakEase absorbent material). Retain and discard as solid waste.

9. Groundwater purged from the borehole may or may not require containment or may be discharged on the ground in vicinity of well head, depending on groundwater quality, site setting, regulatory considerations and project requirements. Resolve with Project Manager prior to entering field.

10. Cut a clean piece of discharge tubing for selected pump (typically ½ in. or 5/8 in. high density polyethylene (HDPE) or Teflon tubing) of sufficient length to fully penetrate the well to its screened depth and to accommodate measuring purge volumes and inorganic parameters at ground surface. Cut tubing should not fall or drop into the well.

11. For submersible pumps, attached tubing and lower pump intake into well, suspending pump intake at the approximate midpoint of the saturated zone for water table wells, or at the screen midpoint for deeper wells. Connect power cables and controller box, and operate the pump according to manufacturer's instructions.

12. Initially operate pump at a discharge rate approximately equal to well recharge rate, using graduated bucket or flow meter and stopwatch to estimate flow, and adjust until drawdown of approximately 0.3 ft. is obtained. At the start of purging, obtain inorganic field parameters of the discharge, in the following order: pH, temperature, specific conductance (conductivity), oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity, and record on field forms or in logbook.

13. Well development continues until representative groundwater, free from drilling fluids, drill cuttings, accumulated sediment or other materials introduced during the well construction is obtained.

    Unless determined by project specific requirements, remove approximately 3 to 5 well volumes, measuring and recording inorganic field parameters for each well volume removed. If, during removal of 3 to 5 well volumes, field parameters have stabilized within 10% for two successive readings, and turbidity has been reduced to 5 nephelometric turbidity units (NTU) or less, then well development is considered complete. Based on discussion with the Project Manager or environmental professional, consider the applicability of Step 14 below, and complete if warranted.

    In certain circumstances and based on project objectives, well development may consist of removing a fixed volume of water from the well that is predicated on the drilling method used for well installation. For wells installed without the introduction of drilling fluids (i.e., hollow stem augers, driven well points), three (3) well volumes are removed. For wells where drilling fluids were introduced (i.e., cased borings, rock coring, mud rotary methods), ten (10) well volumes are removed. In these cases, inorganic field parameter readings may be obtained for informational purposes.

14. A parallel objective of well development may be to remove drilling fluid lost to the formation(s) that was introduced during the drilling process. This aspect of development is complete when the identified volume of fluid is removed, and stabilized inorganic parameters are achieved.

15. If field parameters have not stabilized after Step 13, increase pumping rate to dislodge fine-grained materials from the filter pack, or remove sediment in suspension. It may be necessary to lower pump intake to accommodate drawdown. Avoid pulling coarse sediment into well intake to prevent pump impeller damage.

16. If slow recharge rate does not allow for continuous operation, shut off pump, allow well to recharge, and resume pumping at slower rate and well evacuation until discharge water clears. Resume measuring field parameters (Step 13) until stabilized.

17. Complete documentation as appropriate.

3.8 Well Development Procedure – Inertial Pump Methods

Inertial pumps use a dedicated pre-cleaned single ball check valve ("foot valve") and HDPE discharge tubing to manually remove water from the well.

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Attach foot valve (i.e. Waterra type) to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To remove groundwater from the well, manually lift and lower the HDPE tubing within the well bore by hand, approximately once every three to five seconds, timing the motion to optimize purge water volume removed with each stroke. Clean foot valve if it becomes clogged or obstructed by sediment by carefully removing tubing from well, unthreading the foot valve, and rinsing with distilled water.

4. Monitor inorganic field parameters as in Steps 12 to 14, above.

5. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in groundwater well following sampling.

6. Complete documentation as appropriate.

3.9 Well Development Procedure - Surge Blocks

Surge blocks can be used in conjunction with pre-cleaned, dedicated inertial pumps (single ball check valve or "foot valve") and HDPE discharge tubing.

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Press fit the surge block device securely onto foot valve (i.e. Waterra type), attach foot valve to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To surge the groundwater, lower the surge block into the water column and use as a "plunger" by manually lifting and lowering the HDPE tubing by hand, forcing water to flow into and out of the screened portion of the aquifer. Surge each well for a minimum of 30 minutes to remove the finer material from the aquifer surrounding the borehole, providing a developed zone of uniformly graded sand of higher porosity and higher permeability surrounding the well screen, allowing the water to flow more freely into the well, and reducing potential turbidity.

4. Following the surging portion of the well development, remove the surge block from the foot valve, and purge a minimum of one well volume from the well by removing the fine particles brought into the well during surging.

5. Monitor inorganic field parameters as in Steps 12 to 14, above.

6. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in well following sampling.

7. Complete documentation as appropriate.

3.10 Well Development Procedure - Bailers

Hollow, cylindrical bailers are a type of grab sampling device, and may be constructed of stainless steel, Teflon, or PTFE, typically with a single ball check valve fixed on the bottom. They are manually lowered into the well using a rope tether, allowed to collect well water, then lifted from the well. The collected water is discharged to a graduated bucket, and the process repeated until the well is deemed adequately developed. Stainless steel bailers are generally simple to decontaminate. Teflon or PTFE bailers are considered dedicated or disposable after one-time use.

In general, the use of bailers are not a preferred well development method, due to the time required to remove potentially large volumes of development water, especially in deep wells. Their use, however, creates agitation and mixing within the water column, which suspends sediment and fines, incrementally aiding in clearing the well and filter pack, thereby reducing turbidity.

PTFE ("clear") bailers are often used to collect NAPL for thickness measurements or product analysis. Although not discussed in this procedure, bailers are generally not recommended for groundwater sampling overall, and not acceptable for low-flow groundwater sampling in particular, especially sampling for volatile organic compounds (VOCs), volatile petroleum hydrocarbons (VPH), dissolved metals or other analytes requiring field filtration.

3.11 Restoration and Cleanup

The area around the well head and ground surface shall be completely cleaned up of any development materials (plastic sheeting, tubing, paper towels, litter, etc.), and the well secured.

3.12 Documentation

A complete record of the well development procedure should be documented and incorporated into the project file. Complete portions of the Groundwater Sampling Record form, recording the following information:

- Project information, date and personnel present
- Well location and designation
- Well condition inventory
- Presence of NAPL

- Diameter, depth of well, screened interval (if known), depth to static groundwater, volume of standing water column in well
- Detailed description of well development equipment and procedure used
- Time(s) development started and ended
- Incremental and total volume of purge water removed
- Inorganic field parameter measurements
- Comments on discharge water quality
- Modifications to procedures
- Decontamination method, and discharge water management method
- Drum count of accumulated discharge water, if applicable

Appendix C contains a blank Sampling Report (Form #3004), Groundwater Sampling Record (Form #3005), Monitoring Well Development Report (Form #3006) and Low Flow Field Sampling Form (Form #3010) for reference.

3.13 Precision and Bias

This procedure provides qualitative information only; therefore, a precision and bias statement is not applicable.

TABLE 1
Common Well Development Equipment

Material	Type	Power Requirement	Positive Attributes	Negative Attributes
Mechanical Pumps:				
Grundfos Pump	Submersible pump (variable speed)	120V A.C. current	-Lift height only constrained by cable length (+/- 150 ft.) -Controllable, variable flow rate from 0.01 to ≈35 L/minute -Stainless steel disassembles for simple decontamination See note 1	-Requires generator if no power source available -Risk of cross contamination of sample glassware or tubing from generator fuel -Heavy/cumbersome -Sediment may clog pump impellers -2.0 in. minimum well diameter See note 2
GeoDurham	Submersible Pump (variable speed)	12V D.C. current (Automotive battery)	-Portable power supply -Lift height only constrained by cable length (+/- 75 ft) -Controllable, variable flow rate -Stainless steel for simple decontamination See note 1	-Limit on lowest pump speed/discharge -Sediment may clog pump impellers -Power supply limits duration of pump use -2.0 in. minimum well diameter See note 2
Whale Pumps	Submersible pump (variable speed)	12V D.C. current (Automotive battery)	-Portable power supply -Lift height only constrained by cable length (+/- 30 ft.) -Disassembles for simple decontamination -1.5 in. minimum well diameter	-Power supply limits duration of pump use See note 2
Peristaltic Pumps	Suction lift surface pump (single speed)	12V D.C. current (Automotive Battery)	-Good for purging sediment from silt trap during development -Dedicated tubing -Easy to operate -0.5 in. minimum well diameter	-Not appropriate for sampling VOCs (agitation) -Lift limited to ≈25 ft. BGS -Pump rate 0.01 L/min.
Manual Methods:				
Inertial Pump	Submersible foot valve with discharge tubing	Manually operated	-Dedicated tubing -Inexpensive -Simple to operate -0.5 in. minimum well diameter	-Depth limited by manual capability to lift tubing (typically 70 to 80 ft.) -Tiring for large volumes of development water -Sediment may clog foot valve
Stainless Steel Bailer	Grab sample device with single check valve	Manually operated	-Disassembles for simple decontamination -Simple to operate	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard
Teflon Bailer	Grab sample device with single check valve	Manually operated	-Dedicated -Simple to operate -Inexpensive	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard
Clear Bailer	Grab sample device with single check valve	Manually operated	-Dedicated -Simple to operate -Inexpensive -Can collect NAPL for evaluation	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard

Notes and References:
1. Appropriate for low flow/low stress groundwater sampling.
2. Not appropriate if DNAPL/LNAPL present in monitoring well.

APPENDIX A
REFERENCES

A.1 Reference Procedures

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5521-94, "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers."

- Puls, R.W., Barcelona, M.J., 1996. "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures," US EPA Ground Water Issue, US Environmental Protection Agency. Office of Solid Waste, EPA/540/S-95/504, pp. 1 to 12.

- US Environmental Protection Agency, Region I, (30 July 1996). "Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells," SOP # GW 0001, Revision 2.

A.2 Other References

- US Environmental Protection Agency, 1992. Office of Solid Waste," RCRA Groundwater Monitoring: Draft Technical Guidance," EPA/530/R-93/001, NTIS PB 93-139350, November 1992, pp. 6-46 to 6-50.

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D6634-01, "Standard Guide for the Selection of Purging and Sampling Devices for Groundwater Monitoring Wells."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5903-96 (Reapproved 2001), "Standard Guide for Planning and Preparing for a Groundwater Sampling Event."

- Massachusetts Department of Environmental Protection, "Standard References For Monitoring Wells," January 1991, document WSC-310-91, Section 4.5 Well Development.

A.3 COMMENTS ON REFERENCE PROCEDURES

The procedures and equipment listed in EFP No. 01a and used by Haley & Aldrich are generally as specified in the ASTM and US EPA Reference Procedures. Deviations of EFP No. 01a from the Reference Procedures are not provided. The procedure described in Section 5 has been developed to assist Haley & Aldrich personnel in performing well development, and in some cases simplifies the Reference Procedures.

APPENDIX B
RELATED HALEY & ALDRICH PROCEDURES

- OP2020 Groundwater Monitoring (Observation) Well Abandonment
- OP2031 Groundwater Monitoring (Observation) Well Installation
- OP3000 General Environmental Field Procedures and Protocols
- OP3007 Procedures for Surface Water Sampling
- OP3008 Manual Water Level Measurement Procedure
- OP3010 Groundwater Quality Sampling Procedure
- OP3012 Low Stress/Low Flow Groundwater Sample Collection Procedure
- OP3014 NAPL Monitoring and Sampling
- OP3015 Aquifer Parameter Testing Procedure

APPENDIX C
FORMS

- 3004 Sampling Report
- 3005 Groundwater Sampling Record
- 3006 Monitoring Well Development Report
- 3010 Low Flow Field Sampling Form

HALEY & ALDRICH

SAMPLING RECORD

Page ____ of ____

PROJECT ______________________ **H&A FILE NO.** ______________
LOCATION ______________________ **PROJECT MGR.** ______________
CLIENT ______________________ **FIELD REP** ______________
CONTRACTOR ______________________ **DATE** ______________

Weather ______________________ **Temperature** ______________
Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other___________
Comments ______________________

SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION

Sample No.	Location	Depth (ft)	Time	Sample Description	Sampling Device	Cleaning Prodedure	Container Type

General Comments: (ie: field filtrations, persons communicated with at site, etc.)

HALEY & ALDRICH

GROUNDWATER SAMPLING RECORD

Page of

PROJECT ______________________ **H&A FILE NO.** ______________
LOCATION ______________________ **PROJECT MGR.** ______________
CLIENT ______________________ **FIELD REP** ______________
CONTRACTOR ______________________ **DATE** ______________

GROUNDWATER SAMPLING INFORMATION

	Well No.						
	Water Depth (ft)						
	Time						
	Product						
	Depth Of Well (ft)						
	Inside Diameter (in)						
	Standing Water Depth (ft) (1)						
	Volume Of Water In Well (gal)						
	Purging Device						
	Volume of Bailer/Pump Capacity						
	Cleaning Procedure						
	Bails Removed/ Volume Removed						
	Time Purging Started						
	Time Purging Stopped						
	Sampling Device						
	Cleaning Procedure						
TIME SAMPLES TAKEN	VOA						
	ABN						
	Metals						
PARAMETERS	Color						
	Odor						
	pH						
	Conductivity						
	Turbidity						
	Dissolved Oxygen						
	Temp, ^{0} C						
	Salinity						

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

HALEY & ALDRICH

MONITORING WELL DEVELOPMENT REPORT

Well No.

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP.**	
CONTRACTOR		**DATE**	
ELEVATION SUBTRAHEND			

Estimated Volume of Water Lost During Drilling: ____________ gallons

Comments: ____________

Depth to Water Before Development: ____________ feet

Comments: ____________

Depth to Well Bottom Before Development: ____________ feet

Comments: ____________

Turubitiy of Water Before Development: ____________ NTU

Comments: ____________

Volume of Water Removed: ____________ gallons

Comments: ____________

Method of Removal (bailing, pumping): ____________

Comments: ____________

Depth to Well Bottom After Development: ____________ feet

Comments: ____________

Depth to Water After Development: ____________ feet

Comments: ____________

Turubitiy of Water After Development: ____________ NTU

Comments: ____________

HALEY & ALDRICH

LOW FLOW/MNA FIELD SAMPLING FORM

Page ____ of ____

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

Sampling Data:

Well ID:		Well Depth:	ft	Initial Depth To Water:	ft	Purging Device:			
Start time:		Depth To Top Of Screen:	ft	Depth Of Pump Intake:	ft	Tubing Present In Well:	☐ Yes	☐ No	
Finish Time:		Depth To Bottom Of Screen	ft			Tubing Type:			

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temp-erature (^{o}F) or (^{o}C)	pH	Conduct-ivity (us/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	ORP/eH (mv)	Comments

OPERATING PROCEDURE: OP3016

SLUG TESTS

PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	MGB	DBK/ 02-03			JAK/ September 2003

Total Pages: 14

HALEY & ALDRICH

TABLE OF CONTENTS

OPERATING PROCEDURE: OP3016

SLUG TESTS

1. PURPOSE

1.1 Introduction

This operating procedure (OP) describes the protocol for performing slug tests (in-situ hydraulic conductivity tests, rising-head tests, falling-head tests) including preparation, collection of valid field data, and preliminary evaluation of the data.

A slug test is performed to assess the horizontal hydraulic conductivity of a water-bearing zone. Slug tests are accomplished by stressing the screened water-bearing zone through an "instantaneous" displacement of water (with a slug) or removal of water (with a bailer) and subsequently measuring the water level response in the well over time. A very rapid change in the water level in a well can be created using one of these field methods:

- Inserting and rapidly withdrawing a solid dense object (a.k.a. a slug). Solid slugs are the preferred option;
- Removing water using a bailer. Bailers should be used to remove water only if using a slug is not possible;
- Changing the air pressure in a well causing displacement of well fluids (pneumatic displacement method)

The method chosen will depend on project needs, equipment availability, water disposal/treatment options, pertinent laws and regulations, and operator experience.

The protocols that follow assume that field staff can effectively perform one of these methods for rapidly changing the water level in a well at the start of a slug test, and can then use either a manual or automatic procedure for measuring water level response over time. When practical strive to measure slug test response with automatic datalogger devices.

This OP provides only a guideline for performing slug tests. There are many factors that go into performing slug tests in the field and just as many factors that can affect the quality of the data collected. An experienced hydrogeologist or groundwater specialist should be consulted before preparing a slug test program or performing a slug test.

1.2 Considerations

Certain conditions or activities should be avoided when performing slug tests. In general, a person should **not** conduct any type of slug tests in a well if:

- The well contains a pipe, tube, or other obstruction in the depth range where the water level is anticipated to change
- The casing diameter in a well varies in the depth range where the water level is anticipated to change
- The water level in a well has not yet recovered to nearly static conditions (i.e., 90% or more) after a prior disturbance, (e.g., drilling, purging, development, previous well tests, etc.)
- Non-aqueous phase liquid (NAPL) is present in a well
- The water level in the well cannot be appreciably changed due to minimal slug size or volume, large well casing diameter, etc.

A ***rising-head*** test should generally **not** be conducted:

- If the slug or amount of water to be removed cannot be removed nearly instantaneously (i.e., if removal takes over 5% of the "90%-recovery" time)
- By pumping to remove water, unless the amount of water to be removed by the pump can be removed nearly instantaneously and any back-flush can be eliminated;
- By using bailers. If a bailer must be used, avoid:
    - using a bailer that has a leaky check valve
    - bailing multiple times instead of creating an instantaneous water level change
    - using a bailer with a diameter so close to that of the casing that groundwater is suctioned into the well while the bailer is raised.

Falling-head tests are generally not recommended due to inherent problems associated with reproducibility, the introduction of fluids, and general application restrictions. They are recommended in circumstances when no other option is available. Consult with the Project Manager or an experienced hydrogeologist before undertaking a falling-head test program.

2. EQUIPMENT & SUPPLIES

- A battery-operated water level measurement probe, marked in 0.01-foot increments
- Field books, appropriate field forms (See Appendix C), clipboards, rulers, graph paper, calculator, etc.
- Site maps (property lines, wells, topography, etc.), as needed
- Site-access and well-cap keys, as needed
- A clean bailer or a solid or sealed slug
- Clean rope or string for raising and lowering a bailer or slug
- Appropriate container for withdrawn groundwater and/or decontamination fluids
- Tools necessary for well access (shovel, bolt-cutters, etc.)
- For flowing artesian wells: duct tape, couplings, and extra casing of appropriate diameter for increasing casing height so as to enable measurement of a SWL. (NOTE: Tests on artesian wells are identical to other testing if the casing can be raised to a level above the well's static water level surface. If not, alternative methods such as measurement of pressure may be performed. Appropriate literature or methodologies should be consulted when performing such alternative testing.)
- Data logger and laptop computer with fully charged battery (if required)
- Pressure transducer of appropriate pressure range for the depths of water to be tested, if needed
- Clamps, tape, cable ties, or rope to secure the transducer cable to the well casing

3. PROCEDURE

3.1 Pre-testing Preparatory Activities

There are a number of preliminary steps that should be taken prior to conducting slug tests. These include, at a minimum, the following:

- Review requirements of the project Work Plan and Health & Safety Plan to assure compliance with any applicable requirements or regulations.
- Clear all necessary access issues (permission, physical access, permits, etc.).

- Gather all necessary equipment, materials, and tools necessary to adequately perform the tests.
- Identify the monitoring wells, piezometers, or other monitoring points to be used in tests.

- Gather all necessary installation information on the well to be tested and all monitoring.

- Decontaminate all necessary equipment before entering the site or performing tests in accordance with the Work Plan, if required. As necessary or required, decontaminate all impacted equipment prior to tests, between test locations, and after testing is completed. If decontamination cannot or will not be performed and dedicated equipment will not be used then proceed with testing from the least contaminated to most contaminated locations to minimize cross-contamination.

- Determine the most appropriate method to dispose of decontamination water in accordance with the Work Plan, if required. If potentially contaminated, the water should be containerized for subsequent characterization and proper disposal or treatment in accordance with applicable regulations.

- Synchronize all time devices including watches, computer clocks, datalogger and transducer clocks, etc.

Other information potentially needed for proper slug test data interpretation includes:

- Depth-interval of screen or open section in well

- Sandpack porosity (if water levels intersect screen)

- Sandpack diameter (if water levels intersect screen)

- Stratigraphic horizon materials and elevations

- Hydraulic conductivity of bounding low-hydraulic conductivity units, if present

- Ground-surface elevation

- Typical or historical groundwater elevations or depths-to-water

3.2 Procedure

The steps for conducting a slug test are as follows. An attempt to utilize dataloggers to collect water level measurements should be made if at all possible. Manual measurements should only be used if absolutely necessary or to collect back-up data.

1. Follow all required “Pre-Test Preparatory Activities”, as warranted.

2. Measure and record the Static Water Level (SWL) of the well to be tested, in accordance with the Water Level Measurement OP3008.

3. Test the pressure transducer and data logger, and obtain well-bottom pressures/water column heights and SWL pressures, using the following steps. **NOTE**: attention must be paid to the maximum allowable immersion depth (i.e., the manufacturer specifications for acceptable pressure range of the transducer, where 1 psi = 2.311 feet of water):

   - Place the pressure transducer at least several feet below the top of water as well as below the projected depth of the lowest part of the bailer or slug to be used.
   - Make pressure readings until three uniform values are read consecutively.
   - Raise the datalogger one (1) foot from its original position. View the pressure reading to confirm that the change in position was accurately reported by the transducer.
   - Lower the pressure transducer to the base of the well, and measure and record the pressure/height of water column. Again, refer to note above regarding maximum allowable immersion depth.
   - Return the transducer to its original position and secure the suspension cable to the well casing. Again, make pressure readings until three uniform values are read consecutively. Compare with the original readings to make sure no drift occurs.

4. Perform the following pre-test activities for a ***rising-head*** test:

   - Allow the slug (or bailer) that will be used to move down into the groundwater. (Fully immerse the bailer if possible. If there is not enough water in the well for the bailer to be fully immersed, then let the bottom of the bailer gently come to rest on the well bottom, or a few inches above the well bottom. Prevent agitation of sediment on the bottom of the well, as sediment in the bailer may keep the check valve from properly sealing.) I don't see how it can ever get to the bottom if the transducer is supposed to be below it
   - Measure falling pressures during recovery using the pressure transducer until the water level in the well re-equilibrates. IMPORTANT: the water level in the well should be allowed to return to near-static conditions (within 0.02 feet) before initiating test.
   - Set the pressure transducer below the base of the immersed bailer or slug. Isn't it already supposed to be in place? See 3, above.

5. Start the slug test by creating a nearly instantaneous displacement in water level:

   - Pull the bailer or slug rapidly upwards, either removing it from the well or securing/suspending it within the well several feet above the SWL.
   - Simultaneously pull bailer and to displacing the water, initiate the datalogger, beginning the measuring/recording of rising water levels in the well at the predetermined time frequencies (a logarithmic time scale is usually employed).

- If a bailer is used, listen for cascading water while the bailer is being raised or is suspended. This is a sign of check-valve failure. If failure occurs, clean and repair the valve and start over.

- If a bailer is used, measure the volume of water removed by the bailer after retrieval.

6. Continue measuring the water levels as they change over time until the water in the well rises or falls to the limit specified in the Project Work Plan (usually 90% recovery or one hour, whichever comes first). A pre-set logarithmic sampling interval, with increasing intervals of time, is ideal, usually predetermined by the datalogger's default setup.

7. Compare the volume of groundwater recovered in the bailer, if one is used, with the volume of groundwater estimated to have been removed from the well (V) based on the initial recorded water-level displacement (H) and borehole radius (r), (e.g., $V=H\pi r^2$). If, for a rising-head test, the static water level lies within the screened section of the well, then the sandpack porosity (n) and radius (R) should be accounted for also in the volume calculation, (e.g., $V=H\pi r^2 + nH\pi(R-r)^2$). A similar comparison can be performed if a slug is used in a falling-head test. If the volume recovered and the calculated volume does not reasonably correlate, based on site-specific conditions, the test should be performed again.

8. Record all general and pertinent test data in a field book or on appropriate forms.

9. Decontaminate all necessary equipment in accordance with the Work Plan or Equipment Decontamination OPs.

10. Properly containerize and label spent decontamination fluids or groundwater removed from the well in accordance with the Work Plan or other waste characterization guidance, OPs, and/or regulations.

11. Lock all well caps and secure the site as needed.

12. Submit the slug-test data to a qualified scientist or engineer assigned by the Project Manager for interpretation. The data should be interpreted by an experienced hydrogeologist. Calculations should be based on an appropriate model for the known hydrogeologic conditions in the field.

Any variations from these procedures should first be approved by the Project Manager.

3.3 Field Documentation

The following data should be obtained prior to heading into the field and/or in the field during slug tests and recorded appropriately (either on appropriate forms, in a field book, and/or onto an electronic form copied to computer disk):

- Client name
- Site name and location
- Test company, if applicable

- Name of field staff performing the test
- Test date and time
- Well ID
- Well location
- Well casing, screen and borehole diameter
- Well screen or open-hole section diameter
- Total depth of well
- Any unusual well, weather, or hydrologic features or conditions
- Height (measured distance) of well riser or reference point above or below grade
- Test procedure used (solid slug or pneumatic)
- Storage, transport, and disposal methods for any water removed
- Well drilling method (hollow-stem auger, mud rotary, etc.)
- Decontamination procedures
- Problems and solutions to problems encountered during testing
- Static water level
- Slug volume

APPENDIX A
REFERENCES

- Bouwer, H. 1979. Groundwater Hydrology. New York: McGraw-Hill Book Company.
- Bouwer, H. 1989. The Bouwer and Rice Slug Test -- An Update. Ground Water, vol. 27, no. 3: 304-309.
- Bouwer, H., and R.C. Rice, 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells. Water Resour. Res., vol. 12, no. 3: 423-428.
- Butler, J.J., Jr. 1996. Slug Tests in Site Characterization: Some Practical Considerations. Environ. Geoscience., 3: 154-163.
- Butler, J.J., Jr., and Z. Hyder. 1994. An Assessment of the Nguyen and Pinder Method for Slug Test Analysis. Ground Water Monitoring and Remediation, 14: 124-131.
- Butler, J.J., Jr., C.D. McElwee, and W.Z. Liu. 1996. Improving the Quality of Parameter Estimates Obtained from Slug Tests. Ground Water, 34: 480-490.
- Chirlin, G.R. 1989. A critique of the Hvorslev Method for Slug Test Analysis: The Fully Penetrating Well. Ground Water Monitoring Rev., 1: 365-381.
- Cooper, H.H., Jr., J.D. Bredehoeft, and I.S. Papadopulos. 1967. Response of a Finite Diameter Well to an Instantaneous Charge of Water. Water Resour. Res., 3, no. 1: 263-269.
- Cooper, H.H., Jr., J.D. Bredehoeft, and I.S. Papadopulos. 1973. On Analysis of Slug Test Data, Water Resour. Res., vol. 3, no. 4: 1087-1089.
- Domenico, P.A. and Schwartz, F.W. 1990. Physical and Chemical Hydrogeology, John Wiley & Sons, Inc. New York, 824 pp.
- Fetter, C.W. 1993. Contaminant Hydrogeology, Macmillan Publishing Co., New York, 458 pp.
- Fetter, C.W. 1994. Applied Hydrogeology, 3rd Ed., MacMillan College Publishing Company, New York, 691 pp.
- Hvorslev, M.J. 1951. Time Lag and Soil Permeability in Ground-Water Observations. Bull. No. 36, Waterways Exper. Sta., Corps of Engrs., U.S. Army, Vicksburg, Mississippi: 1-50.
- Hyder, Z. and J.J. Butler, Jr. 1995. Slug Tests in Unconfined Formations; An Assessment of the Bouwer and Rice Technique. Ground Water, vol. 33, no. 1: 16-22.

APPENDIX A
REFERENCES
(Continued)

- Hyder, Z., J.J. Butler Jr., C.D. McElwee, and W.Z. Liu. 1994. Slug Tests in Partially Penetrating Wells. Water Resour. Res., vol. 30: 2913-2919.

- Khilar, K.C. and H.S. Fogler. 1987. Colloidally induced fines migration in porous media. Rev. Chem. Eng. 4, nos. 1-2: 1-149.

- Kruseman, G.P. and N.A. de Ridder. 1990. Analysis and Evaluation of Pumping Test Data, 2nd Ed., International Institute for Land Reclamation and Improvement, the Netherlands: 377 pp.

- Prosser, Pneumatic Displacement Method.

- Shapiro, A.M. and P.A. Hsieh. 1998. How good are estimates of transmissivity from slug tests in fractured rock. Ground Water (in press).

- U.S. Department of the Interior, Bureau of Reclamation. 1985. Ground-Water Manual. United States Government Printing Office. Denver. 480 pp.

- Van der Kamp, G. 1976. Determining aquifer transmissivity by means of well response tests: the underdamped case. Water Resour. Res. 12: 71-77.

- Watson and Burnett, A.D. 1993. Hydrology, an Environmental Approach. Ft. Lauderdale: Buchanon Books. 702 pp.

- Widdowson, M.A., F.J. Molz, and J.G. Melville. 1990. An analysis technique for multilevel and partially penetrating slug test data. Ground Water. 28, no. 6: 937-945.

- Zlotnik, V. 1994. Interpretation of slug and packer tests in anisotropic aquifers. Ground Water. 32, no. 5: 761-766.

APPENDIX B
RELATED HALEY & ALDRICH PROCEDURES

- OP1009 Medical Surveillance Program
- OP1010 Health and Safety Plans
- OP 3000 General Environmental
- OP3008 Manual Water Level Measurement
- OP3015 Aquifer Parameter Testing Procedure
- OP3018 Vertical Water Quality Profiling Procedure
- OP3025 Hydraulic Conductivity
- OP3027 Decontamination Procedure

APPENDIX C
FORMS

APPENDIX D
GLOSSARY