



Revitalizing Auto Communities
Environmental Response Trust

May 19, 2017

U.S. EPA Region 5
Remediation and Reuse Branch
Land and Chemicals Division, LU-9J
77 West Jackson Blvd.
Chicago, IL 60604-3590
Attn: Mirtha Cápiro

RE: Phase 1 Dynamic Groundwater Recirculation (DGR™) Interim Measure Pilot Test
Work Plan
RACER Trust Moraine Facilities
Moraine, Ohio

Dear Ms. Cápiro:

The Revitalizing Auto Communities Environmental Response Trust (RACER Trust) is providing this Phase 1 Dynamic Groundwater Recirculation (DGR™) Interim Measure Pilot Test Work Plan (Work Plan) for the RACER Trust Moraine Facilities in Moraine, Ohio. This Work Plan was prepared as per the February 1, 2017 Request for Interim Measures to Remediate Groundwater Contamination as Source of Vapor Intrusion Off-site letter from the United States Environmental Protection Agency (U.S. EPA). The Work Plan includes a summary of the pilot test objectives, planning activities, well installation activities, hydraulic testing methodologies, investigation derived waste management activities, planned reporting, and project schedule.

If you have any questions, please contact me at (937) 751-8635.

Sincerely,

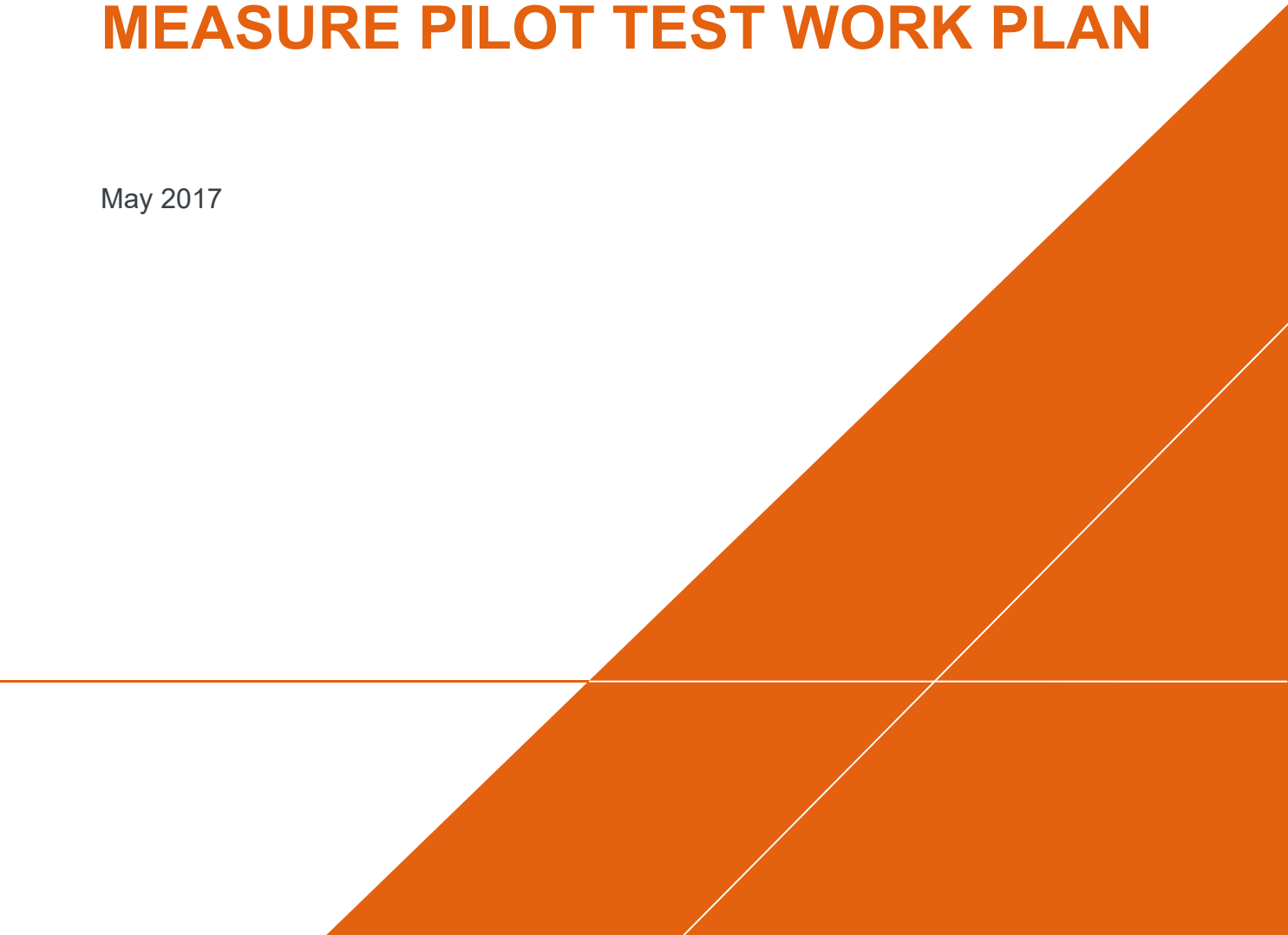
Pamela L. Barnett, PG
Cleanup Manager (DE, LA, MA, OH, PA, VA)
RACER Trust

cc: Valerie Orr – Ohio EPA

Revitalizing Auto Communities Environmental
Response Trust (RACER Trust)

PHASE 1 DYNAMIC GROUNDWATER RECIRCULATION (DGR™) INTERIM MEASURE PILOT TEST WORK PLAN

May 2017

A large orange geometric graphic consisting of a triangle and a rectangle. The triangle is on the left, with its hypotenuse facing right. The rectangle is on the right, with its left side aligned with the hypotenuse of the triangle. A horizontal white line runs across the middle of the graphic, intersecting both the triangle and the rectangle.

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1 INTRODUCTION AND OBJECTIVES

This *Phase 1 Dynamic Groundwater Recirculation Interim Measure Pilot Test Work Plan* (Work Plan) has been developed to describe the design basis and methodology for implementation of the Dynamic Groundwater Recirculation (DGR™) Interim Measure (IM) pilot test at the Revitalizing Auto Communities Environmental Response Trust (RACER Trust) Moraine Facilities (formerly General Motors Corporation [former GM Corporation]) located in Moraine, Ohio (Site). The Site includes the former Delphi Harrison Thermal Systems Moraine Plant (former Delphi Thermal Moraine), former General Motors Powertrain Group, Moraine Engine Plant (former Moraine Engine), and former General Motors Truck Group, Moraine Assembly Plant (former Moraine Assembly) (Figure 1). This Work Plan was prepared in response to a request by the United States Environmental Protection Agency (U.S. EPA) in a letter titled *Request for Interim Measures to Remediate Groundwater Contamination as Source of Vapor Intrusion Off-site* (U.S. EPA 2017). The IM pilot test is a portion of the Phase One DGR™ scope of work summarized in the *Moraine Facilities (13170) 2017 Annual Environmental Action (EA) Budget Request* (RACER Trust 2016a).

The IM pilot test scope of work includes well installation and hydraulic testing to determine extraction and injection influence and capacity. Additionally, the data collected will be used to refine the understanding of hydraulic characteristics in the IM treatment area of the upper aquifer. The objective of Phase I of the DGR™ IM is to reduce site-specific volatile organic compounds (VOCs) in groundwater within the Riverview Plat neighborhood (neighborhood) to concentrations below the Maximum Contaminant Levels (MCLs) within 5 years of initiating full-scale operation. The direct benefit of addressing total site-specific VOCs within the neighborhood is a reduced vapor intrusion risk for structures within the neighborhood that have not provided access for installation of a vapor intrusion mitigation system. A secondary objective is to evaluate the effectiveness of the DGR™ remedy as an option to address the site-wide diffuse plume.

The DGR™ IM pilot test objectives are:

- Install two upper aquifer extraction wells and two monitoring well pairs (shallow and deep) that will also be part of the full-scale DGR™ design
- Complete testing to determine hydraulic influence, evaluate extraction and injection capacity, and refine the understanding of hydraulic characteristics in the upper aquifer
- Evaluate the hydraulic testing data, revise the existing numerical groundwater flow model through validation of hydraulic testing results, and complete groundwater flow model simulations to support the full-scale DGR™ design
- Complete simulations to evaluate the Phase I DGR™ IM program in comparison to groundwater extraction alone
- Collect groundwater samples for target analytes to refine the understanding of potential well fouling and management protocols and total site-specific VOC concentrations before and during testing

A detailed description of the work elements provided above is included in the subsequent sections.

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1.1 DGR™ Overview

Hydraulic containment (i.e., pump-and-treat) is a conventional remedial technology to protect receptors and provide hydraulic control of dissolved-phase contaminants. While this method can be an effective hydraulic control system, there are significant remedial limitations as a result of ambient hydraulic gradient and aquifer hydraulic conductivity conditions. The DGR™ remedy is an evolution of traditional hydraulic containment methods that employs groundwater recirculation to enhance advective flushing by creating the dynamic gradients required to reverse the processes of plume development, with routine optimization to achieve optimal performance.

Extracted groundwater is treated above-grade (using an air stripper and granular activated carbon [GAC] units), amended with chemical additives to prevent scaling/fouling of injection infrastructure, and then redirected into the subsurface via injection wells to segment the on-site and distal plume areas and enable expedited flushing of total site-specific VOCs from groundwater within the neighborhood. The extraction volumes, reinjection flow rates, and targeted reinjection well locations can be modified to adapt to changing site conditions and observed treatment performance.

The hydraulic containment portion of the DGR™ remedy consists of two upper aquifer extraction wells located upgradient of the neighborhood and one extraction well downgradient. It is estimated that a total flow rate of 300 to 400 gpm will be required for the plume dimensions. Details that include calculations and assumptions used for this estimate were presented in the *Draft Direct Groundwater Recirculation Technology Remedial Timeframe Estimates for Off-Site Aquifer Groundwater Plume* memorandum (Arcadis, Inc. 2016a). Based on this preliminary design, the two extraction wells along the property boundary have an estimated combined target flow rate of 220 gpm and will be installed during this IM pilot test. A third extraction well, with a targeted flow rate 150 gpm, will be installed downgradient of the neighborhood during full-scale Phase I DGR™ implementation.

As demonstrated by historical operations at extraction well TW-2, where extraction flow rates of approximately 150 gpm were achieved, hydraulic containment is capable of capturing significant volumes of water from the upper aquifer. However, given the length of the groundwater plume within the neighborhood area and the upper aquifer groundwater velocity, hydraulic containment is not likely to achieve the MCLs as a stand-alone remedy in the neighborhood area within 5 years of remedial operation. However, the DGR™ approach implemented in conjunction with final source area remedies is viewed as an effective means to meet the timeframes proposed. A comparative analysis will be completed in the subsequent full-scale design report detailing the design components that are unique to DGR™.

1.2 Site Description and History

The Site has been used for industrial purposes since the property was acquired in the mid-1920s by former GM Corporation. The historical Site operations have included appliance manufacturing, machining and assembly of automotive air conditioning equipment, automotive machining and painting, and the assembly of diesel engines. The former Moraine Engine and Moraine Assembly facilities occupy approximately 282 acres, while the adjacent former Delphi Thermal Moraine facility occupies approximately 143 acres. Most of the historical structures have been demolished; however, some structures remain on-site (Figure 1). The ground cover is largely comprised of concrete building

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foundation floors, intact and deteriorated concrete and asphalt pavement, and gravel and open soil surfaces with plant growth.

On June 30, 2011, RACER Trust sold the properties, former Delphi Thermal Moraine, former Moraine Engine Plant, and former Moraine Assembly Plant to Industrial Realty Group Moraine, LLC (IRG). As part of the property transfer, RACER Trust retained environmental liability for these properties. The closed South Settling Lagoon was not included in this property transaction and is retained by RACER Properties LLC. IRG currently leases several portions of the Site for industrial purposes. IRG sold several portions of the property to Copart of Connecticut, Inc., Fuyao Asset Management A, LLC, and Inland Property Management, Inc. in 2014. Current Site operations include multi-tenant use for industrial purposes.

Additional details regarding former Site operations and remedial actions are provided in the *Corrective Measures Proposal* (2012 CMP) (Arcadis, Inc. 2012b), the *Updated Former Process Sump Area Draft Data Package* (RACER Trust 2016b), and the *Site-Wide Groundwater Monitoring Report for 2016* (Arcadis, Inc. 2017).

1.3 Area-Specific Conceptual Site Model

This area-specific conceptual site model (CSM) is focused on information as it relates to the upper aquifer in the neighborhood area located southwest of the Site and just south of the closed South Settling Lagoon. Information presented was gathered from the 2012 CMP (Arcadis, Inc. 2012b) and from recent groundwater concentration data presented in the *Site-Wide Annual Groundwater Monitoring Report for 2016* (Arcadis, Inc. 2017).

1.3.1 Area-Specific Geology / Hydrogeology

The neighborhood area is underlain by glacial outwash sand and gravel deposits with a relatively continuous glacial till. There are three main hydrostratigraphic units (i.e., upper aquifer, regional clay till, and lower aquifer), including two principle aquifers (i.e., upper aquifer and lower aquifer). The regional clay till unit extends laterally across the area with a uniform thickness of approximately 11 feet and acts as an aquitard between the upper and lower aquifers. Local boring log data from monitoring and remediation wells indicate that the upper aquifer in this area is mostly comprised of poorly sorted coarse-grained soil (e.g., sand and sand/gravel with some borings containing intervals with minor amounts of fine sand), before terminating at the top of regional clay till aquitard at a depth of approximately 58 to 60 feet below ground surface (bgs).

The upper aquifer saturated thickness ranges from 39 to 43 feet based on area groundwater levels from 2007 to 2016. Results from shallow sieve analyses from boring SPG-1 in the neighborhood (intervals of 10 to 12 feet and 12 to 14 feet bgs) indicate the dominate presence of coarse-grained material, specifically gravel and sand (95 percent [%]) within the shallow portion of the upper aquifer. The 10 to 12 feet bgs interval is a well-graded gravel with silt and sand, and the 12 to 14 feet bgs interval is a poorly-graded gravel with sand. Although these sample results are shallower than the targeted saturated zone, the coarse-grained descriptions at depth are similar to these shallow sample results. Boring logs and well construction logs for the area are provided in Appendix A.

1.3.2 Upper Aquifer Hydraulic Characteristics

Regionally, the upper aquifer consists of two distinguishable facies, a higher permeable (i.e., sand and gravel) facie and a lower permeable (i.e., interbedded fine sand, silt, clay, and till) facie. Based on historical boring logs and soil descriptions, the neighborhood area is dominated by the high permeability zones (i.e., sand and gravel) indicative of rapid advective groundwater transport. Groundwater generally flows from the northeast to the southwest across the neighborhood area and flows toward the Great Miami River. The horizontal hydraulic gradient within the upper aquifer in 2016 between monitoring well HR-1 (located just northeast of the closed South Setting Lagoon) and monitoring well GM-16 (in the southern area of the neighborhood) was 5.6×10^{-4} feet per foot (ft/ft).

Hydraulic testing results from the Pre-Design Investigation (Arcadis, Inc. 2012a) discreet point testing from vertical aquifer profiling intervals indicates an average hydraulic conductivity of 975 feet per day (ft/day) just to the east of the neighborhood at the former Building 21 area. However, historical testing from large scale pumping tests at nearby extraction well TW-2 (located southeast of the neighborhood) recorded an average hydraulic conductivity value of 2,800 ft/day (Geraghty & Miller, Inc. 1990).

1.3.3 Area-Specific Plume Concentrations and Distribution

Total site-specific VOCs concentration distribution within the upper aquifer is shown on Figure 2 within the area of the neighborhood. Concentrations exceeding 100 micrograms per liter (ug/L) just upgradient of the neighborhood are distributed across the eastern half of the closed South Settling Lagoon emanating from the upper aquifer main source areas (approximately 3,500 to 4,000 feet upgradient at the former Process Sump Area and former Oil House Area) and extend downgradient into the north central portion of the neighborhood. Plume concentrations decrease cross gradient and downgradient of the neighborhood. The estimated total plume width is approximately 1,000 feet perpendicular to groundwater flow at the upgradient-northern edge of the neighborhood. The plume width is based on concentrations that exceed 5 ug/L total site-specific VOCs.

1.4 Proposed Final Remedy Components

Through a series of communications, the U.S. EPA requested that additional remedial components be incorporated into the final remedy for the Site to further reduce concentrations of diffuse plume contaminants and expedite the remedial timeframe. The *Proposed Final Remedy Components Amendment* (Amendment) (RACER Trust 2016c) included an update to the proposed final remedy components for the Site that were summarized in the 2012 CMP (Arcadis, Inc. 2012b). The Amendment recommended incorporating DGR™ in the upper aquifer (on-site and off-site) as a component of the final remedy. The Amendment summarized the final remedy components included in the 2012 CMP (Arcadis, Inc. 2012b), detailed the recommended modifications to the 2012 CMP final remedy components, and included information that supports DGR™ as a portion of the final remedy.

Specifically, three final remedy modifications were recommended:

1. DGR™ would be included as a component of the final remedy to address the diffuse groundwater plume in the upper aquifer on-site and off-site.

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2. Minor modifications to the source area treatment footprint within the former Process Sump Area should be made based on delineation activities completed after submittal of the 2012 CMP (Arcadis, Inc. 2012b).
3. If necessary, on-site vapor intrusion mitigation at the existing buildings will be incorporated into the remedy.

In response to comments from the U.S. EPA during a November 7, 2016 phone conversation, the *Proposed Final Remedy Components – Cost Estimate Supporting Documentation* (RACER Trust 2016d) and the *Proposed Final Remedy Components Amendment – Response to U.S. EPA* (RACER Trust 2016e) were submitted to the U.S. EPA and provided additional details with regard to the proposed final remedy. The objectives of the DGR™ IM pilot test align with supporting the proposed final remedy components as they relate to the diffuse plume.

2 PLANNING ACTIVITIES

The field tasks associated with this Work Plan will be completed in accordance with the Standard Operating Procedures (SOPs) presented in Appendix B and field forms presented in Appendix C. Field work will be completed following the procedures identified in the site-specific health and safety plan (HASP; Arcadis, Inc. 2016b). The HASP includes a description of the safety risks associated with the tasks detailed in this Work Plan. A clear process for mitigating these risks is communicated in the HASP.

2.1 Permitting

Based on the activities associated with this Work Plan, a discharge permit with Montgomery County Environmental Services for discharge of water extracted during the IM pilot test to the Montgomery County sanitary sewer system is required. The plans for the discharge activities have been communicated to Montgomery County, and groundwater data that is representative of the groundwater that will be generated during the IM pilot test has been provided to Montgomery County.

The discharge permit is stipulated based on treating total site-specific VOCs to concentrations below the MCLs. Two samples will be collected and analyzed for site-specific VOCs (1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, benzene, cis-1,2-dichloroethene, ethylbenzene, tetrachloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, vinyl chloride, and xylene [total]). One sample will be collected on the first day of system discharge, and a second sample will be collected on the last day of discharge. The samples will be collected from the effluent of the mobile treatment system (Figure 3), prior to discharge into the sanitary sewer system. In addition, the discharge rates are not expected to surcharge the sewer system. If the discharge is surcharging the system, the water will be diverted into on-site storage tanks. A representative from Montgomery County Environmental Services will be on-site to oversee the system start-up process.

In accordance with Ohio Administrative Code (OAC) 3745-27-13 (Rule 13), a request will be submitted to the Ohio EPA for approval to install the proposed wells as the drilling locations are within 300 feet of solid waste in the closed South Settling Lagoon. The request will include an overview of the closed South Settling Lagoon history and information required by Rule 13 (e.g., name/type of facility, address, contact information, identification of the type and amount of waste present, a description of the proposed activities, institutional controls that apply to the Site, controls planned during the proposed activities). Installation of the proposed wells will not be completed until Ohio EPA approval is received. Less than 10 pounds per day of total site-specific VOCs is expected to be emitted from the air stripping tower modular treatment system during the Phase I DGR™ IM pilot test. Therefore, an air permit is not required, as exempted under the OAC 3745-15-05(B).

Finally, an underground injection control (UIC) permit is not required based on OAC 3745-24-11(H). The referenced Code indicates that “the injection of fluids into a class V well for purposes of remediating ground water or soil contamination is authorized without a permit.” Valerie Orr with the Ohio Environmental Protection Agency indicated that this exemption should apply to this project in an email dated February 23, 2017 but will need to review this Work Plan before making a final decision.

3 WELL INSTALLATION

Before installation of the extraction wells, two monitoring well pairs (RMW-91/RMW-92 and RMW-93/RMW-94) will be installed at locations indicated on Figure 2. The monitoring well pairs will be installed in the upper and lower portions of the upper aquifer to evaluate total site-specific VOC concentrations and for monitoring upper and lower hydraulic response in the upper aquifer during testing. Additionally, monitoring the upper and lower portions of the upper aquifer will provide information on vertical concentration distribution as well as vertical flow conditions before, during, and after testing.

Two new extraction wells (EW-1 and EW-2) will be installed in the area north of the neighborhood and south of the closed South Settling Lagoon as indicated on Figure 2. Although injection wells will be utilized as part of the full-scale DGR™ design, one of the extraction wells (EW-1) will be used as an injection well for testing purposes. In addition, the existing carbon source injection wells (RZ-4 west) are planned to be incorporated in the full-scale design and also may be utilized for the IM pilot test. It is likely that new injection wells, as part of the full-scale DGR™ design, will be located within the neighborhood. Using one extraction well for injection well testing will keep the IM pilot test operations on-site and reduce disturbance to residences until the full-scale system implementation.

The use of location-specific information is critical for designing extraction or injection wells to ensure adequate performance expectations and reliable long-term operations (Payne et al., 2008). Based on the CSM and lithologic characteristics (see Section 1.3.1), the upper aquifer sand and gravel target zone in the area of the neighborhood is highly permeable and capable of exceeding extraction and injection expectations.

The sections below detail the extraction well design, installation, and development procedures.

3.1 Utility Clearance

Prior to the installation of the soil borings, underground utilities will be cleared and locations will be surveyed for overhead utilities. Utilities will be cleared following the Arcadis Utility Location Policy and Procedures. A copy of the Arcadis Utility Location Policy and Procedures can be found in the HASP. At a minimum, Arcadis will contact the Ohio Utility Protection Service (OUPS), review available facility utility drawings, and conduct a detailed visual site inspection. Invasive utility clearance procedures will be completed, which may include clearing each boring using an “air-knife” or similar device to an approximate depth of approximately 6 feet bgs. Other lines of evidence which may be utilized include, but are not limited to, a private utility locating service, hand augering or digging, and utility provided utility location maps.

3.2 Monitoring Well Installation, Sampling, and Development

Initial borings will be advanced utilizing sonic or hollow stem auger drilling methods at each of the two monitoring well pair locations to the regional clay till (approximately 60 feet bgs). Soil samples will be collected, field screened for VOCs using a photoionization device (PID), and classified based on the Udden-Wentworth grain size scale (Appendix B). The soil descriptions, including Unified Soil Classification System (USCS) descriptions, grain size distribution, sorting, moisture content,

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consistency/density, color (based on the Munsel color system), and PID readings will be recorded on field boring logs. In addition, select soil samples at location RMW-93/94 will be collected and sent to a local laboratory for grain size analysis. This information will be used to design the extraction well screen.

The lower monitoring well will be installed in the initial boring, and the upper well will be installed in an offset boring. Wells will be constructed of 2-inch diameter Schedule-40 polyvinyl chloride (PVC) with 10-slot PVC or continuous wire-wrapped stainless steel screens. Screen length and depth will be determined based on lithologic and saturation relationships to cover upper and lower portions of the upper aquifer (i.e. near the groundwater table and just above the regional clay till). During installation, after the well screen and sand pack are in place, each well will be pre-developed to ensure proper placement of the filter pack around the well screen. Wells will be completed with either a flush mount well vault or lockable stickup with a concrete pad. Once installed, monitoring wells will be developed by method of surge and volumetric purge. In addition, the ground elevation and the top-of-casing measuring point of each monitoring well will be surveyed by a licensed professional once all the wells are installed.

3.3 Extraction Well Installation

Information from on-site upper aquifer extraction wells (TW-1 and TW-2) installed in 1985 and 1989, respectively, confirms the prolific and coarse nature of the upper aquifer sand and gravel deposits. The screens for extraction wells TW-1 and TW-2 were designed based on grain size analyses and both were installed with the cable tool drilling methodology, with 10-inch diameter telescoping stainless steel wire-wrapped screens. The screen length and slot size were customized, consisting of 6.5 feet of screen with 0.04-inch slot at extraction well TW-1 and 10-feet of screen at varied intervals of 0.07 and 0.09-inch slot at extraction well TW-2.

The high performance of these test wells was confirmed by the upper aquifer IM operation for control of total site-specific VOC migration by extraction well TW-2 that operated from 1996 to 2012. Performance testing during 2004 indicated a specific capacity at extraction well TW-2 of approximately 24 gallons per minute per foot for a well with 10 feet of screen. Long-term operation of extraction well TW-2 averaged 120 gpm. Extraction well TW-2 was capable of pumping at higher flow rates; however, the average long-term flow rate was based on treatment system capabilities.

Based on the success of these two test wells, a similar design and installation methodology is proposed (Figure 3). The recommended screen to be used will be a piped or telescoping 8-inch diameter stainless wire-wrapped screen with an estimated length of 20 to 30 feet. The information compiled from the initial borings (i.e., soil grain size results) will be used to confirm appropriate screen lengths with custom slot sizes for a natural filter pack well. The proposed design parameters, including screen manufacturer specifics, will be used in calculations (Driscoll, 1986) to verify screen transmitting capacity and exceedance of a design flow rate of 150 gpm.

Extraction wells are expected to be installed using hollow stem auger methodologies. During boring advancement, soils will be continuously collected for lithologic descriptions. An outer 10 to 12-inch steel casing will be driven to a depth of approximately 30 feet to accommodate the neat cement well seal. The remaining depth of the borehole will be completed with an 8-inch steel drive casing advanced within the outer casing. The target depth of 62 feet bgs is approximately 2 to 3 feet into the regional clay till horizon, which has a known thickness of 11 or more feet in the area, to accommodate a well sump. If observations

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of soil characteristics vary from the initial monitoring well boring RMW-93/94, additional soil samples may be collected within saturated target intervals and sent to a local lab for grain size analyses to verify screen design. Once the borehole is complete, the well screens will be installed with a stainless steel basal sump with a length of 3 feet. In accordance with Ohio EPA technical guidelines (Ohio EPA 2008), a natural formation pack screen design will be used based on the grain size analyses. Grain size analysis results will be used to determine the optimal slot size (in relation to interval depth) for the custom well screens and will be at least a 70% design retention of the formation. After the well screen is installed to the design depth, the formation will be allowed to collapse along the screen and casing to the depth of the outer casing. To complete the installation, the annular seal will be installed between the 8-inch steel well casing and the outer 10 or 12-inch outer casing to the surface using neat cement.

3.4 Extraction Well Development

Before the well seal is installed, pre-development will be performed after screen installation to allow for the natural formation pack to settle and to avoid any bridging. Final well development will begin once the wells have been completed and sufficient time to allow for the well seal to cure (24 to 48 hours). The process will combine multiple development techniques to allow for an increased removal of fines and to increase hydraulic communication for groundwater to move both in and out of the well screen. To gauge the development process and well-aquifer connectivity, a specific capacity test will be performed and water quality parameters will be collected prior to engaging in well development procedures. The data collected will be used as a baseline comparison throughout well development efforts.

The stages of development will consist of the following:

- Initial pumping or air-lift to remove fines
- Surge entire screen utilizing a double surge block in 2-foot screen increments
- Using a pump or weighted bailer remove fines periodically from the bottom of the well between rounds of surging

Once all stages of development are complete, a second round of water quality parameter collection and specific capacity testing will be completed. A comparison between the baseline values will be assessed to identify if additional rounds of surging and jetting need to be performed. This process will be repeated until specific capacity shows an improvement of less than approximately 10%, measured parameters have stabilized against predetermined criteria, and targeted well yield has been achieved of at least 150 gpm.

4 HYDRAULIC TESTING METHODOLOGY

This section outlines the duration of the various hydraulic test phases and involved monitoring details for the DGR™ IM pilot test. Three types of hydraulic tests will be performed and include:

- Extraction Step Test and Groundwater Sampling – three to four steps to evaluate well performance (flow capabilities) and establish baseline specific capacity and groundwater chemistry
- Extraction Constant Rate Test – 48 to 72-hour constant rate test followed by recovery to evaluate hydraulic influence and refine upper aquifer hydraulic parameters
- Injection Step Test – three to four steps to evaluate optimal injection flow rates

In addition to the three aforementioned tests, recirculation testing will be completed if it is determined to be necessary. The rationale for proposing the recirculation testing was to evaluate the benefits of DGR™ versus conventional pump and treat technologies. This comparative analysis is no longer required based on communications during an April 18 and 19, 2017 meeting with the U.S. EPA, RACER Trust, and Arcadis. If based on an initial review of the DGR™ IM pilot test data (e.g., site-specific VOC data and injection and extraction hydraulic testing data) it is determined that recirculation testing is necessary, the testing will be completed. This section includes the recirculation testing scope of work should it be needed.

For IM pilot test purposes, one of the installed extraction wells will be used as an injection well (EW-1). The following section describes monitoring and testing activities including background monitoring, testing equipment system setup, sampling, and hydraulic testing methods.

4.1 Monitoring

Monitoring wells will be used to measure upper aquifer response during the various hydraulic tests. The monitoring wells that were selected provide comprehensive coverage and enable assessment of the DGR™ pilot system operation effects on upper aquifer groundwater levels throughout the testing area. Pressure transducers will be installed in twelve wells (EW-1, EW-2, W-3-S, W-4-S, RZ-4I, GM-16, GM-63, GM-64, RMW-91, RMW-92, RMW-93, and RMW-94), and periodic manual groundwater level measurements will be taken at ten wells (RZ-4A, RZ-4L, RZ-4O, GM-47, GM-50, W-2-S, WSU-23, GM-19S, HR-16, and HR-17) as described in Table 1 and shown on Figure 2. The monitoring well network outlined for each hydraulic test includes background groundwater water level monitoring (GM-16) located downgradient and outside the testing influence area and barometric pressure observations (using current monitoring equipment at lower aquifer extraction well DN-13). Rainfall data will be collected via download of observations from the Dayton Wright Brothers Airport station operated by the National Oceanic and Atmosphere Administration (NOAA).

Pre-test groundwater level monitoring will be completed prior to initiating the hydraulic tests, for a period of 5 days. The purpose of this monitoring is to establish baseline groundwater level conditions. Pressure transducers will be pre-programmed to record every 15 minutes for the duration of the week preceding the hydraulic testing. Additionally, manual water level data will be collected to supplement the pressure transducer measurements. These measurements will be made at the start and finish of the pre-test monitoring period and at the start and finish of each hydraulic testing phase. Data collected will be used

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to evaluate the presence of any background trends during the testing, evaluate barometric efficiency of the system, and provide data for necessary post-test data corrections.

During the hydraulic tests, pressure transducers will be re-programmed with a higher frequency recording interval based on their spatial location in order to capture early-time instantaneous changes associated with test initiation and completion. Manual groundwater level measurements will be performed at critical moments in testing that includes before start, changes in pumping flow rates, and finish. At the completion of the post-test period, final manual groundwater level measurements and pressure transducer data download will be completed.

4.2 System Setup / Construction

Extraction step test and constant rate test system setup is illustrated on Figure 3. The test system will utilize a variable speed submersible pump assembly capable of reaching approximately 300 gpm. The submersible pump will be placed just above the top of the well screen and discharge / control lines will be extended to the various surface equipment (flow controller and generator). The discharge line will be equipped with a pressure gauge, ball valve, and both instantaneous and totalizing flow meters.

The discharge line will continue to a modular treatment system consisting of bag filtration followed by either granular activated carbon tanks or an air stripper (Figure 3). Treated discharge will continue to a local sanitary sewer point and to two to four 20,000-gallon Frac tanks for storage. The clean water storage will be used for the later phase injection and recirculation testing, as necessary. Samples will be collected to verify system operation, as detailed in Section 2.1.

4.3 Extraction Step Test

Short-term step tests and baseline groundwater sampling will be performed on the extraction wells (EW-1 and EW-2) to evaluate chemistry, specific capacity, and performance. This information will be used to decide on optimal flow rate for additional testing, full-scale DGR™ system design, and assist with future operation and maintenance decisions. In a step drawdown test, the well is pumped at several successively higher flow rates and the drawdown for each rate, or step, is recorded. Steps will be uniform in duration at a maximum time limit of 1 hour. The response of groundwater levels to pumping will be recorded with a pressure transducer, and if feasible, manually measured with an electronic water-level meter for backup. The drawdown will be monitored from the pressure transducer in real time to assure a sufficient water column is available and to assess additional step flow rates.

Each step will begin with a flow rate of about half of the proposed target design flow rate at approximately 75 gpm. After the first test step (1 hour), the flow rate will be increased by about 50 to 75%, and continued groundwater level response will be monitored for the next 1 hour step. The process will be repeated for three to four cycles to a maximum flow rate of approximately 300 gpm. Following the final step, pumping will cease, and recovery will be monitored for approximately 1 to 2 hours.

4.4 Anti-Scaling Bench and Baseline Testing

To evaluate potential scaling of the well screens for the full-scale DGR™ treatment system design and to identify the anti-scaling reagent and dosing rates, an anti-scaling bench-scale test will be performed

PHASE 1 DYNAMIC GROUNDWATER RECIRCULATION (DGR™) INTERIM MEASURE PILOT TEST WORK PLAN

based on groundwater sample results collected during the hydraulic testing. A total of three groundwater samples of one gallon each will be collected for this test. Specifically, two groundwater samples will be collected during the step testing portion of the testing from an influent sampling port after approximately 1,000 gallons and 10,000 gallons of groundwater have been pumped from one of the two newly installed wells for extraction, respectively. The third sample will be collected from the other newly installed wells at the end of step testing. Samples will be submitted to Water Systems Engineering (WSE), Inc. located in Ottawa, Kansas to perform the bench-scale test. The bench-scale test will consist of two components:

1. Evaluation of water chemistry
2. Evaluation of potential scaling mechanisms, reagent selection, and dosage

A complete profile suite of analyses for these three samples will be performed to identify inorganic water chemistry as well as the background microbial populations to identify scaling mechanisms. The data will be evaluated to determine the potential for scaling and biological fouling concerns within the wells.

The profile suite of water chemistry analyses will include the following parameters. In addition, the Langelier Saturation Index (LSI) will be calculated based on water chemistry data.

- Alkalinity and total alkalinity
- Hardness
- Total dissolved solids (TDS)
- pH
- Conductivity
- Oxidation-reduction potential (ORP)
- Temperature
- Calcium (total and dissolved)
- Sodium (total and dissolved)
- Potassium (total and dissolved)
- Magnesium (total and dissolved)
- Manganese (total and dissolved)
- Aluminum (total and dissolved)
- Iron (total and dissolved)
- Sulfate (total and dissolved)
- Chloride (total and dissolved)
- Silica (total and dissolved)

Groundwater sampling results will be used to perform a bench-scale test using a minimum of three chemical classes for the purpose of reducing scaling within the identified treatment process. Likely chemical classes to be evaluated would include dispersants, chelators, and sequestrants. However, the actual testing methodology may be modified based on water chemistry evaluation.

At the completion of this bench-scale test, the anti-scaling treatment processes, optimal reagents, and dosing rates will be recommended in the full-scale DGR™ system design.

In addition, groundwater samples will be collected before the extraction constant rate test, mid-test, and after recovery from the extraction wells and select monitoring wells. The samples will be analyzed for total site-specific VOCs utilizing the low-flow groundwater sampling methodology. However, groundwater

PHASE 1 DYNAMIC GROUNDWATER RECIRCULATION (DGR™) INTERIM MEASURE PILOT TEST WORK PLAN

samples collected from extraction well EW-1 during the constant rate test (mid-test) will be collected from the sample influent port. Samples will be submitted to TestAmerica Laboratories of North Canton, Ohio for analysis of site-specific VOCs by U.S. EPA Method 8260B. Laboratory methodology and quality assurance / quality control (QA/QC) information presented in the amended *Quality Assurance Project Plan* (QAPP) (Arcadis, Inc. 2011) will be followed. Additional samples (duplicates – 1 per 20 samples, equipment blanks – 1 per 20 samples, and matrix spike / matrix spike duplicate [MS/MSD] – 1 per 20 samples, trip blanks – 1 per cooler) will be collected for QA/QC requirements.

4.5 Extraction Constant Rate Test

A 48 to 72-hour constant rate extraction test will be performed to evaluate upper aquifer hydraulic influence and refine local upper aquifer hydraulic parameters. The specific capacity and optimal flow rate will be determined from the step testing and is expected to be near the targeted flow rate of 100 to 150 gpm per extraction well. The response of groundwater levels to pumping will be recorded with a pressure transducer in the extraction well EW-2, and if feasible, manually measured with an electronic water-level meter for backup. Extraction well and area monitoring well pressure transducers will be programmed to record at a high frequency during test initiation and then set to a decreased 5-minute interval for the remainder of testing period. The drawdown will be monitored from the pressure transducer in real time to evaluate the drawdown response and late time gravity drainage response followed by drawdown equilibration before test cessation is decided.

Additionally, during testing, the extraction well flow rate will be closely monitored and recorded every 10 minutes for the first hour and on an hourly basis for the remainder of the testing period. Modular system treatment will also be closely monitored. At the conclusion of the test, final measurements will be recorded, and the recovery phase monitoring will commence.

4.6 Injection Step Test

A series of short-term injection step tests will be performed on the extraction well EW-1 to evaluate feasible injection flow rates (under gravity fed conditions - no applied pressure) for the full-scale DGR™ design. As with extraction step tests, the initial injection step flow rate will be lower and expected to be approximately 30 gpm. Duration of each step is expected to be 1 hour; however, both duration and subsequent injection step flow rates will be adaptive based on initial step results. The injections will be completed by pumping treated water stored in Frac tanks to a manifold at the well head. Flow rate and well head pressure at the manifold will be closely monitored and recorded. The response of groundwater levels to injection steps will be recorded with a pressure transducer at EW-1. The injection step process will be repeated for three to four cycles to establish a safe injection maximum flow rate. Following the final step, injection will cease and recovery will be monitored for approximately 1 to 2 hours.

4.7 Recirculation Test

Recirculation testing will be performed, if needed, to combine both extraction and injection operation components in order to observe test well and upper aquifer response compared to stand-alone extraction and injection tests. Constant flow rates will be decided for both extraction and injection based on the initial hydraulic testing phases. The recirculation test is expected to last for up to 24 hours with treated

PHASE 1 DYNAMIC GROUNDWATER RECIRCULATION (DGR™) INTERIM MEASURE PILOT TEST WORK PLAN

groundwater stored in the Frac tank, and extracted groundwater will be treated and discharged to the local sanitary sewer discharge point. Fluorescein dye will be added to the treated water prior to re-injection to evaluate recirculation hydraulics. Groundwater at new monitoring well pair RMW-93/94 and extracted groundwater will be visually monitored to observe the presence of the fluorescein dye during testing. As with individual extraction and injection testing, both the injection and extraction well (EW-1 and EW-2) groundwater levels will be recorded with a pressure transducer. Flow rates and pressures will also be closely monitored and recorded. Test well and area monitoring well pressure transducers will be programmed to record at a high frequency during test initiation, and then set to a decreased 5-minute interval for the remainder of the testing.

At the conclusion of the test, final measurements will be recorded and the recovery phase monitoring will be completed.

4.8 Post-Test Recovery

A post-test recovery period will be completed for a period of 3 days to evaluate upper aquifer conditions following all phases of hydraulic testing. The pressure transducers will be re-programmed to record at 15 minute intervals for this period. Final manual groundwater level measurements will be collected at the end of the 3-day period, and the final download of pressure transducer data will be retrieved for evaluation.

5 INVESTIGATION DERIVED WASTE MANAGEMENT

A designated staging area will be assigned in a secure area for drilling equipment, materials, and investigation derived waste (e.g., soil cuttings and decontamination water). In addition, the decontamination area for drilling equipment will be constructed in the same area. Each drum or roll-off container will be properly labeled with pending analysis waste label containing the type of waste (e.g., soil), sample designations for the contents contained, the generator information, boring number, accumulation start and end date, U.S. EPA waste number (if applicable), and Department of Transportation proper shipping name (if applicable). Once the materials are characterized, the containers will be labeled hazardous or non-hazardous. If the material is determined to be hazardous, the material will be relocated to an appropriate temporary storage area to await offsite disposal. The field representative will maintain an inventory of the number of waste containers (hazardous and non-hazardous) generated and staged on-site as part of the IM pilot test activities. Hazardous waste is not anticipated to be generated during IM pilot test activities.

Once the materials have been characterized, an off-site disposal facility will be identified. A waste profile and manifest will be completed and submitted to the disposal facility. Each shipment of waste will be thoroughly tracked and recorded.

6 REPORTING AND SCHEDULE

Upon completion of the IM pilot test, applicable data will be processed, evaluated, and reported in a full-scale Phase I DGR™ IM Design. This design will provide a full-scale design basis for the Phase I DGR™ system, including supporting information and Phase I DGR™ IM pilot test evaluation results. Components of the full-scale Phase I DGR™ design may consist of the following:

- Introduction with Site background, regulatory status, and objectives
- Site setting, current site conditions, and area-specific CSM
- Overview of the DGR™ approach
- Results of the IM pilot test
- Updates to the existing MODFLOW-based (McDonald and Harbaugh, 1988) site numerical groundwater flow model
 - o Validation against the results of the proposed hydraulic testing
 - o Model parameter adjustments (i.e., re-calibration), as necessary, to better match the observed response data
 - o Particle-tracking analysis (MODPATH) to verify the recirculation hydraulics observed during the extraction / injection portion of the hydraulic testing
- Once validated/updated, the groundwater flow model will be used to perform MODALL (Potter et. al., 2008) simulations (in conjunction with MODFLOW) to design / optimize the full-scale DGR™ system.
 - o Note: MODALL is a groundwater modeling code developed by Arcadis that uses the cell-by-cell flow terms generated by MODFLOW to determine the percentage of flow in each cell which has either originated from a given source(s) or flows to a specified sink(s). Output is in the form of capture fraction (CF) and pore volume exchange (PVE) rates which can be combined with initial concentration data sets to compute the pore volume flushes necessary to reach a specified concentration level (i.e., Period of Performance) or to locate potential stagnation zones.
- A summary of the results of the bench-scale test
 - o A water chemistry evaluation, potential scaling mechanisms, anti-scaling treatment processes, and reagent selection and dosage
 - o Recommendations for the design of the anti-scaling treatment processes and units for the treatment system
- Phase I DGR™ Design
 - o Permitting requirements
 - o Well network details
 - o Well construction details
 - o Baseline sampling and injection details
 - o System details (e.g., piping, treatment system)
 - o Additive composition
 - o Performance monitoring program
 - o Operation and maintenance
- Schedule
- References
- Supporting data tables, figures, and appendices

PHASE 1 DYNAMIC GROUNDWATER RECIRCULATION (DGR™) INTERIM MEASURE PILOT TEST WORK PLAN

Field implementation planning and subcontractor procurement are expected to occur after agency approval of this Work Plan. The schedule for implementation is expected to be during the second and/or third quarters of 2017. Field implementation will be initiated within approximately 1 to 2 months of Work Plan approval. IM pilot testing activities are expected to be completed within 2 to 3 months of initiation of field implementation, barring schedule impacts that are not able to be controlled (e.g., contractor availability, weather).

7 REFERENCES

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- RACER Trust, 2016d. Proposed Final Remedy Components - Cost Estimated Supporting Documentation. November 22, 2016.
- RACER Trust, 2016e. Proposed Final Remedy Components Amendment – Response to U.S. EPA Comments. November 22, 2016.
- U.S. EPA, 2017. Request for Interim Measures to Remediate Groundwater Contamination as Source of Vapor Intrusion Off-site. February 1, 2017.

TABLES



Table 1
Hydraulic Testing Monitoring Network Details
Phase 1 DGR™ Pilot Test
RACER Trust Moraine Facilities
Moraine, Ohio

Monitoring Location	Purpose	Monitoring Method	Screen Interval (ft bgs)	Geologic Modifier	Distance from EW-1 (ft)	Distance from EW-2 (ft)
GM-16	Background	Transducer	48-58	UA, TT	1040	1028
EW-1	Test Well	Transducer	40-60	UA, TT	0	250
EW-2	Test Well	Transducer	40-60	UA, TT	250	0
W-2-S	Observation	Manual	30-65	UA, TT	491	249
W-3-S	Observation	Transducer	36-76	UA, TT	318	53
W-4-S	Observation	Transducer	30-70	UA, TT	48	313
RZ-4A	Observation	Manual	29.5-59.5	UA, TT	750	500
RZ-4I	Observation	Transducer	30-60	UA, TT	128	392
RZ-4O	Observation	Manual	28-58	UA, TT	279	544
RZ-4L	Observation	Manual	30-60	UA, TT	470	205
HR-16	Observation	Manual	42-62	UA, TT	847	729
HR-17	Observation	Manual	27-47	UA, TT	781	864
GM-19S	Observation	Manual	47-57	UA, TT	504	769
GM-47	Observation	Manual	49.4-59.4	UA, TT	336	444
GM-50	Observation	Manual	29.7-39.7	UA, WT	336	424
GM-63	Observation	Transducer	30-40	UA, WT	203	460
GM-64	Observation	Transducer	50-60	UA, TT	198	455
WSU-23	Observation	Manual	NA	UA, TT	537	283
RMW-91	Observation	Transducer	25-35	UA, WT	612	509
RMW-92	Observation	Transducer	45-55	UA, TT	612	509
RMW-93	Observation	Transducer	25-35	UA, WT	175	88
RMW-94	Observation	Transducer	45-55	UA, TT	175	88

NOTES:

ft - Feet.

ft bgs - Feet below ground surface.

NA - Not available.

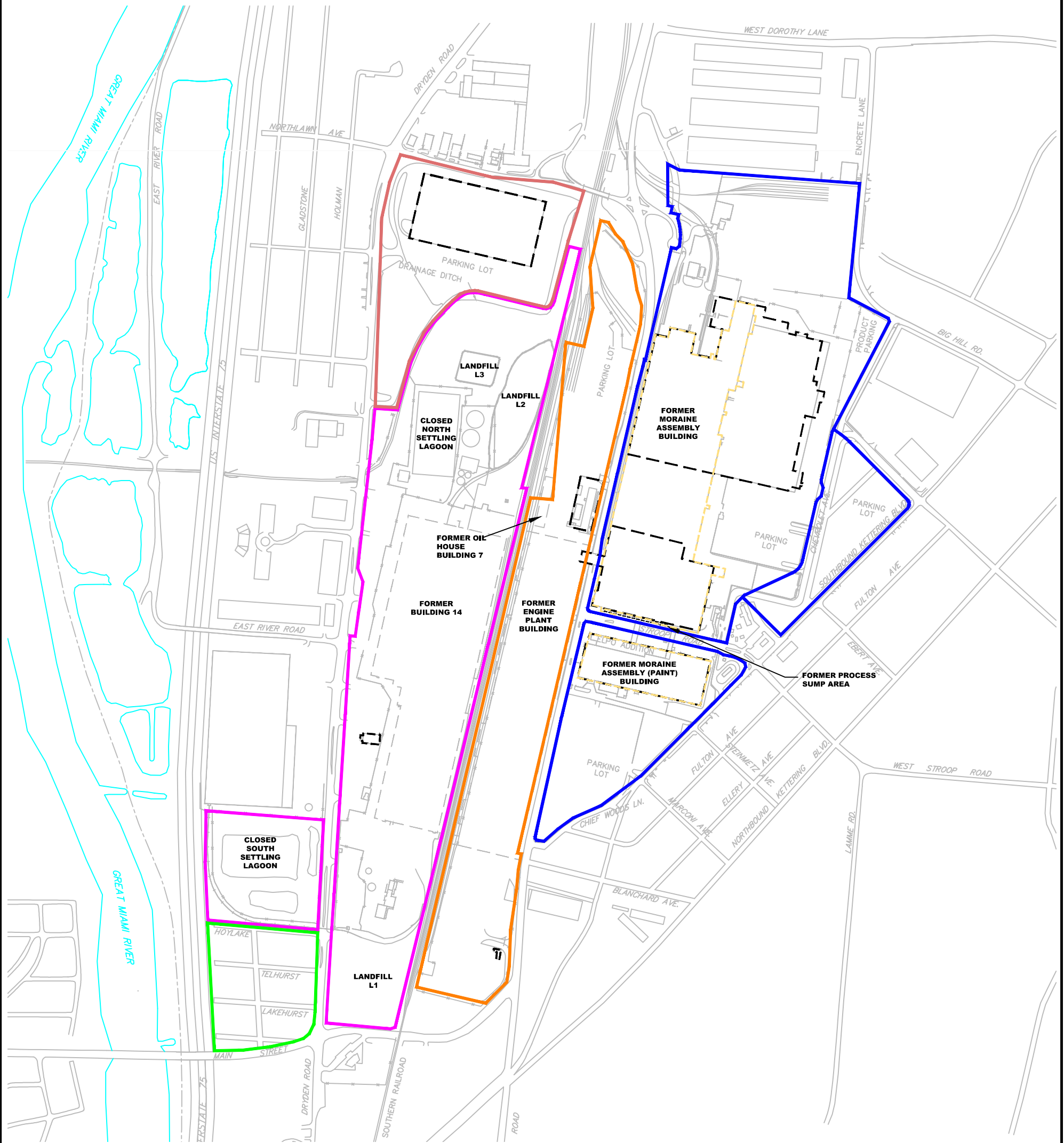
TT - Top of till (regional clay till).

UA - Upper aquifer.

WT - Water table (screen across the water table).

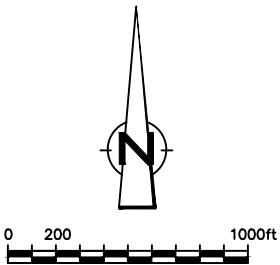
FIGURES





LEGEND

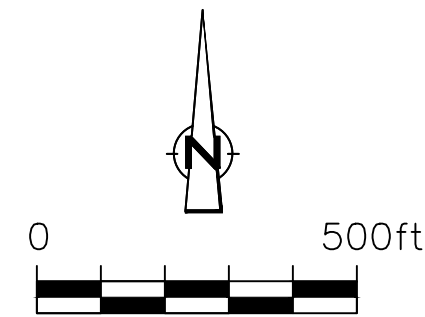
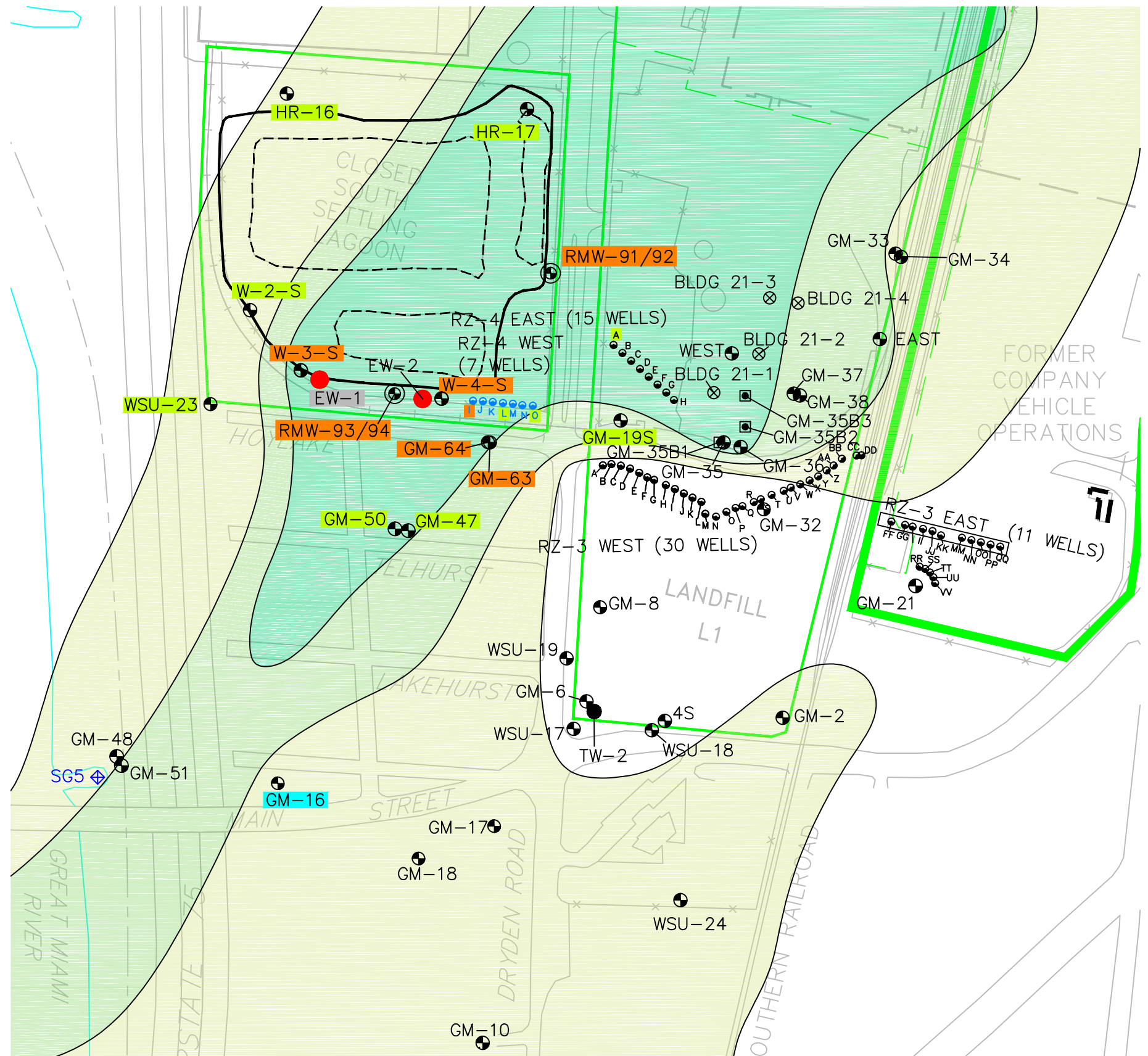
- RIVER LEVEE
- FORMER BUILDING FOOTPRINT
- CURRENT BUILDING FOOTPRINT
- SURFACE WATER FEATURE
- FORMER DELPHI HARRISON THERMAL SYSTEMS, MORaine PLANT PROPERTY BOUNDARY
- FORMER GENERAL MOTORS POWERTRAIN GROUP, MORaine ENGINE PLANT PROPERTY BOUNDARY
- FORMER GENERAL MOTORS TRUCK GROUP, MORaine ASSEMBLY PLANT PROPERTY BOUNDARY
- GENERAL MOTORS LLC, DMAX
- FORMER MORaine ASSEMBLY BUILDINGS
- PHASE I DGR™ PILOT TEST AREA



RACER TRUST
MORaine, OHIO
OH000294.2017

SITE LAYOUT

CITY (Reqd) DIV (GROUP) (Reqd) DB (Reqd) LD (Opt) PIC (Opt) PM (Reqd) TM (Opt) LVR (Opt) ON=OFF=REF-
G:\ENV\CAD\Columbus-Ohio\ACTO\H000294 - RACER\0003\ENH-2017-01.dwg LAYOUT: DIRECT-GW-RECIRC-HYDRAULIC-CONTAINMENT
XREFS: MLCBASE MAP 2010



- LEGEND**
- PROPOSED MONITORING WELL PAIR – SHALLOW/DEEP (UPPER AQUIFER)
 - MONITORING WELL (UPPER AQUIFER)
 - INACTIVE RECOVERY WELL (TW-2)
 - STREAM GAUGE
 - PRE-DESIGN INVESTIGATION BORINGS
 - BORING COMPLETED IN 2015
 - CARBON SOURCE INTRODUCTION WELL
 - CARBON SOURCE INTRODUCTION WELL ALSO USED FOR HYDRAULIC CONTROL/REINJECTION OF GROUNDWATER
 - TRANSDUCER MEASUREMENTS
 - MANUAL MEASUREMENTS
 - BACKGROUND TRANSDUCER MEASUREMENTS
 - EXTRACTION WELL USED FOR INJECTION TESTING
 - EXTRACTION TEST WELL
 - RIVER LEVEE
 - FORMER BUILDING FOOTPRINT
 - SURFACE WATER FEATURE
 - PROPERTY BOUNDARY
 - PARCEL BOUNDARY
 - EXTENT OF LAGOON COVER
 - ug/L MICROGRAMS PER LITER
 - TOTAL CHLORINATED VOCs CONCENTRATIONS**
 - 100–1000 ug/L
 - 50–100 ug/L
 - 5–50 ug/L

NOTE: 1. THE PLUME CONTOURS REFLECT THE MOST RECENT GROUNDWATER SAMPLING DATA FOR THE MONITORING WELLS AND THE HIGHEST VERTICAL AQUIFER PROFILE CONCENTRATIONS FROM APPLICABLE BORINGS.

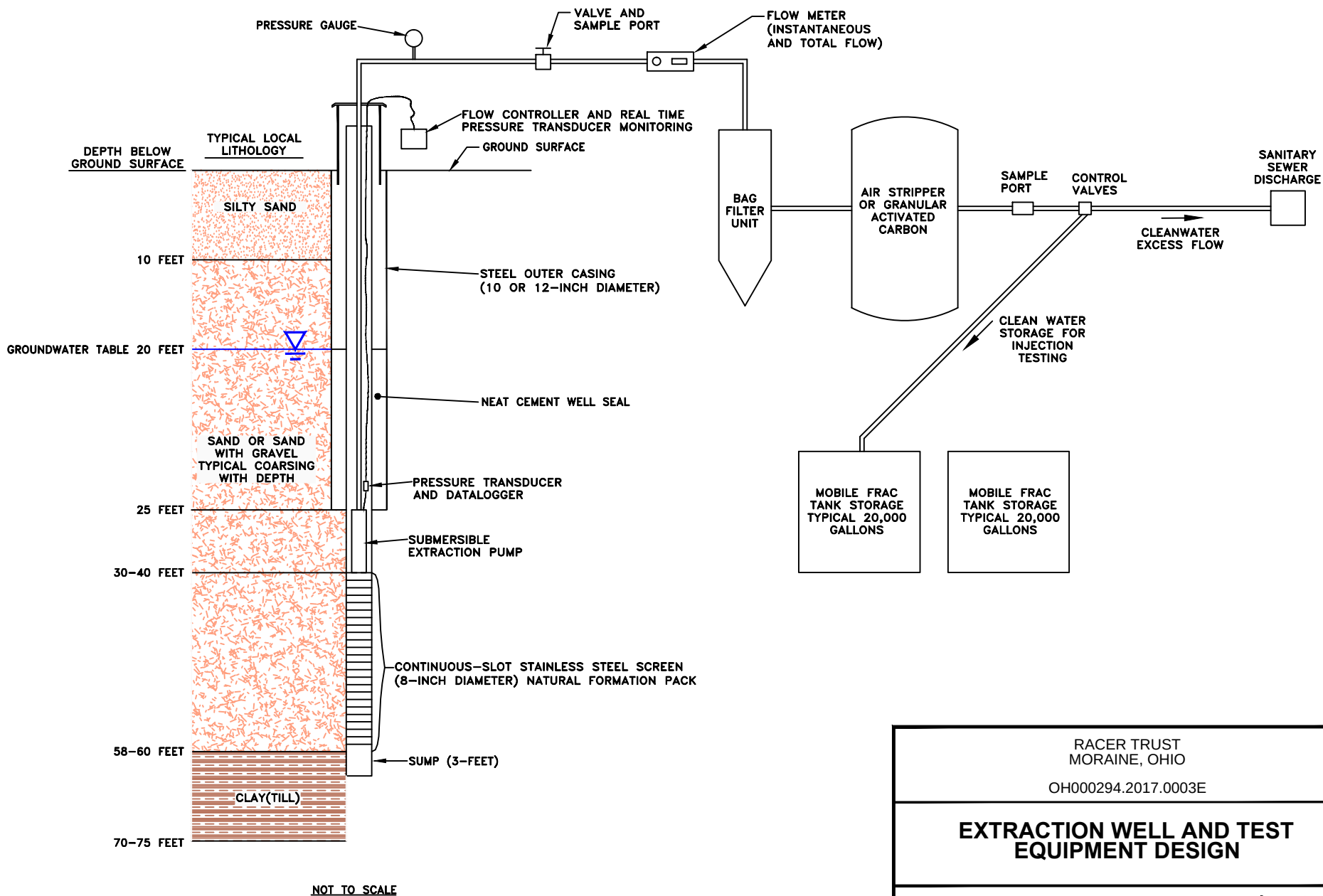
RACER TRUST
MORaine, OHIO
OH000294.2017

**PHASE I DGR™ INTERIM MEASURE PILOT
TEST SITE PLAN**

 **ARCADIS** Design & Consultancy
for natural and
built assets

FIGURE
2

XREFS: IMAGES: PROJECTNAME: ----



RACER TRUST
MORaine, OHIO

OH000294.2017.0003E

EXTRACTION WELL AND TEST EQUIPMENT DESIGN

APPENDIX A

Boring Logs and Well Construction Logs



APPENDIX A

Boring Logs and Well Construction Logs



WELL NO.: **RMW-86/BLDG21-1**

TOTAL DEPTH: **105 feet bls**

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 CITY, STATE: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **6/28/2012**
 DATE COMPLETED: **8/24/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 TOP OF CASING: **729.22 feet AMSL**
 GROUND ELEVATION: **729.60 feet AMSL**
 NORTHING: **620409.7071**
 EASTING: **1483253.2715**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
0				CONCRETE	(0.0 - 0.6) CONCRETE removed by coring.	Cement (0 to 1 ft)
2				SW	(0.6 - 10.0) SAND, medium to coarse grain, medium to large round pebbles, some small cobbles, trace silt, poorly sorted, loose, dry, brown.	2" PVC Sch 40 Casing (0 to 70 ft)
4						
6						
8						
10						Bentonite Slurry (1 to 68 ft)
12				SM	(10.0 - 14.0) SAND, medium grain, silt, some small to medium pebbles, little clay, poorly sorted, loose, moist, very dark grayish brown.	
14					Note: wood fill at 13.5 feet.	
16				CL	(14.0 - 16.5) SILTY CLAY, some medium sand, few small pebbles, poorly sorted, moderately stiff, moist, dark olive brown.	
18				SM	(16.5 - 26.0) SILTY SAND, medium grain, few small to medium pebbles, poorly sorted, loose, dry, light gray. *Soil sample submitted for laboratory analysis from 18 to 20 feet. Note: dry, olive brown from 20 to 25 feet.	
20						
22						
24						
26					Note: cobble, white at 24.5 feet.	
28				SC	(26.0 - 27.0) SAND, medium grain with clay, some silt, few small pebbles, poorly sorted, moderately loose, moist, olive brown.	
30				SM	(27.0 - 31.0) SAND with small round pebbles, some silt, trace clay, poorly sorted, loose, wet at 27 feet. dark olive brown. *Groundwater sample submitted for laboratory analysis from 27 to 32 feet.	
32				CL		
34				SM	(31.0 - 32.0) SANDY CLAY, medium grain, poorly sorted, moderately loose, moist, olive brown.	
36				SM	(32.0 - 35.0) SAND, coarse grain with small round pebbles, some silt, trace clay, poorly sorted, loose, wet, olive brown.	
38				SM		

Notes:

bls: below land surface
 HA: Hand Auger

NR: Not Recorded
 NM: Not Measured
 USCS: Unified Soil Classification System

ppm: parts per million
 PID: Photo-ionization Detector
 HK: Hydroknife AMSL: Above Mean Sea Level

Date: 12/28/2012
 Page: 1 of 3

WELL NO.: **RMW-86/BLDG21-1**

TOTAL DEPTH: **105 feet bls**

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 EASTING: **1483253.2715**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
38	0.1				(35.0 - 36.0) SANDY SILT, some clay, some medium round pebbles, poorly sorted, loose, moist, olive brown.	
40	0.3				(36.0 - 47.0) SAND, medium to coarse grain, silt, some small round pebbles increasing with depth, trace clay, poorly sorted, loose, wet, olive brown. Note: higher clay content from 40 to 45 feet. *Groundwater sample submitted for laboratory analysis from 40 to 45 feet.	
42	0.3					
44	0.4					
46	0.7			SC	(47.0 - 48.0) SAND with clay, coarse grain, poorly sorted, dense, wet, olive brown.	
48	2.1			SW	(48.0 - 53.0) SAND, medium to coarse grain, few small round pebbles, poorly sorted, loose, wet, olive brown.	
50	0.1					
52	0.3				*Groundwater sample submitted for laboratory analysis from 51 to 56 feet.	
54	0.5			SM	(53.0 - 56.0) SILTY SAND, medium to coarse grain, little clay, poorly sorted, moderately stiff, wet, olive brown.	
56	1.2			SC	(56.0 - 60.5) SILTY CLAY, sand, medium grain, some small to medium round pebbles, poorly sorted, stiff to moderately stiff, olive brown.	
58	3.2					
60	0.1			ML	Note: dry from 60 to 60.5 feet.	
62	0.0			CL	(60.5 - 61.0) SILT, moderately loose, moist, dark gray.	
64	0.1				(61.0 - 68.0) SILTY CLAY, some small to medium round pebbles, poorly sorted, hard, dry, dark gray.	
66	0.1					
68	0.0			SW	(68.0 - 75.0) SAND, medium to coarse grain, some small round pebbles, little silt, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 68 to 73 feet.	
70	0.0					
72	0.4					
74	0.2			SW	(75.0 - 85.0) SAND, fine to medium grain, some silt, few small round	
76						

Bentonite
Slurry
(1 to 68 ft)

Bentonite
Chips
(68 to 69 ft)

Sand Pack
(69 to 80 ft)

2" Screen slot

Notes:

bls: below land surface
 HA: Hand Auger

NR: Not Recorded
 NM: Not Measured
 USCS: Unified Soil Classification System

ppm: parts per million
 PID: Photo-ionization Detector
 HK: Hydroknife AMSL: Above Mean Sea Level

Date: 12/28/2012
 Page: 2 of 3

WELL NO.: **RMW-86/BLDG21-1**

TOTAL DEPTH: **105** feet bls

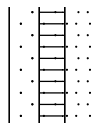
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 EASTING: **1483253.2715**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
76						
78	70	0.1			pebbles, poorly sorted, loose, wet, olive brown.	
		0.2				
80		0.6			Note: more fine sand from 80 to 85 feet.	
82		1.2				
84	103	0.3				
86		0.1		SW	(85.0 - 94.0) SAND, medium to coarse grain, some small round pebbles, trace silt, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 85 to 90 feet.	
88		0.1				
90		0.3				
92	48	0.2				
94		0.1		SM	(94.0 - 95.0) SILT with medium sand, some clay, some small round pebbles, poorly sorted, stiff to dense, moist, gray.	
96		0.0		SM	(95.0 - 105.0) SILTY SAND, medium to coarse grain, some small to medium round pebbles, poorly sorted, loose, dry, light gray.	
98	50	0.0				
100		0.2			Note: less silt, wet from 100 to 105 feet. *Groundwater sample submitted for laboratory analysis from 100 to 105 feet.	
102	53	0.3				
104		0.2				
106					End of boring at 105 feet.	



size 0.10
(70 to 80 ft)

Formation
Collapsed
(80 to 105 ft)

Notes:
 bls: below land surface
 HA: Hand Auger

NR: Not Recorded
 NM: Not Measured
 USCS: Unified Soil Classification System

ppm: parts per million
 PID: Photo-ionization Detector
 HK: Hydroknife AMSL: Above Mean Sea Level

Date: 12/28/2012
 Page: 3 of 3



SOIL BORING LOG

BORING NO.: **BLDG21-2**

TOTAL DEPTH: **65** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **6/27/2012**
 DATE COMPLETED: **8/20/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 GROUND ELEVATION: **730.01 feet AMSL**
 NORTHING: **620508.0325**
 EASTING: **1483367.7447**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0					
2		NM		SW	(0.0 - 10.0) SAND, medium to coarse grain, small to large round pebbles, poorly sorted, loose, dry, brown to tan.
4		NM			
6		NM			
8		NM			
10		NM			
12		1.3		CL	Note: hydroknifed to 10 feet but collapsed at 9.6 feet. (10.0 - 16.0) SANDY CLAY, some silt, medium to coarse grain, few small round pebbles, poorly sorted, soft, medium plasticity, moist, olive brown.
14		2.6			
16		4.8			
18		4.0		SP	(16.0 - 22.0) SAND, fine grain, trace small round pebbles, loose, dry, olive brown. *Soil sample submitted for laboratory analysis from 18 to 20 feet.
20		10.2			
22		5.7			
24		8.2		SM	(22.0 - 25.0) SAND, medium to coarse grain, some small to medium round pebbles, some silt, poorly sorted, loose, dry, olive brown.
26		7.2		SW	Note: moist from 24 to 25 feet. (25.0 - 30.0) SAND, medium to coarse grain with small to medium round pebbles, little silt, poorly sorted, loose, wet. *Groundwater sample submitted for laboratory analysis from 25 to 30 feet.
28		4.2			
30		5.8			
32		0.2		SW	(30.0 - 34.0) SAND, coarse grain with small round pebbles, trace silt, loose, poorly sorted, wet, olive brown.
34		0.2			
36		0.6		SW	(34.0 - 36.0) SAND, medium to coarse grain, few small round pebbles, trace silt, poorly sorted, loose, wet, olive brown.
38		0.2		GW	(36.0 - 43.0) PEBBLES, small round, few medium with medium to coarse grain sand, little silt, trace clay, poorly sorted, loose, wet, olive brown.
40		0.0			

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 1 of 2



SOIL BORING LOG

BORING NO.: **BLDG21-2**

TOTAL DEPTH: **65** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **6/27/2012**
 DATE COMPLETED: **8/20/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 GROUND ELEVATION: **730.01 feet AMSL**
 NORTHING: **620508.0325**
 EASTING: **1483367.7447**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
40		0.0			*Groundwater sample submitted for laboratory analysis from 40 to 45 feet.
42	40	0.0			
44		0.0		SW	(43.0 - 55.0) SAND, medium to coarse grain, some small to medium round pebbles, trace silt, few small cobbles, poorly sorted, loose, wet, olive brown.
46		0.1			
48	38	3.6			
50		0.6			Note: higher silt content from 50 to 55 feet. *Groundwater sample submitted for laboratory analysis from 50 to 55 feet.
52		0.1			
54		0.8			
56		0.6		ML	(55.0 - 57.0) SILT, trace fine grain sand, dense, wet, gray.
58		0.2		CL	(57.0 - 59.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, gray.
60				ML	(59.0 - 60.0) SILT, trace clay, trace small round pebbles, poorly sorted, dense, gray.
62		0.3		SM	(60.0 - 60.5) SAND, fine grain with silt, loose, wet, gray.
64	64	0.2		CL	(60.5 - 65.0) SILTY CLAY, few small to medium round pebbles, poorly sorted, hard, dry, gray.
66		0.2			End of boring at 65 feet.

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 2 of 2



SOIL BORING LOG

BORING NO.: **BLDG21-3**

TOTAL DEPTH: **65** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **6/27/2012**
 DATE COMPLETED: **8/21/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 GROUND ELEVATION: **729.86 feet AMSL**
 NORTHING: **620649.9905**
 EASTING: **1483394.8308**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0					
2		NM		FILL	(0.0 - 9.6) SAND, medium to coarse grain with small to large rounded gravel to cobbles, poorly sorted, loose, dry. Fill includes: concrete and wood. Note rebar found at 4 inches, offset to avoid.
4		NM			
6		NM			Note: sheet metal at 5 feet.
8		NM			Note: more fill debris, concrete and wood from 6 to 9.6 feet.
10		NM			
12		0.1		CL	(9.6 - 12.5) SANDY SILTY CLAY, some small round pebbles, poorly sorted, moderately stiff, moist to dry with depth, black to gray to brown with depth. *Soil sample submitted for laboratory analysis from 10 to 12 feet.
14		0.1		SM	(12.5 - 21.0) SAND, medium grain with silt, some small to medium round pebbles, poorly sorted, loose, dry, olive brown.
16		0.0			Note: few small cobbles from 15 to 20 feet.
18		0.1			
20		0.1			
22		0.1		GW	(21.0 - 22.0) SMALL PEBBLES, round, little medium grain sand, poorly sorted, wet, olive brown.
24		0.2		SM	(22.0 - 26.5) SILTY SAND, medium grain, some small to medium round pebbles, poorly sorted, loose, dry, olive brown.
26		0.3			*Soil sample submitted for laboratory analysis from 24 to 26 feet.
28		0.0		GM	(26.5 - 33.5) PEBBLES, small and round with silt, some medium grain sand, poorly sorted, moderately loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 27 to 32 feet.
30		0.4			
32		0.0			
34		0.0			

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 1 of 2



SOIL BORING LOG

BORING NO.: **BLDG21-3**

TOTAL DEPTH: **65** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **6/27/2012**
 DATE COMPLETED: **8/21/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 GROUND ELEVATION: **729.86 feet AMSL**
 NORTHING: **620649.9905**
 EASTING: **1483394.8308**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
34				ML	(33.5 - 35.0) SILT, few small round pebbles, trace sand, poorly sorted, dense, wet, olive brown.
36	56	0.1		ML	(35.0 - 41.0) SANDY SILT, interbedded lenses of silt and medium grain sand, trace small round pebbles, well sorted, dense, wet, olive brown.
38		0.4			
40		0.1			
42	56	0.1		CL	(41.0 - 44.0) SILTY CLAY, some small to medium round pebbles, trace sand, poorly sorted, hard, dry, dark gray.
44		0.2			
46	53	0.1		SW	(44.0 - 52.5) SAND with small round pebbles, coarse grain, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 45 to 50 feet.
48		0.3			
50		0.2			
52	60	0.2			
54		0.1		ML	(52.5 - 55.0) SILT, dense, wet, gray.
56	42	0.0		CL	(55.0 - 65.0) SILTY CLAY, small to medium round pebbles, trace sand, medium grain, poorly sorted, hard to moderately hard, dry, dark gray. Note: dry, harder from 60 to 65 feet.
58		0.1			
60		0.1			
62	36	0.0			
64		0.0			
66		0.1			
					End of boring at 65 feet.

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 2 of 2



SOIL BORING LOG

BORING NO.: **BLDG21-4**

TOTAL DEPTH: **75** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **7/09/2012**
 DATE COMPLETED: **8/22/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**
 GROUND ELEVATION: **729.63 feet AMSL**
 NORTHING: **620649.9905**
 EASTING: **1483394.8308**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0					
2		NM		FILL	(0.0 - 9.8) FILL, medium to coarse grain sand, large gravel, some small to medium cobbles, poorly sorted, loose, dry. Fill includes: metal, plastic, wood, pipes, rebar.
4		NM			
6		NM			
8		NM			
10		NM			
12		0.0		ML	(9.8 - 15.0) SANDY SILT, medium grain, some small to medium round pebbles, poorly sorted, loose, moist to dry, olive brown.
14		0.1			Note: light gray, few small cobbles from 12 to 15 feet.
16		0.7		CL	*Soil samples submitted for laboratory analysis from 14 to 15 feet and 15 to 16 feet.
18		6.3		ML	(15.0 - 16.5) SILTY CLAY with some medium grain sand, some medium round pebbles, poorly sorted, moderately dense, moist, olive brown.
20		17.1			(16.5 - 20.0) SANDY SILT, medium grain, some small to medium round pebbles, poorly sorted, loose, dry, light olive brown. Note: more sand with depth. *Soil sample submitted for laboratory analysis from 18 to 20 feet.
22		2.7		ML	(20.0 - 22.0) SILT, some small to medium round pebbles, poorly sorted, loose, dry, pale brown.
24		4.9		SM	(22.0 - 25.3) SAND, fine to medium grain with silt, some medium round pebbles, trace small cobbles, poorly sorted, loose, dry, light olive brown.
26		2.3		ML	(25.3 - 27.5) SILT with medium grain sand, some small to medium round pebbles, poorly sorted, moderately dense, wet, light gray. *Groundwater sample submitted for laboratory analysis from 27 to 32 feet.
28		0.7			
30		0.6		SW	(27.5 - 38.0) SAND, medium to coarse grain with small round pebbles, little silt, poorly sorted, loose, wet, olive brown.

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 1 of 3



SOIL BORING LOG

BORING NO.: **BLDG21-4**

TOTAL DEPTH: **75** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
 PROJECT: **Secondary Source Area Investigation**
 SITE LOCATION: **Moraine, Ohio**
 PROJECT NUMBER: **OH000294.2012.0002B**
 LOGGED BY: **Lauren Baumgartner**
 DATE STARTED: **7/09/2012**
 DATE COMPLETED: **8/22/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
 DRILLER: **Jason Greer**
 DRILLING METHOD: **Rotosonic**

 GROUND ELEVATION: **729.63 feet AMSL**
 NORTHING: **620649.9905**
 EASTING: **1483394.8308**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
30	28	0.0			Note: more small round pebbles from 32 to 38 feet.
32		0.0			
34		0.0			
36	94	0.0			
38		0.0		SM	(38.0 - 50.0) SAND with small round pebbles, medium to coarse grain, silt, poorly sorted, loose, wet, olive brown. Note: more silt with depth.
40		0.1			
42	42	0.0			
44		0.0			
46		0.1			*Groundwater sample submitted for laboratory analysis from 45 to 50 feet.
48	46	0.0			
50		0.4			
52	44	0.2			
54		0.6		SM	(50.0 - 58.0) SILTY SAND, medium grain, trace small round pebbles, poorly sorted, moderately stiff, moist, olive brown. Note: cobbles at 55 feet.
56		0.6			
58	50	0.6			
60		0.6			
				ML	(58.0 - 60.0) SILT, moderately stiff, slight black staining at 58 feet, moist, gray. *Saturated soil sample submitted for laboratory analysis from 58 to 60 feet.

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

*Indicates sample submitted for laboratory analysis.

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 2 of 3



SOIL BORING LOG

BORING NO.: **BLDG21-4**

TOTAL DEPTH: **75** feet bls

PROJECT INFORMATION

CLIENT: **RACER Trust**
PROJECT: **Secondary Source Area Investigation**
SITE LOCATION: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2012.0002B**
LOGGED BY: **Lauren Baumgartner**
DATE STARTED: **7/09/2012**
DATE COMPLETED: **8/22/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
DRILLER: **Jason Greer**
DRILLING METHOD: **Rotosonic**

GROUND ELEVATION: **729.63 feet AMSL**
NORTHING: **620649.9905**
EASTING: **1483394.8308**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
60	62	0.1		CL	(60.0 - 64.0) SILTY CLAY, some small to medium round pebbles, trace sand, poorly sorted, hard, dry, dark gray.
62		0.2			
64	NM	0.5		SM	(64.0 - 65.0) SILTY SAND with pebbles, clay, medium to coarse grain, small sub-rounded pebbles, poorly sorted, moderate stiff, dry, gray.
66		0.1		CL	(65.0 - 69.0) SILTY CLAY, few small to medium round pebbles, poorly sorted, hard, dry, dark gray.
68		0.1			
70		0.1		SW	(69.0 - 75.0) SAND with small round pebbles, coarse grain, trace silt, poorly sorted, loose, wet, olive brown.
72		0.0			
74		0.0			
76					End of boring at 75 feet.

Notes:

bls: below land surface

HA: Hand Auger

*Indicates sample submitted for laboratory analysis.

NR: No Recovery

NM: Not Measured

USCS: Unified Soil Classification System

ppm: parts per million

PID: Photo-ionization Detector

HK: Hydroknife

AMSL: Above Mean Sea Level

Date: 12/11/2012

Page: 3 of 3



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45225
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 2

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-3
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-15-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-15-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"
DEPTH TO WATER: IMMEDIATE 36.0' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER OR % Core Rec.	Recovery
728.6	0'						
		Sand, gravel and clay, mixed, dark brown to light brown, gray zones, oil odor - fill	1	5-6.5	SS	6-8-11	18"
		Sand with gravel, poorly sorted, fine to coarse, moistly light brown and white	2	10-11.5	SS	7-22-40	16"
		Sand with gravel, poorly sorted, fine to coarse, mostly light brown and white	3	15-16.5	SS	12-14-29	16"
		Sand and gravel, poorly sorted, wet	4	35-36	SS	16-54	6"
		Sand and gravel, poorly sorted, wet	5	40-41	SS	16-75	8"
		Till - top 3" sand lense, medium gray, wet bottom 7" silt, with gravel interbedded, clayey hard gray	6	45-46	SS	30-52	10"
		Silt, clayey, sand lenses (moist); gravel throughout, dark gray	7	50-51.5	SS	27-37-50	18"

A-6

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other conditions.

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-3
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Rt
		Silt. clayey, sand lenses, (moist); gravel throughout, dark gray, sandier, does not appear as competent as all previous till zones found. Sandier, damper	8	55-56.5 58-58	SS ST	12-22-26	1
		Silt, clayey, sand lenses (moist); gravel throughout, dark gray	9	60-61	SS	30-51	1
		Silt, clayey, sand lenses (moist); gravel throughout, dark gray	10	65-66.5	SS	16-25-43	1
		BORING COMPLETED					
		REMARKS:					
		1. Logged by G. F. Schank, (G&M)					
		2. Set well at 100.0' (see well detail table)					
		3. See log for GM-4					
		4. Till layer 44 to 68'					



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 192

912 MORRIS STREET
CHARLESTON W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
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BOX NUMBER 11
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606-261-2043

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FIELD

TEST BORING REPORT

10-18-82 vf
Page 1 of 3

CLIENT Geraghty & Miller, Inc.

ORDER No. 10191.001

PROJECT GMC, Harrison Radiator Division, Monitoring Wells,
Moraine, Ohio

HOLE No. GM-4

LOCATION As shown on well location plan

DRILLER Russel Fields (Moody's)

Cable

DRILL No. tool #1

DATE STARTED 9-1-82

ELEVATION REFERENCE Top of ex-well guard pipe adj. to GM-5; with
cap off (see well location plan) Elev. 731.48

DATE COMPLETED 9-14-82

CASING: DIAMETER 8"

SAMPLER: DIAMETER & TYPE Bailer

HAMMER WT. FALL

DEPTH TO WATER: IMMEDIATE

HAMMER WT. FALL

DEPTH TO WATER DAYS AFTER COMPLETION

UPON COMPLETION

WATER USED IN DRILLING Full depth

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 5" ON SAMPLER (or % Core Rec.)	RECOVER
728.9	0'						
		Silt, little fine sand and organics, dark brown	1	0-1			
		Sand, fine to coarse, some gravel, silt and clay, brown, hard	2	5-10			
		Sand, fine to coarse, some gravel, silt and clay, brown, hard	3	10-15			
		Sand, medium to coarse and gravel, some fine sand, silt and clay, gravel, cobbles and pebbles, little fine to coarse sand, silt and clay, brown (may contain water)	4	15-20			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	5	20-25			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	6	25-30			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	7	30-35			

A-8

Respectfully submitted,

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical characteristics of materials encountered in test.

10-18-82 vf

Page 2 of 3

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-4
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	R
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	8	35-40			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay, some fine to coarse sand and pebble gray (fill) (oil film maybe from rods)	9	40-45			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	10	45-50			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	11	50-55			
		Gravel, cobbles and pebbles and coarse sand, trace fine sand, silt and clay	12	55-60			
		Silt and clay, some fine to coarse sand and pebble, gray (till)	13	60-65			
		Silt and clay, some fine to coarse sand and pebble, gray (till), with larger gravel	14	65-70			
		Gravel, cobbles, pebbles, coarse sand	15	70-75			
		Sand, medium to coarse, poorly sorted, some gravel, mostly brown	16	75-80			
		Sand, medium, well sorted, trace fine brown	17	80-85			
		Sand, medium, well sorted, trace fine brown, trace coarse	18	85-90			
		Sand and gravel, poorly sorted, trace fines, 1 foot clay lense from 91 to 92 feet.	19	90-95			
		Gravel and sand poorly sorted	20	95-100			
		Gravel and sand, coarse, changing to sand with gravel, silty, trace clay, poorly sorted	21	100-105			

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-4
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % CORE REC.
		Sand, medium, well sorted, trace fine, trace coarse brown	22	105-110		
		Gravel with sand, coarse, poorly sorted	23	110-115		
		Gravel with sand, coarse, poorly sorted	24	115-120		
		Gravel with sand, coarse, poorly sorted sandier	25	120-125		
		Gravel with sand, coarse, poorly sorted sandier	26	125-130		
		Sand, medium to coarse, poorly sorted; gravel	27	130-135		
		Gravel, coarse, some sand, some larger than gravel	28	135-140		
		Gravel, very coarse and larger than gravel	29	140-145		
		Very coarse sand and gravel	30	145-150		
		BORING COMPLETED				
		REMARKS:				
		1. Logged by J. R. Mildenerberger & G. F. Schank (G & M)				
		2. Monitoring well set at 150.0, (see well detail table)				
		3. Till layer 43' to 7'±				

NO CARBON PAPER
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State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

COUNTY Montgomery TOWNSHIP Moraine SECTION OF TOWNSHIP _____
OWNER Harrison Radiator Div. GMC ADDRESS Moraine, Ohio
LOCATION OF PROPERTY in landfill on Dryden Road

CONSTRUCTION DETAILS			BAILING OR PUMPING TEST (specify one by circling)		
Casing diameter <u>2"</u>	Length of casing <u>140'</u>		Test rate <u>N/A</u> gpm	Duration of test _____ hrs	
Type of screen <u>PVC</u>	Length of screen <u>10'</u>		Drawdown _____ ft	Date _____	
Type of pump _____			Static level (depth to water) _____ ft		
Capacity of pump _____			Quality (clear, cloudy, taste, odor) _____		
Depth of pump setting _____					
Date of completion <u>9/12/82</u>			Pump installed by _____		
WELL LOG* <u>E.M. 4</u>			SKETCH SHOWING LOCATION		
Formations: sandstone, shale, limestone, gravel, clay	From	To	Locate in reference to numbered state highways, street intersections, county roads, etc.		
<u>burden</u>	0 ft	5 ft			
<u>Dry Sand and Gravel</u>	5	50			
<u>Glacial till</u>	50	65			
<u>Sand and gravel</u>	65	150			
5412					

DRILLING FIRM Moody's of Dayton, Inc.
ADDRESS P.O. Box 123, Miamisburg, Oh. 45342

DATE October 26, 1982

SIGNED

• If additional space is needed to complete well log, use next consecutive numbered form.

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State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

593778

COUNTY Montgomery TOWNSHIP Moraine SECTION OF TOWNSHIP _____
OWNER Harrison Radiator Div. GMC ADDRESS Moraine, Ohio
LOCATION OF PROPERTY in landfill on Dryden Road

CONSTRUCTION DETAILS		BAILING OR PUMPING TEST (specify one by circling)	
Casing diameter <u>2"</u>	Length of casing <u>140'</u>	Test rate <u>N/A</u> gpm	Duration of test _____ hr
Type of screen <u>PVC</u>	Length of screen <u>10'</u>	Drawdown _____ ft	Date _____
Type of pump _____		Static level (depth to water) _____	
Capacity of pump _____		Quality (clear, cloudy, taste, odor) _____	
Depth of pump setting _____			
Date of completion <u>9/12/82</u>		Pump installed by _____	

[illegible]

DRILLING FIRM Moody's of Dayton, Inc.
ADDRESS P.O. Box 123, Miamisburg, Oh. 45342

DATE October 26, 1982
SIGNED Tennitt Craver

• If additional space is needed to complete well log, use next consecutive numbered form.

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THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

"AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC, AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS, CONCLUSIONS, OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL."

FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 3

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-5
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-7-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cad off (see well location plan) Elev. 731.48 DATE COMPLETED 9-7-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 35"
DEPTH TO WATER: IMMEDIATE 38.0' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Recover
729.6	0'						
		Silt, and sand and gravel, (fill), moist, brown	1	0-1.5	SS	9-17-17	12"
		Sand, fine to medium and silt some gravel, little metal debris, black to brown sweet odor, (fill)	2	5-6.5	SS	10-10-5	6"
		Sand, fine, light brown, moist, trace silt, sand fine to coarse and gravel, trace silt, moist (slight oil odor) light brown	3	10-11	SS	12-52	8"
		Sand fine to coarse and gravel, trace silt, moist (oil odor), light brown	4	15-16.5	SS	6-16-27	10"
		Sand fine to coarse and gravel - pebble, trace silt, moist (slight oil odor), light brown	5	20-21.5	SS	13-30-30	12"
		Sand fine to coarse, and gravel, little silt and clay, moist, light brown	6	25-26.5	SS	13-30-3	16"

A-11

Respectfully submitted.

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other analyses.

10-18-82 vf

Page 2 of 3

PROJECT GMC, Harrison Radiator Division, Monitoring Wells,
Morain, Ohio

HOLE No. GM-5

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	
		Sand, fine to coarse, and gravel, little silt and clay, moist, light brown	7	30-31.5	SS	15-30-3	:
		Sand fine to coarse, little gravel, pebble, moist, light brown (slight oil odor)	8	35-36.5	SS	14-31-40	1
		Sand fine to coarse and gravel, wet, brown (slight oil odor)	9	40-41.5	SS	16-21-28	1
		Gravel and fine to coarse sand, trace silt and clay with 3" silty clay lense, brown, wet (slight oil odor)	10	45-46.5	SS	10-24-31	1
		Silt, trace clay, light orange brown grading down to gray very moist	11	50-51.5	SS	17-34-4	1
		Silt, some clay and fine sand, little medium to coarse sand and gravel, gray, moist (till)	12	55-56	SS	30-60	1:
		Silt, some clay and fine sand and gravel, pebble, little medium to coarse sand with fine to coarse sand lenses, gray moist, (till)	13	60-61	SS	21-53	1:
		Silt, some clay and sand and gravel, pebble little medium to coarse sand, with fine to medium sand stringers, gray, moist (till)	14	65-66	SS	35-72	12
		Sand and gravel - no sample	15	70-71	SS	25-54	C
		Sand fine to coarse, little gravel, pebble, trace silt orange brown, wet, silt, some clay and fine sand, gray, moist	16	75-76.5	SS	20-38-44	10
		Sand fine to medium, little coarse sand and gravel, pebble, trace silt, wet, brown	17	80-81.5	SS	24-48-60	14'

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-5
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER OR % CORE REC.
		Sand, fine trace medium sand and silt brown, wet	18	85-86	SS	22-58
		Sand, fine trace medium sand and silt brown, wet	19	90-91	SS	41-70
		Sand, fine to coarse and gravel, little silt and clay, brown, wet	20	95-96.5	SS	21-44-65
		Sand and gravel, - no sample -	21	100-101	SS	38-55
		BORING COMPLETED				
		REMARKS:				
		1. Logged by J. R. Mildenerger				
		2. Monitoring well set at 100.0' (see well detail table)				



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

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BOX NUMBER 11
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606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-6
Moraine, Ohio

LOCATION As shown on well location plan

DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-16-82

ELEVATION REFERENCE Top of ex-well guard pipe adj. to GM-5; with
cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-16-82

CASING DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL

SAMPLER DIAMETER & TYPE None HAMMER WT. FALL

DEPTH TO WATER: IMMEDIATE UPON COMPLETION

DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER	RECOVER
728.4	0'						
		45.0' No samples - see log for GM-3 and 4					
683.4'	45.0'						
		BORING COMPLETED					
		REMARKS:					
		1. Monitoring well set at 45' (see well detail table)					

A-14

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other conditions.



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

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10-18-82 vf
Page 1 of 3

FIELD TEST BORING REPORT

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-7
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-8-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-8-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"
DEPTH TO WATER: IMMEDIATE 44' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Recovery
732.7	0'						
		Silt, some sand gravel and debris, black to brown, moist (fill)	1	0-1.5	SS	10-19-20	14"
		Silt, little sand, gravel and wood debris, black, moist (fill), (slight odor)	2	5-6.5	SS	10-11-10	16"
		Silt and fine sand, some gravel and debris, black, very wet, (fill), (slight odor) (3 tries for spoon rec'y)	3	10-11.5	SS	9-6-6	
		Sand, fine to coarse and gravel, little silt, light orange brown moist	4	15-16.5	SS	10-14-16	10"
		Sand, fine to coarse and gravel, little silt, light orange brown moist	5	20-21.5	SS	7-13-22	10"
		Sand, fine to coarse and gravel, little silt, light orange brown moist	6	25-26.5	SS	21-38-42	12"
		Gravel and fine to coarse sand, trace silt	7	30-31	SS	22-51	5"

A-15

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing stability.

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-7
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Rec
		Clay, silty, some gravel little fine to medium sand, brown, moist, gravel little silty clay and sand, brown moist	8	35-36.5	SS	12-21-21	
		Sand, fine to coarse and gravel, trace silt, light brown, moist	9	40-41	SS	26-52	8'
		Sand, fine to coarse and gravel, trace silt, light brown, wet	10	45-46	SS	26-62	8'
		Sand, fine to coarse and gravel, little silt, brown, wet	11	50-51	SS	54-64	8'
		Silt, trace fine sand and clay, gray very moist (till)	12	55-56	SS	34-56	12"
		Silt, some fine sand and clay little medium to coarse sand and gravel, pebble, gray, moist (till)	13	60-61.5	SS	16-31-4	18"
		Sand, fine to coarse and gravel, some silt gray wet (till)	14	65-66	SS	44-60	12"
		Silt, some fine sand and clay, little medium to coarse sand and gravel, pebble (till)	15	70-71	SS	28-60	12"
		Sand fine to coarse and gravel, trace to little silt, brown wet	16	75-76	SS	41-64	10"
		Sand fine to coarse and gravel, trace to little silt, brown wet	17	80-81	SS	44-54	12"
		Sand fine to coarse, some gravel, trace silt, brown, wet	18	85-86	SS	36-52	12"
		Sand, fine to coarse, little gravel, trace silt, brown, wet	19	90-91	SS	34-60	10"



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 19

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P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-8
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-9-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-9-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger
SAMPLER: DIAMETER & TYPE None HAMMER WT. FALL
DEPTH TO WATER: IMMEDIATE HAMMER WT. FALL
DEPTH TO WATER DAYS AFTER COMPLETION UPON COMPLETION
WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER	RECOVERED
732.8	0'						
	50.0'	No samples - see log for GM-7					
		BORING COMPLETED					
		REMARKS:					
		1. Monitoring well set at 50.0'					

A-18

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical characteristics of material.

Respectfully submitted,
THE H. C. NUTTING CO.



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1927

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45225
513-321-5816

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FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 2

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-9
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-10-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev 731.48 DATE COMPLETED 9-10-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"
DEPTH TO WATER: IMMEDIATE 35.0' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER OR % CORE REC.	Recovery
723.6'	0'						
		Silt, some fine sand, trace clay, roots, brown, crumbly, dry	1	0-1.5	SS	4-7-7	18"
		Sand, medium, silty, trace clay, trace gravel, well sorted, brown	2	5-6.5	SS	2-2-2	16"
		Gravel and sand, poorly sorted, oil odor	3	10-11.5	SS	18-22-22	14"
		Gravel and sand, poorly sorted, no oil smell	4	15-16.5	SS	11-24-25	16"
		Sand with gravel, poorly sorted, sand is tan to off white, gravel is small to coarse (chert)	5	20-21.5	SS	7-28-26	16"
		Sand with gravel, poorly sorted, sand is tan to off white, gravel is small to coarse (chert), wet zones	6	25-26.5	SS	11-16-22	12"
		Gravel and sand, iron stains, wet zones, oil smell, poorly sorted	7	30-31.5	SS	7-26-38	16"
		Sand and gravel, poorly sorted, wet, very slight oil odor	8	35-36.5	SS	22-28-35	16"

A-19

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing stability, settlement or other conditions.

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-9
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	R
		Sand and gravel, poorly sorted, wet, no oil odor	9	40-41	SS	25-51	1
		sand and gravel, poorly sorted, wet, very slightly oil odor, trace clay	10	45-46.5	SS	28-32-42	1
		Clay, gray, gravel interbedded, some sand lenses, hard	11	50-51	SS	28-60	1
		Silt, clayey, trace fine sand, gravel throughout, hard, some vegetation, gray, some large gravel	12	55-56.5	SS	17-36-44	1
		Silt, clayey, trace fine sand, gravel throughout, hard, some vegetation, gray some large gravel	13	60-61.5	SS	21-35-51	18
		Silt, clayey, trace fine sand, gravel throughout, hard, some vegetation, gray, some large gravel, some sand lenses, brown and gray	14	65-66.5	SS	21-35-50	18
		Sand with gravel, poorly sorted	15	70-71.5	SS	19-31-42	16
		Sand, medium to coarse, with gravel, poorly sorted, brown	16	75-76	SS	31-54	8
		Sand and gravel, poorly sorted	17	80-81	SS	61-75	12'
		Sand and gravel, poorly sorted	18	85-86.5	SS	25-28-33	15'
		Sand and gravel, poorly sorted	19	90-91	SS	41-61	12'
		Sand and gravel, poorly sorted	20	95-96.5	SS	19-20-21	14'
		Sand and gravel, poorly sorted	21	100-101.5	SS	32-40-40	14'
		BORING COMPLETED					
		REMARKS: .					
		1. Logged by G.F. Schank (G&M)					
		2. Monitoting well set at 100' (see well detail table)					
		3. Till layer 50 to 69'					



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

912 MORRIS STREET
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304-344-0821

4120 AIRPORT ROAD
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BOX NUMBER 11
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606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-10
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-11-82
Top of ex-weel guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-11-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger
SAMPLER: DIAMETER & TYPE none HAMMER WT. FALL
DEPTH TO WATER: IMMEDIATE HAMMER WT. FALL
DEPTH TO WATER DAYS AFTER COMPLETION UPON COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLows PER 6" ON SAMPLER	Recovery
723.5	0'					OF % Core Rec.	
	50.0'	50.0' No samples - see log for GM-9					
		BORING COMPLETED					
		REMARKS:					
		1. Monitoring well set at 50.0' (see well detail table)					

A-21

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical characteristics of materials.



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 19

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

"AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC, AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS, CONCLUSIONS, OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL."

FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 3

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-11
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-5-82
Top of ex-well guard pipe to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-5-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"
DEPTH TO WATER: IMMEDIATE 35' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING below 64' (150ga)

ELEVATION 723.6	DEPTH 0'	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Recr
		Sand and silt, fine, trace clay, some vegetation, reddish brown	1	0-1.5	SS	3-8-9	18"
		Sand and gravel, medium to coarse, gravel is small, trace silt, brown	2	5-6.5	SS	6-13-15	18"
		Gravel with sand, small to large, mostly brown, slight oil smell	3	10-11.5	SS	20-28-28	16"
		Gravel with sand, small to large, mostly brown, slight oil smell, some dampness	4	15-16.5	SS	13-18-20	14"
		Gravel and sand, poorly sorted, sand is brown, very slight oil odor, some dampness	5	20-21.5	SS	12-27-27	16"
		Gravel and sand, poorly sorted, sand is brown, very light oil odor, some dampness	6	25-26.5	SS	16-33-41	14"
		Gravel and sand, poorly sorted, sand is brown, no odor, 3 inches in top are wet, dry in bottom	7	30-31.5	SS	11-21-54	12"

A-22

Respectfully submitted,

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-11
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	
		Sand and gravel, poorly sorted, wet, sand is brown (approx. 9" run-up in augers)	8	35-36.5	SS	150-21-22	1
		Gravel and sand, poorly sorted, 3" sand lenses in top, wet	9	40-41.5	SS	23-33-48	1
		Gravel and sand, poorly sorted, sandier toward bottom	10	45-46	SS	36-54	1
		Till, clay and silt, trace sand, interbedded gravel, grayish green, hard	11	50-51	SS	27-54	1
		Till, clay and silt, trace sand, interbedded gravel, grayish green, hard, piece of wood in tip, siltier	12	55-56	SS	24-51	1
		Till, clay and silt, trace sand, interbedded gravel, grayish green, hard, trace of vegetation	13	60-61	SS	22-62	1
		Sand with gravel, medium to coarse, poorly sorted, mostly brown	14	65-66.5	SS	17-34-53	10
		Sand with gravel, medium to coarse poorly sorted, mostly brown	15	70-71.5	SS	16-38-48	10
		Sand, medium, well sorted, brown, some coarse	16	75-76	SS	22-70	10
		Sand, fine to medium, fairly well sorted, brown, trace coarse, trace silt	17	80-81	SS	45-75	10
		Silt, clayey, trace fine sand, plastic gray, (driller said felt like clay from 84-86 ft.)	18	85-86	SS	51-72	10
		Gravel with some sand, poorly sorted	19	90-91.5	SS	13-24-40	12

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-11
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % CORE REC.	
		Gravel with some sand, poorly sorted very coarse	20	95-96.5	SS	13-24-40	1
		Sand and gravel, poorly sorted	21	100-101	SS	28-55	1
		BORING COMPLETED					
		REMARKS:					
		1. Logged by G. F. Schank (G&M)					
		2. Monitoring well set at 100.0' (see well detail table)					
		3. Till layer 49 to 64'					
		4. 2 ft. run-up in augers at 64'					



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4129 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

Page 1 of 2

CLIENT Geraghty & Miller, Inc.

ORDER No. 10191.001

PROJECT GMC, Harrison Radiator Division, Monitoring Wells,
Moraine, Ohio

HOLE No. GM-12

LOCATION As shown on well location plan

DRILLER Siebert Hill (Moody's)

DRILL No. Cable tool #2

DATE STARTED 9-7-82

ELEVATION REFERENCE Top of ex-well guard pipe adj. to GM-5: with
cap off (see well location plan) Elev. 731.48

DATE COMPLETED 9-18-82

CASING: DIAMETER 8"

SAMPLER: DIAMETER & TYPE Bailer

HAMMER WT. FALL

DEPTH TO WATER: IMMEDIATE

HAMMER WT. FALL

DEPTH TO WATER DAYS AFTER COMPLETION

UPON COMPLETION

WATER USED IN DRILLING below 20'

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Recovery
723.8	0'						
		0-100' No samples - see log for GM-11					
		Sand, fine to coarse and gravel, trace silt, brown	1	100-105			
		Gravel and coarse sand, little medium fine sand, trace silt, brown	2	105-110			
		Sand fine to coarse and gravel, trace silt, brown	3	110-115			
		Sand, fine to coarse, little gravel, trace silt, brown	4	115-120			
		Sand, fine to coarse, little gravel, trace silt, brown	5	120-125			
		Sand, fine to coarse and gravel, trace silt, brown	6	125-130			
		Sand, fine to coarse and gravel, little silt, brown	7	130-135			
		Sand fine to coarse, some gravel, little silt, brown	8	135-140			

A-25

Respectfully submitted,

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical characteristics of the soil.

PROJECT GMC, Harrison Radiator Division, Monitoring Wells HOLE No. GM-12
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.
		Sand, fine to coarse and gravel, little silt, brown	9	140-145		
		Sand, fine to coarse and gravel, little silt, brown	10	145-150		
		BORING COMPLETED				
		REMARKS:				
		1. Auger rig drilled 20' hole for starting casing				
		2. Logged by J. R. Mildenerberger (G&M)				
		3. Monitoring well set at 150.0' (see well detail table)				

593779

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

CONSTRUCTION DETAILS

G.M. #12

WELL LOG*

SKETCH SHOWING LOCATION

From

To

Overburden

0 ft

4 ft

1 sand & gravel

4

49

Glacial till

49

64

Coarse sand & gravel

64

150

Locate in reference to numbered
state highways, street intersections, county roads, etc.

N

Dwyden Rd

Sellers Ad

Moraine
City Bldg

9

DRILLING FIRM, Moody's of Dayton, Inc.

DATE October 26, 1982

ADDRESS P.O. Box 123, Miamisburg, Oh. 45342

SIGNED

* If additional space is needed to complete well log, use next consecutive numbered form.

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THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 4101
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 3

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-13
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-3-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-4-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"
DEPTH TO WATER: IMMEDIATE 34' UPON COMPLETION
DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING below 64' (150 g

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Rec
723.7	0'						
		Silt, some fine to medium sand, trace clay and organics, dark reddish brown, moist (6" topsoil)	1	0-1.5	SS	3-5-6	18
		Sand, fine to coarse, some gravel, little silt, brown, moist	2	5-6.5	SS	5-15-32	18
		Sand, fine to coarse and gravel, trace, silt, light brown, moist	3	10-11.5	SS	10-22-30	14
		Sand medium to coarse some gravel, light brown, moist	4	15-16.5	SS	6-10-22	16
		Sand, medium to coarse and gravel, little fine sand, trace silt, light brown, moist	5	20-21.5	SS	16-24-20	16
		Sand, fine to coarse and gravel, little silt and clay, light brown, moist (slight oil odor)	6	25-26	SS	36-52	10
		28ft. - very hard drilling, boulder or large cobble 29'					

A-27

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-13
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or 1/4 Core Rec.	
		Sand, fine to coarse and gravel, little silt and clay, moist to very moist, some Fe stained lenses, (slight oil odor)	7	30-31.5	SS	13-19-35	
		Gravel, some fine to coarse sand, little silt and clay, wet, brown (slight oil odor)	8	35-36.5	SS	11-17-20	
		Sand, medium to coarse (with lenses of fine to medium) and gravel - pebbles trace silt, brown, wet, (slight oil odor)	9	40-41.5	SS	17-27-34	1
		Sand, medium to coarse (with lenses of fine to medium) and gravel-pebbles trace silt, brown, wet (slight oil odor)	10	45-46	SS	16-53	1
		Sand, fine to coarse some gravel, little silt and clay, brown, wet (slight oil odor)	11	50-51.5	SS	36-38-37	1
		Sand, fine to coarse some gravel, little silt and clay, brown, wet, (slight oil odor)	12	55-56	SS	27-57	1
		Silt and clay, some fine sand, little medium to coarse sand and gravel, dark gray moist (till)	13	60-61	SS	27-70	1
		Sand, fine to coarse, some gravel, little silt, brown, wet	14	65-66	SS	32-52	10
		Sand, fine to medium, uniform, little coarse sand and gravel, pebble, light brown, wet	15	70-71	SS	30-54	10
		Sand, fine uniform, trace medium sand and silt, some zones of Fe staining, brown, wet	16	75-76.5	SS	17-34-42	16

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-13
Morain, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER OR % Core Rec.	Rt
		Sand, fine, little medium to coarse sand and gravel, trace silt, brown, wet	17	80-81	SS	42-74	1
		Gravel, some fine to coarse sand, little silt, light brown, wet, (slight oil odor)	18	85-86	SS	32-104	1
		Sand, fine to coarse, little gravel and silt, brown, wet	19	90-91	SS	38-57	8
		Sand, fine to coarse, and gravel, little silt, brown, wet	20	95-96.5	SS	14-23-30	12
		Sand, fine to coarse, and gravel, little silt, brown, wet (cobble blocked spoon)	21	100-101.5	SS	28-31-30	3
		BORING COMPLETED					
		REMARKS:					
		1. Logged by J. R. Mildenerberger (G&M)					
		2. Monitoring well set at 100.0' (see well detail table)					
		3. Till layer 57-64'					



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1927

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf
Page 1 of 2

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-14
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Bob Myers (Moody's) DRILL No. Cable tool #1 DATE STARTED _____
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED _____
CASING: DIAMETER 8" HAMMER WT. _____ FALL _____
SAMPLER: DIAMETER & TYPE -Railer HAMMER WT. _____ FALL _____
DEPTH TO WATER: IMMEDIATE _____ UPON COMPLETION _____
DEPTH TO WATER _____ DAYS AFTER COMPLETION _____ WATER USED IN DRILLING Full depth

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	RECOVER
723.4	0'						
		100.0' See GM-13					
		Gravel and sand, poorly sorted, fossiliferous, small to large	1	100-105			
		Gravel and sand, poorly sorted, fossiliferous, small to large	2	105-110			
		Gravel and sand, poorly sorted, fossiliferous, small to large, trace white clay	3	110-115			
		Gravel and sand, poorly sorted, fossiliferous, small to large	4	115-120			
		Gravel and sand, poorly sorted, fossiliferous, small to large	5	120-125			
		Gravel and sand, poorly sorted, fossiliferous, small to large	6	125-130			
		Gravel and sand poorly sorted, fossiliferous, small to large, gravel is coarser	7	130-135			

A-31

Respectfully submitted,

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical characteristics of materials recovered.

10-18-82 vf

Page 2 of 2

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-14
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 5" ON SAMPLER or % Core Rec.
		Coarse gravel with sand	8	135-140		
		Coarse gravel with sand, sandier	9	140-145		
		Coarse gravel with sand, gravel not as coarse	10	145-150		
		BORING COMPLETED				
		REMARKS:				
		1. Logged by G.F. Schank (G&M)				
		2. Monitoring well set at 150.0' (see well detail table)				

593780

COUNTY Montgomery TOWNSHIP Moraine SECTION OF TOWNSHIP _____
OWNER Harrison Radiator Div. GMC ADDRESS Moraine, Ohio
LOCATION OF PROPERTY Park across street from City Building

CONSTRUCTION DETAILS		BAILING OR PUMPING TEST (specify one by circling)	
Casing diameter <u>2"</u>	Length of casing <u>140'</u>	Test rate <u>N/A</u> gpm	Duration of test _____ hr
Type of screen <u>PVC</u>	Length of screen <u>10'</u>	Drawdown _____ ft	Date _____
Type of pump <u>N/A</u>		Static level (depth to water) _____ f	
Capacity of pump _____		Quality (clear, cloudy, taste, odor) _____	
Depth of pump setting _____			
Date of completion <u>9/28/82</u>		Pump installed by _____	

G.M. #14		WELL LOG*		SKETCH SHOWING LOCATION	
Formations: sandstone, shale, limestone, gravel, clay		From	To	Locate in reference to numbered state highways, street intersections, county roads, etc.	
Overburden		0 ft	4 ft		
Sand & Gravel		4	56		
Glacial till		56	75		
Sand and gravel		75	150		
				5412	

DRILLING FIRM Moody's of Dayton, Inc.
ADDRESS P.O. Box 123, Miamisburg, Oh. 45342

DATE October 26, 1982

SIGNED

*If additional space is needed to complete well log, use next consecutive numbered form.

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THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1921

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CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

Page 1 of 2

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-15
Moraine, Ohio

LOCATION As shown on well location plan

DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-13-82

ELEVATION REFERENCE Top of ex-well guard pipe adj. to GM-5; with DATE COMPLETED 9-13-82
cap off (see well location plan) Elev. 731.48

CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL

SAMPLER: DIAMETER & TYPE 2" O. D. Split Spoon HAMMER WT. 140# FALL 30"

DEPTH TO WATER: IMMEDIATE 35.0' UPON COMPLETION

DEPTH TO WATER DAYS AFTER COMPLETION WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or 1/2 Core Rec.	Recor.
724.6	0'						
		Silt, topsoil, roots, some fine sand, brown	1	0-1.5	SS	6-14-15	18"
		Sand and gravel, poorly sorted, brown sand is fine to medium, gravel is coarse	2	5-6.5	SS	10-13-9	18"
		Sand and gravel, poorly sorted, brown, sand is fine to medium, gravel is fine to coarse, 1" of sand was damp	3	10-11.5	SS	13-25-25	10"
		Gravel and sand, poorly sorted, very slight oil odor	4	15-16.5	SS	16-30-4	12"
		Sand and gravel, poorly sorted, oil, odor, some damp spots	5	20-21.5	SS	15-26-27	15"
		Sand and gravel, poorly sorted, no odor, iron stains	6	25-26	SS	12-60	10"
		Sand and gravel, fine to coarse, brown, iron stains, moist to wet in top of spoon	7	30-31.5	SS	16-32-48	18"
		Encountered water at 35.0'					

A-33

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical

PROJECT GMC, Harrison Radiator Division, Monitoring Wells, HOLE No. GM-15
Moraine, Ohio

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER OR % CORE REC.	R
		Sand, medium to coarse and gravel, little silt and fine sand, wet, brown	8	35-36.5	SS	12-50-26	1
		Sand, medium to coarse and gravel, little silt and fine sand, wet, brown	9	40-41.5	SS	21-28-38	
		Sand, medium to coarse some gravel, little silt and fine sand, wet, brown	10	45-46.5	SS	16-31-40	1
		Gravel, some fine to coarse sand, trace silt, brown, wet	11	50-51.5	SS	15-18-36	
		Sand, fine to coarse, some gravel, little silt, brown, wet	12	55-56.5	SS	21-28-4	14
		Sand, fine to coarse, some gravel, little silt, brown, wet, silt, some fine sand and gravel - pebble, gray	13	60-61	SS	41-60	
		Silt, some fine to coarse sand and gravel, gray, moist, little clay	14	65-66	SS	21-62	12
		Silt and fine sand, little medium to coarse sand and gravel and clay, gray, moist	15	70-71.5	SS	12-21-33	18
		Sand, fine, some silt, gray, wet	16	75-76	SS	38-55	16
		Sand, fine, some silt, gray, wet	17	80-81	SS	47-62	12
		Sand, fine, some silt, gray, wet	18	85-86	SS	37-56	
		Sand, fine to coarse, little gravel and silt, brown, wet	19	90-91	SS	36-58	
		Sand, fine to coarse and gravel, trace silt, brown, wet	20	95-96	SS	50-62	
		No sample	21	100-101.5	SS	23-25-37	
		BORING COMPLETED					
		REMARKS:					
		1. Logged by G.F. Schank (G&M)					
		2. Monitoring well set at 100.0' (see well detail table)					



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 192

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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FIELD TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells HDLE No. GM-16
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-14-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-14-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger HAMMER WT. FALL
SAMPLER: DIAMETER & TYPE None HAMMER WT. FALL
DEPTH TO WATER: IMMEDIATE UPON COMPLETION
DEPTH TO WATER _____ DAYS AFTER COMPLETION _____ WATER USED IN DRILLING _____

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	Re:
724.6'	0'						
		60.0' No samples, see GM-15					
664.6	60.0'						
		BORING COMPLETED					
		REMARKS:					
		1. Monitoring well set at 58.0' (see well detail table)					

A-35

Respectfully submitted,
THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other physical



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 19

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0871

4128 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45228
513-371-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-7043

"AS A MUTUAL PROTECTION TO CLIENTS, THE PUBLIC, AND OURSELVES, ALL REPORTS ARE SUBMITTED AS THE CONFIDENTIAL PROPERTY OF CLIENTS, AND AUTHORIZATION FOR PUBLICATION OF STATEMENTS, CONCLUSIONS, OR EXTRACTS FROM OR REGARDING OUR REPORTS IS RESERVED PENDING OUR WRITTEN APPROVAL."

FIELD TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc.

ORDER No 10191.001

PROJECT GMC, Harrison Radiator Division, Monitoring Wells,
Moraine, Ohio

HOLE No. GM-17

LOCATION As shown on well location plan

DRILLER Willard Martin

DRILL No. 36

DATE STARTED 9-11-82

Top of ex-well guard pipe adj. to GM-5; with
 DRILL No. 36

ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48

DATE COMPLETED 9-12-82

CASING: DIAMETER 3.5" I. D. Hollow Stem Auger

HAMMER WT. _____ FALL _____

SAMPLER: DIAMETER & TYPE

HAMMER WT. _____ FALL _____

DEPTH TO WATER: IMMEDIATE

UPON COMPLETION

DEPTH TO WATER _____ DAYS AFTER COMPLETION

WATER USED IN DRILLING

WATER USED IN DRILLING							
ELEVATION 723.6	DEPTH 0'	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER or % Core Rec.	RECORD
673.6	50.0'	No samples, see GM-11 and GM-12 BORING COMPLETED REMARKS: 1. Monitoring well set at 50.0' (see well detail table)					

A-36

Respectfully submitted,

THE H. C. NUTTING CO.

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of test data.



THE H. C. NUTTING COMPANY

GEOTECHNICAL AND TESTING ENGINEERS

SINCE 1912

912 MORRIS STREET
CHARLESTON, W. VA 25301
304-344-0821

4120 AIRPORT ROAD
P.O. BOX C
CINCINNATI, OHIO 45226
513-321-5816

BOX NUMBER 11
HIGHLAND HEIGHTS, KY 41076
606-261-2043

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TEST BORING REPORT

10-18-82 vf

CLIENT Geraghty & Miller, Inc. ORDER No. 10191.001
PROJECT GMC, Harrison Radiator Division, Monitoring Wells HOLE No. GM-18
Moraine, Ohio
LOCATION As shown on well location plan
DRILLER Willard Martin DRILL No. 36 DATE STARTED 9-9-82
Top of ex-well guard pipe adj. to GM-5; with
ELEVATION REFERENCE cap off (see well location plan) Elev. 731.48 DATE COMPLETED 9-9-82
CASING: DIAMETER 3.5" I. D. Hollow Stem Auger
SAMPLER: DIAMETER & TYPE None HAMMER WT. FALL
DEPTH TO WATER: IMMEDIATE HAMMER WT. FALL
DEPTH TO WATER DAYS AFTER COMPLETION UPON COMPLETION
WATER USED IN DRILLING

ELEVATION	DEPTH	DESCRIPTION OF MATERIALS	SAMPLE No.	SAMPLE DEPTH	TYPE OF SAMPLE	BLOWS PER 6" ON SAMPLER	Rec
723.6	0'					OF 1/2 CORE REC.	
	55.0'	No samples, see GM-13, GM-14 BORING COMPLETED REMARKS: 1. Monitoring well set at 55.0' (see well detail table)					

A-37

Samples recovered from this test boring are available for inspection, which is strongly recommended. The company assumes no responsibility for interpretations made by others of load bearing, stability, excavating or other conditions.

Respectfully submitted,
THE H. C. NUTTING CO.

MORaine ENGINE PLANT

Moraine, Ohio

Depth (Feet)	Blows (/8 in.)	Recovery (Feet)	HNU (PPM)	Sample	Graphic Log	Soil Class	Description
0							TOPSOIL: 0-.5 ft.; silt & clay, fine sand; brn, dry-damp, mostly loose becoming dk brown, damp, semi-pliable, semi-cohesive.
5	5-11 28-12	0.5	0.3				FILL silt & clay, some concrete blocks and gravel (1-cs); some sand (1-cs); brn to light gray, dry-damp, loose to stiff.
10	8-18 15-18	1.8	0.3				SAND & GRAVEL: sand (50%), 1-cs: gravel (50%), 1-cobble; brn, dry-damp, loose.
15	12-15 13-8	1.8	0.3				SAND & GRAVEL: same as above, damp.
20	7-11 22-18	1.1	0.3				SAND & GRAVEL same as above.
25	5-8-18-34	1.2	0.3				SILT, CLAY, SAND & GRAVEL: sand (40%), 1-cs; gravel (40%), 1-cobble, silt & clay (20%); brown, (moist-wet), slightly pliable, slightly cohesive.
30	7-21 24-29	2.0	0.3				SAND & GRAVEL: sand (50%), 1-cs; gravel (50%), 1-cobble; trace silt and clay, brown, wet, loose.

☒ Composite to Lab ☒ VOC to Lab ☐ Split-Spoon Not Analyzed

Page 1 of 2

Drilling Co.: Burlington Environmental

Geologist: R. Astle

Begin Drilling: 08/01/94

Driller: Dan Fisher

Total Depth: 82

End Drilling: 08/03/94

Drilling Method: HSA 4 1/4"

Surface Elev.:

Converted to Well: Yes

Drilling Fluid: Plant Potable Water

Datum: Feet, MSL

Well Name: GM-21

Remarks:

West Coord.: 8051

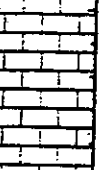
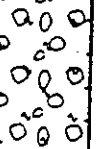
South Coord.: 1518

080258.001

moraine

MORaine ENGINE PLANT

Moraine, Ohio

Depth (Feet)	Blows (6 in.)	Recovery (Feet)	HNU (PPM)	Sample	Graphic Log	Soil Class	Description
33	18-30 38-28	2.5	0.3				SILT, CLAY, SAND & GRAVEL: sand (40%), f-cs; gravel (40%), f-cobble; silt and clay (20%); brn to light brn, wet, loose to slightly cohesive, slightly pliable.
38	50/2	0.5	0.3				SILT, CLAY, SAND & GRAVEL: same as above, hard drilling.
43	50/4	0.5	0.3				LIMESTONE: angular fragments, white-gray, vesicular, microcrystalline, boulder? Bent spoon, auger refusal, pulled augers and redrilled to 50' - 15' south of prior location.
48	5-12 20-28	0.5	0.4				SILT, CLAY, SAND & GRAVEL: sand (40%), f-cs; gravel (40%), f-cobble; silt & clay (20%); gray brn with orange staining, wet, slightly tight (stiff). Heaving sands.
53							NO SAMPLE: 6 feet of heaving sands. Drill harder and smoother at 55 feet, possible till or sand.
58							
63	6-8-10-13	1.1	0.3				TILL: gravelly sand silt & clay, silt & clay (80%); gravel (10%), f-med; sand (10%), f-cs; olive gray, damp, pliable, cohesive.
							End of Boring at 62 Feet.

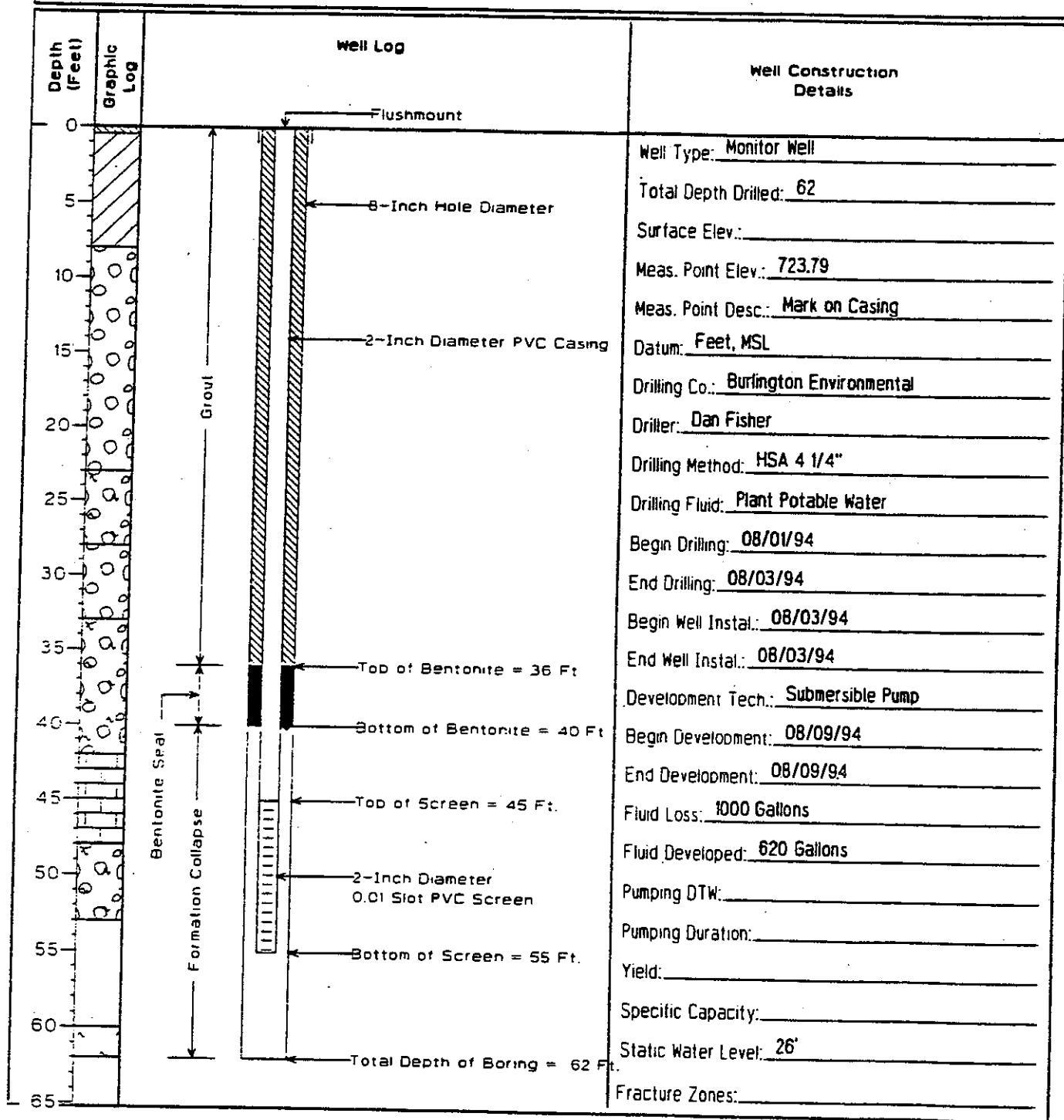
☒ Composite to Lab ☐ VOC to Lab ☐ Split-Spoon Not Analyzed

Page 2 of 2

Drilling Co.: Burlington Environmental Geologist: R. Astle Begin Drilling: 08/01/84
 Driller: Dan Fisher Total Depth: 62 End Drilling: 08/03/84
 Drilling Method: HSA 4 1/4" Surface Elev.: _____ Converted to Well: Yes
 Drilling Fluid: Plant Potable Water Datum: Feet, MSL Well Name: GM-21
 Remarks: _____ West Coord.: 6051 South Coord.: 1518
 OH0258.001 moraine

MORaine ENGINE PLANT

Moraine, Ohio



For Lithologic Descriptions See Log of Boring: GM-21

West Coord.: 6051

South Coord.: 1518

Page 1 of 1

Remarks:

OH0258.001

Geologist: R. Astle

moraine

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
0		Ground Surface						
0-2		TOP SOIL top soil; silt and sand; dark brown; no odor; white soft sand and silt near 2'			0-2		1.7	0
2-4		SILTY SAND white soft sand and silt; black; clayey sand with traces of gravel; possible small fragments of sludge; a couple of broken glass fragments			2-4		1.7	7.0
4-6		SILTY SAND little recovery; organic material; soft brownish black; silt and sand; one piece of metal		Yes	4-6		0.2	12.5
6-8		CLAYEY SAND clayey sand; trace gravel; dark brown-black; moist			6-8		1.7	1.5
8-10		CLAY clay; dark brown-black; moist; black gravel			8-10		0.5	0.5
10-12		CLAYEY SAND clayey sand; more sand and gravel			10-12		0.5	2.5
12-14		SAND/GRAVEL sand and gravel; loose; medium to light brown			12-14		1.17	0.5
14-16		SAND/GRAVEL sand and gravel; hard; coarse			14-16		1.3	0
16-18					16-18		1.7	0
18-20					18-20		1.9	0

Scientist: Eric Gray
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 8/31/99 10:00
End Drilling: 9/1/99 16:42
Hole Size: 8"
Total Depth: 60'
Datum:
File Name: gmotors\gmcrfilwinlogs\gm32.log

Surface Elev.: 732.47
North Coord.: 3485.66736
East Coord.: 6070.27614
Converted to Well: Yes
Well Name: GM-32
Revised: 3/1/00

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
21		SAND/GRAVEL sand and gravel; hard; course; few large cobbles			20-22		1.25	0
22		SAND/GRAVEL sand and gravel; hard; course; less cobbles			22-24		1.0	0
23					24-26		0.75	0.5
24					26-28		1.17	0
25					28-30		1.3	0
26					30-32		0	
27		no recovery - a single rock - moist						
28		SAND/GRAVEL water; coarse gravel and sand			32-34		0.67	0
29					34-36		1.0	0
30		SAND/GRAVEL wet; coarse-grained gravel and sand			36-38		1.17	0
31					38-40		1.17	0
32								
33								
34								
35								
36								
37								
38								
39								
40								

Scientist: Eric Gray
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 8/31/99 10:00
End Drilling: 9/1/99 16:42
Hole Size: 8"
Total Depth: 60'
Datum:
File Name: gmotors\gmcrfiwinlogs\gm32.log

Surface Elev.: 732.47
North Coord.: 3485.66736
East Coord.: 6070.27614
Converted to Well: Yes
Well Name: GM-32
Revised: 3/1/00

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
41					40-42		1.0	0
42								
43					42-44		0.75	0
44								
45					44-46		0.75	0
46								
47					46-48		0.25	0
48								
49					48-50		0.5	0
50		CLAY clay; grayish-brown; soft; moist						
51		SAND/GRAVEL sand and gravel; gray; moist; no clay			50-52		1.0	0
52								
53					52-54		1.3	0
54								
55		SAND/GRAVEL sand and gravel; very wet			54-56		2.0	0
56								
57					56-58		2.0	0
58								
59					58-60		2.0	0
60		TILL						

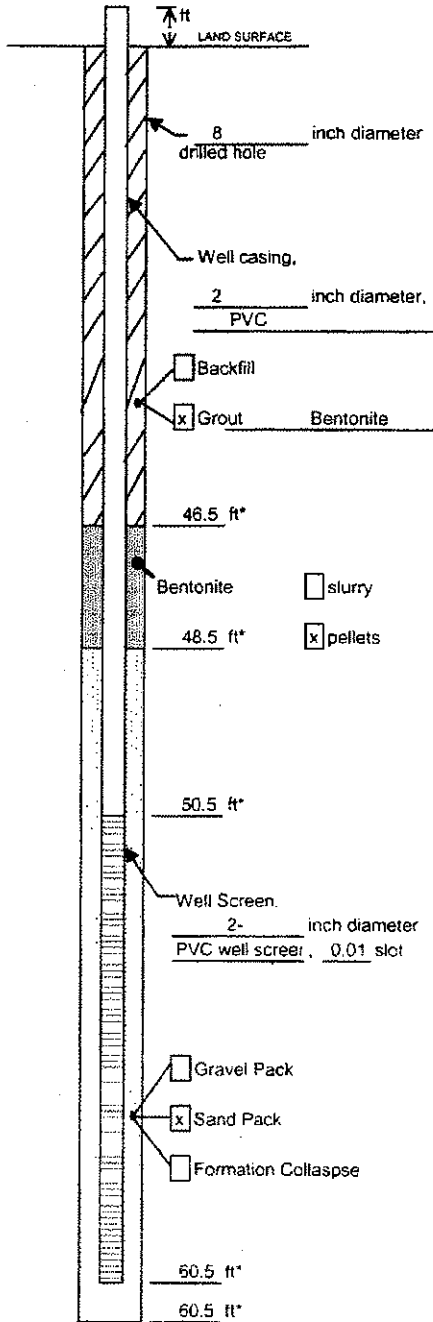
Scientist: Eric Gray
 Project Manager: Nancy Gillotti
 Drilling Co.: Belasco Drilling
 Driller: Greg/Rick
 Drilling Method: Hollow Stem Auger
 Drilling Fluid: NA

Begin Drilling: 8/31/99 10:00
 End Drilling: 9/1/99 16:42
 Hole Size: 8"
 Total Depth: 60'
 Datum:
 File Name: gmotors\gmcrf\winlogs\gm32.log

Surface Elev.: 732.47
 North Coord.: 3485.66736
 East Coord.: 6070.27614
 Converted to Well: Yes
 Well Name: GM-32
 Revised: 3/1/00

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0002.00007 Well GM-32

Town/City Moraine, Ohio

County Montgomery State Ohio

Permit No. _____

Land-Surface Elevation and Datum:

732.47 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 8/31/99

Drilling Method Hollow stem auger

Drilling Contractor Belasco Drilling

Drilling Fluid _____

Development Technique(s) and Date(s)

Bailer and rope - 9/22/99

Fluid Loss During Drilling _____ gallons

Water Removed During Development _____ gallons

Static Depth to Water _____ feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

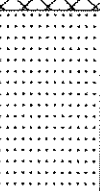
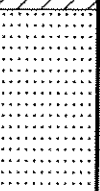
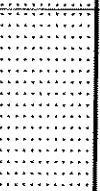
Specific Capacity _____ gpm/ft

Well Purpose Groundwater monitoring well

Remarks _____

Prepared by W. Ferguson

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
0	4,5,7,7	16	1.3			FILL	FILL topsoil; very soft; sandy silt; dry; brown	
2	5,4,3,4	20	1.7			SW	SAND very loose; moist; dark brown/black; sand 80%; gravel 15%; silt 5%; well graded	
4	3,3,4,2	19	12.3			CL	CLAY soft; moist; dark brown-black; clay 80%; sand 15%; gravel 5%; high plasticity	
6	2,3,4,4	20	18.2			CL	CLAY medium stiff; moist; olive gray; clay 80%; sand 15%; silt 5%; oily; stained; medium plasticity	
8	8,12,8,9	19	15.2			SW	SAND medium dense; moist; black; sand 80%; gravel 10%; silt 10%; oily; stained; well graded	
10	10,8,12, 30	19	15.0			SW	SAND medium dense; moist; black; sand 80%; gravel 15%; silt 5%; oily; stained; well graded	
12								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/2/01

Driller: Denzel Wright

Total Depth: 58'

End Drilling: 4/2/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.30

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2277.98

East Coord.: 5761.66

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
12	18,21,30, 18	17	19.2			SW	SAND medium dense; moist; light gray; sand 85%; gravel 10%; silt 5%; well graded	
14	10,13,19, 35	19	14.2			SW	SAND medium dense; moist; light gray; sand 90%; gravel 10%; well graded	
16	10,30,30, 40	19.5	7.5			SW	SAND dense; moist; light gray; sand 85%; gravel 15%; well graded	
18	46,48,50	16	8.1			SW	SAND refusal; dense; moist; light gray; sand 85%; gravel 10%; silt 5%; well graded	
20	12,34,35, 50	22	15.0			SW	SAND dense; moist; light gray; sand 85%; gravel 10%; silt 5%; well graded	
22	16,30,30	20	1.8			SW	SAND spoon refusal; dense; moist; yellowish-orange; sand 90%; gravel 10%	
24								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/2/01

Driller: Denzel Wright

Total Depth: 58'

End Drilling: 4/2/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.30

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 2277.98

East Coord.: 5761.66

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

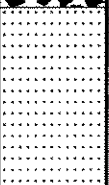
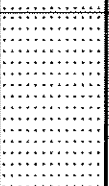
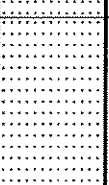
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Filename: April Logs



Log of Boring: GM-33

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
24	17,9,9,9	20	0.3			GW	GRAVEL medium dense; moist; yellowish-orange; gravel 60%; sand 30%; silt 10%; well graded	
26	9,10,24, 30	20	7.8			SW	SAND medium dense; moist; light brown-black; sand 80%; gravel 15%; silt 5%; oily stained; well graded	
28	35,22,24, 24	20	7.3			SW	SAND medium dense; moist; light brown-gray; sand 60%; gravel 35%; silt 5%; oily stained; well graded	
30	18,15,38, 38	7	1.7			SW	SAND dense; wet; light brown; sand 85%; gravel 10%; silt 5%; well graded	
32	21,28,35, 40	22	2.3			GW	GRAVEL dense; wet; light brown; gravel 60%; sand 35%; silt 5%; well graded	
34	20,24,24, 28	24	0.3			GW	GRAVEL dense; wet; light brown; gravel 80%; sand 20%; well graded	
36								

☒ Composite Sample to Lab

Grab Sample to Lab

 Split-Spoon Not Analyzed

Page 3 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/2/01

Driller: Denzel Wright

Total Depth: 58'

End Drilling: 4/2/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.30

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2277.98

East Coord.: 5761.66

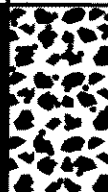
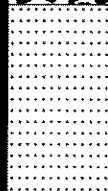
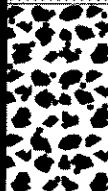
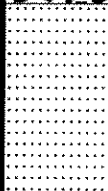
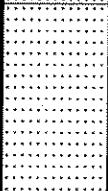
Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
36	17,13,20, 23	22	3.1			GW	GRAVEL dense; wet; light brown; gravel 60%; sand 40%; well graded	
38	17,23,28, 30	24	6.1			SW	SAND dense; wet; light brown; sand 80%; gravel >15%; silt <5%; well graded	
40	21,21,25, 25	22	5.7			GW	GRAVEL dense; wet; light brown; sand 85%; gravel 10%; silt 5%; well graded	
42	31,21,17, 14	18	0.1			SW	SAND dense; wet; light brown; well graded; sand 85%; silt 10%; gravel 5%	
44	13,17,25, 30	24	0.3			SW	SAND dense; wet; light brown; well graded; sand 80%; gravel 15%; silt 5%	
46	25,17,25, 28	22	0.9			GW	GRAVEL dense; wet; light brown; well graded; gravel 70%; sand 25%; silt <5%	
48								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/2/01

Driller: Denzel Wright

Total Depth: 58'

End Drilling: 4/2/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.30

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2277.98

East Coord.: 5761.66

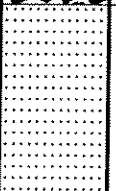
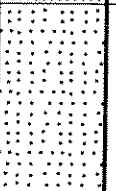
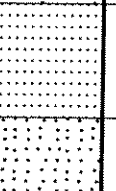
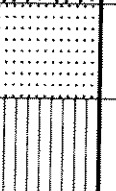
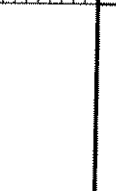
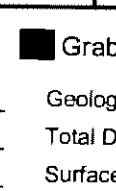
Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
48	30,32,40, 50	22	0.9			GW	GRAVEL dense; wet; light brown; well graded; gravel 60%; sand 40%; silt <3%	
50	16,21,30, 35	24	0.0			SW	SAND dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
52	12,24,30, 37	24	0.0			SP	SAND dense; wet; light brown; poorly graded; sand 90%; gravel 10%; silt <3%	
54	23,28,33, 33	24	0.0			SW	SAND dense; wet; light brown; well graded; sand 80%; gravel 15%; silt 5%	
						SP	SAND dense; wet; gray; poorly graded; well sorted; sand 95%; silt 5%	
56	16,22,50	24	0.0			SW	SAND refusal; dense; wet; light brown; well graded; sand 80%; gravel 15%; silt 5%	
						ML	SILT hard; wet; gray; poorly graded; greenish gray; silt 60%; clay 30%; sand <10%	
58							Bottom of boring	
60								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/2/01

Driller: Denzel Wright

Total Depth: 58'

End Drilling: 4/2/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.30

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 2277.98

East Coord.: 5761.66

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

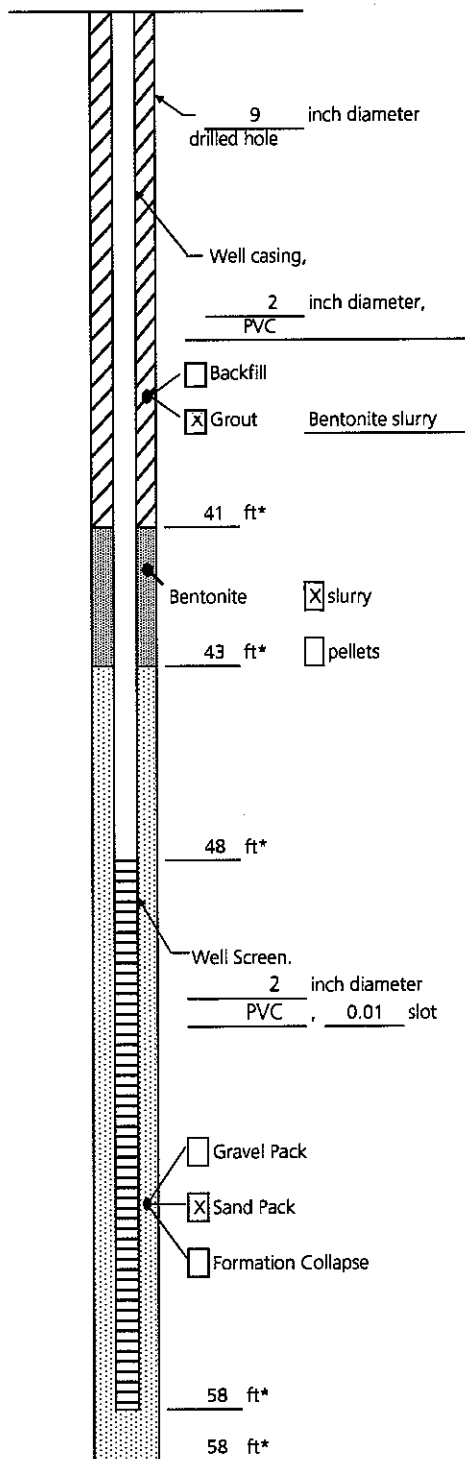
Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0004.00004 Well GM-33

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

730.30 LS/729.77 TOC feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/2/2001

Drilling Method Hollow stem auger

Drilling Contractor Wright Drilling

Drilling Fluid N/A

Development Technique(s) and Date(s)

Pumping and surge block 4/10/01 - 4/16/01

Fluid Loss During Drilling N/A gallons

Water Removed During Development 255 gallons

Static Depth to Water 28.04 feet below M.P.

Pumping Depth to Water 50.80 feet below M.P.

Pumping Duration 2 hours

Yield 1.3 gpm Date 4/11/2001

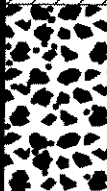
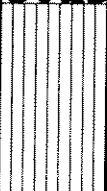
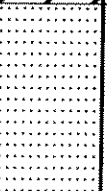
Specific Capacity NA gpm/ft

Well Purpose Groundwater sampling and

water level measurements.

Remarks Flush mount.

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
0	6,9,11	11	1.3			CL	CLAY asphalt 5"; fill dense; moist; light brown; well graded; clay 30%; silt 40%; gravel 15%; sand 10%	
2	6,9,7,6	22	0.9			GW	GRAVEL fill; dense; moist; light brown; well graded; gravel 60%; sand 20%; clay 10%; silt 10%	
4	0,1,3,4	0					No recovery	
6	2,3,6,4	13.5	1.7			ML	SILT dense; moist; light brown; well graded; clay 35%; silt 35%; sand 15%; gravel 15%	
8	2,3,3,6	22.5	0.9			CH	CLAY medium stiff; moist; light brown; clay 80%; silt 10%; sand <5%; gravel <5%; medium plasticity	
10	3,12,12, 11	24	0.7			SW	SAND loose; moist; light brown; well graded; sand 70%; gravel 20%; silt 10%	
12								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 4

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 36'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.06

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2278.47

East Coord.: 5769.74

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
12	16,16,34, 22	24	2.5			SW	SAND medium dense; moist; yellowish orange; well graded; sand 75%; gravel 25%; silt <3%	
14	14,45,45, 40	24	6.6			SW	SAND medium dense; moist; light gray; well graded; sand 75%; gravel 25%; silt <3%	
16	25,27,30, 32	24	9.9			SW	SAND medium dense; moist; light gray; well graded; sand 75%; gravel 25%; silt <3%	
18	9,45,50	18	10.2			SW	SAND medium dense; moist; light gray; well graded; sand 75%; gravel 25%; silt <3%; spoon refusal	
20	23,50,-,-	12	7.2			SW	SAND medium dense; moist; light gray; well graded; sand 75%; gravel 25%; silt <3%; spoon refusal	
22	21,50/5,-,-	12	8.6			SW	SAND medium dense; moist; light gray; well graded; sand 75%; gravel 25%; silt <3%; spoon refusal	
24								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 4

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 36'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.06

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2278.47

East Coord.: 5769.74

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
24	31,50/5,-,-	12	4.0			SW	SAND dense; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%; spoon refusal	
26	45,34,34, 16	20	1.7			SW	SAND dense; moist; light gray-light brown; well graded; sand 80%; gravel 15%; silt <5%	
28	16,21,28, 45	22	2.1			SW	SAND dense; moist; light gray-light brown; well graded; sand 80%; gravel 15%; silt <5%	
30	21,40,50,-	18	3.1			SW	SAND dense; moist; light gray-light brown; well graded; sand 80%; gravel 15%; silt <5%; spoon refusal	
32	40,50	8	1.7			SW	SAND dense; wet; olive gray; well graded; poorly sorted; sand 80%; gravel; 15%; silt <5%; spoon refusal	
34	10,50/5	12	3.5			SW	SAND dense; wet; olive gray; well graded; sand 80%; gravel; 15%; silt <5%; spoon refusal	
36								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 4

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 36'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.06

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 2278.47

East Coord.: 5769.74

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
36							Bottom of boring	
38								
40								
42								
44								
46								
48								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 4

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 36'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.06

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 2278.47

East Coord.: 5769.74

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

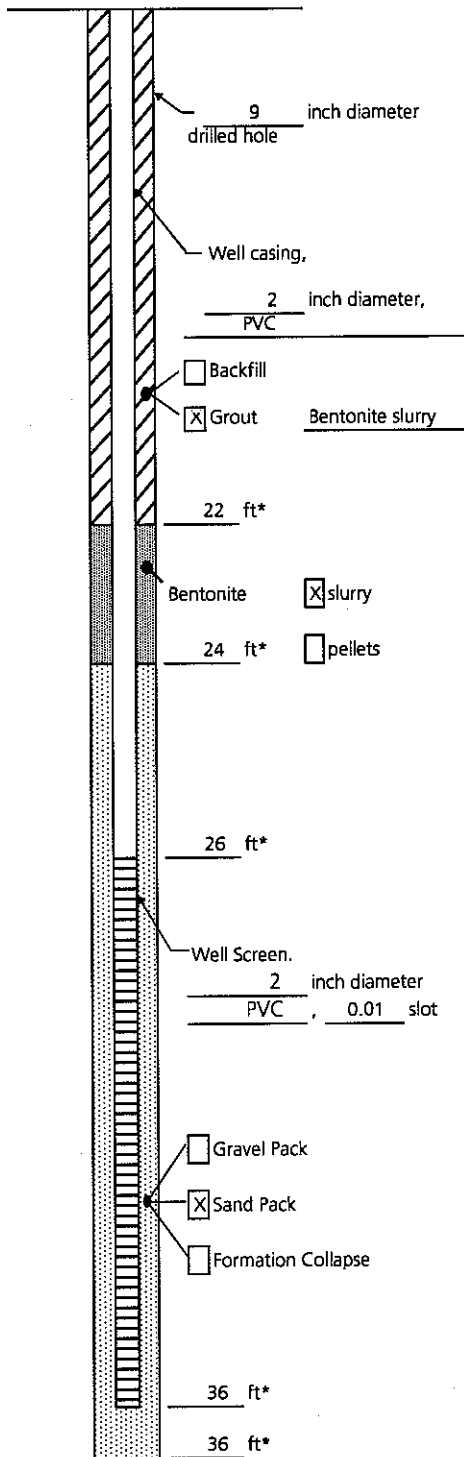
Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0004.00004 Well GM-34

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

731.06 LS/730.56 TOC feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/3/2001

Drilling Method Hollow stem auger

Drilling Contractor Wright Drilling

Drilling Fluid N/A

Development Technique(s) and Date(s)

Pumping 4/9/01

Fluid Loss During Drilling N/A gallons

Water Removed During Development 36 gallons

Static Depth to Water 28.84 feet below M.P.

Pumping Depth to Water 28.85 feet below M.P.

Pumping Duration 1.05 hours

Yield 1.41 * gpm Date 4/10/2001

Specific Capacity NA gpm/ft

Well Purpose Groundwater sampling and

water level measurements.

Remarks Flush mount.

*1.26 gpm on 4/10/01

1.41 gpm on 4/9/01

Prepared by C. Capell

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
0	-8,12,15	18	1.5			SW	SAND 7" of concrete; fill; medium dense; dry; yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
2	16,13,8,7	20	1.7			SW	SAND fill; medium dense; dry; yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
4	9,6,5,4	22	1.7			SW	SAND fill; medium dense; dry; yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
6	4,9,9,6	20	3.4			SW	SAND loose; moist; white-black-dark brown; well graded; sand 85%; gravel 15%; silt <5%; pieces of wood present	
8	3,6,3,4	22	109.9			CL	CLAY medium stiff; low-medium plasticity; moist; dark gray-black; clay 65%; silt 25%; sand <5%; gravel <5%	
10	3,3,6,10	22	3.0			CL	CLAY medium stiff; low-medium plasticity; moist; dark gray-black; clay 60%; silt 20%; sand 10%; gravel 10%	
12								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1750.11

East Coord.: 5509.95

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
12	10,11,8, 12	18	2.5			SW	SAND loose; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
14	11,19,19, 20	24	1.9			SW	SAND loose; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
16	12,20,17, 17	24	2.5			SW	SAND loose; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
18	12,14,16, 26	24	2.5			GW	GRAVEL/SAND loose; moist; light brown; well graded; gravel 60%; sand 35-40%; silt <5%	
20	50,26,50	18	2.3			SW	SAND medium dense; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
22	50/5	0	-				No recovery; spoon refusal	
24								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1750.11

East Coord.: 5509.95

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
24	20,30,30, 50	22	2.1			SW	SAND medium dense; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
26	30,35,50,-	18	2.0			SW	SAND refusal; medium dense; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
28	25,50/5	12	2.1			SW	SAND refusal; medium dense; moist; light brown; well graded; sand 80%; gravel 15%; silt <5%	
30	30,26,30, 30	24	3.4			SW	SAND medium dense; wet; yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
32	12,15,24, 24	13	2.3			GW	GRAVEL/SAND medium dense; wet; yellowish orange; well graded; gravel 75%; sand 20%; silt <5%	
34	21,21,30, 50	21	2.8			GW	GRAVEL/SAND medium dense; wet; yellowish orange; well graded; gravel 75%; sand 20%; silt <5%	
36								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1750.11

East Coord.: 5509.95

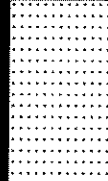
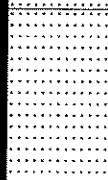
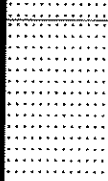
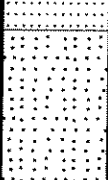
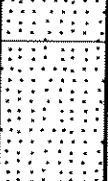
Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
36	6,6,8,8	15	1.7			GW	GRAVEL/SAND medium dense; wet; yellowish orange; well graded; gravel 75%; sand 20%; silt <5%	
38	39,50/5	14	3.6			SW	SAND/GRAVEL refusal; dense; wet; light brown-yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
40	6,9,9,15	12	1.5			SW	SAND/GRAVEL loose; wet; yellow orange; well graded; sand 80%; gravel 10%; silt <5%	
42	10,26,30, 35	16.5	1.9			SW	SAND/GRAVEL medium dense; wet; yellowish orange; well graded; sand 75%; gravel 15%; silt <5%	
44	8,15,41, 30	21	3.8			SP	SAND/GRAVEL medium dense; wet; light brown; poorly graded; sand 75%; gravel 20%; silt <5%	
46	7,10,10, 20	22	4.1			SP	SAND/GRAVEL medium dense; wet; light brown; poorly graded; sand 75%; gravel 20%; silt <5%	
48								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1750.11

East Coord.: 5509.95

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
48	30,50/6	9	2.8			SP	SAND/GRAVEL medium dense; wet; light brown; poorly graded; sand 75%; gravel 20%; silt <5%; spoon refusal	
50	8,20,30, 50/6	24	6.9			SP	SAND loose; wet; brown; poorly graded; sand 95%; silt <5%	
52	13,20,25, 30	24	6.2			SW	SAND/GRAVEL dense; wet; brown; well graded; sand 80%; gravel 15%; silt <5%	
54	16,35,50/ 3	18	7.3			SW	SAND/GRAVEL very dense; wet; brown; well graded; sand 75%; gravel 20%; silt <5%	
56	7,14,24, 38	24	5.4			SP	SAND dense; wet; brown; poorly graded; sand 90%; gravel 5%; silt <5%	
58	10,16,28, 32	24	5.1			SP	SAND dense; wet; brown; poorly graded; sand 90%; gravel 5%; silt <5%	
60								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1750.11

East Coord.: 5509.95

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs



Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
60	10,18,20, 22	24	2.3			SP	SAND dense; wet; brown; poorly graded; sand 90%; gravel 10%; silt <5%	
62	46,50/6	12	0.0			CL	SAND/CLAY very soft; wet; low plasticity; gray; clay 70%; silt 20%; sand 10%	
64	44,50/6	20	0.0			SP	SAND/GRAVEL refusal; dense; wet; olive gray; poorly graded; sand 75%; gravel; 20%; silt <5%	
66	48,50/5	0					No recovery	
68	38,50/6	18	0.0			CL	SILT/CLAY hard; moist; low plasticity; olive gray; clay 55%; silt 40%; sand <5%	
70							Bottom of boring	
72								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/4/01

Driller: Brian Wright

Total Depth: 70'

End Drilling: 4/6/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.56

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 1750.11

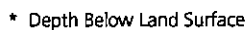
East Coord.: 5509.95

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs



Prepared by C. Capell

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	-8,11,16	15	0.0				SW	SAND 7" of concrete; loose; dry; light gray white; sand 90%; gravel 5%; silt <5%	
2	25,23,12, 15	24	1.3				SP	SAND medium dense; dry-moist; white-purple-light brown; poorly graded; sand 100%	
4	7,7,8,5	22	5.4				SP	SAND medium dense; dry-moist; white-purple-light brown; poorly graded; sand 100%	
6	3,3,2,1	22	6.8				SP	SAND loose; moist; white-light gray-brown; poorly graded; sand 100%	
								wet at 7' and light gray-white	
8	2,7,7,8	18	1.1				CH	CLAY medium stiff; moist; brown; clay 80%; silt 20%; medium plasticity	
10	1,3,5,4	20	1.3				CL	CLAY medium stiff; moist; olive gray; clay 70%; silt 20%; gravel 10%; medium plasticity	
12									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 34'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.44

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1754.76

East Coord.: 5551.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	2,4,10,7	20	0.5				SP	SAND loose; moist; light brown; poorly graded; sand 90%; gravel 10%	
14	3,4,10,10	20	1.5				SP	SAND loose; moist; light brown; poorly graded; sand 90%; gravel 10%	
16	4,8,8,8	20	0.9				SP	SAND loose; moist; light brown; poorly graded; sand 90%; gravel 10%	
18	10,16,17, 17	20	0.5				SP	SAND loose; moist; light brown; poorly graded; sand 90%; gravel 10%	
20	5,7,11,12	22	0.9				SP	SAND loose; moist; olive gray; poorly graded; sand 95%; gravel <5%	
22	19,25,30, 30	22	0.7				SW	SAND medium dense; moist; light brown; well graded; sand 70%; gravel 35%; silt <5%	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 34'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.44

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1754.76

East Coord.: 5551.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	12,21,44, 44	20	0.3				SW	SAND medium dense; moist; light brown; well graded; sand 70%; gravel 35%; silt <5%	
26	10,15,23, 25	20	0.9				SW	SAND medium dense; moist; light brown; well graded; sand 70%; gravel 35%; silt <5%	
28	13,31,50	18	0.5				SW	SAND medium dense; moist; light brown; well graded; sand 70%; gravel 35%; silt <5%	
30	10,26,30, 30	22	4.2				SW	SAND medium dense; wet; yellowish orange; well graded; sand 75%; gravel 25%; silt <3%	
32	17,29,40, 45	24	2.3				SW	SAND medium dense; wet; yellowish orange; well graded; sand 75%; gravel 25%; silt <3%	
34								Bottom of boring	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/3/01

Driller: Denzel Wright

Total Depth: 34'

End Drilling: 4/3/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 731.44

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1754.76

East Coord.: 5551.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

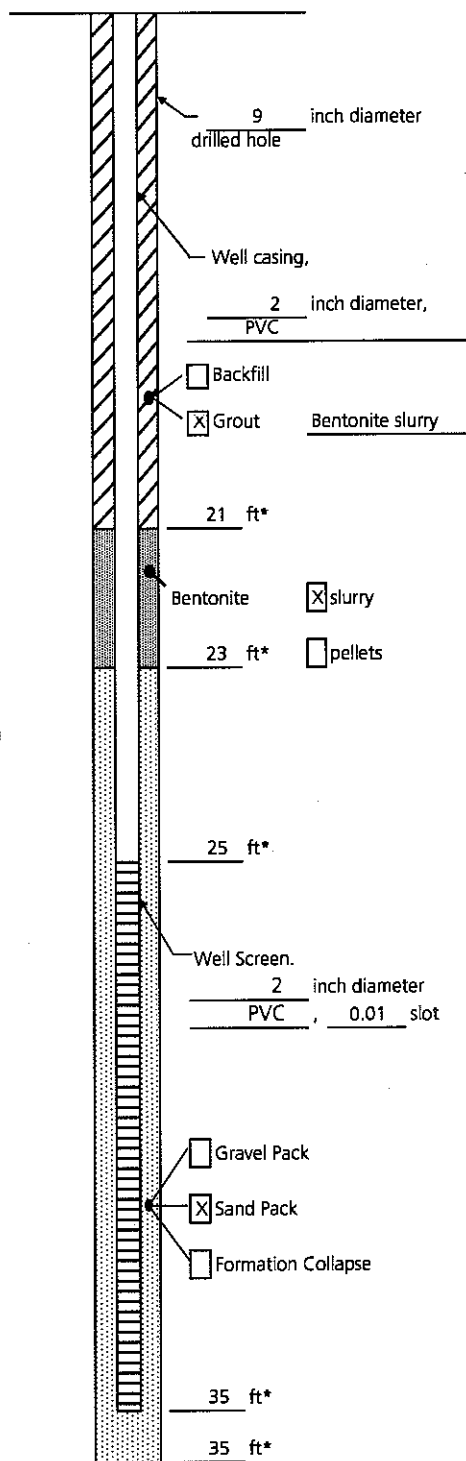
Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0004.00004 Well GM-36

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

731.44 LS/731.11 TOC feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/3/2001

Drilling Method Hollow stem auger

Drilling Contractor Wright Drilling

Drilling Fluid N/A

Development Technique(s) and Date(s)

Pumping 4/9/01

Fluid Loss During Drilling N/A gallons

Water Removed During Development 55 gallons

Static Depth to Water 29.92 feet below M.P.

Pumping Depth to Water NR feet below M.P.

Pumping Duration 0.66 hours

Yield 1.34 gpm Date 4/9/2001

Specific Capacity NA gpm/ft

Well Purpose Groundwater sampling and

water level measurements.

Remarks Flush mount.

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
0	7,18,22, 17	19	2.0			ML	SILT asphalt; fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%; pieces of glass present	
2	4,3,5,2	16	0.0			ML	SILT fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%; pieces of glass present	
4	2,3,2,2	11	0.2			ML	SILT fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%; pieces of glass present	
6	0,1,2,3	20	0.0			CL	SILT/CLAY soft; medium plasticity; moist; light brown-olive gray; clay 75%; silt 20%; sand <5%	
8	3,8,7,8	24	0.0			CL	SILT/CLAY medium stiff; medium plasticity; moist; light brown-yellowish orange; clay 75%; silt 20%; sand <5%	
10	8,11,11, 13	18	0.0			SW	SAND/GRAVEL loose; moist; light brown-yellowish orange; well graded; sand 75%; gravel 20%; silt <5%	
12								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/9/01

Driller: Brian Wright

Total Depth: 56'

End Drilling: 4/9/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.36

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 1857.31

East Coord.: 5696.09

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
12	8,12,14, 18	20	0.0			SW	SAND/GRAVEL loose; moist; yellowish orange; well graded; sand 75%; gravel 20%; silt <5%	
14	20,22,22, 24	20	0.0			SW	SAND/GRAVEL medium dense; moist; yellowish orange; well graded; sand 80%; gravel 20%	
16	14,18,26, 20	22	0.0			SW	SAND/GRAVEL medium dense; moist; light brown-yellowish orange; well graded; sand 80%; gravel 20%	
18	18,22,19, 28	22	0.0			SW	SAND/GRAVEL medium dense; moist; light brown-yellowish orange; well graded; sand 80%; gravel 20%;	
20	16,17,34, 50/6	18	0.0			SW	SAND/GRAVEL medium dense; moist; yellowish orange; well graded; sand 60%; gravel 35%; silt <5%	
22	44,46,50/ 6	14	0.0			SW	SAND/GRAVEL medium dense; moist; light brown; well graded; sand 60%; gravel 35%; silt <5%	
24								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/9/01

Driller: Brian Wright

Total Depth: 56'

End Drilling: 4/9/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.36

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 1857.31

East Coord.: 5696.09

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
24	35,26,50/ 6	20	0.0			SW	SAND/GRAVEL medium dense; moist; light brown; well graded; sand 60%; gravel 35%; silt <5%	
26	100/3	0	-				No recovery	
28	35,46,50	22	0.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 60%; gravel 35%; silt <5%	
30	9,9,19,50/ 6	18	0.4			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
32	4,20,50/6	24	0.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
34	4,16,50/6	20	0.6			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
36								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/9/01

Driller: Brian Wright

Total Depth: 56'

End Drilling: 4/9/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.35

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1857.31

East Coord.: 5696.09

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
36	6,10,22, 24	24	1.3			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
38	12,11,50/ 6	24	0.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
40	21,10,6,4	24	1.6			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
42	40,43,50/ 6	24	1.6			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
44	33,38,50/ 6	24	2.3			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
46	12,23,29, 23	24	3.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 75%; gravel 20%; silt <5%	
48								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/9/01

Driller: Brian Wright

Total Depth: 56'

End Drilling: 4/9/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.36

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1857.31

East Coord.: 5696.09

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs



Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
48	21,21,36, 34	24	1.6			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
50	28,38,50/ 6	22	8.5			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
52	48,50/1	22	15.7			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
54	44,50/3	24	0.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
56						CL	SILT/CLAY medium stiff; low plasticity; gray; poorly graded; clay 60%; silt 40% Bottom of boring	
58								
60								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 5

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/9/01

Driller: Brian Wright

Total Depth: 56'

End Drilling: 4/9/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.36

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1857.31

East Coord.: 5696.09

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
0	15,24	12	3.3			ML	SILT 10" of asphalt; fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%	
2	7,18,18,5	22	0.0			ML	SILT fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%	
4	10,3,5,5	14	0.7			ML	SILT fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%	
6	4,4,10,10	6	0.9			ML	SILT fill; loose; dry; stained; dark brown-red-blue-orange; silt 70%; sand 25%; gravel <5%	
8	1,2,3,6	24	0.4			CL	CLAY/SILT stained; medium stiff; medium plasticity; moist; light brown-yellowish orange; clay 75%; silt 20%; sand <5%	
10	3,4,6,7	22	0.0			CL	CLAY/SILT stained; medium stiff; medium plasticity; moist; light brown-yellowish orange; clay 75%; silt 20%; sand <5%	
12								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/10/01

Driller: Brian Wright

Total Depth: 34'

End Drilling: 4/10/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.31

Converted to Well: Y Well I.D.: _____

Drilling Fluid: None

North Coord.: 1857.56

East Coord.: 5686.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum: _____

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
12	3,6,6,7	14	0.0			SP	SILT/SAND loose; moist; light brown-yellowish orange; poorly graded; sand 90%; silt 10%; gravel <3%	
14	5,10,10, 12	18.5	0.0			SP	SILT/SAND loose; moist; light brown-yellowish orange; poorly graded; sand 90%; silt 10%; gravel <3%	
16	9,11,17, 17	24	0.0			SW	SAND/GRAVEL loose; moist; light brown-yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
18	16,19,25, 35	22	0.0			SW	SAND/GRAVEL loose; moist; light brown-yellowish orange; well graded; sand 80%; gravel 15%; silt <5%	
20	28,28,26, 27	22	0.0			GW	GRAVEL/SAND medium dense; moist; light brown; well graded; gravel 70%; sand 25%; silt <5%	
22	9,10,20, 28	20	0.0			GW	GRAVEL/SAND medium dense; moist; light brown; well graded; gravel 70%; sand 25%; silt <5%	
24								

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/10/01

Driller: Brian Wright

Total Depth: 34'

End Drilling: 4/10/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.31

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1857.56

East Coord.: 5686.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

Waste Pile/Staging Area Investigation

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample	Graphic Log	Soil Class.	Description	Depth to Water
24	21,28,28, 30	18	0.0			SW	SAND/GRAVEL medium dense; moist; light brown; well graded; sand 60%; gravel 40%; silt <3%	
26	50/6	11.5	0.0			SW	SAND/GRAVEL medium dense; moist; light brown; well graded; sand 60%; gravel 40%; silt <3%	
28	35,50/6	11	0.2			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 60%; gravel 40%; silt <3%	
30	16,18,20, 30	23	1.0			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
32		20	0.3			SW	SAND/GRAVEL medium dense; wet; light brown; well graded; sand 80%; gravel 15%; silt <5%	
34							Bottom of boring	
36								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 3

Drilling Co.: Wright Drilling

Geologist: Cindy Capell

Begin Drilling: 4/10/01

Driller: Brian Wright

Total Depth: 34'

End Drilling: 4/10/01

Drilling Method: Hollow Stem Auger

Surface Elev.: 730.31

Converted to Well: Y Well I.D.:

Drilling Fluid: None

North Coord.: 1857.56

East Coord.: 5686.00

Remarks: Analyzed for TCL VOCs, SVOCs, PCBs, TAL metals

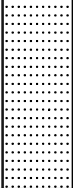
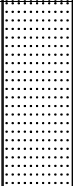
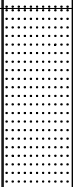
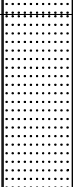
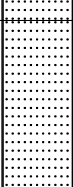
Project No.: OH000294.0002.00006

Datum:

Filename: April Logs

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	12	0.0				GP	GRAVEL Poorly graded, dry	
2	N/A	12	0.0				SW	SAND AND GRAVEL Brown, medium-fine, gravel (20%), little silt, dry	
4	N/A	12	0.0				SW	Same as above	
6	N/A	12	0.0				SW	Same as above	
8	N/A	24	0.0				SW	Same as above	
10	N/A	24	0.0				SW	Same as above	
12	N/A	24	0.0				SW	Same as above	

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
14	N/A	24	0.0				GP	GRAVEL Poorly graded, dry	
16	N/A	24	0.0				SW	SAND & GRAVEL Brown, medium-fine sand, gravel (10%), little silt, dry	
18	N/A	8	0.0				SW	Same as above, gravel (30%)	
20	N/A	8	0.0				SW	Same as above	
22	N/A	8	0.0				SW	Same as above	
24	N/A	8	0.0				SW	Same as above	

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks: _____

Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
26	N/A	20	0.0				SW	Same as above, wet at 27'	
28	N/A	20	0.0				GP	GRAVEL Poorly graded, wet	
30	N/A	20	0.0				GW	GRAVEL Brown, coarse sand (40%), wet Water sample collected at 30' for site specific VOCs.	
32	N/A	20	0.0				GW	Same as above	
34	N/A	20	0.0				GW	Same as above, medium-coarse sand (30%)	
36	N/A	24	1.3				GW	Same as above	

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks: _____

Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
38	N/A	24	1.3				SW	SAND & GRAVEL Brown, medium-coarse sand (50%), fine gravel, wet	
40	N/A	24	1.5				SW	Same as above	
42	N/A	24	1.4				SW	Same as above	
44	N/A	24	1.4				SW	Same as above	
								Water sample collected at 45' for site specific VOCs.	
46	N/A	20	1.4				SW	Same as above, gravel (20%)	
48	N/A	20	0.0				SW	Same as above	
50									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	20	0.0				SW	Same as above, fine gravel (50%)	
52	N/A	20	0.0				SW	Same as above, gravel (10%)	
54	N/A	20	0.0				SW	Same as above, gravel (20%)	
56	N/A	24	0.0				SW	SAND Brown, medium-coarse, wet	
58	N/A	24	0.0				SP	SAND Brown, medium, little silt, poorly graded, saturated	
60	N/A	24	0.0				CL	SILTY CLAY Gray, gravel (10-20%), stiff-very stiff, low plasticity, 4" gravel layer above silty clay Water sample collected at 60' for site specific VOCs.	
62	N/A	24	0.0				CL	Same as above, gravel (10%)	

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
64	N/A	24	0.0				CL	Same as above	
66	N/A	12	0.0				CL	Same as above, gravel (20%)	
68								End of boring	
70									
72									
74									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic Corporation

Geologist: T. Fortner

Begin Drilling: 2/23/06 @ 1650

Driller: J. Sigler

Total Depth: 67

End Drilling: 2/24/06 @ 1126

Drilling Method: Rotosonic

Surface Elev.: 727.03

Converted to Well: Y Well I.D.: GM-47

Drilling Fluid: Water

North Coord.: 1312.270

East Coord.: 4776.411

Remarks: _____

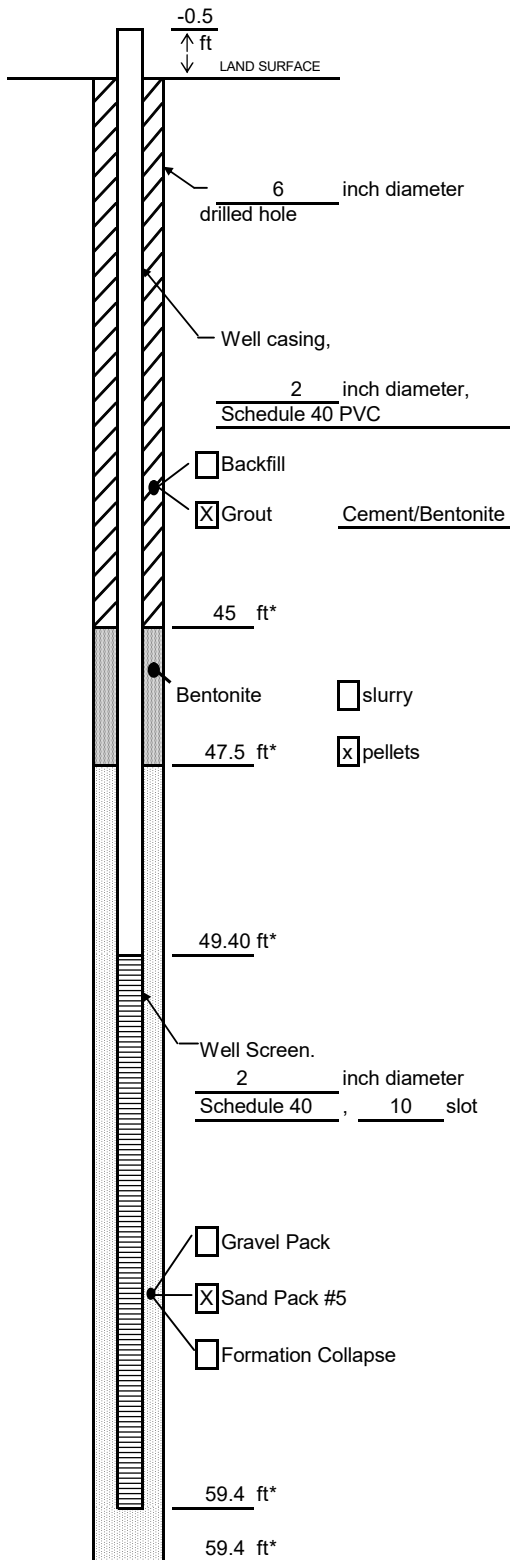
Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.75

Filename: February 2006

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well GM-47

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

727.03 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 2/24/2006

Drilling Method Rotosonic

Drilling Contractor Prosonic Corporation

Drilling Fluid Water

Development Technique(s) and Date(s)

Submersible pump 2/25/06

Fluid Loss During Drilling NA gallons

Water Removed During Development 600 gallons

Static Depth to Water 21.91 feet below M.P.

Pumping Depth to Water 50-59.5 feet below M.P.

Pumping Duration 4.00 hours

Yield 3 gpm Date 2/25/06

Specific Capacity N/A gpm/ft

Well Purpose Monitoring Well

Remarks TOC Elevation = 726.75

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								See GM-47 for lithologic description from 0-40'	
2									
4									
6									
8									
10									
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 1

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 4/24/06

Driller: B. Smith

Total Depth: 40

End Drilling: 4/24/06

Drilling Method: Rotosonic

Surface Elev.: 727.034

Converted to Well: Y Well I.D.: GM-50

Drilling Fluid: Water

North Coord.: 1311.64197

East Coord.: 4773.28499

Remarks: Shallow pair to GM-47.

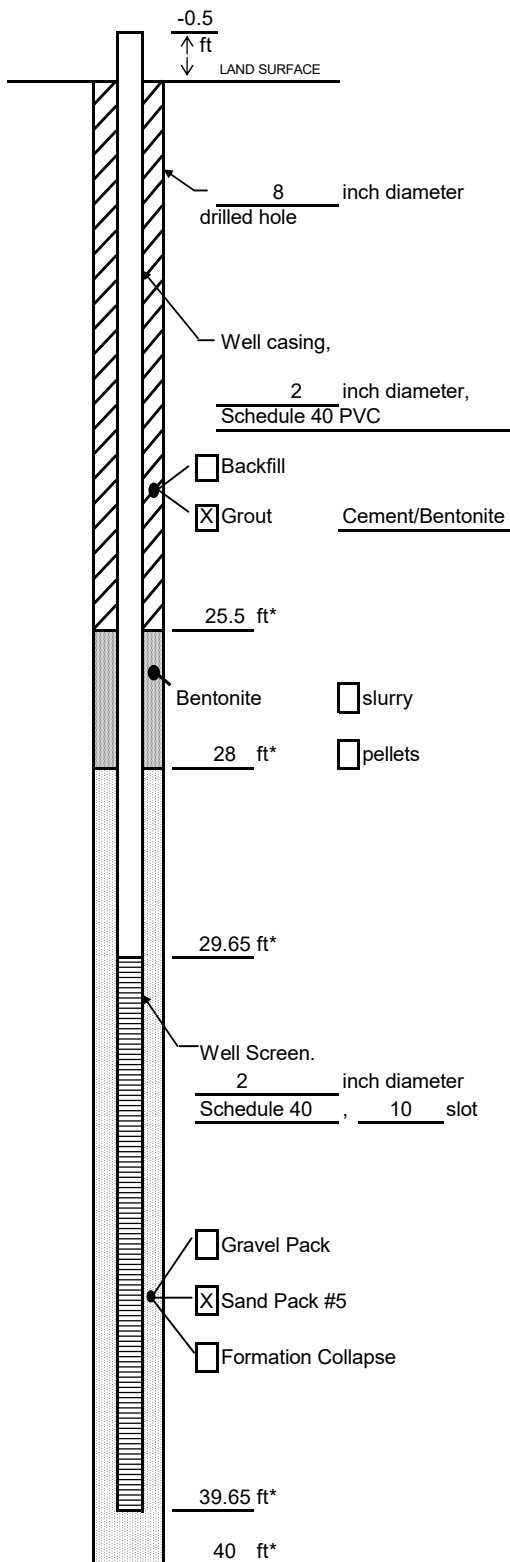
Project No.: OH000294.0008.00002

Datum: TOC Elev = 722.109

Filename: July 2006

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well GM-50

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

727.034 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/24/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 4/26/06

Fluid Loss During Drilling NA gallons

Water Removed During Development 200 gallons

Static Depth to Water 20.39 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.50 hours

Yield NM gpm Date 4/26/06

Specific Capacity NM gpm/ft

Well Purpose Monitoring Well

Remarks TOC Elevation = 726.555

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								See RZ-4J for lithologic description from 0-40'	
2									
4									
6									
8									
10									
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 1

Drilling Co.: Boart Longyear

Geologist: J. Wallace

Begin Drilling: 8/31/06

Driller: D. Remmler

Total Depth: 40

End Drilling: 8/31/06

Drilling Method: Hollow Stem Auger

Surface Elev.: 726.207

Converted to Well: Y Well I.D.: GM-63

Drilling Fluid: Water

North Coord.: 1625.02787

East Coord.: 4918.82945

Remarks: Shallow pair to GM-64.

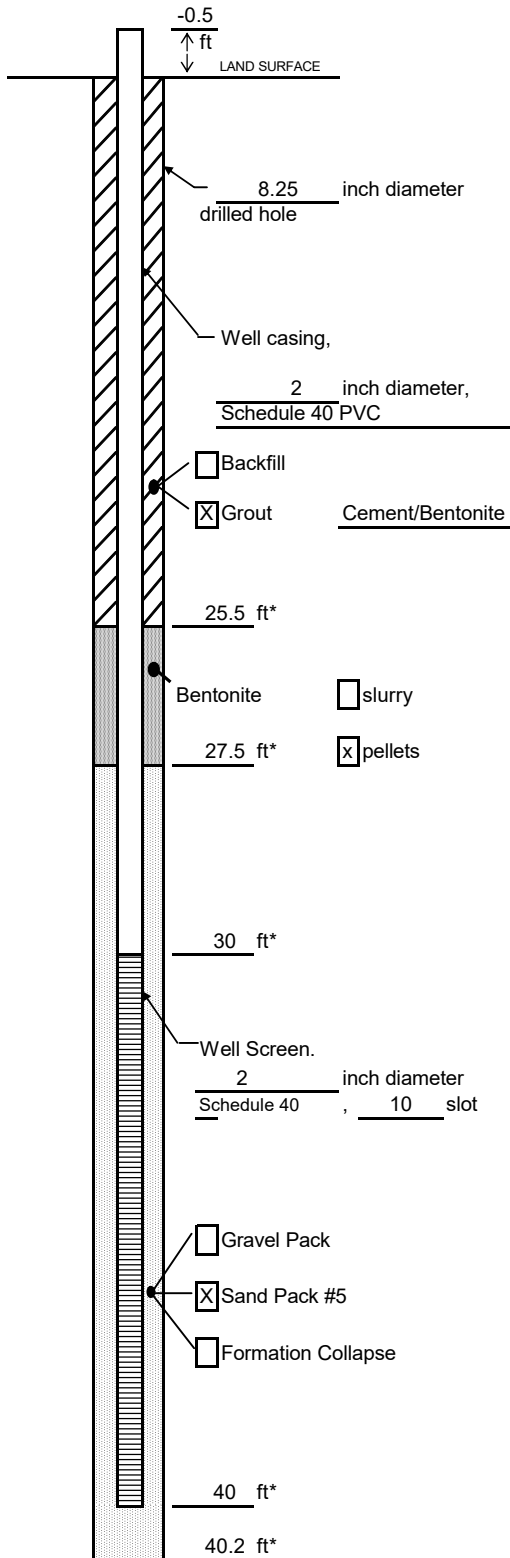
Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.791

Filename: July 2006

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project General Motors Corporation Well GM-63Town/City MoraineCounty Montgomery State OhioPermit No. NA

Land-Surface (LS) Elevation and Datum:

726.207 feet ☒ Surveyed☐ EstimatedInstallation Date(s) 9/1/2006Drilling Method Hollow Stem AugerDrilling Contractor Boart LongyearDrilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 9/1/06Fluid Loss During Drilling 15 gallonsWater Removed During Development 50 gallonsStatic Depth to Water ~20.2 feet below M.P.Pumping Depth to Water 38 feet below M.P.Pumping Duration NA hoursYield ~1.6 gpm Date 9/1/06Specific Capacity NM gpm/ftWell Purpose Monitoring Well

WSU-22 Replacement (Shallow)

Remarks TOC Elevation = 725.791Time 13:40, 13:45, 13:50, 13:55, 14:00pH 6.65, 6.58, 6.58, 6.58, 6.59Conductivity 1.41, 1.41, 1.42, 1.41, 1.41Turbidity 588, 286, 157, 92, 59Temperature 18.8, 18.6, 18.6, 18.5, 18.5Prepared by J. Wallace

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								See RZ-4J for lithologic description from 0-60'	
2									
4									
6									
8									
10									
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 1

Drilling Co.: Boart Longyear

Geologist: J. Wallace

Begin Drilling: 8/31/06

Driller: D. Remmler

Total Depth: 60

End Drilling: 8/31/06

Drilling Method: Hollow Stem Auger

Surface Elev.: 726.384

Converted to Well: Y Well I.D.: GM-64

Drilling Fluid: Water

North Coord.: 1624.73847

East Coord.: 4913.72063

Remarks: Shallow pair to GM-54.

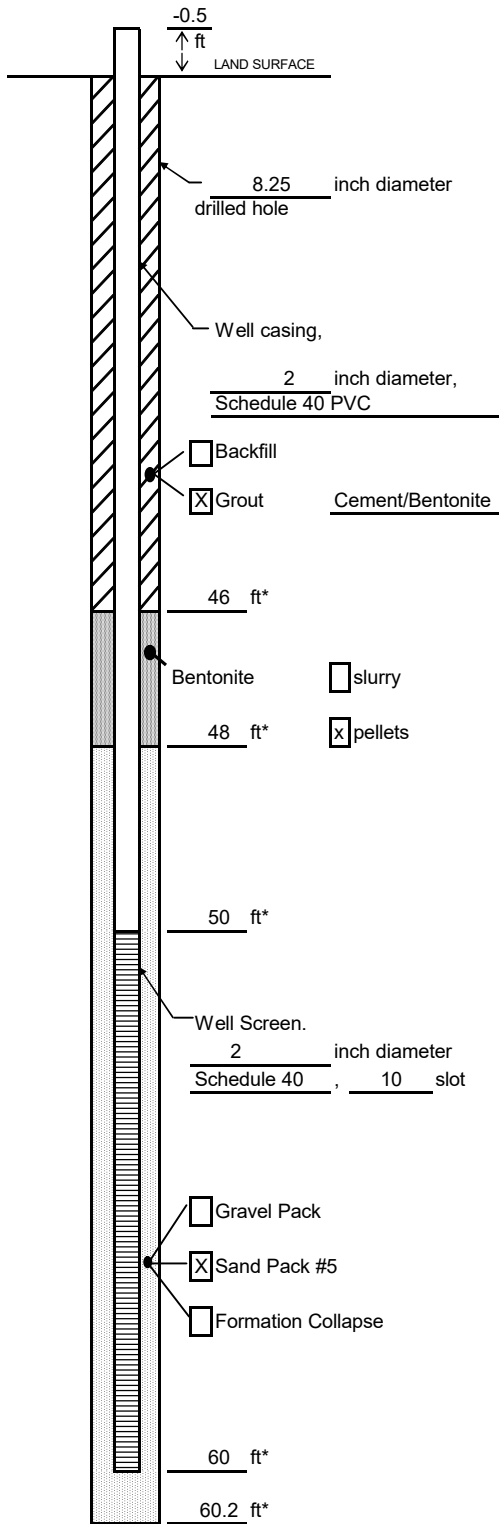
Project No.: OH000294.0008.00002

Datum: TOC Elev. 725.951

Filename: July 2006

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project General Motors Corporation Well GM-64Town/City MoraineCounty Montgomery State OhioPermit No. NA

Land-Surface (LS) Elevation and Datum:

726.384 feet ☒ Surveyed☐ EstimatedInstallation Date(s) 8/31/2006Drilling Method Hollow Stem AugerDrilling Contractor Boart LongyearDrilling Fluid None. However, ~25 gallons wateradded due to heaving sands

Development Technique(s) and Date(s)

Pumping - surge with pumpFluid Loss During Drilling 25 gallonsWater Removed During Development 55 gallonsStatic Depth to Water 20.4 feet below M.P.Pumping Depth to Water 58 feet below M.P.Pumping Duration 0.85 hoursYield NM gpm Date 8/31/06Specific Capacity NM gpm/ftWell Purpose Monitoring WellWSU-22 Replacement (Deep)Remarks TOC Elevation = 725.951Time 13:00, 13:05, 13:10, 13:15, 13:20, 13:25pH 6.78, 6.64, 6.64, 6.67, 6.66, 6.67Conductivity 1.29, 1.28, 1.28, 1.29, 1.29, 1.29Turbidity 10+, 10+, 999, 999, 999, 10+Temperature 19.7, 19.7, 19.6, 19.5, 19.6, 19.6Pumped 25 gallons prior to taking readingsPrepared by J. Wallace

PROJECT NO.
OH019.05

BORE HOLE NO.
HR-16

PROJECT Harrison Radiator

LOCATION Moraine, Ohio

DRILLING CONTRACTOR Reynolds Supply, Inc.

DRILLING EQUIPMENT Cable Tool Bucyrus Erie 60

HYDROGEOLOGIST S. Ackers

DRILLER Rick Wilmot

DATE START/TIME
11/2/89 9:40 a.m.

DATE FINISH/TIME
11/6/89 10:15 a.m.

SURFACE ELEVATION

TOTAL DEPTH 70'

WELL CASING
4-inch, sch 40 PVC

SCREEN TYPE
4-inch PVC

LENGTH 20 feet

SLOT .010 inch

REMARKS

Bottom of well set at 62.5 feet below ground

DEPTH (FT.)	SAMPLE (NO.)	BORE HOLE LOG		GWA/MD (PPM)	GRAPHIC LOG
		LITHOLOGIC DESCRIPTION	REMARKS		
5		CLAY - silt (75%); tr cs-med sand(10%); tr f-vf sand (10%); tr cs gravel (5%)	2' little cs-f sand tr med cobble tr cs gravel		
10		CLAY - silt (60%); some cs-md gravel (20%); some cs-f sand (20%); yellowish brown	8' tr cs-f cobbles (5%)		
15		No change			
20		CS-md SAND (50%); Some f-vf sand(30%); tr silt-clay(10%); tr med-f gravel(5%); tr f-md cobbles(5%); greyish orange	Clay-silt lessening		
25		CS-med GRAVEL (50%); Some Cs-md sand (35%); tr f-vf sand(10%);tr med-f cobbles (5%)	16' noticed tile in bailer sample		
30		Med-f SAND (85%); tr silt & clay (10%); tr cs sand (5%); Greyish orange; angular-subangular	24' tr cs gravel tr cs sand		
		Med-f GRAVEL (60%); Some cs-md sand (30%); tr f-vf sand (5%) angular-subangular			
		Med-vf SAND (85%); tr cs sand (5%) silty clay (10%)			
		Cs-med SAND (60%); Some f-vf sand (30%); tr silty clay (10%); greyish orange			

PROJECT NO. OHO19.05

BORE HOLE NO. HR-16

PROJECT Harrison Radiator

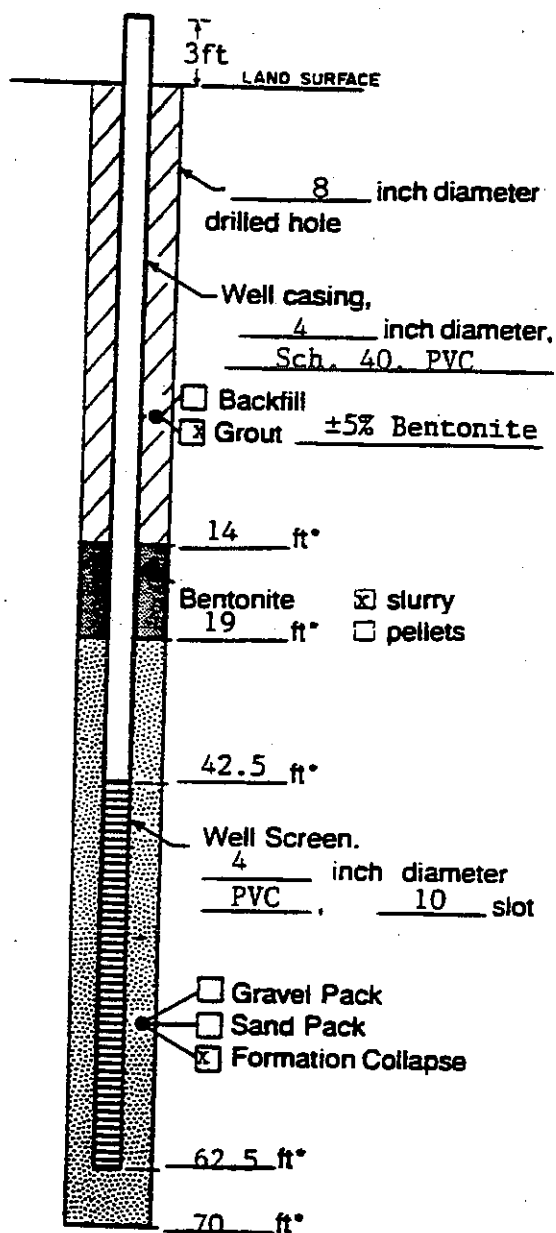
LOCATION Moraine, Ohio

REMARKS

DEPTH (FT.)	SAMPLE NO.	LITHOLOGIC DESCRIPTION	REMARKS	OVA/PID (PPM)	GRAPHIC LOG
		CLAY (85%); tr f-vf sand(10%);trf-vf gravel (5%)	Grey to olive grey		
40		F-vf SAND(75%); little cs sand (15%); tr md-f gravel (5%); tr silt clay(10%); color greyish orange No clay nodules	in color		
45		Cs-md SAND (50%); Some cs-md gravel (30%); tr f-vf sand (10%); tr med-f cobbles (10%) tr clay nodules; greyish orange, wet-moist			
50					
55					
60		Cs-f GRAVEL (60%); some cs-med sand (30%) tr f-med sand (10%)	Iron staining on on gravel		
65		CLAY (80%); tr f-vf sand (10%); tr cs-md sand (5%) tr med-f gravel (5%); olive grey; moist-damp	65' dark oil residue on sample (organic)		
70		Cs-md SAND (85%); tr f-vf gravel (10%); tr cs gravel (5%) End of Boring 70'			

WELL CONSTRUCTION LOG

(UNCONSOLIDATED)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

*Depth Below Land Surface

Project Harrison Radiator Well HR-16
Town/City Moraine
County Montgomery State Ohio
Permit No. _____
Land-Surface Elevation _____
and Datum _____ feet ☐ Surveyed
☐ Estimated
Installation Date(s) 11/6/89
Drilling Method Cable Tool
Drilling Contractor Reynolds Supply, Inc.
Drilling Fluid City of Dayton Water Supply

Development Technique(s) and Date(s)
Submersible pump, 11/21/89

Fluid Loss During Drilling _____ gallo
Water Removed During Development 902 gallo
Static Depth to Water 21.67' (11/21/89) feet below M.
Pumping Depth to Water _____ feet below M.
Pumping Duration 1.4 hours
Yield 11 gpm Date 11/21/89
Specific Capacity _____ gpm/ft
Well Purpose Ground-Water Quality and Elevation
Monitoring

Remarks MP=Top of PVC well casing
Eight inch casing left in ground to 19' below
ground surface (because grout being absorbed)

Prepared by Scott Ackers

PROJECT NO. OH019.05		BORE HOLE NO. HR-17	
PROJECT Harrison Radiator		LOCATION Moraine, Ohio	
DRILLING CONTRACTOR Reynolds Supply, Inc.		DRILLING EQUIPMENT Cable Tool Bucyrus Erie 60	
HYDROGEOLOGIST S. Ackers		DRILLER Rick Wilmer	
DATE START / TIME 11/9/89 9:30 am	DATE FINISH / TIME 11/10/89 4:00 pm	SURFACE ELEVATION	TOTAL DEPTH 56'
WELL CASING 4-inch. sch 40 PVC	SCREEN TYPE 4-inch PVC	LENGTH 20 feet	SLOT 010 inch

REMARKS
Bottom of well set at 47 feet below ground

DEPTH (FT.)	SAMPLE (NO.)	BORE HOLE LOG		GVA/MD (PPM)	GRAPHIC LOG
		LITHOLOGIC DESCRIPTION	REMARKS		
5		SANDY LOAM (top soil); clay (60%); some f-md sand (30%) tr Cs-md sand (5%); tr f-md pebbles (5%); yellowish brown; rounded- sub-rounded			
		Cs-VCS SAND (60%); little f-vf sand (15%); clay & silt (15%) tr md-f pebbles (5%)	7' tr md-f cobbles		
10		VCS-md SAND (60%); little md-f gravel (20%); tr md-f sand (10%); tr clay-silt (10%); angular- sub-angular; light yellowish brown	9' cobble 10" in diameter		
15		Cs-md SAND (65%); tr VC sand (10%); tr silt and clay (10%); tr f-vf pebbles (10%); tr md gravel (5%); sub- angular to rounded; greyish orange	13' drilling becomes difficult		
20			20' no significant change		
25			23' drilling is difficult		
30		md-f GRAVEL (50%); some Cs-md sand (30%); tr f-vf pebbles (10%); tr silty-clay (10%); angular to sub- rounded; greyish orange	28' drilling becomes softer		
			31-32' tr md-f cobbles		
			34' no signif. change		

PROJECT NO. OH019.05

BORE HOLE NO. HR-17

PROJECT Harrison Radiator

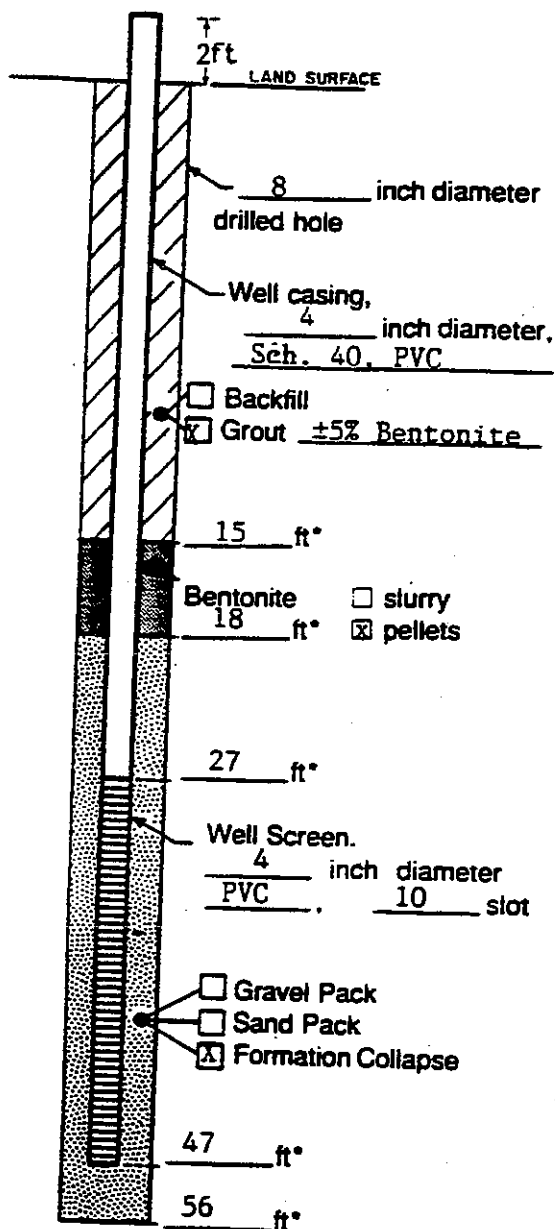
LOCATION Moraine, Ohio

REMARKS

DEPTH (FT.)	SAMPLE NO.	LITHOLOGIC DESCRIPTION	REMARKS	GRAV/PIG (PPM)	GRAPHIC
40		VCS-md SAND (60%); little f-md sand (20%); some silty clay (15%); tr f gravel (5%)	38'-40' color change moderate yellowish brown 41' color change: greyish orange. 40' drilling is difficult		
45		44' SAND & gravel shows sign of oxidation	43' oil sheen on drilling fluid		
50		VC-Cs SAND (80%); tr clay nodules (10%); tr-f gravel (5%); tr f-vf sand (5%); dusky yellow-light olive; damp-moist	48' CLAY (90%)tr VCS-CS sand (10%) yellowish grey-light olive; organic brown residue		
55		53' CLAY (as above); damp, bailing difficult			
60		End of Boring 56'			
65					
70					

WELL CONSTRUCTION LOG

(UNCONSOLIDATED)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

*Depth Below Land Surface

Project Harrison Radiator Well HR-17

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface Elevation _____

and Datum _____ feet ☐ Surveyed

☐ Estimated

Installation Date(s) 11/10/89 - 11/13/89

Drilling Method Cable Tool

Drilling Contractor Reynolds Supply, Inc.

Drilling Fluid City of Dayton Water Supply

Development Technique(s) and Date(s)

Submersible pump, 11/21/89

Fluid Loss During Drilling _____ gallon

Water Removed During Development 670 gallon

Static Depth to Water 20.87' (11/21/89) feet below M.

Pumping Depth to Water _____ feet below M.

Pumping Duration 1.1 hours

Yield 10 gpm

Date 11/21/89

Specific Capacity _____ gpm/ft

Well Purpose Ground-Water Quality and Elevation

Monitoring

Remarks MP=Top of PVC well casing

Prepared by Scott K. Ackers

Borehole Number: RZ-3E

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
0		Ground Surface						
1		SAND/GRAVEL sand and gravel; some black staining; some debris; such as wood fragments, nails, etc.; dry; no odor			0-2		2.0	0
2		SAND/GRAVEL sand and gravel with much black staining; dry; some fine black wood particles which had the high readings; other materials same as seen in RZ-30			2-4		1.0	70.0
3					4-6		0.1	3.0
4		SAND very little recovery; sand dark brown-black			6-8		1.0	0.0
5		SAND/GRAVEL sand and gravel; slightly moist; black staining; some odor			8-10		1.5	0.2
6		SAND/GRAVEL sand and gravel; slightly moist; looks clean; no odor			10-12		0.1	0
7		SAND/GRAVEL very little recovery			12-14		1.5	0.5
8		SAND/GRAVEL sand and gravel; slightly moist; no staining			14-16		0.8	0
9					16-18		1.5	0.2
10					18-20		1.5	0
11		Stop split spooning-auger down beyond this point. Some heaving sands and regional clay till at 63' bls. Due to heavy sands, the well could not be set at till and was therefore set at 50'						
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								

Scientist: Bill Ferguson/Eric Gray
 Project Manager: Nancy Gillotti
 Drilling Co.: Belasco Drilling
 Driller: Ray/Matt
 Drilling Method: Hollow Stem Auger
 Drilling Fluid: NA

Begin Drilling: 9/10/99
 End Drilling: 9/14/99
 Hole Size: 10"
 Total Depth: 63'
 Datum:
 File Name: gmotors\gmcrfilwinlogs\r2-3e.log

Surface Elev.: 729.89
 North Coord.: 1635.81147
 East Coord.: 5290.20644
 Converted to Well: Yes
 Well Name: RZ-3E
 Revised: 3/1/00

Borehole Number: RZ-3E**Client:** General Motors**Site Location:** Moraine, Ohio**Project:** Interim Measures**Project No:** OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64		End of Borehole						

Scientist: Bill Ferguson/Eric Gray
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Ray/Matt
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/10/99
End Drilling: 9/14/99
Hole Size: 10"
Total Depth: 63'
Datum:
File Name: gmotors\gmcrfi\winlogs\r2-3e.log

Surface Elev.: 729.89
North Coord.: 1635.81147
East Coord.: 5290.20644
Converted to Well: Yes
Well Name: RZ-3E
Revised: 3/1/00

Borehole Number: RZ-30

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
0		Ground Surface						
0		TOP SOIL grass with topsoil layer						
1		CLAY clay with red streaks and sand with some gravel; dry			0-2		0.8	0
2		CLAY/SILT brown clay with silt; some gravel present; dry			2-4		1.3	1.5
3		CLAY black clay; oily odor; well compacted (fill material) white and gray cumbly fill material; oily odor			4-6		1.0	2.0
4					6-8		1.0	2.0
5					8-10		0.8	0.75
6		SAND/GRAVEL yellow, pink-brown fill material; some sand and gravel; weak oily odor			10-12		1.5	3.0
7		SAND/GRAVEL black sand and gravel; weak oily odor; some fill material present						
8		SAND/GRAVEL blue to black fill material; slight oily odor; some sand and gravel at top						
9								
10								
11								
12								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrcfilwinlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

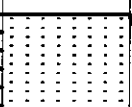
Borehole Number: RZ-30

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
13		SAND/GRAVEL fill material (black) at base which grades into sand and gravel at top; weak oily smell; sand and gravel relatively clean Hit something at 13' had to move hole over 5' to the east (towards RZ-3P) but still 5' from fence			12-14		0.3	2.25
14		Drilled to 14' for split spoon sample. Hit another object at 6.5' had to move hole 2' west (3rd hole is between original hole and 2nd hole) SAND sand (medium-coarse); dry; no trace of fill material			14-16		1.2	0
16		SAND/GRAVEL sand and gravel (coarse); cobble size; dry			16-18		0.8	0
18		SAND/GRAVEL coarse sand and gravel; cobble size; dry; faint oily odor			18-20		1.2	0
20		SAND/GRAVEL coarse sand and gravel; dry; loosely packed			20-22		0.4	0
22		SAND/GRAVEL coarse sand and gravel; dry; faint oily odor			22-24		2.0	0
23								
24								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrfilwinlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

Borehole Number: RZ-30

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
25		SAND/GRAVEL medium to coarse sand and gravel; dry; some compaction	▼		24-26		0.6	0
26		SAND/GRAVEL sand and gravel; dry; very faint oily odor still present			26-28		1.1	0.3
27								
28		SAND/GRAVEL sand and gravel; dry; compacted			28-30		1.5	0
29								
30		SAND/GRAVEL sand and gravel; gravel dominant; dry; loosely compacted			30-32		0.4	0
31								
32		SAND/GRAVEL coarse sand and gravel; wet; compacted	▼		32-34		1.4	0
33								
34		SAND/GRAVEL sand and gravel; wet; slightly compacted			34-36		0.8	0
35								
36								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrf\winlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

Borehole Number: RZ-30

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
37		SAND/GRAVEL gravel dominant with coarse sand; wet			36-38		1.0	0
38		SAND/GRAVEL coarse sand and gravel with gravel becoming dominant at base; wet			38-40		1.1	0
39								
40		SAND coarse sand; wet			40-42		1.2	0
41		CLAY brown clay; well compacted; wet						
42		SAND/GRAVEL coarse sand and gravel; wet			42-44		2.0	0
43		CLAY gray clay; well compacted; wet						
44		SAND/GRAVEL sand and gravel; wet			44-46		2.0	0
45		CLAY gray clay; wet; well compacted						
46		SAND/GRAVEL sand and gravel; wet; black coloration			46-48		0.75	0
47		SAND/GRAVEL sand and gravel; wet						
48								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrfi\winlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

Borehole Number: RZ-30**Client:** General Motors**Site Location:** Moraine, Ohio**Project:** Interim Measures**Project No:** OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
49		No split spoons taken due to heavy sands, drilled down to till at 63.5' but central drilling core and augers became stuck so hole was abandoned. Started drilling 4th hole (5' west of the original hole) hit something at 32.5' and could not drill through-hole was abandoned. Started 5th hole (2.5' east of 4th hole) hit till at 67.5', set well at 68'.						
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrfilwinlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

Borehole Number: RZ-30**Client:** General Motors**Site Location:** Moraine, Ohio**Project:** Interim Measures**Project No:** OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
61		No split spoons taken due to heavy sands, drilled down to till at 63.5' but central drilling core and augers became stuck so hole was abandoned. Started drilling 4th hole (5' west of the original hole) hit something at 32.5' and could not drill through-hole was abandoned. Started 5th hole (2.5' east of 4th hole) hit till at 67.5', set well at 68'.						
62								
63								
64	----	REGIONAL/CLAY TILL						
65	----							
66	----							
67	----							
68		End of Borehole						
69								
70								
71								
72								

Scientist: J.E.K.
Project Manager: Nancy Gillotti
Drilling Co.: Belasco Drilling
Driller: Greg/Rick
Drilling Method: Hollow Stem Auger
Drilling Fluid: NA

Begin Drilling: 9/7/99
End Drilling: 9/10/99
Hole Size: 10"
Total Depth: 68'
Datum:
File Name: gmotors\gmcrflwinlog\rz-30.log

Surface Elev.: 732.74
North Coord.: 1589.02814
East Coord.: 5527.52146
Converted to Well: Yes
Well Name: RZ-30
Revised: 3/1/00

Borehole Number: RZ-3Y

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
0		Ground Surface						
0		TOP SOIL						
1		top soil; organic matter present			0-2		0.9	0
1		CLAY						
2		brown clay; with sand; dry						
2		SAND/GRAVEL						
3		sand and gravel; dry; very loosely compacted			2-4		1.1	0
3		SAND/GRAVEL						
4		sand and gravel; dry						
4		CLAY						
5		fill material; black; crumbly; clay-like material			4-6		0.5	0
5		fill material; black; faint oily smell						
6		SAND/GRAVEL						
7		sand and gravel; dry; faint oily odor			6-8		0.5	0
7		SAND/GRAVEL						
8		sand and gravel; dry; black discoloration; some cohesion						
8		SAND			8-10		0.6	0
9		fill material; black; dry; contains some sand						
10		SAND/GRAVEL			10-12		1.5	0
11		sand and gravel; dry; no coloration or staining						
11		SAND/GRAVEL						
12		sand and gravel; dry; some staining						
12		CLAY						
13		clay; dark brown-gray; slightly moist			12-14		1.5	0
13		CLAY						
14		light brown clay; slightly moist; contains some gravel						
14		SAND/GRAVEL			14-16		1.25	0
15		sand and gravel; black discoloration; moist						
15		SAND						
16		clean coarse sand; moist						

Scientist: J.E.K.
 Project Manager: Nancy Gillotti
 Drilling Co.: Belasco Drilling
 Driller: Greg/Rick
 Drilling Method: Hollow Stem Auger
 Drilling Fluid: NA

Begin Drilling: 9/10/99
 End Drilling: 9/13/99
 Hole Size: 10"
 Total Depth: 50'
 Datum:
 File Name: gmotors\gmcrfitwinlog\rz-3y.log

Surface Elev.: 732.18
 North Coord.: 1729.22419
 East Coord.: 5733.97932
 Converted to Well: Yes
 Well Name: RZ-3Y
 Revised: 3/1/00

Borehole Number: RZ-3Y

Client: General Motors

Site Location: Moraine, Ohio

Project: Interim Measures

Project No: OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
17		SAND/GRAVEL sand and gravel; moist; relatively clean (some black discoloration at top of spoon)			16-18		2.0	0
18		SAND/GRAVEL sand and gravel; moist; clean						
19								
20								
21		Drilled down to till at 58' but encountered heavy sands coming into the augers. At the till about 8' of material was overlying the center rods which prevented the well from being set. The augers had to be pulled out and the hole re-drilled down to 50' to set the well.						
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								

Scientist: J.E.K.
 Project Manager: Nancy Gillotti
 Drilling Co.: Belasco Drilling
 Driller: Greg/Rick
 Drilling Method: Hollow Stem Auger
 Drilling Fluid: NA

Begin Drilling: 9/10/99
 End Drilling: 9/13/99
 Hole Size: 10"
 Total Depth: 50'
 Datum:
 File Name: gmotors\gmcrcfilwinlog\rz-3y.log

Surface Elev.: 732.18
 North Coor.: 1729.22419
 East Coor.: 5733.97932
 Converted to Well: Yes
 Well Name: RZ-3Y
 Revised: 3/1/00

Borehole Number: RZ-3Y**Client:** General Motors**Site Location:** Moraine, Ohio**Project:** Interim Measures**Project No:** OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								

Scientist: J.E.K.

Project Manager: Nancy Gillotti

Drilling Co.: Belasco Drilling

Driller: Greg/Rick

Drilling Method: Hollow Stem Auger

Drilling Fluid: NA

Begin Drilling: 9/10/99

End Drilling: 9/13/99

Hole Size: 10"

Total Depth: 50'

Datum:

File Name: gmotors\gmcrfilwinlog\rz-3y.log

Surface Elev.: 732.18

North Coord.: 1729.22419

East Coord.: 5733.97932

Converted to Well: Yes

Well Name: RZ-3Y

Revised: 3/1/00

Borehole Number: RZ-3Y**Client:** General Motors**Site Location:** Moraine, Ohio**Project:** Interim Measures**Project No:** OH000294.0002.00007

SUBSURFACE PROFILE				SAMPLE				
Depth (feet)	Symbol	Description	Estimated Water Level	Sample Sent To Lab?	Sample Interval	Blows/ft	Recovery (feet)	HNU (ppm)
49								
50		End of Borehole						
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								

Scientist: J.E.K.

Project Manager: Nancy Gillotti

Drilling Co.: Belasco Drilling

Driller: Greg/Rick

Drilling Method: Hollow Stem Auger

Drilling Fluid: NA

Begin Drilling: 9/10/99

End Drilling: 9/13/99

Hole Size: 10"

Total Depth: 50'

Datum:

File Name: gmotors\gmcrfilwinlog\rz-3y.log

Surface Elev.: 732.18

North Coord.: 1729.22419

East Coord.: 5733.97932

Converted to Well: Yes

Well Name: RZ-3Y

Revised: 3/1/00

RZ-3R

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	-					ASPHALT	
							FILL	FILL Brown, gravelly clay with sand and gravel, fill, dry	
2	N/A	24	-					CONCRETE	
							ML	SILT Brown, clayey silt with sand and gravel, hard, no plasticity, dry	
4	N/A	24	1.1				ML	SILT Brown, clayey silt with sand and gravel, hard, no plasticity, dry	
							SW	SAND Fine to coarse grained sand (60%) and gravel (40%), dry, well graded	
6	N/A	24	1.0						
							SW	SAND Fine to coarse grained sand (60%) and gravel (40%), dry, well graded	
8	N/A	24	2.3						
							SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
10	N/A	24	2.8						
							SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
12									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotasonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	2.3				SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
14	N/A	24	1.8				SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
16	N/A	24	1.0				SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
18	N/A	24	1.8				SW	SAND Fine to coarse grained sand (80%) and cobble-sized gravel (20%), dry, well graded	
20	N/A	24	0.8				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
22	N/A	24	2.2				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotasonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
26	N/A	24	0.8				GW	GRAVEL Wet (saturated), medium to coarse grained sand (25%) and gravel (75), cobbles visible, well graded	
28	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
30	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
32	N/A	24	1.3				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
34	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotasonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
38	N/A	24	1.3				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
40	N/A	24	0.8				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
42	N/A	24	1.1				SW	SAND Wet (saturated), medium to coarse grained sand (75%) and gravel (25%), cobbles visible, well graded	
44	N/A	24	1.1				SP	SAND Fine to medium grained sand (90%) and gravel (10%), cobbles visible, wet (saturated), poorly graded	
46	N/A	24	0.8				SP	SAND Fine to medium grained sand (90%) and gravel (10%), cobbles visible, wet (saturated), poorly graded	
48									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotosonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

Datum: _____

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	1.3			SP	SAND Fine to medium grained sand (90%) and gravel (10%), cobbles visible, wet (saturated), poorly graded	
50	N/A	24	1.1			SW	SAND Medium to coarse grained sand (60%) and gravel (40%), wet (saturated), cobbles visible, well graded	
52	N/A	24	1.1			CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, dry, till	
54	N/A	24	0.8			CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, dry, till	
56	N/A	24	1.1			CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, dry, till	
58	N/A	24	0.8			CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, dry, till	
60								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotosonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 1443

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 1525

Drilling Method: Rotosonic

Surface Elev.: 724.61

Converted to Well: Y Well I.D.: RZ-3RR

Drilling Fluid: Water

North Coord.: 39°41'22.213"

East Coord.: 84°13'21.312"

Remarks:

Project No.: OH000294.0007.00008

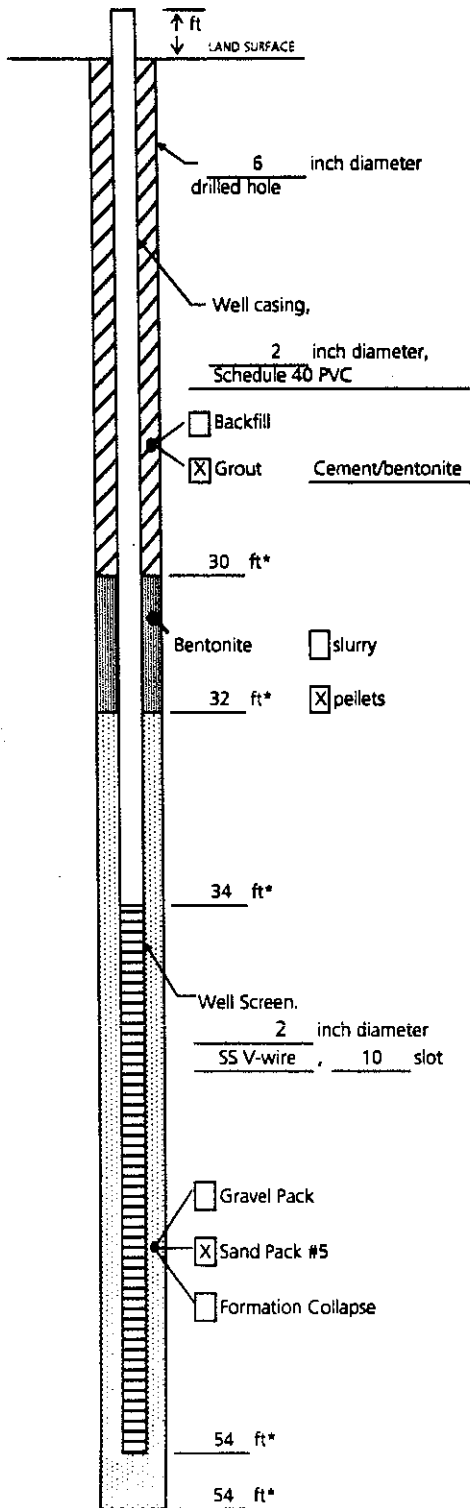
Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0007.00008 Well RZ-3RR

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

724.61 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 5/2/2005

Drilling Method Rotosonic

Drilling Contractor Prosonic

Drilling Fluid Potable water

(approximately 125 gallons)

Development Technique(s) and Date(s)

Submersible pump (proactive mini-typhoon)

Fluid Loss During Drilling N/A gallons

Water Removed During Development 60 gallons

Static Depth to Water NM feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 0.50 hours

Yield 2 gpm Date 5/2/2005

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks _____

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	-				ASPHALT	
						FILL	FILL Gravely sand with silt, dry	
2	N/A	24	1.0			FILL	FILL 8" asphalt, gravely sand with silt, dry Concrete	
4	N/A	24	1.1			ML	SILT Dark gray, clayey silt, dry, no plasticity, hard, 10% sand and gravel	
						ML	SILT Dark gray, clayey silt, dry, no plasticity, hard, 10% sand and gravel	
6	N/A	24	0.8			ML	SILT Dark gray, clayey silt, dry, no plasticity, hard, 10% sand and gravel	
8	N/A	24	1.0			SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
10	N/A	24	1.1			SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
12								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	2.3				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
14	N/A	24	2.0				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
16	N/A	24	1.8				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
18	N/A	24	1.0				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
20	N/A	24	1.0				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
22	N/A	24	1.3				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	0.8				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
26	N/A	24	1.1				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
28	N/A	24	0.8				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
30	N/A	24	1.1				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
32	N/A	24	0.8				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
34	N/A	24	0.8				SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	1.0			SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), cobbles visible	
38	N/A	24	1.3			SW	SAND Medium to coarse-grained sand (80%) and gravel (20%), wet (saturated), very large cobbles visible	
40	N/A	24	0.8			SP	SAND Fine grained sand and silt, 10% gravel, poorly sorted, wet (saturated), cobbles visible	
42	N/A	24	1.3			SP	SAND Fine grained sand and silt, 10% gravel, poorly sorted, wet (saturated), cobbles visible	
44	N/A	24	1.3			SP	SAND Fine grained sand and silt, 10% gravel, poorly sorted, wet (saturated), cobbles visible	
46	N/A	24	0.8			SP	SAND Fine grained sand and silt, 10% gravel, poorly sorted, wet (saturated), cobbles visible	
48								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (ppm)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	1.1				SP	SAND Fine grained sand and silt, 10% gravel, poorly sorted, wet (saturated), cobbles visible	
50	N/A	24	0.8				SW	SAND medium to coarse grained sand and gravel, wet (saturated), well graded	
52	N/A	24	1.3				CL	CLAY Gray, clayey silt, hard, no plasticity, dry, till, 10% gravel	
54	N/A	24	1.1				CL	CLAY Gray, clayey silt, hard, no plasticity, dry, till, 10% gravel	
56	N/A	24	1.1				CL	CLAY Gray, clayey silt, hard, no plasticity, dry, till, 10% gravel	
58	N/A	24	0.8				CL	CLAY Gray, clayey silt, hard, no plasticity, dry, till, 10% gravel	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 5/2/05 @ 10:15

Driller: D. O'Mara

Total Depth: 60

End Drilling: 5/2/05 @ 10:58

Drilling Method: Rotosonic

Surface Elev.: 724.57

Converted to Well: Y Well I.D.: RZ-3SS

Drilling Fluid: Water

North Coord.: 39°41'22.124"

East Coord.: 84°13'21.149"

Remarks: _____

Project No.: OH000294.0007.00008

Datum: _____

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	1.1				SW	SAND Dry, fine to medium grained sand (50%) and gravel (50%), cobbles visible	
14	N/A	24	1.1				SW	SAND Dry, fine to medium grained sand (50%) and gravel (50%), cobbles visible	
16	N/A	24	1.4				SW	SAND Dry, fine to medium grained sand (50%) and gravel (50%), cobbles visible	
18	N/A	24	1.8				SW	SAND Dry, fine to medium grained sand (50%) and gravel (50%), cobbles visible	
20	N/A	24	1.1				GW	GRAVEL Wet (saturated), coarse-grained gravel (60%), cobbles and fine to coarse grained sand (40%), well graded	
22	N/A	24	1.1				GW	GRAVEL Wet (saturated), coarse-grained gravel (60%), cobbles and fine to coarse grained sand (40%), well graded	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/29/05 @ 8:04

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/29/05 @ 9:03

Drilling Method: Rotosonic

Surface Elev.: 724.53

Converted to Well: Y Well I.D.: RZ-3TT

Drilling Fluid: Water

North Coord.: 39°41'22.034"

East Coord.: 84°13'21.022"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	1.0				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
26	N/A	24	1.1				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
28	N/A	24	0.8				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
30	N/A	24	1.1				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
32	N/A	24	0.8				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
34	N/A	24	1.0				GW	GRAVEL Medium grained gravel (80%) and medium to coarse grained sand (20%), wet (saturated)	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/29/05 @ 8:04

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/29/05 @ 9:03

Drilling Method: Rotasonic

Surface Elev.: 724.53

Converted to Well: Y Well I.D.: RZ-3TT

Drilling Fluid: Water

North Coord.: 39°41'22.034"

East Coord.: 84°13'21.022"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.8				GW	GRAVEL Medium grained gravel (80%) and medium to coarse grained sand (20%), wet (saturated)	
							SW	SAND Fine to coarse sand (75%) and gravel (25%), wet (saturated), well graded	
38	N/A	24	0.8				SW	SAND Fine to coarse sand (75%) and gravel (25%), wet (saturated), well graded	
							SW	SAND Fine to coarse sand (75%) and gravel (25%), wet (saturated), well graded	
40	N/A	24	0.8				SW	SAND Fine to coarse sand (75%) and gravel (25%), wet (saturated), well graded	
							SW	SAND Fine to coarse sand (75%) and gravel (25%), wet (saturated), well graded	
42	N/A	24	1.1				SW	SAND Fine to medium grained sand (90%) and gravel (10%), wet (saturated), cobbles visible	
							SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
44	N/A	24	1.1				SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
							SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
46	N/A	24	1.0				SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
							SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
48									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/29/05 @ 8:04

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/29/05 @ 9:03

Drilling Method: Rotosonic

Surface Elev.: 724.53

Converted to Well: Y Well I.D.: RZ-3TT

Drilling Fluid: Water

North Coord.: 39°41'22.034"

East Coord.: 84°13'21.022"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	1.1				SP	SAND Fine grained sand (90%) and gravel (10%), wet (saturated), poorly graded	
50	N/A	24	0.8				SW	SAND Coarse grained sand and gravel with gray clay, no plasticity, well graded, wet (saturated)	
52	N/A	24	1.1				ML	CLAY Gray, clayey silt, hard, no plasticity, dry, 10% gravel, till	
54	N/A	24	0.8				ML	CLAY Gray, clayey silt, hard, no plasticity, dry, 10% gravel, till	
56	N/A	24	1.0				ML	CLAY Gray, clayey silt, hard, no plasticity, dry, 10% gravel, till	
58	N/A	24	1.0				ML	CLAY Gray, clayey silt, hard, no plasticity, dry, 10% gravel, till	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/29/05 @ 8:04

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/29/05 @ 9:03

Drilling Method: Rotasonic

Surface Elev.: 724.53

Converted to Well: Y Well I.D.: RZ-3TT

Drilling Fluid: Water

North Coord.: 39°41'22.034"

East Coord.: 84°13'21.022"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Log of Boring: RZ-3TT

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/29/05 @ 8:04

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/29/05 @ 9:03

Drilling Method: Rotosonic

Surface Elev.: 724.53

Converted to Well: Y Well I.D.: RZ-3TT

Drilling Fluid: Water

North Coord.: 39°41'22.034"

East Coord.: 84°13'21.022"

Remarks:

Project No.: OH000294.0007.00008

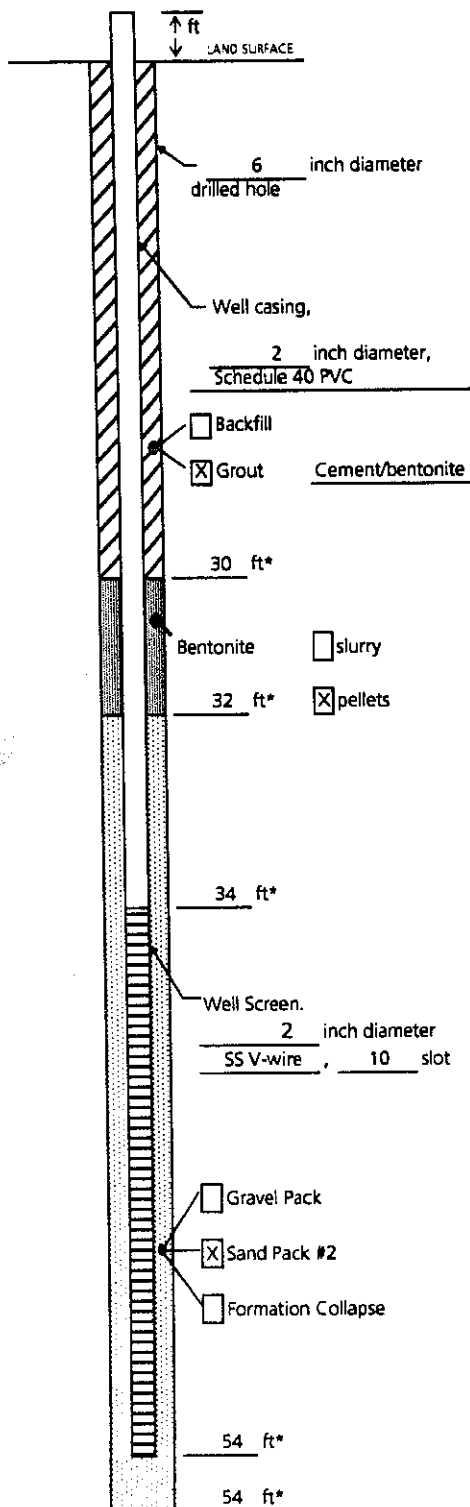
Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0007.00008 Well RZ-3TT

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

724.53 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/29/2005

Drilling Method Rotosonic

Drilling Contractor Prosonic

Drilling Fluid Potable water

(approximately 120 gallons)

Development Technique(s) and Date(s)

Submersible pump (proactive mini-typhoon)

Fluid Loss During Drilling N/A gallons

Water Removed During Development 60 gallons

Static Depth to Water NM feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 0.50 hours

Yield 2 gpm Date 5/2/2005

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks _____

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	9.3					ASPHALT	
							FILL	FILL Brown, clay silt with gravel, concrete, brick present	
2	N/A	24	7.8				ML	SILT Black, clayey silt with gravel, hard, no plasticity, dry	
4	N/A	24	6.5				ML	SILT Black, clayey silt with gravel, hard, no plasticity, dry	
6	N/A	24	38.5				ML	SILT Black, clayey silt with gravel, hard, no plasticity, dry, hydrocarbon odor present	
8	N/A	24	44.5				ML	SILT Black, clayey silt with gravel, hard, no plasticity, dry, hydrocarbon odor present	
10	N/A	24	20.9				ML	SILT Brown, clayey silt, medium hardness, dry, slight plasticity	
12									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotasonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	14.1				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
14	N/A	24	4.2				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
16	N/A	24	1.8				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
18	N/A	24	1.3				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), cobbles visible, dry, well graded	
20	N/A	24	1.0				SW	SAND Fine to coarse sand (50%) and gravel (50%), well graded, cobbles visible	
22	N/A	24	2.1				SW	SAND Fine to coarse sand (50%) and gravel (50%), well graded, cobbles visible	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotosonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

Datum: _____

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	2.4				SW	SAND Fine to coarse sand (50%) and gravel (50%), well graded, cobbles visible	
26	N/A	24	1.7				SW	SAND Fine to coarse sand (75%) and gravel (25%), cobbles visible, wet (saturated), well graded	
28	N/A	24	1.1				SW	SAND Fine to coarse sand (75%) and gravel (25%), cobbles visible, wet (saturated), well graded	
30	N/A	24	1.9				GW	GRAVEL Fine to coarse grained sand (25%) and gravel (75%), cobbles visible, well graded, wet (saturated)	
32	N/A	24	1.7				GW	GRAVEL Fine to coarse grained sand (25%) and gravel (75%), cobbles visible, well graded, wet (saturated)	
34	N/A	24	2.1				GW	GRAVEL Fine to coarse grained sand (25%) and gravel (75%), cobbles visible, well graded, wet (saturated)	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotosonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

Datum: _____

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	1.3			SW	SAND Fine to coarse grained sand (90%) and gravel (10%), cobbles visible, well graded, wet (saturated)	
38	N/A	24	1.1			SW	SAND Fine to coarse grained sand (90%) and gravel (10%), cobbles visible, well graded, wet (saturated)	
40	N/A	24	1.6			SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
42	N/A	24	2.2			SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
44	N/A	24	1.9			SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
46	N/A	24	1.7			SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
48								

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotasonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	1.0				SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
50	N/A	24	1.5				SP	SAND Fine to medium grained sand (90%) and gravel (10%), poorly sorted, wet (saturated)	
52	N/A	24	1.2				SW	SAND Interbedded gray clay (till), sand and gravel, wet (saturated), well graded	
54	N/A	24	1.7				SW	SAND Interbedded gray clay (till), sand and gravel, wet (saturated), well graded	
							CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, till	
56	N/A	24	1.0				CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, till	
58	N/A	24	1.5				CL	CLAY Gray, clayey silt, hard, no plasticity, 10% gravel, till	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotasonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Log of Boring: RZ-3UU

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 1448

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 1531

Drilling Method: Rotosonic

Surface Elev.: 723.97

Converted to Well: Y Well I.D.: RZ-3UU

Drilling Fluid: Water

North Coord.: 39°41'21.899"

East Coord.: 84°13'20.915"

Remarks:

Project No.: OH000294.0007.00008

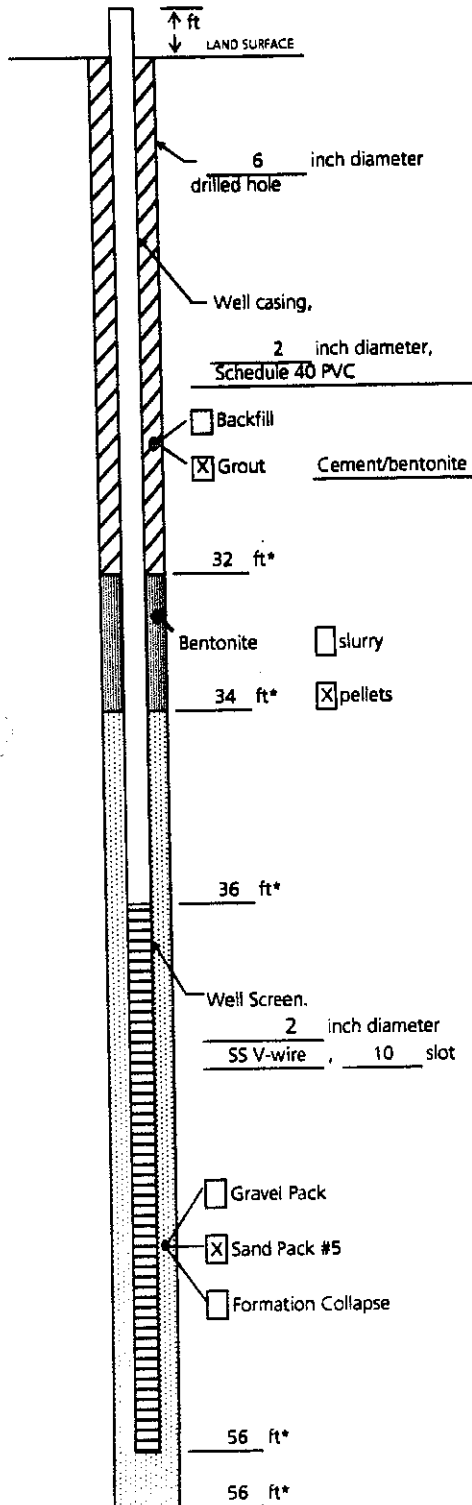
Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0007.00008 Well RZ-3UU

Town/City Moraine

County Montgomery State Ohio

Permit No. _____

Land-Surface (LS) Elevation and Datum:

724.45 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 4/28/2005

Drilling Method Rotosonic

Drilling Contractor Prosonic

Drilling Fluid Potable water

(approximately 120 gallons)

Development Technique(s) and Date(s)

Submersible pump (proactive mini-typhoon)

Fluid Loss During Drilling N/A gallons

Water Removed During Development 60 gallons

Static Depth to Water 17.83 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 0.50 hours

Yield 2 gpm Date 5/2/2005

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks _____

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	0.8					ASPHALT	
							FILL	FILL Damp, pea gravel to coarse gravel with sand	
2	N/A	24	1.4				CL	CLAY Brown, silty clay, medium plasticity, medium hardness, dry to damp	
4	N/A	24	0.4				CL	CLAY Brown, silty clay, medium plasticity, medium hardness, dry to damp	
6	N/A	24	0.1				ML	SILT Gray, clayey silt with fine sand, dry, low plasticity, medium hardness	
8	N/A	24	1.4				ML	SILT Gray, clayey silt with fine sand, dry	
10	N/A	24	0.8				ML	SILT Gray, clayey silt with fine sand, dry	
12									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotasonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Log of Boring: RZ-3VV

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (inches)	OVA (ppm)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	0.7				ML	SILT Brown, clayey silt, medium plasticity, medium hardness, dry	
14	N/A	24	1.0				ML	SILT Brown, clayey silt, medium plasticity, medium hardness, dry	
16	N/A	24	1.0				ML	SILT Brown, clayey silt, medium plasticity, medium hardness, dry	
18	N/A	24	0.8				ML	SILT Brown, clayey silt, medium plasticity, medium hardness, dry	
20	N/A	24	1.0				GW	GRAVEL Wet (saturated), coarse grained sand (40%) and gravel (60%), well graded	
22	N/A	24	1.3				GW	GRAVEL Wet (saturated), coarse grained sand (40%) and gravel (60%), well graded	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotasonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	1.1				GW	GRAVEL Wet (saturated), coarse grained sand (40%) and gravel (60%), well graded	
26	N/A	24	1.0				SW	SAND Wet (saturated), fine to coarse grained sand (75%) and gravel (25%), well graded	
28	N/A	24	1.3				SW	SAND Wet (saturated), fine to coarse grained sand (75%) and gravel (25%), well graded	
30	N/A	24	1.9				SW	SAND Wet (saturated), fine to coarse grained sand (75%) and gravel (25%), well graded	
32	N/A	24	1.7				SW	SAND Wet (saturated), fine to coarse grained sand (75%) and gravel (25%), well graded	
34	N/A	24	1.4				SW	SAND Wet (saturated), medium to coarse grained sand (70%) and fine to coarse grained gravel (25%), cobbles visible, well graded	
36									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotasonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	1.7				SW	SAND Wet (saturated), medium to coarse grained sand (70%) and fine to coarse grained gravel (25%), cobbles visible, well graded	
38	N/A	24	1.7				SW	SAND Wet (saturated), medium to coarse grained sand (70%) and fine to coarse grained gravel (25%), cobbles visible, well graded	
40	N/A	24	2.9				SW	SAND Wet (saturated), fine to medium grained sand (80%) with coarse gravel (20%), cobbles visible, well graded	
42	N/A	24	3.2				SP	SAND Wet (saturated), fine grained sand (90%) and gravel (10%), poorly graded, cobbles visible	
44	N/A	24	4.7				SP	SAND Wet (saturated), fine grained sand (90%) and gravel (10%), poorly graded, cobbles visible	
46	N/A	24	4.2				SP	SAND Wet (saturated), fine grained sand (90%) and gravel (10%), poorly graded, cobbles visible	
48									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotasonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	3.9				SP	SAND Wet (saturated), fine grained sand (90%) and gravel (10%), poorly graded, cobbles visible	
50	N/A	24	3.8				SW	SAND Fine to coarse grained sand (75%) and gravel (25%), wet (saturated), well graded	
52	N/A	24	3.4				GW	GRAVEL Medium to coarse grained sand (25%) and gravel (75%), cobbles visible, well graded, wet (saturated)	
54	N/A	24	3.4				GW	GRAVEL Medium to coarse grained sand (25%) and gravel (75%), cobbles visible, well graded, wet (saturated)	
56	N/A	24	2.6				CL	CLAY Gray, silty clay, hard, no plasticity, 10% gravel, till, dry	
58	N/A	24	2.1				CL	CLAY Gray, silty clay, hard, no plasticity, 10% gravel, till, dry	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotasonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks:

Project No.: OH000294.0007.00008

Datum:

Filename: RZ May 2005 Soil Boring

ARCADIS

Log of Boring: RZ-3VV

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Prosonic

Geologist: D. Manzo

Begin Drilling: 4/28/05 @ 9:37

Driller: D. O'Mara

Total Depth: 60

End Drilling: 4/28/05 @ 11:04

Drilling Method: Rotosonic

Surface Elev.: 724.17

Converted to Well: Y Well I.D.: RZ-3VV

Drilling Fluid: Water

North Coord.: 39°41'21.751"

East Coord.: 84°13'20.929"

Remarks: _____

Project No.: OH000294.0007.00008

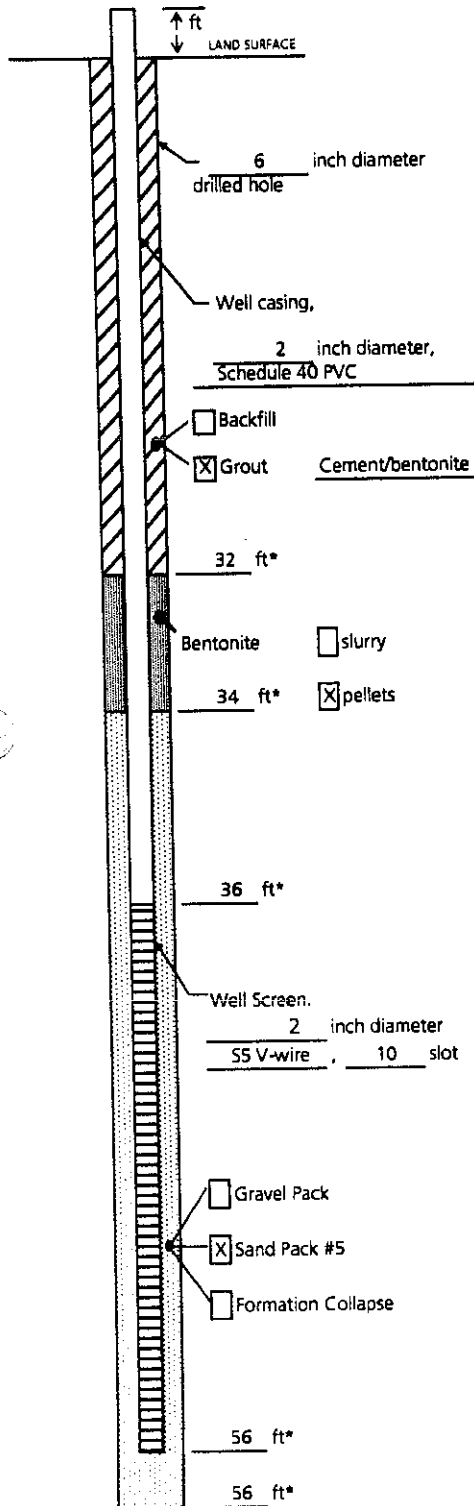
Datum: _____

Filename: RZ May 2005 Soil Boring

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project OH000294.0007.00008 Well RZ-3VV
Town/City Moraine
County Montgomery State Ohio
Permit No. _____

Land-Surface (LS) Elevation and Datum:

724.17 feet ☒ Surveyed
☐ Estimated

Installation Date(s) 4/28/2005

Drilling Method Rotosonic

Drilling Contractor Prosonic

Drilling Fluid Potable water

(approximately 120 gallons)

Development Technique(s) and Date(s)

Submersible pump (proactive mini-typhoon)

Fluid Loss During Drilling N/A gallons

Water Removed During Development 60 gallons

Static Depth to Water 17.83 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 0.50 hours

Yield 2 gpm Date 5/2/2005

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks _____

Prepared by J. Manzo

RZ-4

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	0						No recovery	
2	N/A	24	1.9				CL	SILTY CLAY Black-dark gray, fine-medium gravel (30%), soft, medium plasticity, moist	
4	N/A	24	0.9				CL	Same as above	
6	N/A	24	2.2				SP	SAND Brown, medium-coarse, fine-medium gravel (30%), moist	
8	N/A	24	0.8				SP	Same as above	
10	N/A	24	0.0				SP	Same as above, fine-coarse gravel (30%)	
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotosonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	4.1				SP	Same as above	
14	N/A	24	4.0				SP	Same as above	
16	N/A	24	1.2				SP	Same as above	
18	N/A	24	4.1				SP	Same as above	
20	N/A	24	4.3				GP	GRAVEL Cobbles with trace fine-medium sand, dry (mostly dolomite)	
22	N/A	24	5.5				SP	SILTY SAND Brown, fine-medium, fine gravel (40%), poorly graded, wet	
24									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotosonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

Remarks: _____

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	0.0				SP	Same as above	
26	N/A	24	0.0				GP	GRAVEL Fine, medium-coarse sand (30%), wet	
28	N/A	24	0.0				SP	SAND Brown, medium-coarse, fine to medium gravel (20%), cobbles (5%), poorly graded, wet	
30	N/A	24	0.0				SP	Same as above	
32	N/A	24	0.0				SP	Same as above	
34	N/A	24	0.0				SP	Same as above	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotasonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.0				SP	Same as above, fine-medium gravel (30%), no cobbles	
38	N/A	24	0.0				SP	Same as above	
40	N/A	24	0.0				SP	SAND Brown, fine, with some silt, poorly graded, wet	
42	N/A	24	0.9				SP	Same as above	
44	N/A	24	0.0				SP	Same as above	
46	N/A	24	1.9				SP	SAND Brown, medium-coarse, fine-medium gravel (10%), wet	
48									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotosonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	0.1				SP	Same as above	
50	N/A	24	1.7				SP	Same as above, no gravel	
52	N/A	24	1.0				SP	Same as above	
54	N/A	24	2.2				CL	SILTY CLAY Brown, stiff, fine gravel (20%), low plasticity, moist	
56	N/A	24	4.7				SM	SILTY SAND Gray, fine-medium, poorly graded, moist	
58	N/A	24	4.8				SM	Same as above	
60							CL	SILTY CLAY	

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotasonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								Gray, stiff, brittle low plasticity, fine gravel (10-20%), dry End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1020

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/14/06 @ 1200

Drilling Method: Rotasonic

Surface Elev.: 726.146

Converted to Well: Y Well I.D.: RZ-4A

Drilling Fluid: Water

North Coord.: 1937.34929

East Coord.: 5167.33957

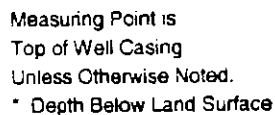
Remarks: _____

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 725.709

Filename: July 2006

(Unconsolidated)

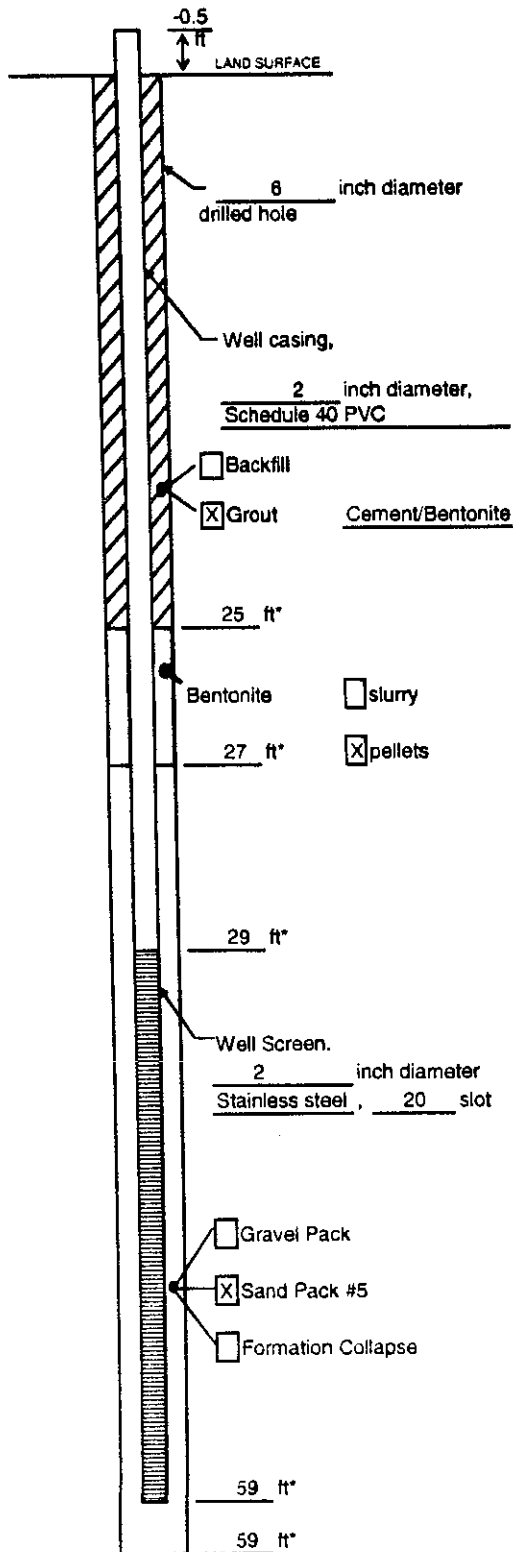


Prepared by C. Cattell

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4B

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

726.160 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/15/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/28/06

Fluid Loss During Drilling ~150 gallons

Water Removed During Development 240 gallons

Static Depth to Water 19.2 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration NM hours

Yield NM gpm Date 7/28/06

Specific Capacity NM gpm/ft

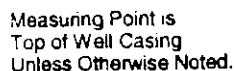
Well Purpose Introduction well

Remarks TOC Elevation = 725.767

Clear non-turbid

Prepared by C. Catlett

(Unconsolidated)



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General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0		0						No recovery	
2	N/A	24	6.1				FILL	FILL Black, silt, gravel, sand, ashbits of wood, glass and metal, dry	
4	N/A	24	0.2				CL	SANDY CLAY Brown, fine, fine-medium gravel (10%), medium plasticity, soft, moist	
6	N/A	24	2.4				CL	Same as above	
8	N/A	24	0.6				SW	SAND/GRAVEL Brown, fine-medium sand, fine-medium gravel, well graded, dry	
10	N/A	24	5.4				CL	SANDY CLAY Brown, fine sand, fine-medium gravel (10%), soft, medium plasticity, moist	
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotosonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.075

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	7.2				SP	SAND Brown, fine-medium, coarse gravel (5%), poorly graded, dry	
14	N/A	24	8.1				SP	Same as above	
16	N/A	24	0.0				SW	Same as above, fine-medium gravel (10%)	
18	N/A	24	0.0				SW	Same as above	
20	N/A	24	0.0				SW	Same as above	
22	N/A	24	0.0				SW	Same as above, wet	
24									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotosonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.075

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	0.0				SW	Same as above, medium-coarse sand, medium gravel (5%)	
26	N/A	24	0.0				SW	Same as above	
28	N/A	24	0.0				SW	Same as above	
30	N/A	24	0.0				GW	GRAVEL Brown, fine-coarse, coarse sand (20%), well graded, wet	
32	N/A	24	0.0				GW	Same as above	
34	N/A	24	0.0				SW	SAND Brown, medium-coarse, fine gravel (30%), well graded, wet	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotosonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.075

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.0				SW	Same as above	
38	N/A	24	0.0				SM	SILTY SAND Brown, fine, poorly graded, wet	
40	N/A	24	0.0				SW	SAND Brown, medium-coarse, trace medium gravel, well graded, wet	
42	N/A	24	0.0				SW	Same as above	
44	N/A	24	0.0				SW	Same as above	
46	N/A	24	0.0				SW	Same as above	
48									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotasonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.075

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	0.0				SW	Same as above	
50	N/A	24	0.0				SW	Same as above	
52	N/A	24	0.0				SW	Same as above	
54	N/A	24	0.0				SW	Same as above	
56	N/A	24	0.0				SW	Same as above	
58	N/A	24	0.0				CL	CLAY Gray, stiff, fine gravel (10%), low plasticity, dry	
60	N/A	24	0.0				CL	Same as above	

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotasonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.075

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60	N/A	24	0.0				CL	SANDY CLAY Gray, fine sand, fine gravel (10%), high plasticity, moist	
62	N/A	24	0.0				CL	Same as above	
64	N/A	12	0.0				CL	Same as above	
66								End of boring	
68									
70									
72									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: T. Fortner

Begin Drilling: 7/14/06 @ 1407

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/14/06 @ 1616

Drilling Method: Rotasonic

Surface Elev.: 727.549

Converted to Well: Y Well I.D.: RZ-4D

Drilling Fluid: Water

North Coord.: 1893.66411

East Coord.: 5246.27240

Remarks:

Project No.: OH000294.0009.0004B

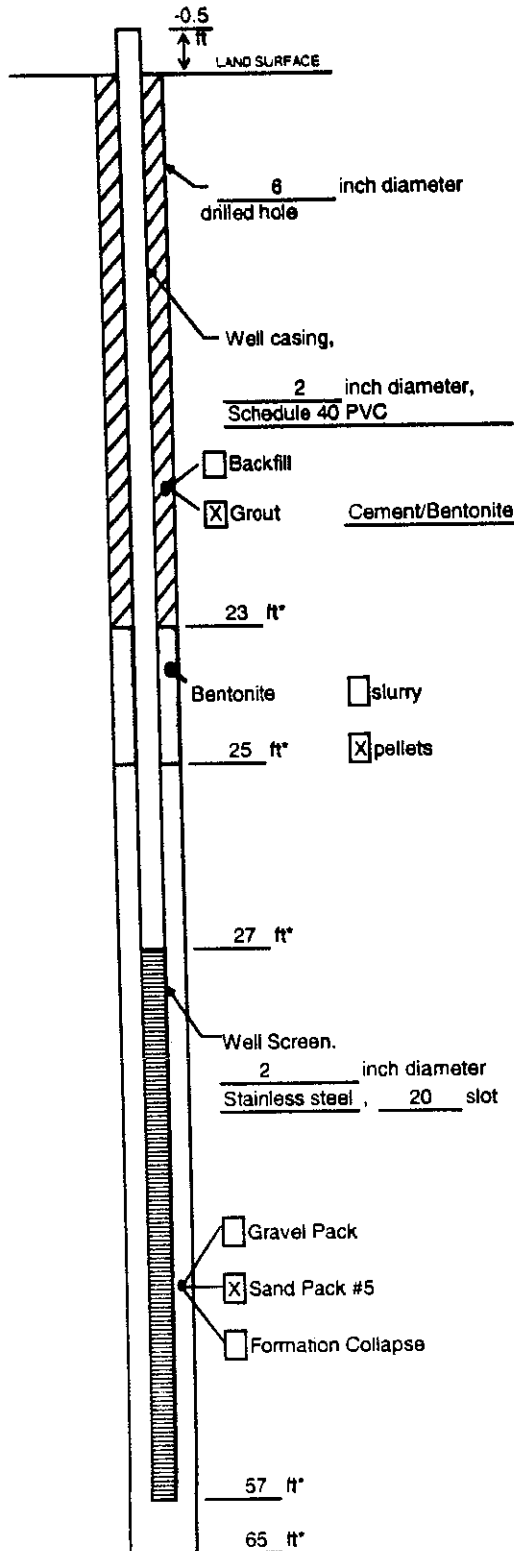
Datum: TOC Elev. 727.075

Filename: July 2006

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4D

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

727.549 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/14/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/28/06

Fluid Loss During Drilling ~150 gallons

Water Removed During Development 240 gallons

Static Depth to Water 20.5 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration NM hours

Yield NM gpm Date 7/28/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.075

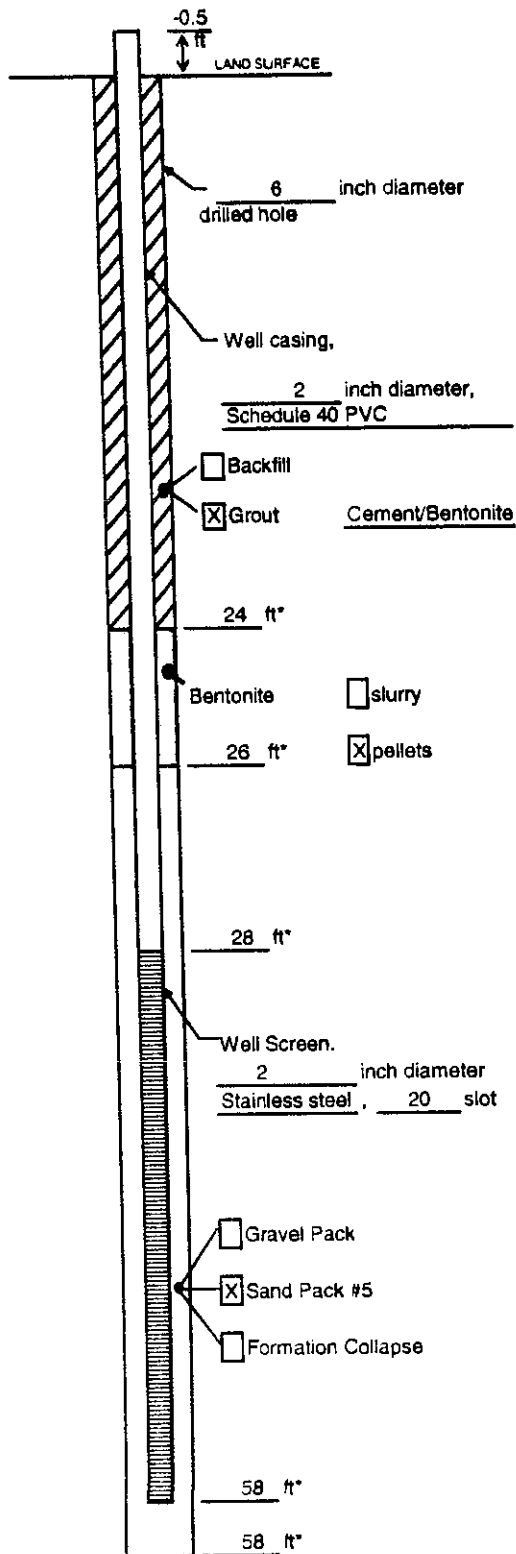
Clear non-turbid

Prepared by C. Catlett

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4E

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

727.910 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/16/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/28/06

Fluid Loss During Drilling -150 gallons

Water Removed During Development 210 gallons

Static Depth to Water 20.83 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration NM hours

Yield NM gpm Date 7/28/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.399

Clear non-turbid

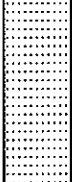
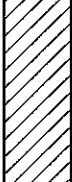
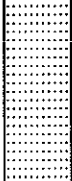
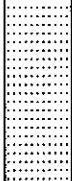
Prepared by C. Catlett

(Unconsolidated)

Prepared by C. Catlett

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								No recovery	
2	N/A	24	4.5				FILL	FILL Black, silt, sand, gravel, glass, wood, and metal, moist	
4	N/A	24	6.1				SW	SAND Black, sand and gravel, loose, wet, odor	
6	N/A	24	1.3				CL	SANDY CLAY Grayish-brown, gravel (15%), medium stiff, moist	
8	N/A	24	2.1				SW	SAND Yellowish brown, gravel (20%), loose, moist	
10	N/A	24	1.6				SW	SAND Brown, medium-coarse, fine-medium gravel (10%), loose, moist	
12									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotosonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	1.2				SW	Same as above	
14	N/A	24	0.7				SW	Same as above, gravel (15%), moist	
16	N/A	24	0.6				SW	Same as above	
18	N/A	24	0.7				SW	Same as above	
20	N/A	24	0.6				SW	Same as above, gravel (10%)	
22	N/A	24	0.7				SW	Same as above, wet at 24'	
24									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotosonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	0.0				SW	Same as above	
							SW	Same as above	
26	N/A	24	0.0				SW	Same as above	
28	N/A	24	0.0				SW	Same as above	
30	N/A	24	0.0				SW	SAND Brown, medium-coarse, gravel (10%), loose, wet	
32	N/A	24	0.0				SW	Same as above	
34	N/A	24	0.0				SW	Same as above	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotosonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks: _____

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.0				SW	Same as above	
38	N/A	24	0.0				SW	Same as above, sand coarse, coarse gravel (50%)	
40	N/A	24	0.0				SW	Same as above	
42	N/A	24	0.0				SW	Same as above, medium-coarse sand, gravel (10%)	
44	N/A	24	0.0				SW	SAND Brown, fine-medium sand, trace gravel, loose, wet	
46	N/A	24	0.0				SW	Same as above	
48									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotasonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	0.0				SW	Same as above	
50	N/A	24	0.0				SW	Same as above	
52	N/A	24	0.0				SW	Same as above	
54	N/A	24	0.0				SM	SILTY SAND Yellowish brown, trace gravel, stiff, very moist	
							CL	SILTY CLAY Gray, little sand, trace gravel, very stiff, low plasticity	
56	N/A	24	0.0				CL	Same as above	
58	N/A	24	0.0				CL	CLAY Gray, silty clay, trace fine gravel, very stiff (till)	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotasonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/15/06 @ 0732

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/16/06 @ 0840

Drilling Method: Rotosonic

Surface Elev.: 728.547

Converted to Well: Y Well I.D.: RZ-4G

Drilling Fluid: Water

North Coord.: 1850.65783

East Coord.: 5324.55440

Remarks:

Project No.: OH000294.0008.00002

Datum: TOC Elev. 728.159

Filename: July 2006

(Unconsolidated)



Prepared by C. Catlett

(Unconsolidated)

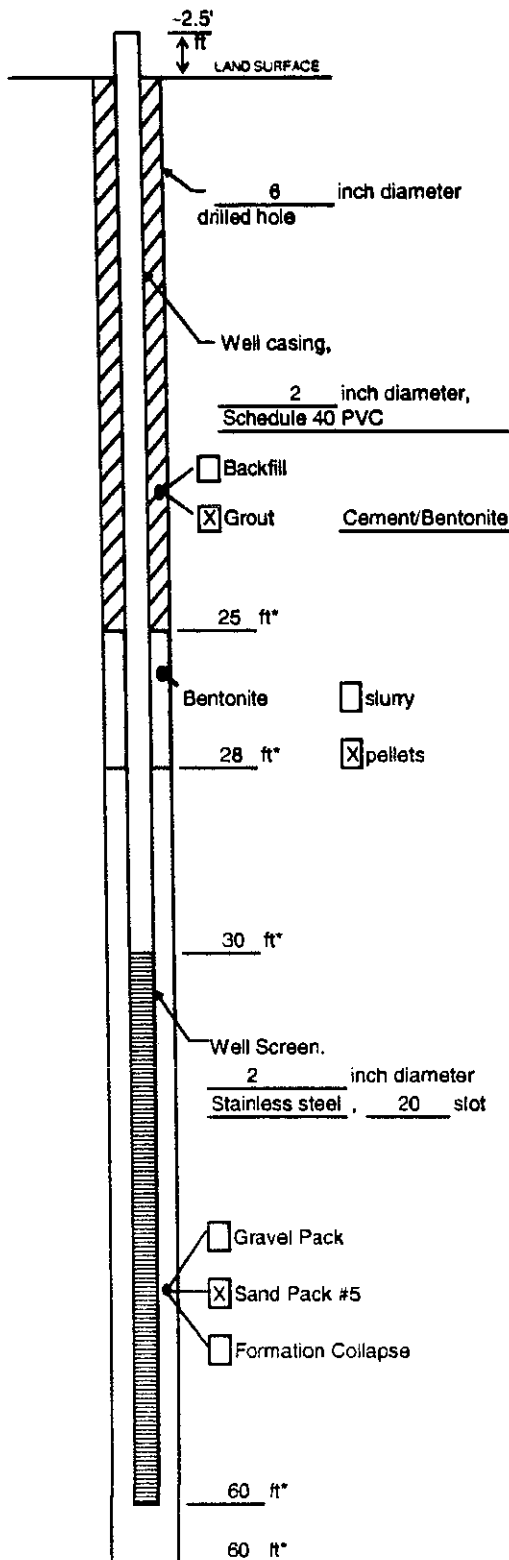


Prepared by C. Cattlett

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-41

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

724.428 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/17/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/28/06

Fluid Loss During Drilling ~250 gallons

Water Removed During Development 240 gallons

Static Depth to Water 22.3 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.00 hours

Yield 4 gpm Date 7/28/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 728.553

Clear non-turbid

Prepared by J. Manzo

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								No recovery	
2								No recovery	
4	N/A	24	0.0				SW	SAND Brown, fine-medium, medium-coarse gravel (15%), loose, dry	
6	N/A	24	0.7				SW	SAND Light grayish brown, fine-medium, medium-coarse gravel (15%), loose, dry	
8	N/A	24	0.3				SW	Same as above	
10	N/A	24	2.7				SW	Same as above	
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	2.4				SW	Same as above	
14	N/A	24	5.3				SW	Same as above	
16	N/A	24	5.1				SW	Same as above	
18	N/A	24	5.2				SW	Same as above	
20	N/A	24	2.7				SW	Same as above	
22	N/A	24	1.6				SW	Same as above	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	4.7				SW	Same as above	
26	N/A	24	3.9				SW	SAND Brown, coarse sand with fine-medium gravel (20%), loose, wet	
28	N/A	24	3.3				SW	Same as above	
30	N/A	24	8.7				SW	Same as above	
32	N/A	24	9.4				SW	Same as above	
34	N/A	24	6.6				SP	SAND Brown, medium sand, loose, wet	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.0				SP	Same as above	
38	N/A	24	5.6				SW	SAND Brown, sand and gravel (20%), loose, wet	
40	N/A	24	9.6				SP	SAND Brown, medium sand, loose, wet	
42	N/A	24	0.0				SP	Same as above	
44	N/A	24	6.2				SP	Same as above	
46	N/A	24	0.0				SW	Same as above, gravel (10%)	
48									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	5.8				SW	SAND Brown, medium-coarse sand, loose, wet	
50	N/A	24	0.0				SW	SAND Brown, sand with gravel (5-10%), loose, wet	
52	N/A	24	5.8				SW	Same as above	
54	N/A	24	0.0				SW	Same as above	
							ROCK	Boulder	
56							ROCK	Same as above	
58							ROCK	Same as above	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60							ROCK	Same as above	
	N/A	12	0.0				CL	SILTY CLAY Gray, little sand, trace gravel, dense	
62	N/A	24	4.1				CL	Same as above	
64	N/A	12	4.0				CL	Same as above	
								End of boring	
66									
68									
70									
72									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

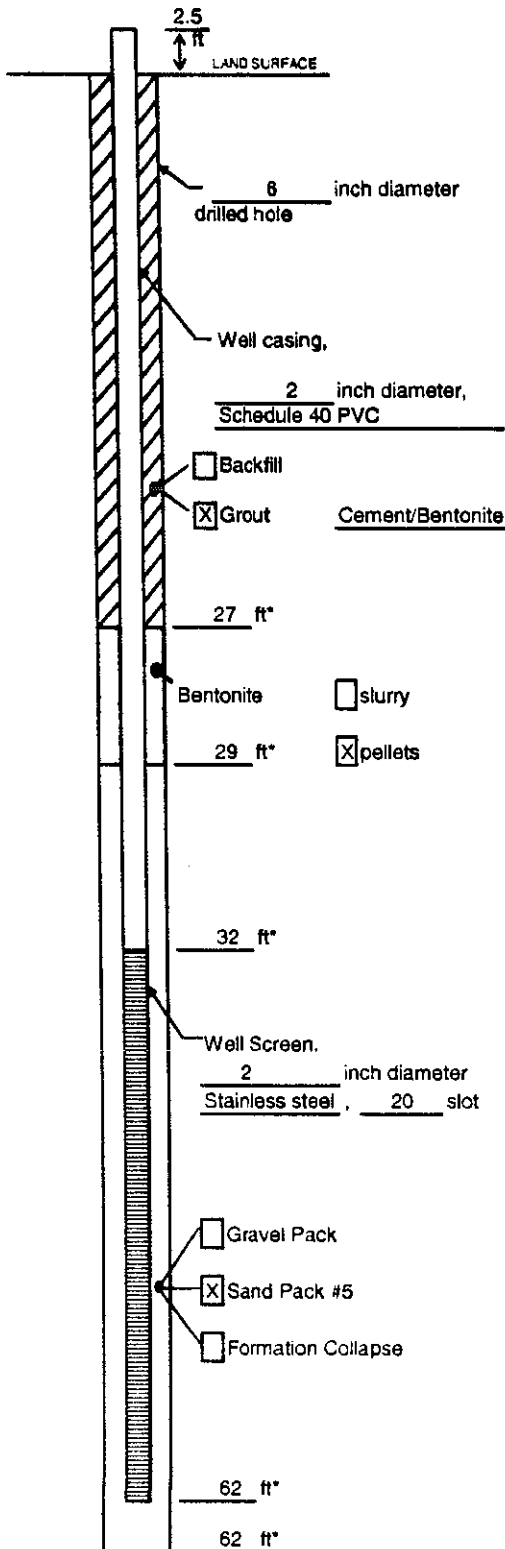
Datum: TOC Elev. 727.965

Filename: July 2006

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4J

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

724.262 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/16-7/17/06

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling ~200 gallons

Water Removed During Development 240 gallons

Static Depth to Water 21.66 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.00 hours

Yield 4 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.965

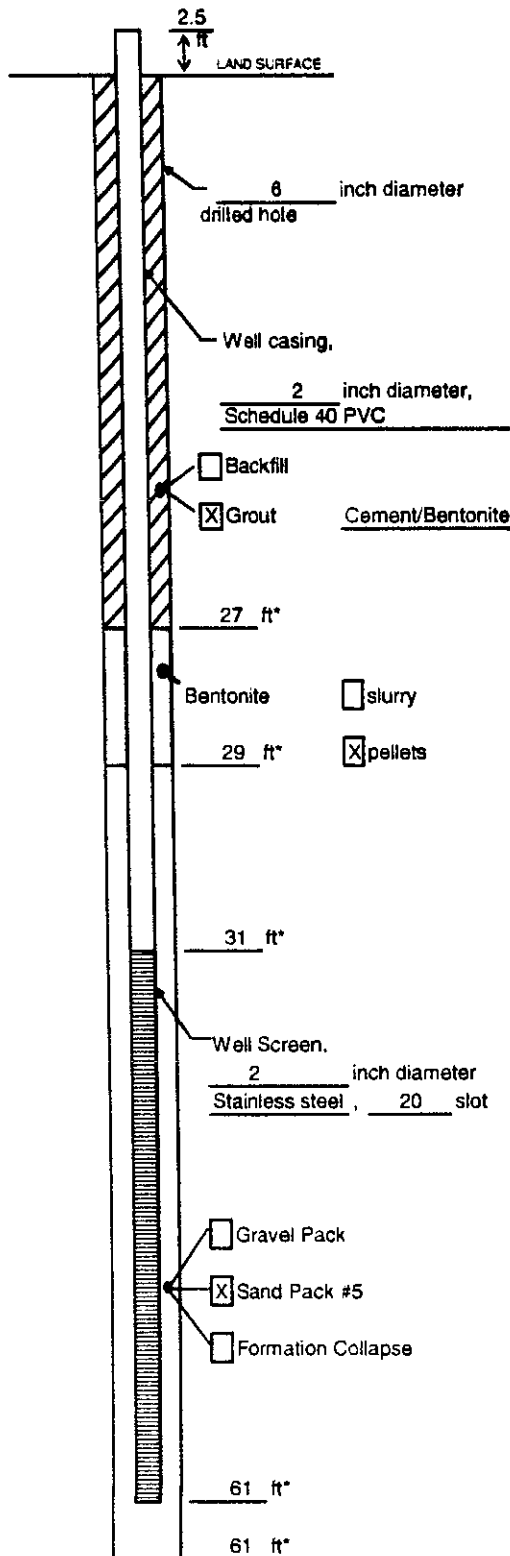
Clear non-turbid

Prepared by J. Manzo

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4K

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

724.677 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/26/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling -200 gallons

Water Removed During Development 240 gallons

Static Depth to Water 21.22 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.20 hours

Yield 3 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.530

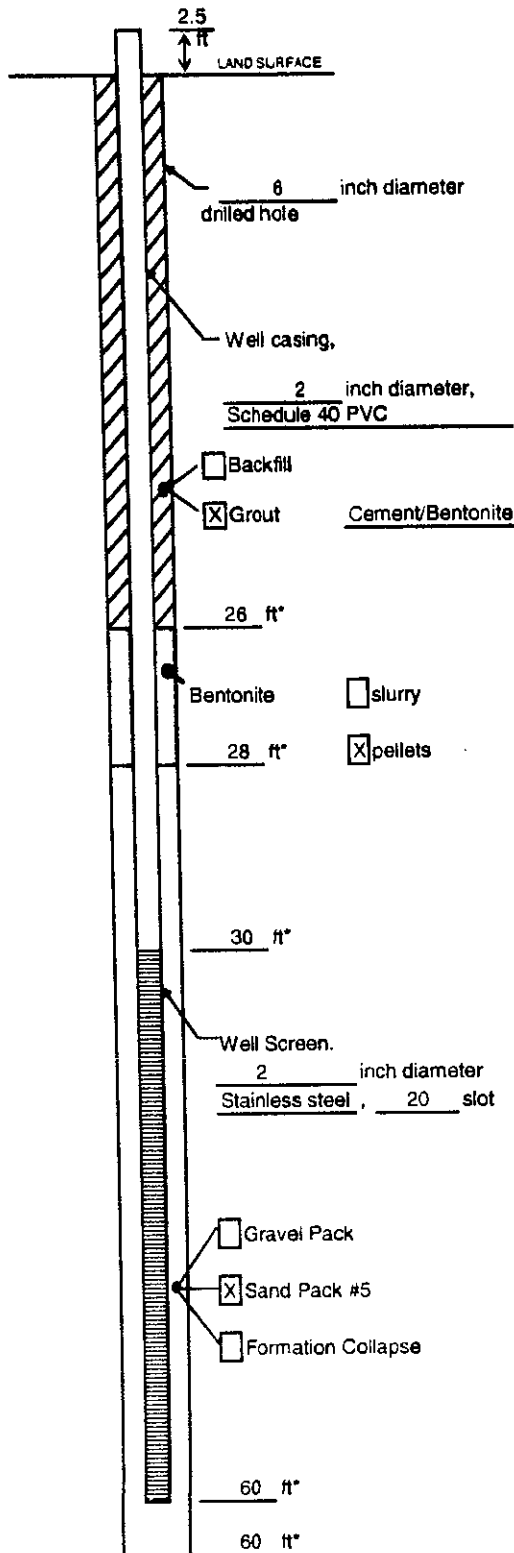
Clear non-turbid

Prepared by T. Fortner

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4L

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

725.289 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/19/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling ~200 gallons

Water Removed During Development 240 gallons

Static Depth to Water 21.22 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.00 hours

Yield 4 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.539

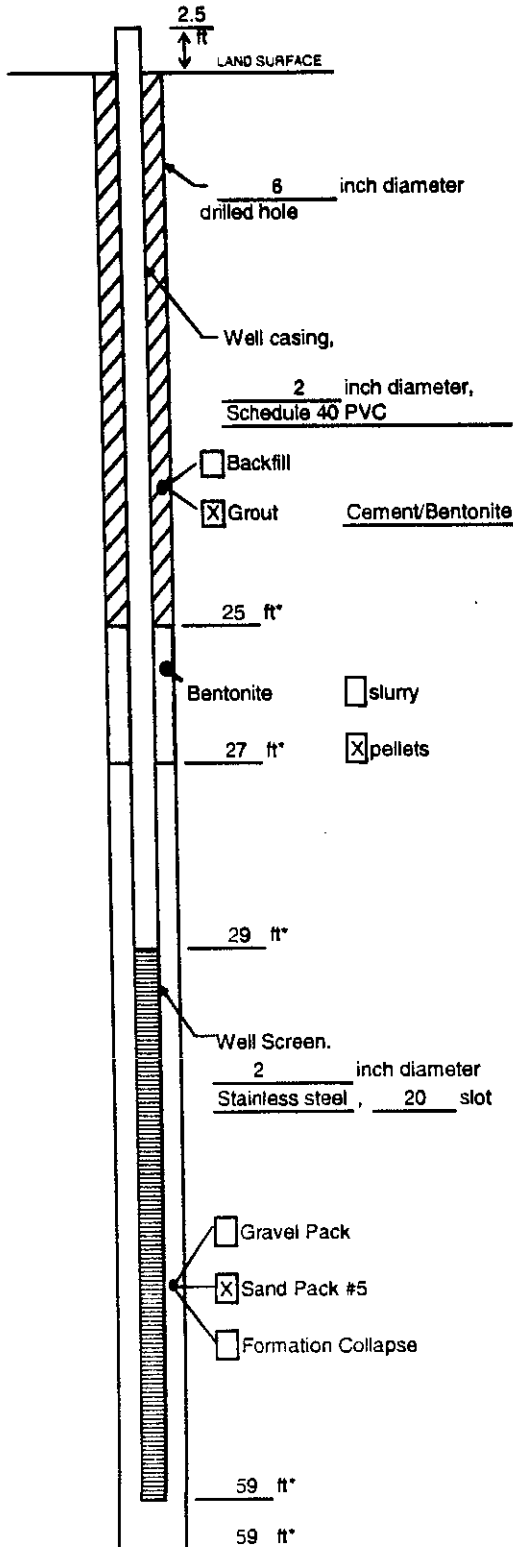
Clear non-turbid

Prepared by T. Fortner

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4M

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

725.466 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/19/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling -200 gallons

Water Removed During Development 240 gallons

Static Depth to Water 20.57 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.20 hours

Yield 3 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 726.898

Clear non-turbid

Prepared by T. Fortner

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	0.0				ML	CLAYEY SILT Brown, organic rich, gravel (25%), hard, dry	
2	N/A	24	0.0				ML	Same as above	
4	N/A	24	0.0				SM	SILTY SAND Fine-coarse, fine-coarse gravel and cobbles (25%), well graded, dry	
6	N/A	24	0.0				SM	Same as above	
8	N/A	24	0.0				SM	Same as above	
10	N/A	24	0.0				SW	SAND Fine-coarse, fine-coarse gravel (25%), trace cobbles, trace silt, well graded, dry	
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotasonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 726.189

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	0.0				SW	Same as above	
14	N/A	24	0.0				SW	Same as above	
16	N/A	12	0.0				SW	Same as above	
18	N/A	12	0.0				SW	Same as above	
20	N/A	12	0.0				SW	Same as above	
22	N/A	12	0.0				SW	Same as above, sand (60%), gravel (40%), dry to slightly moist	
24									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotosonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks: _____

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 726.189

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	12	0.0				SW	Same as above, wet at 25'	
26	N/A	12	0.0				SW	Same as above	
28	N/A	12	0.0				GW	GRAVEL Fine, coarse sand (40%), trace cobbles, well graded, wet	
30	N/A	12	0.0				GW	Same as above	
32	N/A	12	0.0				GW	Same as above	
34	N/A	8	0.0				GW	Same as above	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotosonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks: _____

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 726.189

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	8	0.0				SW	Same as above, trace large cobbles	
38	N/A	8	0.0				SW	Same as above	
40	N/A	8	0.0				SW	Same as above	
42	N/A	8	0.0				SW	Same as above	
44	N/A	8	0.0				SW	Same as above	
46	N/A	8	0.0				SW	Same as above	
48									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotosonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 726.189

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	8	0.0				SW	Same as above	
50	N/A	8	0.0				SW	Same as above	
52	N/A	8	0.0				SW	Same as above	
54	N/A	24	0.0				SW	Same as above	
56	N/A	24	0.0				SW	Same as above	
58	N/A	24	0.0				CL	SILTY CLAY Gray, hard, trace cobbles, gravel (10%), low plasticity, dry	
60									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotasonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 726.189

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60								End of boring	
62									
64									
66									
68									
70									
72									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: J. Manzo

Begin Drilling: 7/17/06 @ 0953

Driller: M. Osterberg

Total Depth: 60

End Drilling: 7/17/06 @ 1109

Drilling Method: Rotosonic

Surface Elev.: 725.710

Converted to Well: Y Well I.D.: RZ-4N

Drilling Fluid: Water

North Coord.: 1703.08968

East Coord.: 4987.64606

Remarks: _____

Project No.: OH000294.0009.0004B

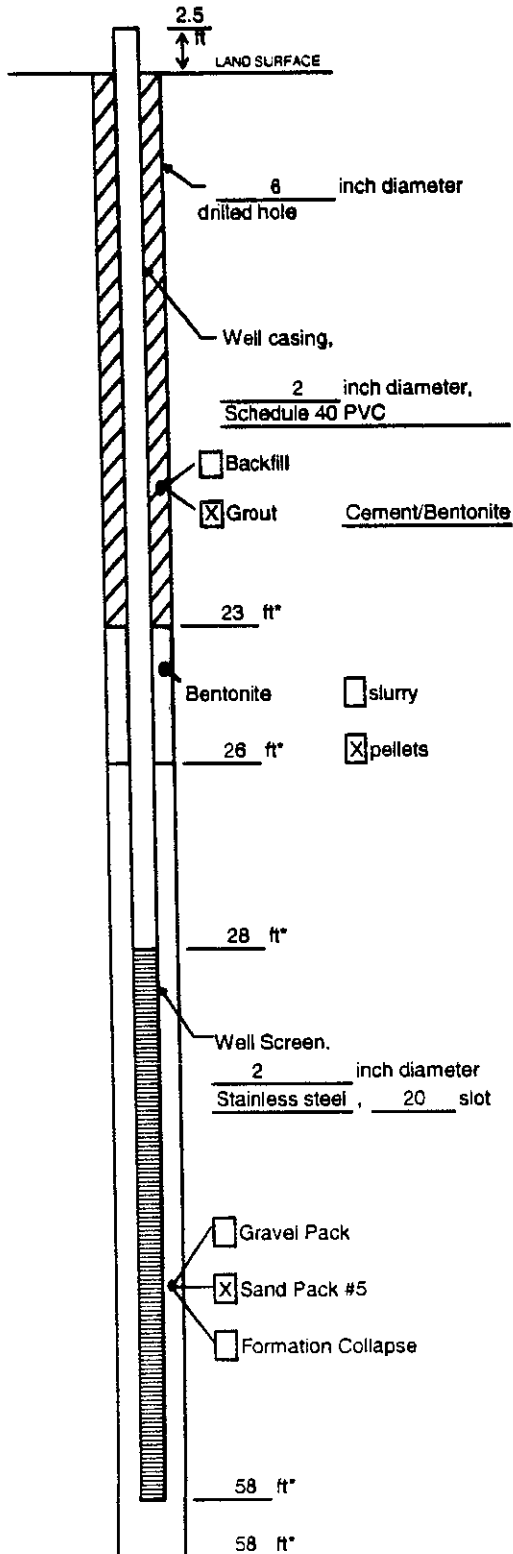
Datum: TOC Elev. 726.189

Filename: July 2006

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4N

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

725.710 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/17/2006

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling ~250 gallons

Water Removed During Development 250 gallons

Static Depth to Water 19.85 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.10 hours

Yield 4 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 726.189

Clear non-turbid

Prepared by J. Manzo

(Unconsolidated)



G. PUBLIC MOTORS: Web Logs Q4rd 2008, Web Construction Logs, ALS

Prepared by T. Fortner

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								No recovery	
2								No recovery	
4	N/A	24	0.0				SW	SAND Brown, fine-medium, medium-coarse gravel (15%), loose, dry	
6	N/A	24	0.7				SW	SAND Light grayish brown, fine-medium, medium-coarse gravel (15%), loose, dry	
8	N/A	24	0.3				SW	Same as above	
10	N/A	24	2.7				SW	Same as above	
12									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 1 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
12	N/A	24	2.4				SW	Same as above	
14	N/A	24	5.3				SW	Same as above	
16	N/A	24	5.1				SW	Same as above	
18	N/A	24	5.2				SW	Same as above	
20	N/A	24	2.7				SW	Same as above	
22	N/A	24	1.6				SW	Same as above	
24									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 2 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
24	N/A	24	4.7				SW	Same as above	
26	N/A	24	3.9				SW	SAND Brown, coarse sand with fine-medium gravel (20%), loose, wet	
28	N/A	24	3.3				SW	Same as above	
30	N/A	24	8.7				SW	Same as above	
32	N/A	24	9.4				SW	Same as above	
34	N/A	24	6.6				SP	SAND Brown, medium sand, loose, wet	
36									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 3 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
36	N/A	24	0.0				SP	Same as above	
38	N/A	24	5.6				SW	SAND Brown, sand and gravel (20%), loose, wet	
40	N/A	24	9.6				SP	SAND Brown, medium sand, loose, wet	
42	N/A	24	0.0				SP	Same as above	
44	N/A	24	6.2				SP	Same as above	
46	N/A	24	0.0				SW	Same as above, gravel (10%)	
48									

☒ Composite Sample to Lab

☐ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 4 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
48	N/A	24	5.8				SW	SAND Brown, medium-coarse sand, loose, wet	
50	N/A	24	0.0				SW	SAND Brown, sand with gravel (5-10%), loose, wet	
52	N/A	24	5.8				SW	Same as above	
54	N/A	24	0.0				SW	Same as above	
							ROCK	Boulder	
56							ROCK	Same as above	
58							ROCK	Same as above	
60									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 5 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotasonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

Datum: TOC Elev. 727.965

Filename: July 2006

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
60							ROCK	Same as above	
	N/A	12	0.0				CL	SILTY CLAY Gray, little sand, trace gravel, dense	
62	N/A	24	4.1				CL	Same as above	
64	N/A	12	4.0				CL	Same as above	
								End of boring	
66									
68									
70									
72									

☒ Composite Sample to Lab

☒ Grab Sample to Lab

☐ Split-Spoon Not Analyzed

Page 6 of 6

Drilling Co.: Boart Longyear

Geologist: C. Catlett

Begin Drilling: 7/16/06 @ 1635

Driller: M. Osterberg

Total Depth: 65

End Drilling: 7/16/06 @ 1810

Drilling Method: Rotosonic

Surface Elev.: 724.428

Converted to Well: Y Well I.D.: RZ-4J

Drilling Fluid: Water

North Coord.: 1690.15438

East Coord.: 4887.95475

Remarks:

Project No.: OH000294.0009.0004B

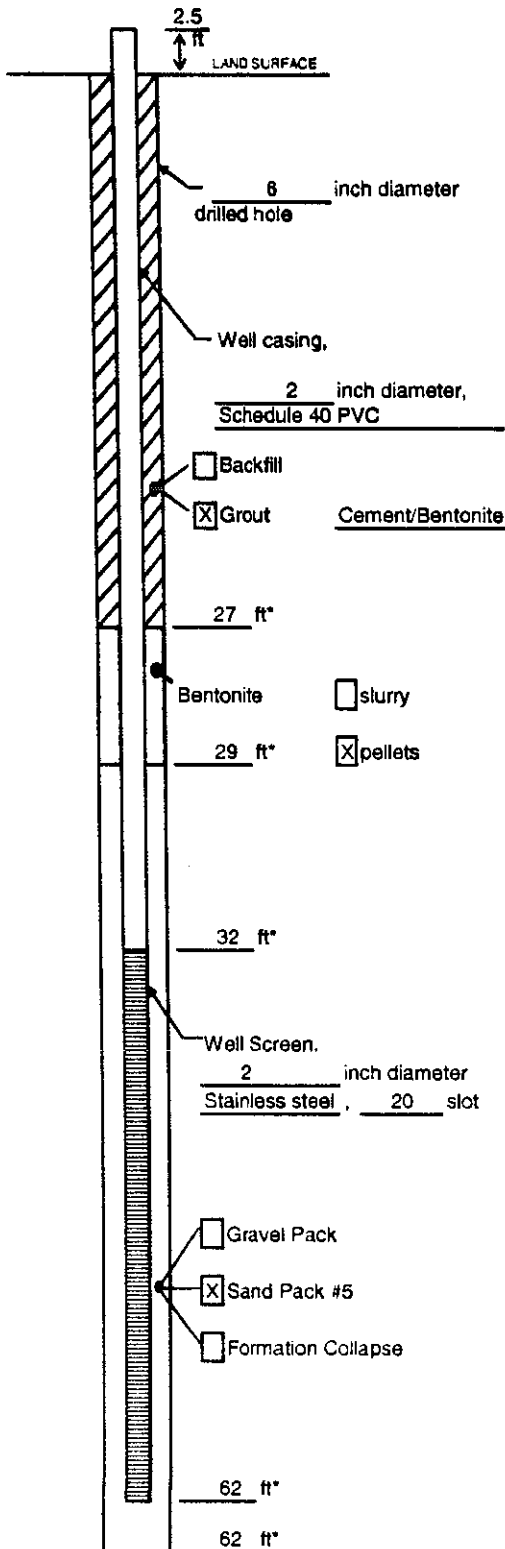
Datum: TOC Elev. 727.965

Filename: July 2006

ARCADIS

Well Construction Log

(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project General Motors Corporation Well RZ-4J

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

724.262 feet ☒ Surveyed

☐ Estimated

Installation Date(s) 7/16-7/17/06

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pumping - surge with pump 7/29/06

Fluid Loss During Drilling ~200 gallons

Water Removed During Development 240 gallons

Static Depth to Water 21.66 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1.00 hours

Yield 4 gpm Date 7/29/06

Specific Capacity NM gpm/ft

Well Purpose Introduction well

Remarks TOC Elevation = 727.965

Clear non-turbid

Prepared by J. Manzo

PROJECT NO. **OH0610DY05**

BORE HOLE NO. **Test Well #2**

PROJECT **Harrison Radiator**

LOCATION **Davton, Ohio**

DRILLING CONTRACTOR **Reynolds Supply, Inc.**

DRILLING EQUIPMENT **Cable Tool**

HYDROGEOLOGIST **J.B. Naser/G.H. Colvin**

DRILLER **Rick Wilmot**

DATE START/TIME **5-5-89**

DATE FINISH/TIME

SURFACE ELEVATION

TOTAL DEPTH **48 feet**

WELL CASING **10 inch**

SCREEN TYPE **Stainless Steel**

LENGTH **10 foot**

SLOT **.070 and .090**

REMARKS

DEPTH (FT.)	SAMPLE (NO.)	BORE HOLE LOG		CVA/PID (PPM)	GRAPHIC
		LITHOLOGIC DESCRIPTION	REMARKS		
5		Fill: SILT (50Z); Clay (20Z); med. gravel (10Z); sand (20Z); med. brown		0.0	
10		Fill: CLAY (40Z); sand (40Z); gravel (20Z); dk. gray		0.0	
15		GRAVEL (40Z); cs. sand (30Z); med. sand (15Z); tr. fine sand; tr. silt, gray			
20		GRAVEL (35Z); v. cs. sand (30Z); cobbles (20Z); cs. sand (10Z); tr. med. sand; tr. fine sand, gray			
25		GRAVEL (40Z); cobbles (30Z); v. cs. sand (20Z); tr. cs. sand (20Z); tr. cs. sand; tr. med. sand, gray, cobbles and gravel is nearly equant and rounded		0.0	
30		GRAVEL (40Z); cobbles (25Z); v. cs. sand (20Z); cs. sand (10Z); tr. med. sand; reddish brown	color change	0.2	

PROJECT NO. OH0610DY05

BORE HOLE NO.

Test Well #2 --

PROJECT Harrison Radiator

LOCATION

Dayton, Ohio

REMARKS

DEPTH (FT.)	SAMPLE NO.	LITHOLOGIC DESCRIPTION	REMARKS	OVA/PID (PPM)	GRAPHIC
40		GRAVEL (30%); v. cs. sand (35%); cobbles (10%); cs. sand (15%); med. & fine sand; gray brown; sand fraction is angular, gravel fraction is rounded			
45		same as above but contains significantly more silt		0.3	
50		Till: CLAY (50%); gravel (30%); v. cs. sand (15%); cs. sand (tr.); brn.			
55		<u>Bottom of boring = 48 feet</u>			
60					
65					
70					

LOG OF BORING NO. W-2-S

GROUNDWATER MONITORING WELLS, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-18-81

SURFACE ELEVATION: 725.01'

DATE COMPLETED: 9-21-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	Brown clay, trace of sand, trace of gravel				
3.0'	Brown sand and gravel - damp				
10'					
20'					
30'					
	(Becomes wet at 35.5')				
40'					
50'					
60'					
(continued on next page)					

METHOD: DRIVE CASING	WATER OBSERVATIONS	TYPE SAMPLER:
TECHNICIAN: PATTERSON	INITIAL DEPTH: 35.0'	_____ A. SPLIT SPOON
JOB NO.: 26418 (kab)	COMPLETION DEPTH: 34.5'	_____ B.
	DEPTH AFTER: 24 HRS. 35.3'	_____ C. SHELBY TUBE

BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. W-2-S

GROUNDWATER MONITORING WELLS, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-18-81

SURFACE ELEVATION: 725.01'

DATE COMPLETED: 9-21-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS / FT. OR CORE REC.
60'	(continued)				
63.0'					
64.0'	Gray silt, trace of clay - moist				
	Brown sand and gravel - wet				
	Bottom of boring at 65.0'				
70'					
80'					
90'					
100'					
110'					
120'					

METHOD: DRIVE CASING

TECHNICIAN: PATTERSON

JOB NO.: 26418 (kab)

WATER OBSERVATIONS

INITIAL DEPTH: 35.0'

COMPLETION DEPTH: 34.5'

DEPTH AFTER: 24 HRS. 35.3'

TYPE SAMPLER:

A. SPLIT SPOON

B.

C. SHELBY TUBE

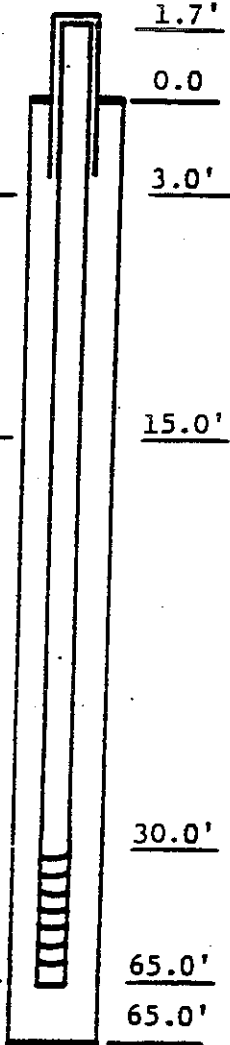
BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF WELL NO. W-2-S
GROUNDWATER MONITORING WELLS, HARRISON RADIATOR,
DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring
DATE INSTALLED: location plan
 9-21-81

SURFACE ELEVATION: 725.01'
TOP OF PIPE ELEVATION: 726.75'*

TYPE OF PIEZOMETER: Monitor Well - 4" Schedule 40 PVC Casing

DATE	WATER SURFACE DEPTH (FT.)	WATER SURFACE ELEV. (FT.)		INSTALLATION DESCRIPTION
9-21-81	34.5	690.5		DESCRIPTION DEPTH (FT.)
9-22-81	35.3	689.7		
10-5-81	35.3	689.7		
				

TECHNICIAN PATTERSON

JOB NO. 26418

NOTES: PVC screen length - 35 feet
 Screen slot size - 0.010 inches
 Guard pipe - 5" x 4' 2" black iron with locking cap
 * Elevation given is top of guard pipe without cap

LOG OF BORING NO. W-3-S

GROUNDWATER MONITORING WELLS, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-23-81

SURFACE ELEVATION: 731.47'

DATE COMPLETED: 9-23-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 5" ON SAMPLER	"N" BLOWS / FT. OR CORE REC.
0.0'	(FILL) Topsoil and sand and gravel - moist				
6.0'	(ORIGINAL) Brown sand and gravel - moist				
10'					
20'					
30'					
40'					
50'	(Becomes wet at 41.0')				
60'	(continued on next page)				

METHOD: DRIVE CASING

WATER OBSERVATIONS

TYPE SAMPLER:

TECHNICIAN: PATTERSON

INITIAL DEPTH: 41.0'

A. SPLIT SPOON

JOB NO.: 26418 (kab)

COMPLETION DEPTH: 41.0'

B.

DEPTH AFTER: 24 HRS. 41.0'

C. SHELBY TUBE

BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. W-3-S (second page)

GROUNDWATER MONITORING WELL, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-23-81

SURFACE ELEVATION: 731.47'

DATE COMPLETED: 9-23-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
60'	(continued)				
70'					
80'	Bottom of boring at 76.0'				
90'					
100'					
110'					
120'					

METHOD: DRIVE CASING	WATER OBSERVATIONS	TYPE SAMPLER:
TECHNICIAN: PATTERSON	INITIAL DEPTH: 41.0'	_____ A. SPLIT SPOON
OB NO.: 26418 (kab)	COMPLETION DEPTH: 41.0'	_____ B.
	DEPTH AFTER: 24 HRS. 41.0'	_____ C. SHELBY TUBE

BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF WELL NO. W-3-S
GROUNDWATER MONITORING WELLS, HARRISON RADIATOR,
DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring
location plan
DATE INSTALLED: 9-23-81

SURFACE ELEVATION: 731.47'
TOP OF PIPE ELEVATION: 733.39'*

TYPE OF PIEZOMETER: Monitoring Well - 4" Schedule 40 PVC Casing

DATE	WATER SURFACE DEPTH (FT.)	WATER SURFACE ELEV. (FT.)	INSTALLATION DESCRIPTION
9-23-81	41.0	690.5	DESCRIPTION DEPTH (FT.) Cement Grout Bentonite Seal Sand and Gravel 1.9' 0.0' 3.0' 11.0' 36.0' 76.0' 76.0'
9-24-81	41.0	690.5	
10-5-81	42.0	689.5	

TECHNICIAN PATTERSON

JOB NO. 26418

NOTES: PVC screen length - 40 feet
Screen slot size - 0.010 inches
Guard pipe - 5" x 4' 2" black iron with locking cap
*Elevation given is top of guard pipe without cap

LOG OF BORING NO. W-4-S

GROUNDWATER MONITORING WELLS, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-25-81

SURFACE ELEVATION: 726.66'

DATE COMPLETED: 9-28-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
0.0'	Brown sand and gravel, some silt, trace of cobbles				
10'					
20'					
30'					
40'	(Becomes wet at 37.5')				
50'					
60'					

(continued on next page)

METHOD: DRIVE CASING

WATER OBSERVATIONS

TYPE SAMPLER:

TECHNICIAN:

PATTERSON

INITIAL DEPTH: 37.5'

A. SPLIT SPOON

B.

JOB NO.:

26418 (kab)

COMPLETION DEPTH: 37.5'

DEPTH AFTER: 24 HRS. 37.5'

C. SHELBY TUBE

BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF BORING NO. W-4-S (second page)
GROUNDWATER MONITORING WELLS, HARRISON RADIATOR, DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring location plan

DATE STARTED: 9-25-81

SURFACE ELEVATION: 726.66'

DATE COMPLETED: 9-28-81

STRATUM	DESCRIPTION OF MATERIAL	SAMPLE NO. & TYPE	SAMPLE DEPTH	BLOWS PER 6" ON SAMPLER	"N" BLOWS /FT. OR CORE REC.
60'	(continued)				
70'					
80'	Bottom of boring at 70.0'				
90'					
100'					
110'					
120'					

METHOD: DRIVE CASING

TECHNICIAN: PATTERSON

NO.: 26418 (kab)

WATER OBSERVATIONS

INITIAL DEPTH: 37.5'

COMPLETION DEPTH: 37.5'

DEPTH AFTER: 24 HRS. 37.5'

TYPE SAMPLER:

____ A. SPLIT SPOON

____ B.

____ C. SHELBY TUBE

BOWSER - MORNER
TESTING LABORATORIES, INC.

LOG OF WELL NO. W-4-S
GROUNDWATER MONITORING WELLS, HARRISON RADIATOR,
DAYTON OPERATIONS, MORaine, OHIO

BORING LOCATION: As shown on boring
location plan
DATE INSTALLED: 9-28-81

SURFACE ELEVATION: 726.66'
TOP OF PIPE ELEVATION: 727.80'*

TYPE OF PIEZOMETER: Monitoring Well - 4" Schedule 40 PVC Casing

DATE	WATER SURFACE DEPTH (FT.)	WATER SURFACE ELEV. (FT.)	INSTALLATION DESCRIPTION
9-28-81	37.6	689.1	DESCRIPTION DEPTH (FT.) 1.1' 0.0' Cement Grout 2.0' Bentonite Seal 4.0' Sand and Gravel 30.0' 70.0' 70.0'
9-29-81	37.6	689.1	
10-5-81	37.3	689.4	

TECHNICIAN PATTERSON

JOB NO. 26418

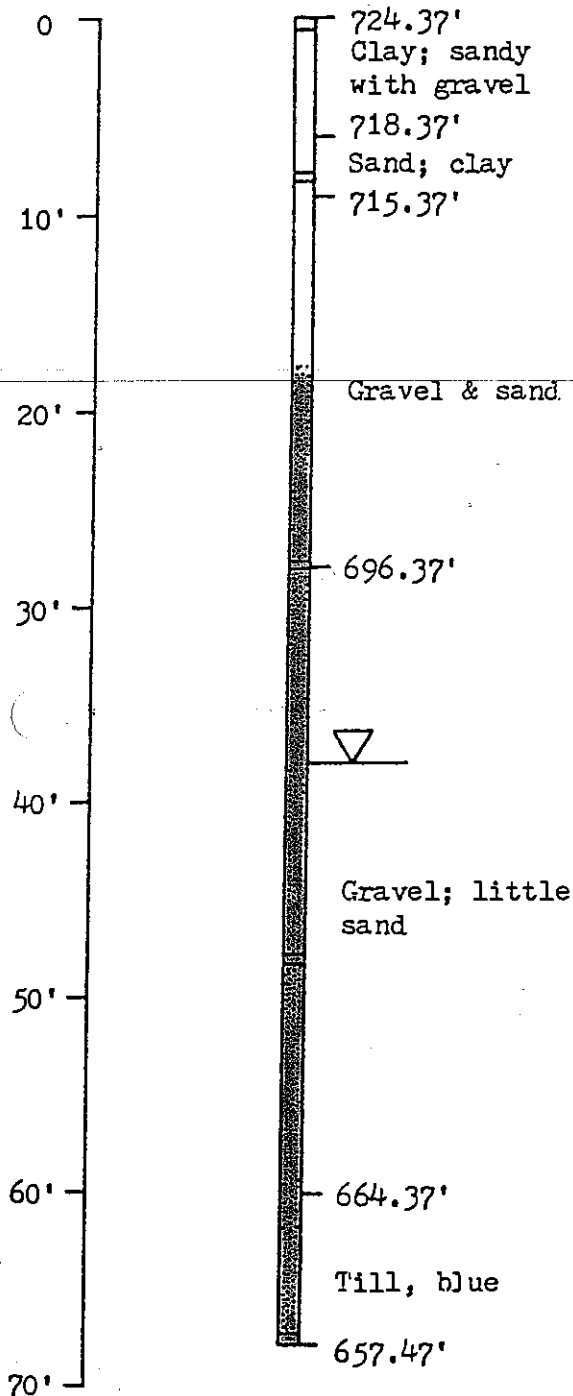
NOTES: PVC screen length - 40 feet
Screen slot size - 0.010 inches
Guard pipe - 5" x 4' 2" black iron with locking cap
* Elevation given is top of guard pipe without cap

ROUGH DRAFT

Location: Northeast corner of the intersection
of Dryden and Sellars Roads; Moraine,
Ohio

WELL 17

fig. A-1



DRILLING RECORD

Method: Hollow-Stem Auger
Date: 8/06/81
Crew: Dan Lewis/Jim Walker;
Wright State University;
Dayton, Ohio 45435
Casing: PVC
Diameter: 2.0" I.D.
Length: 66.9'
Coupling: Solvent weld
Screen: Perforated PVC
Diameter: 2.0" I.D.
Length: 30'
Perforation Diameter: .140"
Scheme: 360°; 96/ft.

SERVICE RECORD

Development: 9/04, 10/16/81
Cap Installation: 8/14/81
Repairs: None to date

BASIC DATA

Water Table: 38'
Elevation - top of cap: 725.12'
Height of Cap Above Ground: 9"

STATUS OF WELL

Active

REVISIONS

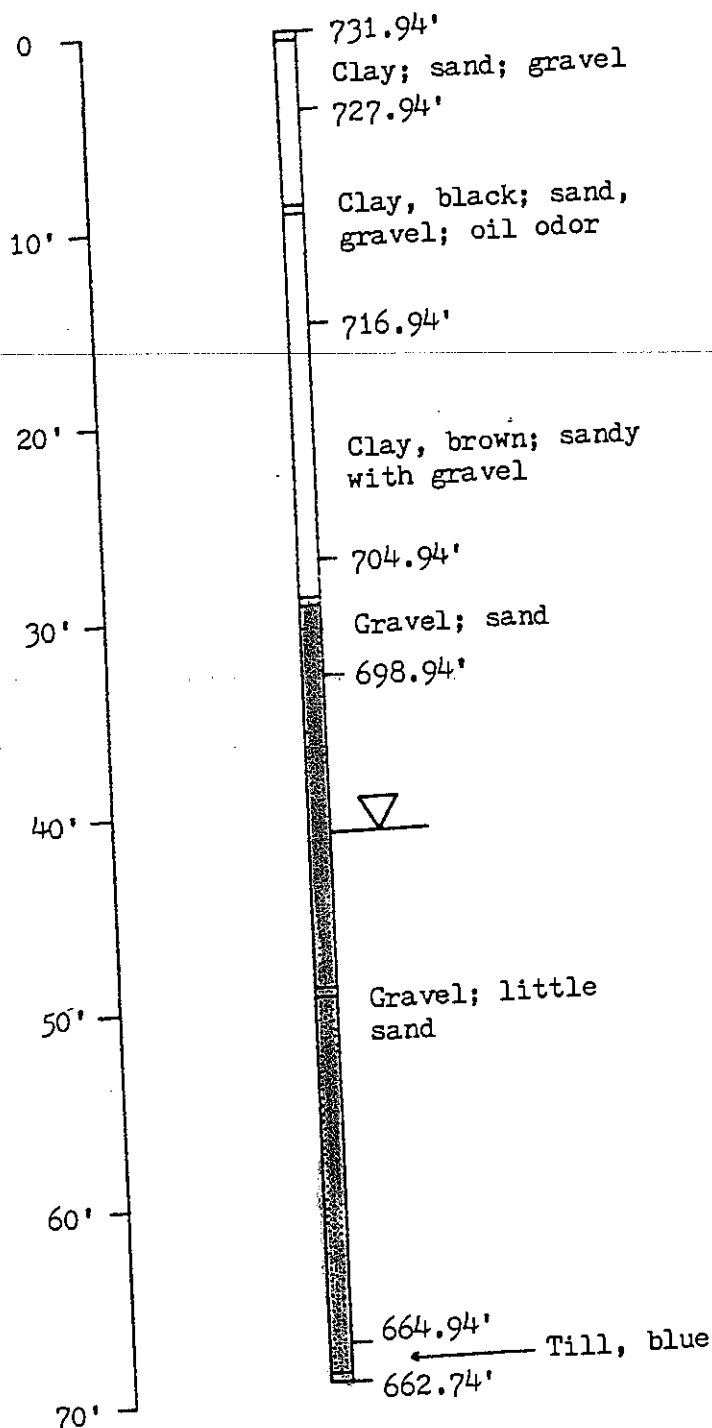
Original: 11/17/81
Revised:

ROUGH DRAFT

WELL 18

Location: 200' east of Dryden Road;
24' north of Sellars Road;
Moraine, Ohio

fig. A-2



DRILLING RECORD

Method: Hollow-Stem Auger

Date: 8/10/81

Crew: Dan Lewis/Jim Walker;

Wright State University;

Dayton Ohio 45435

Casing: PVC

Diameter: 2.0" I.D.

Length: 69.2'

Coupling: Solvent weld

Screen: Perforated PVC

Diameter: 2.0" I.D.

Length: 40'

Perforation Diameter: .140"

Scheme: 360°; 96/ft.

SERVICE RECORD

Development: 9/04, 10/16

Cap Installation: 8/22/81

Repairs: None to date

BASIC DATA

Water Table: 41'

Elevation - top of cap: 732.60'

Height of cap above ground: 8"

STATUS OF WELL

Active

REVISIONS

Original: 11/17/81

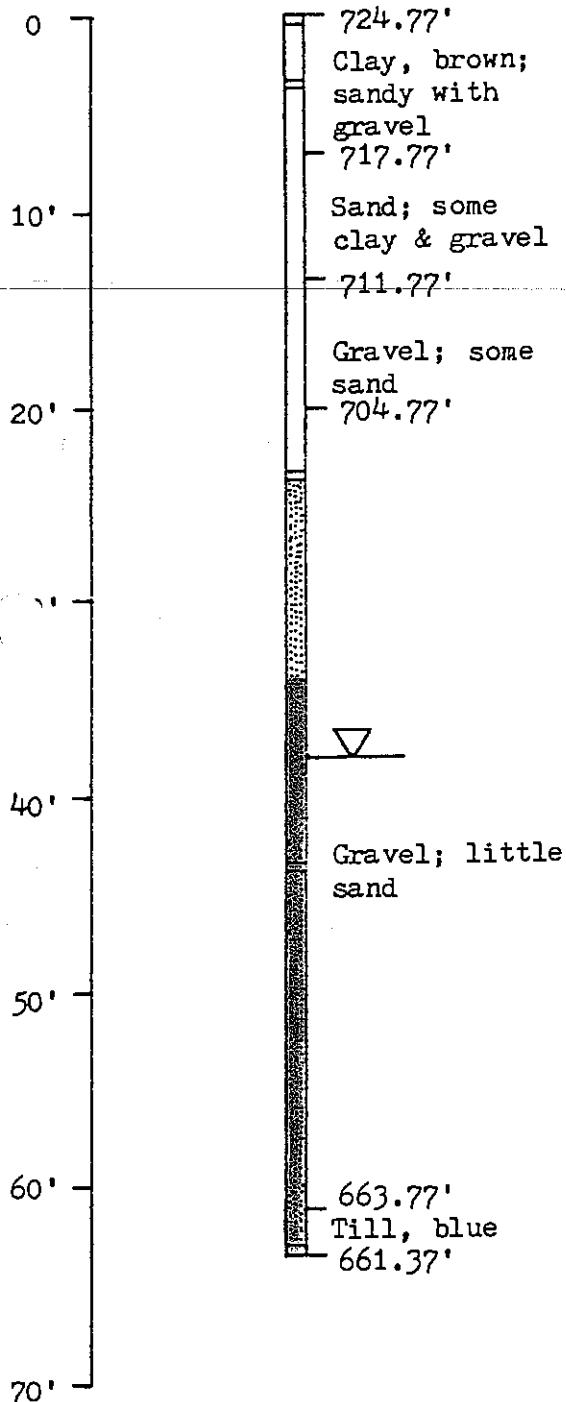
Revised:

ROUGH DRAFT

Location: 250' north of Sellars Road;
10' east of Dryden Road;
Moraine, Ohio 45435

WELL 19

fig. A-3



DRILLING RECORD

Method: Hollow-Stem Auger
Date: 8/12/81
Crew: Dan Lewis/Jim Walker;
Wright State University;
Dayton, Ohio 45435
Casing: PVC
Diameter: 2.0" I.D.
Length: 63.4'
Coupling: Solvent weld
Screen: Perforated PVC
Diameter: 2.0" I.D.
Length:
Perforation Diameter: .140"
Scheme: 360°; 96/ft.

SERVICE RECORD

Development: 9/04, 10/08/81
Cap Installation: 8/14/81
Repairs: None to date

BASIC DATA

Water Table: 38'
Elevation - top of cap: 725.44'
Height of Cap Above Ground: 8"

STATUS OF WELL

Active

REVISIONS

Original: 11/17/81
Revised:

APPENDIX B

Standard Operating Procedures



Appendix B. Standard Operating Procedures

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Appendix B. Standard Operating Procedures

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SOP 1

Vertical Aquifer Profiling

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for the use of vertical aquifer profiling during borehole advancement using sonic or direct push drilling methodologies. This SOP may be modified and/or amended to utilize with other drilling methodologies.

II. Summary of Method

Vertical aquifer profiling can be utilized to obtain groundwater samples at discrete intervals within a boring using various drilling techniques without setting a permanent monitoring well.

III. Health and Safety Considerations

There are no specific health and safety concerns or cautions related to vertical aquifer profiling where there is no soil or groundwater contamination. There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated. The material safety data sheet should be read before using tracer dyes (e.g., fluorescein dye). Some individuals can experience a mild allergic reaction to skin contact with fluorescein. In addition, there are physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to completing drilling activities including vertical aquifer profiling.

IV. Interferences

- The temporary well screen may not be properly sealed off allowing cross contamination between groundwater from intervals other than the target interval.
- Dilution of the groundwater sample from drilling fluids introduced during borehole advancement.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

VI. Equipment and Supplies

Equipment supplied by driller includes:

- Retractable temporary well screen;
- Submersible pump with flow control for extracting drilling fluid and groundwater;
- Poly storage tank; and
- Utility pump for mixing dye.

Equipment supplied by consultant includes:

- Fluorescein tracer;
- Bottles for retaining dyed drilling water samples and prepared visual dye standards;
- Graduated cylinders (50 mL and 1 L);
- Scale for measuring mass of dye to nearest 1 gram;
- Bottles for groundwater sampling;
- Digital camera;
- Potable water source;
- Chain of custody;
- Field forms; and
- Flashlight or other portable lighting device.

VII. Vertical Aquifer Profiling using Sonic Drilling Methods

Dye Batch Preparations

1. Prior to drilling, measure the proper mass of powdered dye for mixing with drilling water – 38 grams of fluorescein will be added to every 500 gallons of water to yield on average tracer concentration of approximately 20 mg/L.
2. If the drilling water “batch” is larger or smaller than 500 gallons, the same ratio of dye to drilling water will be used.
3. Measure the mass of the dye using a scale with an accuracy of +/- 1 gram.
4. Add the dye to the drilling water batch tank while also adding potable water to provide agitation to assist mixing the dye.
5. A utility pump should also be used to mix the tracer with the drilling water by recirculating water in the tank for at least 5 minutes. Alternatively, if equipped, the water can be recirculated using the internal piping of the drill rig.
6. Place 40 mL of the dyed drilling water into the 50 mL graduated cylinder for use in preparing the visual standard discussed below.
7. Collect 4 additional 40 mL unpreserved VOA vials from each batch of drilling water – label all four of these vials “DW-1” for the first batch of drilling water, “DW-2” for the second batch, etc. These samples will be archived for potential use in preparing other standards with other dilutions (optional) of for submittal for laboratory analysis, if necessary.
8. A visual standard will be prepared for each batch of dyed drilling water, as follows:
 - Pour 40 mL of dyed drilling water from the 50 mL graduated cylinder into the 1 L graduated cylinder.
 - Add 760 mL of un-dyed potable water to the 1 L graduated cylinder to produce 800 mL of “visual standard”.

- Fill one 40-mL unpreserved VOA vial with visual standard solution and label “VS1” for the visual standard from the first batch of drilling water, “VS2” for the visual standard from the second batch of drilling, etc.
- These visual standards represent a 95% dilution of the drilling water, and will provide a visual standard to verify that sufficient purging has been performed to remove at least 95% of the drilling water from a given interval, indicating that the purge water consists of at least 95% formation water.
- Discard the remaining fluid within the graduated cylinder using an appropriate container.
- Photograph the “DW” samples and the “VS” sample from each batch of drilling water with adequate, consistent light, against a white background.
- Keep all of the dyed drilling water (“DW”) samples and visual standard (“VS”) samples in a cooler to keep them dark, as the dye will degrade with exposure to light.
- If the tracer batch tank is translucent, then black, 1 millimeter plastic will be used to cover the tank during the day to minimize photodegradation of the tracer batch water.
- The drilling water source should be sampled for chlorine and pH at the start of the project. Chlorine will consume fluorescein; if present in detectable quantities, there should be a “wait period” of at least four hours between dye addition and sampling (and use) of the drilling fluid. pH values below approximately 5 standard units results in reduced fluorescence of the fluorescein.

Drilling Procedures

1. The borehole will be advanced following a sonic drilling to the target sampling depth.
2. Ideally, the borehole should be advanced dry without any drilling fluids but if this cannot be done then the dyed drilling water will be used.

3. If using drilling water, a positive head should be maintained during drilling, which should prevent dilution of the drilling water by formation water. However, any water upwelling from the casing during drilling will be contained in a tub positioned over the borehole.
4. A retractable temporary well screen will be placed inside the casing and lowered to the target depth.

Groundwater Sampling Procedures

1. The targeted sample interval will be purged using a pump. During purging, purge water will be periodically collected in a 40-mL unpreserved VOA vial and compared to the visual standard ("VS" sample) prepared from the drilling water used to drill that depth interval.
2. If the purge water contains significant suspended particulates/turbidity, it may be necessary to allow particulates to settle before comparing the purge water sample to the visual standard.
3. Purging will continue until one of the following two conditions is met:
 - The purge water clarity in terms of remaining dye content matches or exceeds the clarity of the visual standard, indicating that the purge water consists of at least 95% formation water.
 - o In this case, the purge water sample and the associated visual standard will be photographed against a white background to document that the purging goal has been reached.
 - A different practical purging limit has been reached, based on purge volume or time.
 - o In this case, the purge water sample and the associated visual standard will be photographed against a white background to document the degree of purge water visual clarity that was attained.
 - o Also, a sample of the purge water (optional) will be obtained in a 40mL unpreserved VOA vial; this sample, and one of the vials of

dyed drilling water, will be submitted for quantitative analysis of fluorescein. The analytical results for fluorescein will be used to calculate a COC correction factor, if deemed necessary.

- After purging has been completed, the pumping flow rate will be lowered to or below 1,000 mL/min and then groundwater samples will be collected from the discharge end of the pump tubing for COC analysis in accordance with the approved work plan.

VIII. Aquifer Profiling using Direct Push Drilling Methods

Drilling Procedures

1. The borehole will be advanced using direct push drilling by driving the tool string to the desired sampling depth.
2. Once the targeted sampling depth has been reached, the SP-22 screen with 1.25 inch center rods will be lowered inside the borehole casing.
3. Once the screen is in place, the outer casing will be retracted to expose the screen.
4. A submersible pump and disposable tubing will be lowered into the well and a grab groundwater sample will be collected.

IX. Data and Record Management

All relevant information regarding vertical aquifer profiling including, sample depths, purging volumes, drilling fluid usage and volumes will be recorded in field book (see SOP 18). The groundwater analytical data will be saved electronically once field work is completed.

X. Quality Control and Quality Assurance

Duplicate groundwater samples will be collected at a rate specified in the QAPP to ensure accuracy when sampling.

XI. References

None.

SOP 2

Chain-of-Custody, Sample Labeling and Sample Shipping Procedures

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody (COC), handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to ensure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory. A COC must be completed by the sampling team for all samples immediately upon collection. The COC will be delivered to the analytical laboratory. A sample COC is included in Appendix B. When shipping laboratory samples it is necessary that the correct procedures are followed in order for the subsequent analytical data to be valid and useable.

II. Summary of Method

When samples are collected, the appropriate sample label should be completed and placed on the sample as soon as it is collected. An example sample label is included in Appendix B. In addition, the COC shall be completed upon the collection of the sample. After the sample is collected and correctly label, the sample should be immediately placed in a cooler with wet ice. When shipping samples, the COC should be included and should match the sample labels placed on the containers. The samples should be shipped on ice for morning delivery to the destination laboratory.

NOTE: In some cases, the COC might be completed at the end of a sampling event in which each sample collected does not warrant laboratory analysis. In this scenario a running list of samples collected should be kept in the field notes or on another field form to ensure that every sample is tracked.

III. Health and Safety Considerations and Cautions

Care should be taken when handling sample containers with preservatives which could be harmful. Preserved containers could off-gas when opened and/or be acidic/caustic. Coolers containing sample bottles and ice become very heavy; the transportation of these coolers should be done in a manner to reduce the possibility of injury. In addition, the site-specific health and safety plan should be consulted before completing any field work.

IV. Interferences

- It is important that all sample containers be accurately labeled. The COC should match the label placed on the container. If this is not done correctly, the receiving laboratory may not be able to distinguish between samples, causing confusion and possible loss of or misidentification of samples.
- Samples should be shipped on wet ice in coolers for morning delivery to the destination laboratory. If the receiving laboratory does not receive the samples in a timely manner the samples could violate temperature and/or holding time restrictions.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Sample containers;
- Indelible ink pens (black or blue);
- Daily field log (example attached in Appendix B) or logbook;
- Coolers;
- Re-sealable bags (e.g. Zip-lock™ bags);
- Clear packing tape, strapping tape;
- Department of Transportation shipping forms, as applicable;
- Chain-of-Custody (example attached in Appendix B);
- Custody seals (example attached in Appendix B);
- Wet ice;

- Cushioning and absorbent material (i.e., bubble wrap or bags);
- Temperature blank; and
- Sample labels (example attached in Appendix B).

VII. COC, Sample Labeling and Sample Shipping Procedures

1. The sample should be labeled in accordance with the Quality Assurance Project Plan for the project.
2. When labeling the sample, ensure that the correct time and date, preservative, and medium are correct.
3. Complete all information fields (MUST PRINT LEGIBLY) on the COC including project name, project location, laboratory, project manager, and sampler.
4. When a sample is collected, complete the COC with the sample identification, matrix, date and time, sample container, analytical parameters or method number, and preservative.
5. Ensure that the COC and sample label correspond, especially in terms of sample identification, date, and time.
6. Protect the sample with appropriate shipping materials (e.g. bubble wrap) and place the sample in an ice filled cooler.
7. Prior to shipping the samples, complete another check to ensure that the COC has a record of every sample container to be shipped in the cooler. Each cooler must contain a COC. A cooler may have more than one COC.
8. Prior to shipping, drain free water from the cooler, place sealed, ice-filled plastic bags around the samples, and ensure that the sample containers are protected from breakage.
9. Sign/relinquish the COC, keeping a carbon copy for the file, and seal the COC in a baggie.

10. Seal the cooler with tape and place a cooler COC seal over the opening, sign and date.
11. Ship the cooler to the destination laboratory via overnight courier.

VIII. Data and Record Management

As described the data should be recorded as described in the appropriate forms. Chain-of-custody records will be transmitted to the ARCADIS Project Manager or designee at the end of each day unless otherwise directed by the ARCADIS Project Manager. The sampling team leader retains copies of the chain-of-custody forms for filing in the project file. When appropriate, this recorded data will be input and/or tabulated electronically. Record retention shall be in accordance with project requirements

IX. Quality Control and Quality Assurance

After fieldwork is completed, the COC and field notes will be used for the validation of the field sampling event.

X. References

None.

SOP 3

Calibration and Use of Photo Ionization Detector for Field Screening of VOCs

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure is for health and safety monitoring and screening surface or subsurface soil samples collected in the field for volatile organic compounds (VOCs) using a photo-ionization detector (PID). The purpose of this procedure is to provide uniformity in the field screening of soil samples. In addition, a PID may be utilized for health-and-safety monitoring. Non-volatile chemicals will not be detected by a PID, and that different PID lamp sizes enable detection sensitivity of different VOCs.

II. Summary of Method

In order to collect uniform field screening data, it is necessary to follow the guidelines set forth in this SOP. Soil screening for VOCs in the field is a good estimate of relative concentrations in a given sample. Screening can also be useful in determining the presence or absence of VOCs in soil samples. A PID can also be utilized for health-and-safety monitoring. To ensure consistency during sampling, the PID is to be calibrated daily according to the manufacturer's instructions.

III. Health and Safety Considerations and Cautions

Collecting and screening samples of contaminated soil could pose health and safety concerns related to direct contact, ingestion, and/or inhalation. Utilizing pressurized gas during calibration should be done with care. Installing or removing fittings on a pressurized gas canister could lead to the release of pneumatic pressure. The site specific health and safety plan must be consulted before conducting these activities.

IV. Interferences

- The area in which the PID readings are collected should be free of any background VOCs, or, if this is not able to be accomplished, an ambient air background VOC reading should be noted and recorded or a zero-air pressurized gas canister used.
- The intake port of the PID should be clear of any debris and/or water.
- As with any piece of equipment, it is necessary that it be properly calibrated and checked to ensure that readings are not artificially high or low. The

equipment should be calibrated in an area in which the background environment is not influenced by VOCs.

- High humidity could result in erratic readings.
- The appropriate regulator should be utilized when calibrating the PID, use of an incorrect regulator will lead to erroneous readings.
- The appropriate correction factor should be used when measuring total VOC concentrations. Each specific VOC will have an independent correction factor based on the standard in which the PID was calibrated. You should refer to the manufacturer's manual for a list of correction factors.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course, associated 8-hour refresher courses, and the any site-specific required training prior to engaging in any field activities.

VI. Equipment and Supplies

- Photo-ionization detector (PID) including manual;
- Calibration Gas, tubing and regulator;
- Particulate filter;
- Sealable plastic bags (e.g., Ziploc bags); and
- Soil boring log and/or soil sampling log.

VII. Calibration of PID

- Record the time of calibration (cal), PID serial number, and calibration gas lot number and expiration date in the daily log.
- Turn on instrument and record the pre-calibration reading.

- Follow the manufacturer's instructions to zero the meter by applying ambient or zero air.
- Follow the manufacturer's instructions to calibrate the meter by applying SPAN calibration gas of known concentration (e.g. isobutylene at 100 ppm concentration).
- Following calibration, complete a bump test to ensure the instrument is reading correctly. If the reading shown by the instrument is greater than $\pm 10\%$ of the cal gas concentration, relocate to an area not influenced by VOCs and recalibrate.

Calibration Check:

- o Exit the work area and turn meter to "on" position. Check that the meter is reading a value of zero.
- o Perform steps 1 and 2 from "Instrument Daily Calibration" above.
- o Attach the 100 ppm SPAN gas and verify that the reading is within 10 ppm of 100.
- If the value shown by the instrument is greater than 10% of the calibration gas concentration, take meter away from work zone and recalibrate as outlined above.

VIII. Field Screening of Sample

- Sample Preparation
 - o Before classification of the soil, collect and preserve samples for laboratory analysis (if any).
 - o Collect the sample and place into a sealable plastic bag. Attempt to decant as much free water from the sample as possible if the sample is saturated.
 - o The sample should be allowed to remain in the sealed bag for approximately 10 minutes. To enhance volatilization, the samples should be broken apart and placed in a heated area.

- Sample Screening
 - o Ensure that the PID is calibrated and is reading zero in an uncontaminated ambient air environment. If a zero reading is not able to be obtained, an ambient air background VOC reading should be recorded.
 - o Slightly open the sealed bag containing the soil sample and insert the PID probe into the bag making sure that the probe does not contact any soil or fluid in the bag.
 - o Record the peak reading on the boring log and/or soil sampling log.
 - o Remove the PID probe from the bag and confirm that the PID reading returns to zero or to the site background concentration in ambient air. If the PID does not return to zero or to the site background concentration, check the PID probe and recalibrate the PID.
 - o Dispose of the soil in accordance with applicable environmental regulations (SOP 9).

IX. Data and Record Management

Screening results, calibration data, and other relevant information must be documented in the daily field log, logbook and/or calibration log. After completion of field tasks, the logs will be scanned and saved electronically.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original boring logs and/or soil sampling logs. The logs will be reviewed to ensure that the field soil screening data was correctly transferred to the electronic logs.

XI. References

None.

SOP 4

Soil Sample Collection and Classification

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) applies to collecting surface and subsurface soil samples in the field and classifying the soil samples. This SOP incorporates elements from various standard systems such as American Society for Testing and Materials (ASTM) D2488-06, Unified Soil Classification System (USCS), and the Wentworth Classification System. This SOP has been developed to emphasize field observation and documentation of details required to:

- Make hydrostratigraphic interpretations guided by depositional environment/geologic settings.
- Provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.
- Collection of soil samples for field screening and possible laboratory analysis.

The purpose of this procedure is to provide uniformity in soil description and classification.

II. Summary of Method

In order to objectively record lithologic information it is necessary to follow the guidelines set forth in this SOP. The use of standard classifications systems will allow for a uniform description of soils between field personnel. Use of this SOP will ensure that all required lithologic information is recorded.

III. Health and Safety Considerations and Cautions

Collecting and classifying samples of contaminated soil could pose health and safety concerns associated with direct contact, ingestion, and/or inhalation. The site specific health and safety plan must be consulted before conducting these activities.

IV. Interferences

This SOP and use of the Udden-Wentworth Grain Size Scale and USCS will minimize the subjectivity inherent in describing soil characteristics.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Soil descriptions shall be documented by a qualified on-site geologist. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist.

VI. Equipment and Supplies

- Stainless steel butter knife or other cutting utensil;
- Plastic sheeting;
- USCS classification Geotechnical Gauge or similar;
- Soil Description Field Guide (attached);
- Soil boring log and/or soil sampling log (attached in Appendix B);
- Distilled water;
- Field card showing Wentworth scale;
- Munsell® soil color chart;
- Tape measure divided into tenths of a foot;
- Hand lens;
- Digital camera;
- Sealable plastic bags;
- Sample jars and lids;
- Nitrile Gloves;

- Clear Tape;
- Personal protective equipment (PPE) as required by the HASP; and
- Decontamination equipment.

VII. Classification of Sample

Sample Preparation

1. Before classification of the soil, collect and preserve samples for field PID screening and laboratory analysis (if any).
2. Complete labels for samples for laboratory analysis and complete chain-of-custody. Store sample containers in an ice-filled cooler pending shipment to the laboratory (see SOP 2).
3. Place sample on disposable plastic sheeting. If the sample has been collected from a boring, ensure that the top of the sample can be differentiated from the bottom.
4. If the sample is a cohesive soil such as clay, cut the sample down the middle using a previously decontaminated cutting utensil in order to expose a clean surface.

Sample Classification

1. Soil classification based on the Udden-Wentworth grain size scale.

Determination of components is based on using the Udden-Wentworth particle size classification and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of $\frac{1}{2}$. Due to visual limitations, the finer classifications of Udden-Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the field gauge card that shows Udden-Wentworth scale or by measuring with a ruler. An optional settling test or wash method (Appendix X4 of ASTM D2488) may be used for determining presence and estimating percentage of clay and silt.

2. Describe the color (dark gray, light gray, yellowish orange, etc.) of the sample and compare it to the Munsell® soil color chart descriptions. Record the color in the soil boring log and/or soil sampling log.
3. Characterize the degree of saturation of the sample. Use the terms “dry”, “moist”, or “wet”.
4. Determine the minor and major components of the soil (clay, silt, sand, gravel, angularity, plasticity, dilatancy, sorting, etc.). Record the information in the soil boring log and/or soil sampling log.
5. To measure and record the depth below ground surface (bgs) of top and bottom of each stratum, the following information should be recorded.
 - Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.
 - Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).
 - Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.
 - Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval.
6. Describe the overall texture and appearance of the sample. Is the sample homogeneous or is it divided into discreet lenses or layers of different grain sizes (as is often the case)? Are there any abrupt changes in grain size, color, degree of saturation, or consistency?

7. If the major component of the sample is silt or clay, describe the consistency based on the USCS description (hard, medium, stiff, etc.) and indicate the method used to designate consistency (e.g., n-value, penetrometer, etc.).
8. If the major component is sand or gravel, note the grain size and assign the appropriate Udden-Wentworth descriptor (medium sand, coarse gravel, cobble, etc.) and the relative percentage of materials of that size. Record the sizes and percentages in the soil boring log and/or soil sampling log.
9. Select the appropriate 2-letter soil descriptor from the USCS classification chart. Record the letter symbol in the soil boring log and/or soil sampling log.
10. Record additional relevant information such as evidence of contamination, presence of organic material (roots, etc.) or anthropogenic material (e.g., brick, plastic), and evidence of soil structures (e.g., mottling, micro-fractures, etc.).
11. Document formation types and unusual features with photographs.
12. Complete field screening (if required) after completing boring log entry. Record field screening data on boring log (see SOP 3).

VIII. Data and Record Management

Submit copies of all field logs to the project manager at the end of each work day. Keep original versions of all field logs in the field until the end of the project. Field-generated logs will be converted into electronic logs.

IX. Waste Management

Project-specific requirements should be identified and followed.

The following procedures or similar waste management procedures are generally required. Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other

disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. For more information on investigative derived waste handling and sampling see SOPs 9 and 19.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original boring logs and/or soil sampling logs. The electronic logs will be reviewed for completeness and accuracy.

XI. References

Geotechnical Gauge, WF McCollough.

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 “Sand Grain Sizing Folder”.

ARCADIS Soil Description Field Guide, July 10, 2008.

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 “Munsell® Color Soil Color Charts.

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).



FINE-GRAINED SOILS	
Description	Criteria
Descriptor - Plasticity	
Nonplastic	A 1/8-inch (3mm) thread cannot be rolled at any moisture content.
Low	Thread can barely be rolled, and lump cannot be formed when drier than plastic limit.
Medium	Takes considerable time and rolling to reach plastic limit. Thread cannot be rolled after reaching plastic limit. Lump crumbles when drier than plastic limit.
High	Thread is easy to roll and quickly reaches plastic limit. Thread can be rerolled several times after reaching plastic limit. Lump can be formed without crumbling when drier than plastic limit.
Descriptor - Dilatancy	
No Dilatancy	No visible change when shaken or squeezed.
Slow	Water appears slowly on the surface of soil during shaking and does not disappear or disappears slowly when squeezed.
Rapid	Water appears quickly on surface of soil during shaking and disappears quickly when squeezed.
Minor Components with Descriptors	
Moisture	
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
Consistency	
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated 1 inch by thumb.
Medium stiff	N-value 5-8 or indented about 1/2 inch by thumb with great effort.
Stiff	N-value 9-15 or indented about 1/4 inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty.
Color using Munsell	
Geologic Origin (if known)	
Other	

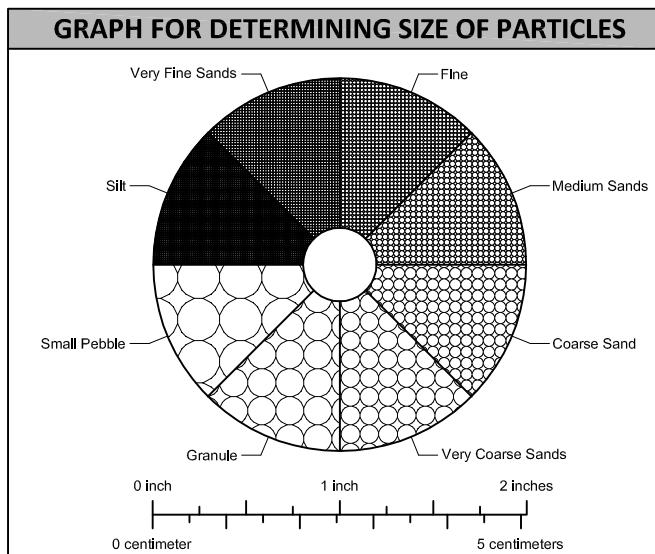
DESCRIPTION ORDER	
Depth Interval	
Principal Components with Descriptors	
Minor Components with Descriptors	
Sorting	
Field Moisture Condition	
Density/Consistency	
Color using Munsell	
Geologic Origin (if known)	
Other descriptions as NOTES:	
- Odor	
- Stratigraphy	
- Structure	
- Sphericity	
- Cementation	
- Reaction to acid	

MINOR COMPONENTS % MODIFIERS	
Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

FOR COARSE-GRAINED SOILS	
Description	Criteria
Descriptor - Angularity	
Angular	Particles have sharp edges and relatively planar sides with unpolished surfaces.
Subangular	Particles are similar to angular but have rounded edges.
Subround	Particles have nearly planar sides but have well-rounded corners and edges.
Round	Particles have smoothly curved sides and no edges.
Minor Components with Descriptors	
Sorting Cu= d60/d10	
Well Sorted	Near uniform grain-size distribution Cu= 1 to 3.
Poorly Sorted	Wide range of grain size Cu= 4 to 6.
Moisture	
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
Density	
Very loose	N-value 1 - 4
Loose	N-value 5 - 10
Medium Dense	N-value 11 - 30
Dense	N-value 31 - 50
Very dense	N-value >50
Color using Munsell	
Geologic Origin (if known)	
Other	
Cementation	
Weak Cementation	Crumbles or breaks with handling or little finger pressure.
Moderate Cementation	Crumbles or breaks with considerable finger pressure.
Strong Cementation	Will not crumble with finger pressure.
Reaction with Dilute HCl Solution (10%)	
No Reaction	No visible reaction.
Weak Reaction	Some reaction, with bubbles forming slowly.
Strong Reaction	Violent reaction, with bubbles forming immediately.

Udden-Wentworth Scale			
Fraction	Sieve Size	Grain Size	Approximate Scale
Boulder		256 - 4096 mm	Larger than volleyball
Large Cobble		128 - 256 mm	Softball to volleyball
Small Cobble		64 - 128 mm	Pool ball to softball
Very Large Pebble		32 - 64 mm	Pinball to pool ball
Large Pebble		16 - 32 mm	Dime size to pinball
Medium Pebble		8 - 16 mm	Pencil eraser to dime size
Small Pebble	No. 5+	4 - 8 mm	Pea size to pencil eraser
Granule	No. 10 - 5	2 - 4 mm	Rock salt to pea size
Very Coarse Sand	No. 18 - 10	1 - 2 mm	See field gauge card
Coarse Sand	No. 35 - 18	0.5 - 1 mm	See field gauge card
Medium Sand	No. 60 - 35	0.25 - 0.5 mm	See field gauge card
Fine Sand	No. 120 - 60	0.125 - 0.25 mm	See field gauge card
Very Fine Sand	No. 230 - 120	0.0625 - 0.125 mm	See field gauge card
Silt and Clay. See SOP for description of fines	Not Applicable	<0.0625 mm	Analyze by pipette or hydrometer

PARTICLE PERCENT COMPOSITION ESTIMATION					
1%	10%	20%	30%	40%	50%



EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10 feet to 15 feet Clay, some silt, medium to high plasticity; trace small to very large pebbles, subround to subangular up to 2 inches diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10YR 4/3).



EXAMPLE OF SOIL DESCRIPTION AND PHOTO

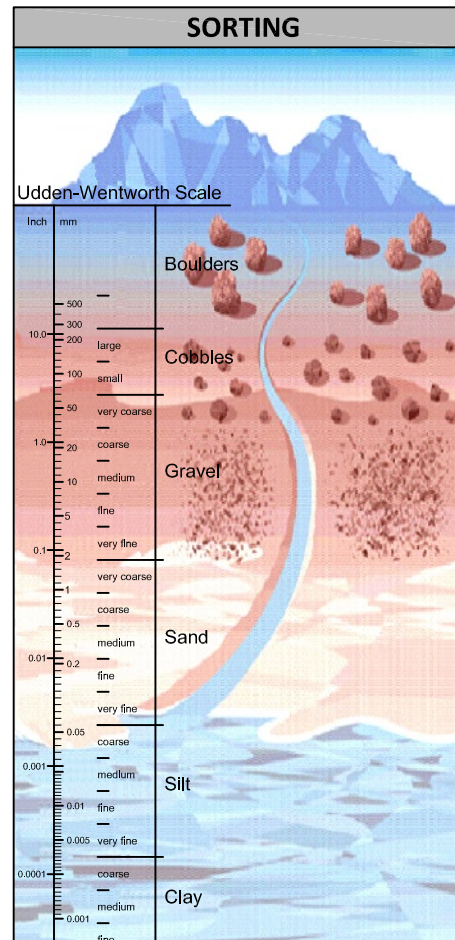
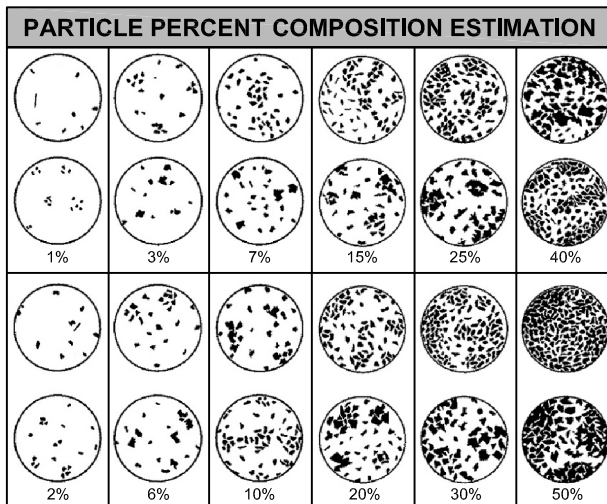
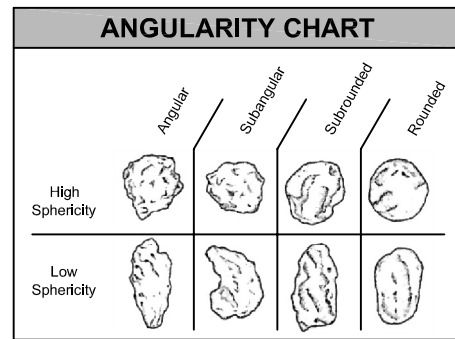
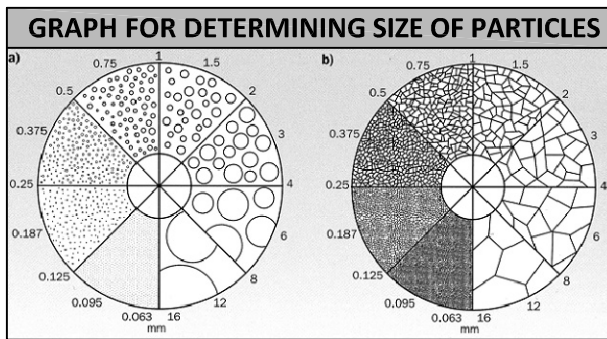
10 feet to 15 feet Sand, medium to pebbles, coarse, subround to subangular; trace silt; poorly sorted; wet; grayish brown (10YR 5/2).



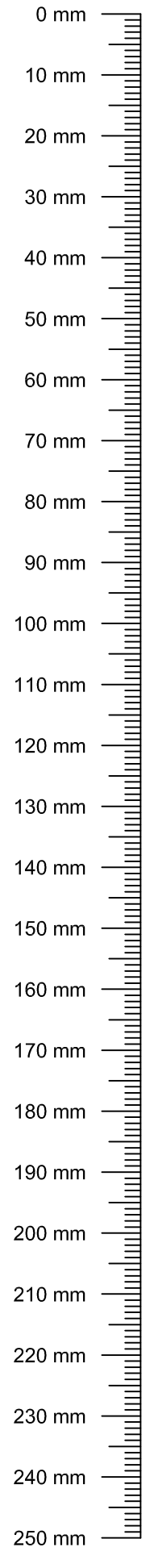
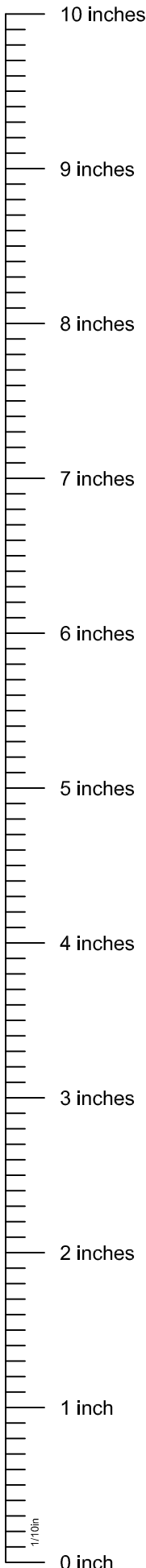


VARIATIONS IN SOIL STRATIGRAPHY	
Term	Thickness of Configuration
Parting	0 - to 1/16-inch thickness.
Seam	1/16 - to 1/2-inch thickness.
Layer	1/2 - to 12-inch thickness.
Stratum	> 12-inch thickness.
Pocket	Small erratic deposit, usually less than 1 foot in size.
Varved Clay	Alternating seams or layers of sand, silt, and clay (laminated).
Occasional	≤ 1 foot thick.
Frequent	> 1 foot thick.

SOIL STRUCTURE DESCRIPTIONS	
Term	Description
Homogeneous	Same color and appearance throughout.
Laminated	Alternating layers < 1/4 inch thick.
Stratified	Alternating layers ≥ 1/4 inch thick.
Lensed	Inclusions of small pockets of different materials, such as lenses of sand scattered through a mass of clay; note thickness.
Blocky	Cohesive soil can be broken down into small angular lumps, which resist further breakdown.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated.



SETTLING TABLE (SILT/CLAY)							
Diameter of Particle (mm)	<0.625	<0.031	<0.016	<0.008	<0.004	<0.002	<0.0005
Depth of Withdrawal (cm)	10	10	10	10	5	5	3
Time of Withdrawal	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec
Temperature (Celsius)							
20	00:00:29	00:01:55	00:07:40	00:30:40	00:61:19	04:05:00	37:21:00
21	00:00:28	00:01:52	00:07:29	00:29:58	00:59:50	04:00:00	
22	00:00:27	00:01:50	00:07:18	00:29:13	00:58:22	03:54:00	
23	00:00:27	00:01:47	00:07:08	00:28:34	00:57:05	03:48:00	
24	00:00:26	00:01:45	00:06:58	00:27:52	00:55:41	03:43:00	33:56:00
25	00:00:25	00:01:42	00:06:48	00:27:14	00:54:25	03:38:00	
26	00:00:25	00:01:40	00:06:39	00:26:38	00:53:12	03:33:00	
27	00:00:24	00:01:38	00:06:31	00:26:02	00:52:02	03:28:00	
28	00:00:24	00:01:35	00:06:22	00:25:28	00:50:52	03:24:00	31:00:00
29	00:00:23	00:01:33	00:06:13	00:24:53	00:49:42	03:10:00	
30	00:00:23	00:01:31	00:06:06	00:24:22	00:48:42	03:05:00	



SOP 5

Hydrophobic Dye Smear Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for the use of applying hydrophobic dye to soil samples. The purpose is to qualitatively determine the presence of non-aqueous phase liquids (NAPL) within soil by a positive or negative result from the dye.

II. Summary of Method

In order to complete the hydrophobic dye smear test in a uniform manner, it is necessary to follow the guidelines set forth in this SOP. The application of hydrophobic dye to a soil sample can allow for a quick analysis of the presence or absence of NAPL within a soil sample interval.

III. Health and Safety Considerations and Cautions

There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated and impacted with NAPL. The material safety data sheet should be read before using a hydrophobic dye. Caution should be used when combining soil with a hydrophobic dye to ensure the correct ratio is utilized (see section VII). In addition, there are always physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to performing vertical aquifer profiling activities.

IV. Interferences

None.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

VI. Equipment and Supplies

- Hydrophobic dye (Oil Red O[®] dye or similar);
- Measuring spoon (teaspoon);
- Disposable plastic dishes or cups; and

- Distilled Water.

VII. Hydrophobic Dye Smear Test

- Approximately 10 cubic centimeters (cc) of soil and 1 cc of Oil Red O® dye powder produced by Rowley Biochemical, will be placed into a small disposable dish.
- Depending on the soil moisture content, distilled water will be added to the mix of dye and soil.
- The soil and dye will be mixed and smeared together into a paste consistency in the dish by hand with a nitrile-glove.
- All soil samples containing NAPL will produce a distinct red color within the soil and/or on the glove. Samples without NAPL will not exhibit any coloration change within the soil and on the glove.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

None.

X. References

None.

SOP 6

Decontamination of Heavy Equipment

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) applies to heavy equipment, such as drill rigs, well casings/tooling, and auger flights. These could contain potential sources of interference to environmental samples. The sampling equipment may have come in contact with the materials adjacent to the matrix being sampled or media may be attached to the actual sampling equipment. For these reasons, it is important that the sampling equipment be cleaned prior to use.

Two methods are used for cleaning heavy equipment: pressure washed and/or steam-cleaning and manual scrubbing. Pressure washed and/or steam-cleaning can remove visible debris. Since these provide a high pressure medium, they are very effective for solids removal. They are also easy to handle and generate low volumes of wash solutions.

Heavy equipment will be thoroughly pressure washed and/or steam-cleaned or manually scrubbed upon arrival on site and when moved between sampling locations. Drill rig items (such as auger flights, drill rods, and drill bits) will be cleaned before changing sample locations

II. Summary of Method

Decontamination procedures are used to remove the presence of contaminants from heavy equipment and associated sampling equipment prior to use and between sampling locations. Decontamination consists of cleaning the equipment with the use of water and reagent grade soap, wiping it dry, or steam cleaning.

III. Health and Safety Considerations and Cautions

Residual media removed during decontamination may pose a health and safety hazard. High pressure and/or steam washing poses hazards associated with flying debris pressurized hoses/vessels and scalding/burns. Generate a Job Loss Analysis for each piece of equipment and follow the site-specific health and safety plan before completing this activity.

IV. Interferences

If equipment is not appropriately decontaminated, the possibility for cross-contamination exists. If this SOP is followed strictly, the possibility of cross-contamination between sampling locations can be diminished.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Equipment to be decontaminated;
- Potable water;
- Pressure washer and/or steam Cleaner;
- Reagent grade soap;
- Paper towels;
- Brushes;
- Field logbook or daily log; and
- 55-gallon drums or poly tank.

VII. Decontamination Procedures

- Use steam cleaner to provide a high pressure, high temperature wash and rise to equipment.
- Visually inspect equipment for signs of visible contamination.
- Repeat steps 1 and 2 as necessary.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

None.

X. References

None.

SOP 7

Decontamination

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for decontaminating non-dedicated field equipment. Non-dedicated sampling equipment must be decontaminated to eliminate the possibility of sample cross-contamination at a given sample location or between multiple sampling locations. Typically, this equipment is constructed of stainless steel or other impermeable material. Use of plastic equipment is discouraged and should only be used when contaminant levels are anticipated to be relatively low.

II. Summary of Method

Decontamination procedures are used to remove the presence of contaminants from sampling and/or monitoring equipment prior to use and between sampling locations. Decontamination consists of cleaning the equipment with the use of water and laboratory quality detergent, rinsing, and wiping or air drying.

III. Health and Safety Considerations and Cautions

Residual media removed during decontamination may pose a health and safety hazard. The site-specific health and safety plan should be consulted before conducting this activity.

IV. Interferences

If equipment is not appropriately decontaminated, the possibility for cross-contamination exists. If this SOP is followed strictly, the possibility of cross-contamination between sampling locations can be diminished.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

Equipment to be decontaminated:

- Distilled water (potable water is acceptable in equipment in which samples are not collected);
- 5-gallon buckets or similar clean container;
- Laboratory quality detergent (i.e. Alconox);
- Paper towels;
- Brushes;
- Field logbook or daily log; and
- Sealable Plastic Bags.

VII. Decontamination Procedures

1. Fill one clean 5-gallon bucket (or similar) with distilled (or potable where appropriate) water and detergent, this will be the initial decontamination step. Fill another clean 5-gallon bucket with distilled (or potable where appropriate) water; this will be the second step. If equipment is heavily soiled add an additional bucket of a detergent/water mix prior to the first bucket.
2. Remove any solid debris and/or soil from the equipment to be decontaminated and place the equipment into the 5-gallon bucket with the detergent/water mixture.
3. Agitate the equipment in the detergent/water mixture and scrub with a brush making sure the entire surface of the equipment is cleaned.
4. Remove the equipment from the detergent/water mixture and place into the 5-gallon bucket with distilled (or potable where appropriate) water.

5. Agitate the equipment in the water and scrub with a brush making sure the entire surface of the equipment is cleaned.
6. Inspect the equipment to ensure that there is no residue which would indicate possible contamination. If residue is observed, repeat steps 3 through 6.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

Rinsate blanks, also known as equipment blanks (SOP 15), will be collected at a rate specified in the QAPP. These samples will be submitted for laboratory analysis and be used for data validation purposes.

X. References

None.

SOP 8

Borehole and Well Abandonment

Motors Liquidation Company

Moraine, Ohio

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Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for abandoning a borehole or temporary/permanent monitoring well or piezometer. Correct procedures are to be followed to reduce the possibility of vertical migration of surface water or groundwater into an open borehole or between water bearing zones separated by an aquitard, eliminate the potential for the borehole to expand by cave-in, and eliminate the potential for accidental injury. The procedures in this SOP concur with the requirements of the Ohio Department of Natural Resources and the Ohio Administrative Code 3745-9-07 and 3745-9-10.

II. Summary of Method

Removing of well materials from a borehole or pulling of drilling materials such as augers will leave an open borehole which requires proper abandonment. Abandonment of a borehole requires backfilling with a permanent, non-permeable fill material such as bentonite or cement/bentonite grout to seal off the borehole from the migration of water.

III. Health and Safety Considerations and Cautions

There is direct-contact, ingestion, and inhalation concerns at sites where soil or groundwater is contaminated. Further, there are physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to performing borehole or well abandonment activities.

IV. Interferences

If the borehole or well is incorrectly abandoned, preferential groundwater communication across and aquitard may occur. Proper abandonment procedures will eliminate the potential for vertical cross contamination.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, prior to engaging in any field activities along with any site-specific training which is required for the site.

VI. Equipment and Supplies

- Field logbook and/or daily log (see Appendix B);
- Weighted tape;
- Electronic water level meter; and
- Non-permeable fill material (i.e. cement, bentonite).

VII. Abandonment Procedures

Abandonment of a soil boring:

1. Before abandoning the borehole, collect a depth-to-water (SOP 16) and total depth reading inside the boring if possible. Record these measurements in the log book and/or daily log (SOP 18).
2. Have the drilling subcontractor mix cement / bentonite slurry or pour bentonite chips inside the boring until all the annular void is filled with slurry or chips. Drilling materials, such as rods and augers, should be retracted from the borehole slowly to decrease the possibility of bridging if using bentonite chips.
3. Where necessary, the cement grout shall be pumped to the bottom of the borehole by use of a "tremie" pipe. The tremie pipe should be inserted to the bottom of the boring, and the grout pumped through the pipe filling the borehole from the bottom to the top. The tremie pipe can be removed as the borehole is being filled with grout.
4. After the borehole is completely abandoned, record all relevant information in your field log book and/or daily log including the volume of material used to abandon the borehole (SOP 18).
5. Decontaminate all drilling equipment per SOP 6.
6. Check the abandoned borehole the next day to see if any settlement has occurred. If settlement has occurred, fill in the remaining space with grout, bentonite, concrete, or soil depending on the final use of the area and the amount of settling below grade.

Abandonment of a well (temporary or permanent) screened in one water bearing zone:

1. Before abandonment of the well, collect depth-to-water and total depth measurements in the monitoring well.
2. Have the drilling subcontractor remove any protective well materials such as a procasing or flush-mount, if applicable. These materials can be disposed of as municipal waste.
3. Have the drilling subcontractor slowly remove the well by applying an even upward force onto the riser pipe.
4. If the well casing breaks upon the attempted removal, use drilling rods or similar to advance the well to the bottom of the original borehole. In this scenario, tremie in a cement/bentonite slurry from the bottom of the well to land surface. If the well is able to be completely removed, fill the open annular space with bentonite or a cement/bentonite slurry. In the rare occurrence in which the well is unable to be pulled due to access or safety concerns, fill the inside of the well screen to one-foot above the screen with sand, fill the rest of the of the well with bentonite or a cement/bentonite grout.
5. Ensure that the land surface is completed to grade level to decrease a trip hazard.
6. Check the abandoned borehole the next day to see if any settlement has occurred. If settlement has occurred, fill in the remaining space with grout, bentonite, concrete, or soil depending on the final use of the area and the amount of settling below grade.
7. Decontaminate all drilling equipment per SOP 6.
8. Ensure that the drilling subcontractor will fill out the "Water Well Sealing Report" and submit it to the Ohio Department of Natural Resources (ODNR). Fill out all relevant information in the log book and/or daily log.

Abandonment of a well (temporary or permanent) screened in more than one water bearing zone:

1. Before abandonment of the well, collect depth-to-water and total depth measurements in the monitoring well.
2. Have the drilling subcontractor remove any protective well materials such as a procasing or flush-mount, if applicable. These materials can be disposed of as municipal waste.
3. Have the drilling subcontractor slowly remove the well by applying an even upward force onto the riser pipe.
4. Once the well has been removed, have the drilling subcontractor create a borehole of at least the original diameter in which the boring was installed to a depth of the original total depth of the well.
5. At this point follow the steps listed in section VII "Abandonment of a soil boring".

VIII. Data and Record Management

Information regarding the abandonment of boreholes and wells should be recorded in the field log book and/or daily log (SOP 18). If a well is abandoned, the drilling subcontractor is required to complete and submit a Well Abandonment Form to ODNR. In a scenario abandonment is completed on private property, copies of the form(s) should also be provided to the property owner.

IX. Quality Control and Quality Assurance

Copies of the completed well abandonment forms submitted to ODNR, should be acquired from the drilling subcontractor and checked for accuracy.

X. References

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, 2010.

<http://www.epa.state.oh.us/ddagw/tgmweb.aspx>

Ohio Administrative Code 3745-9-07 and 3745-9-10.

SOP 9

IDW Sampling

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for waste characterization sampling investigation-derived waste (IDW). The objective of this SOP is to describe the procedures to manage IDW, both hazardous and nonhazardous, which may be generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. IDW may include soil, groundwater, drilling fluids, decontamination liquids, personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials that may have come in contact with potentially impacted materials, will be collected and staged at a location designated as temporary waste storage. Waste materials will be analyzed for constituents of concern to evaluate proper disposal methods. PPE and disposable sampling equipment will be placed in DOT-approved containers prior to disposal. These items typically do not require laboratory analysis. This SOP describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly disposed. The procedures for handling IDW are based on the United States Environmental Protection Agency's Guide to Management of Investigation Derived Wastes (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical data indicates otherwise. IDW will be managed to ensure the protection of human health and the environment. Waste characterization sampling is performed so that the wastes can be disposed in accordance with applicable regulations.

II. Summary of Method

Waste characterization sampling involves the collection and laboratory analysis of composite samples of IDW.

III. Health and Safety Considerations and Cautions

Collecting samples of contaminated soil, water, sludges, etc., could pose health and safety concerns related to direct contact, ingestion, and/or inhalation. The site specific health and safety plan must be consulted before performing these activities.

IV. Interferences

When collecting IDW samples, a composite sample should be collected (see SOP 19). If this procedure is not followed, it is possible for a given sample to exhibit an artificially high or low concentration of given parameters. By following the sampling procedures closely, it is possible to obtain a representative sample of the waste for disposal.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site-specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Laboratory prepared and certified sample containers;
- Daily field log (example attached in Appendix B) or logbook;
- Sampling utensils;
- Stainless steel bowl;
- Socket wrench set;
- Hammer;
- Leather gloves;
- Nitrile gloves;
- Appropriate drum or container labels (outdoor waterproof self adhesive);
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as specified in the Chain-of-Custody SOP and Field Sampling Handling, Packing, and Shipping SOP (See SOP 2 and Appendix B);
- Indelible ink and/or permanent marking pens; and
- Bailer and rope (if sampling water).

VII. Sampling Procedure

NOTE: Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Testing In Progress, Hazardous, or Non-Hazardous);
- Waste generator's name (e.g., client name);
- Project name;
- Name and telephone number of ARCADIS project manager;
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%);
- Media (e.g., solid, liquid);
- Accumulation start and end date; and
- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

Sampling During a Subsurface Investigation

1. Samples should be collected and placed in a stainless steel bowl as the soil is being placed into 55-gallon drums during drilling activities. Soil cuttings placed in the stainless steel bowl should be randomly selected as to be representative of the entire boring.
2. Once the selected borings/subsurface work is completed, composite the samples collected in the stainless steel bowl, by gently mixing the soil.
3. Fill the appropriate IDW sample containers and place into an ice-filled cooler.

4. Record the sampling date, time, and sample identification in the field log book and/or daily log. Fill out the Chain-of-Custody which will accompany the sample to the laboratory.
5. Ensure that all the 55-gallon drums or other containers are appropriately labeled.

Sampling After a Subsurface Investigation

1. First, confirm the origin of the 55-gallon drums or containers containing IDW waste by checking the identification.
2. Open the selected 55-gallon drums or containers.
3. If the waste is a soil matrix, collect a sample from the 55-gallon drum or container. Place all the samples into the stainless steel bowl and mix gently to composite the sample (See SOP 19).
4. If the IDW is water, use a disposable bailer to collect a representative sample from the 55-gallon drums and/or poly tank.
5. Fill each of the sample containers with the composite soil or water sample.
6. Secure all 55-gallon drums, containers and/or poly tanks.
7. Correctly label the sample for laboratory analysis per SOP 2 and fill out all appropriate paperwork including the field logbook and/or daily log per SOP 18.
8. Once the data are received from the laboratory, ensure that the IDW is correctly labeled on the containers (i.e. remove "pending analysis" labels).

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically. Data received from laboratory analysis will be input and/or tabulated electronically.

All IDW will be documented as generated on a Drum/Container Inventory Log maintained in the field log book. The Drum/Container Inventory will record the generation date, type, quantity, matrix and origin of materials in every

drum/container, as well as a unique identification number for each drum/container. The drum/container inventory will be used during drum/container pickup to assist with labeling of drums/containers. The drum/container storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

IX. Quality Control and Quality Assurance

If field forms and lab data is input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy. The chain-of-custody and sample labels for waste characterization samples will be filled out in accordance with the Quality Assurance Project Plan.

X. References

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

USEPA. 1991. Guide to Discharging CERCLA Aqueous Wastes to Publicly Owned Treatment Works (POTWs). Office of Remedial and Emergency Response. Hazardous Site Control Division OS-220W. March 1991.

SOP 10

Pneumatic Slug Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
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Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for accurately completing a slug test using pneumatic pressure and pressure transducer to evaluate instantaneous change in head and recovery. This method may be used for permanent wells or temporary wells formed by the drilling pipe drop tube and temporary screen (SOP1). The purpose for this procedure is to provide uniformity of the method so that accurate measurements are always generated. The collection of accurate slug test data is critical for determining hydraulic conductivity.

II. Summary of Method

Pneumatic slug tests are conducted by sealing the permanent or temporary well head and applying air pressure to displace the groundwater level. As air pressure is increased in the well, the groundwater level falls until the water pressure and the air pressure return to equilibrium. After the groundwater level is stable, air is released from the sealed well head by opening an air release valve. The water level recovery is a rising head test and produces very high quality data with little interference. A pressure transducer is used to monitor and record the change of the groundwater level during the pneumatic slug test.

III. Health and Safety Considerations and Cautions

- For a permanent well, when unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).
- Care should be taken when sealing the well head assembly to the well casing or drop tube. The attachment should be very secure and air tight.
- When removing the well caps, there is potential for the release of vapors, the well must be off-gassed and the air must be monitored for vapors.
- The Health and Safety Plan should be reviewed before performing field activities associated with pneumatic slug tests.

IV. Interferences

If the groundwater is not allowed to equilibrate before a test is performed, an artificially high or low reading could be recorded. Allowing sufficient time for the groundwater to equilibrate will allow for accurate readings. The groundwater is equilibrated when the water level is stable. If the transducer is not decontaminated correctly between locations, it is possible for cross-contamination to occur. Follow decontamination procedures in SOP 7. Sufficient time needs to be allowed for transducer to equilibrate with the groundwater temperature to avoid instrument drift.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Field personnel are required to have sufficient knowledge and experience for completing slug testing.

VI. Equipment and Supplies

- Electronic water level meter;
- Vented pressure transducer;
- Laptop computer with appropriate software;
- Pneumatic slug test manifold;
- Field measurement log;
- Compressed nitrogen canisters with two stage regulator or air compressor with regulator and appropriate hoses;
- Decon equipment for transducer;
- Leak detection fluid;
- Teflon pipe thread sealant tape; and

- Plumbers putty or similar product.

VII. Pneumatic Slug Test Procedures

1. Measure water level (Refer to SOP 16).
2. Collect all field measurements on the supplied field form. Decontaminate the probe and tape (Refer to SOP 7).
3. Attach the pneumatic slug test manifold onto the top of the well casing. Tighten the rubber connector to ensure an airtight seal.
4. Lower transducer through the well casing and set below the static water level at a known distance. The transducer must be placed so that when the water level is depressed with air pressure the transducer will remain submerged below the water. Allow the transducer to cool to ambient groundwater temperature before zeroing and beginning the slug test to prevent any baseline drift. After cooling, raise the transducer just above the water level to zero at atmospheric temperature.
5. Place the transducer at the proper depth and mark the location where the transducer cable will be secured to the compression connector. Make a ball of plumbers putty at the marked location around the cable. Tighten by hand to seal the connection to the putty/transducer cable.
6. Attach transducer to the laptop computer running the appropriate software to conduct the slug test. The transducer should be set to record readings at 0.5 to 1 second intervals, shorter intervals of 0.5 seconds may be necessary for possible high hydraulic conductivity formations ($> 10^{-2}$ cm/sec) determined by review of boring log (i.e. gravel) to properly record oscillatory responses. Start the data recording on the computer and pressure transducer.
7. Close the air release valve.
8. Open the inlet air valve with the pressure regulator closed.
9. Attach nitrogen/air supply to the fitting at the pressure regulator.

10. Slowly open the pressure regulator to pressurize well head and depress water level a sufficient distance without lowering the head below the top of the well screen. Larger distances may be needed for high-conductivity formations. Begin with a low pressure and gradually increase the pressure in order to obtain the desired water level and do not over pressurize the well (1 psi is equal to 2.3 feet of water).
11. Close inlet valve and leak check the system with leak detection fluid and on the pressure gauge and fix any leaks. If the leak is very slow or down the well, the regulator may be used to maintain a constant pressure head.
12. Check the transducer response and air pressure to verify system is stable. If it is stable proceed to the next step, if not check the seals.
13. Record the baseline pressure on the field form.
14. Quickly open the release valve to initiate the pneumatic slug test.
15. Allow sufficient time for water level to recover to static level. Slug test is complete.
16. Save files to a known location on the laptop computer prior to equipment disassembly.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms and saved on the laptop and flashcard for double backup.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

ASTM D 7242-06

Geoprobe® Pneumatic Slug Test Kit Standard Operating Procedure

SOP 11

Low Flow Drawdown Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Kevin Wilson

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for completing a low-flow drawdown test using a pressure transducer and submersible pump to evaluate change in head from pumping at low-flow rates (less than 1000 milliliters per minute [mL/min]) and subsequent recovery. This method may be used for permanent wells or temporary wells (drilling pipe drop tube and temporary screen [SOP 1]). The purpose for this procedure is to provide uniformity of the method so that accurate measurements are always generated.

II. Summary of Method

Low-flow drawdown tests are conducted by pumping the permanent or temporary well at a low-flow rate of less than 1000 mL/min until a steady head is reached and maintained for approximately 15 minutes. The pumping rate may be adjusted during the test in order to maintain/achieve a maximum drawdown of approximately 20% of the initial water column or packed interval. After the completion of the initial pumping period, the pump will be shut off and recovery data will be recorded for approximately 15 minutes or until 90% recovery is achieved. A pressure transducer is used to monitor and record the change of the groundwater level during the low-flow drawdown test at 1 second intervals. Start and stop times, pump rates, and pump rate adjustment times will be recorded for each low-flow drawdown test. At the end of each test, groundwater level data will be downloaded from the pressure transducer to a field laptop computer, reviewed for data quality, and saved for later hydraulic conductivity analysis.

III. Health and Safety Considerations and Cautions

- For a permanent well, when unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).
- Care should be taken when sealing a packer in the drop tube. The attachment should be very secure and air tight.
- When removing the well caps, there is potential for the release of vapors, the well must be off-gassed and the air must be monitored for vapors.

- The Health and Safety Plan should be reviewed before performing field activities related to low-flow drawdown testing.

IV. Interferences

If the groundwater is not allowed to equilibrate before a test is completed. Allowing sufficient time (approximately 5 to 15 minutes) for the groundwater to equilibrate will allow for accurate readings. The groundwater is equilibrated when the water level is stable. If the transducer is not decontaminated correctly between locations, it is possible for cross-contamination to occur. Follow decontamination procedures in SOP 7. Sufficient time (approximately 5 minutes) needs to be allowed for transducer to equilibrate with the groundwater temperature to avoid instrument drift.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Field personnel are required to have sufficient knowledge and experience for completing hydraulic testing.

VI. Equipment and Supplies

- Electronic water level meter;
- Vented or non-vented pressure transducer (pressure range of 35 feet/11 meters/15 psi);
- Laptop computer with appropriate software;
- Submersible pump with flow controller/meter;
- Field log; and
- Decon equipment for transducer, pump and electronic water level meter.

VII. Low-Flow Drawdown Test Procedures

1. Measure water level (Refer to SOP 13) or record packer depth.

2. Collect all field measurements on the supplied field log. Decontaminate the probe and tape (Refer to SOP 7).
3. Lower the submersible pump such that the intake of the pump is approximately at the middle of the saturated portion of the well screen and lower the transducer above the pump. Note: be certain not to exceed the maximum depth rating of the transducer.
4. Attach transducer to the laptop computer running the appropriate software. The transducer should be set to record readings at 1 second intervals. Start the data recording on the computer and pressure transducer.
5. Monitor the transducer to record sufficient background and ensure groundwater levels are steady for at least 5 minutes.
6. Turn on submersible pump and record flow rate and start time.
7. Monitor transducer output and adjust flow rate to maintain/achieve a maximum drawdown of approximately 20% of the initial water column and not exceed 1000 mL/min. If flow rate requires rates greater than 1000 mL/min, stop and communicate to field team leader. A pneumatic slug test may need to be completed.
8. If the well diameter permits, periodically check the drawdown manually using a water level indicator. Be certain to record these checks in the field log book.
9. Record flow rate adjustment times and flow rates.
10. After approximately 15 minutes, stop pump and monitor transducer output for 15 minutes or until 90% recovery is achieved. Record pump stop time.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms and saved on the laptop and flashcard for double backup.

IX. Data Analysis

The pumping test data will be analyzed using AQTESOLV® to estimate the hydraulic conductivities of each interval tested. AQTESOLV® assists in graphically and automatically matching type curves or straight lines to drawdown curves to solve empirical and partial differential equations describing fluid flow through a porous media. While a completely unique solution to each pumping test may not be possible, AQTESOLV can provide a range of solutions from which a relative hydraulic conductivity value can be determined.

X. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

XI. References

Robbins, G.A., A.T. Aragon-Jose, A. Romero, 2009. Determining Hydraulic Conductivity Using Pumping data from Low-Flow Sampling. Ground Water, Vol. 47, No. 2, p. 271.

RACER Trust
Moraine, Ohio

SOP 12 - INSTALLATION OF GROUNDWATER MONITORING WELLS

Rev #: 1.0

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APPROVAL SIGNATURES

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05/17/2017

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The procedure set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) hydraulic conductivity testing of formations adjacent to the open interval of the well.

3 SUMMARY OF METHOD

Monitoring wells are installed to monitor discrete intervals within a hydrogeologic system. Drilling methods utilized for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, cable-tool, spun casing, sonic, dual-rotary (Barber Rig), hollow-stem auger, and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary, mud rotary, cable-tool, or sonic methods. The drilling

method to be used will be selected based on site-specific consideration of anticipated drilling/well depths, site geology, type of monitoring to be conducted, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. All well construction materials will be new, re-used well materials will not be utilized. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- Well casing;
- Screen;
- Bentonite;
- Sand; and
- Grout.

4 INTERFERENCES

The improper placement of the well screen could lead to a dry monitoring well. The primary concern when installing groundwater monitoring wells is to place the well screen across the appropriate interval within the water bearing unit.

- While drilling, care should be taken not to allow cross communication with significant water bearing units if possible. Properly placed casing and well seals should be used to prevent this communication.
- Well materials should be chosen which are compatible with any contaminants that may be encountered. Some materials (e.g. PCV) might dissolve over time when exposed to solvents in high concentrations.
- Well should be properly installed with correct well slot size vs. sand pack, surface infiltration; well seal; etc.

5 PERSONNEL QUALIFICATIONS

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

6 EQUIPMENT LIST

The following materials will be available to Arcadis personnel during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan of Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);

- Personal protective equipment (PPE), as required by the HASP;
- Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- Appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- Soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- Appropriate sample containers and labels (See Appendix B);
- Drum labels as required for investigation derived waste handling;
- Chain-of-custody forms (see Appendix B);
- Insulated coolers with ice, when collecting samples requiring preservation by chilling;
- Photoionization detector (PID);
- Ziploc style bags;
- Water level or oil/water interface meter;
- Locks and keys for securing the well after installation;
- Decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels); and
- Daily Log and/or field notebook.

Prior to mobilizing to the site, Arcadis personnel will contact the drilling subcontractor to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- Drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- Disposable plastic liners, when drilling with direct-push equipment;
- Well screen materials;
- Well riser materials;
- Well construction materials;
 - o Bentonite hole plug
 - o Appropriate-sized sand pack
 - o Well vault or pro-casing
 - o Cement
 - o Powdered bentonite
- Well construction/boring log, for ODNR;
- Weighted measuring tape;
- Drums/containers for investigation derived waste;
- Drilling and sampling equipment decontamination materials; and
- Decontamination pad materials, if required.

7 CAUTIONS

- Pressure Transducers/Data Loggers
 - o Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
 - o Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).

- o To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
- o For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
- o For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
- o In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
- o Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
- o Sufficient background water levels should be recorded (at least 12 to 24 hours).
- o Logarithmic or head-change settings should not be used to log data, only linear.
- o Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.
- Data Recording and Management
 - o All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
 - o Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidentally lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
 - o Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care

- o Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination (see SOP X)
 - o Make sure all equipment that enters the test wells (pump, water-level meter, pressure transducer) is decontaminated before use.
- Weather
 - o Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in most cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

8 HEALTH AND SAFETY CONSIDERATIONS

There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated. Further, there are always physical hazards related to operation of a drill rig. The HASP should be consulted prior to performing borehole or well installation activities.

9 GROUNDWATER MONITORING WELL INSTALLATION

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.
2. The screened interval will be determine based on field observations, scope, and discussed prior to monitoring well installation.
3. Install the well to the total depth specified after conducting a soil boring investigation. No PVC Cements are to be used during the well construction.
4. Sound the bottom of the well with weighted measuring tape and subtract the portion of the well which is above the land surface (or add the distance from land surface to the top of the well casing if the well is below land surface) to determine if the well screen is being placed in the correct interval. If the boring is too deep and the annulus has not collapsed – fill void with bentonite chips to no more than 2 feet below depth of the bottom of screen. Hydrate chips and let rest for a sufficient amount of time for expansion– re-measure – fill remaining void with sand and set well in borehole.
5. Center well screen and casing in borehole.
6. Place the sand (or gravel) pack around the well screen and install to 2-feet above the well screen. Drill casing should be removed slowly during emplacement of the sand pack. Sound the sand pack top to confirm placement depth and record on well construction log. Sounding is completed to verify that the sand being placed does not “bridge” or create voids.

For wells with natural formation pack screen design, the natural formation pack will be installed in accordance with Ohio EPA technical guidelines (Ohio EPA 2008) based on grain size analyses. Grain size analysis results will be used to determine the optimal slot size (in relation to interval depth) for custom well screens and will be at least a 70% design retention of the formation.

7. Pre-develop well following SOP 13.
8. Place at least 3-feet of bentonite chips on top of the sand pack and hydrate the chips with potable water if above saturation. Drill casing should be removed slowly during emplacement. Care should be taken to ensure that the chips do not bridge in the annulus between the well casing and the wall of the borehole. Let the hydrated chips rest for an extended period of time to allow sufficient expansion of the bentonite and record depth on well construction log.
9. Mix a cement/bentonite grout and install using a tremie-pipe to approximately 3 feet (frost line). Allow grout to settle for a sufficient amount of time.
10. Install a lockable protective pro-casing or flush mount well vault and secure in place with a concrete pad. Ensure that the cement extends to grout level just below frost line to prevent heaving.
11. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.
12. During typical installation of steel pro-casings, bollards are placed around the well for protection. The bollards and casings should be painted with a bright color to increase visibility.
13. Label the well with the correct ID using a permanent method. Secure the pro-casing or well cap with a lock.

10 DATA AND RECORD MANAGEMENT

Drilling activities will be documented in a field notebook (SOP 18). Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features. The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed by a licensed surveyor in the state of Ohio. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. (Water Level measurement SOP 16). Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

11 QUALITY ASSURANCE

After the completion of the electronic logs they will be compared to the original field logs to ensure accuracy.

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP 7.

12 REFERENCES

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, Chapter 7: Monitoring Well Design and Installation, February 2008.
http://epa.ohio.gov/ddagw/gw_support.aspx#126913976-technical-guidance-manual-tgm

SOP 13

Groundwater Monitoring Well Development

Motors Liquidation Company

Moraine, Ohio

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Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for development of groundwater monitoring wells, used for water levels, hydraulic testing, and groundwater sampling. The method described below is for the predevelopment and development of wells through the use of a submersible pump (Ohio EPA, R.1, 2008).

When developing a well using the pumping method, the pump is lowered to the screened portion of the well. During purging, the pump is moved up and down the screened interval to remove fines including silt. Optionally, a surge block may also be used in addition to the pumping.

II. Summary of Method

The predevelopment of monitoring wells involves removing water from the drill casing before installing the sand pack and surging and removing water after the well and sand pack has been installed, but prior to casing removal and annular seal installation. The development of groundwater monitoring wells is completed to ensure the removal of all water related to the drilling process and fine materials (i.e. silt). The determination that formation water is entering the well is completed by monitoring the yield, groundwater chemistry, and turbidity. Development also ensures that the groundwater enters the well as readily as possible given the hydraulic properties and conditions of the producing formation. This process ensures the collection of a representative sample and accurate hydraulic testing results.

III. Health and Safety Considerations

There are specific health and safety concerns or cautions related to the development of groundwater monitoring wells: 1). repetitive motion with surging and setting the pump; 2). and there is direct-contact, ingestion, and inhalation concerns on sites where groundwater is contaminated. Further, there are physical hazards related to operation of a groundwater pump. The site-specific health and safety plan should be consulted prior to performing well development activities.

IV. Interferences

The presence of non-aqueous phase liquids (NAPL) could be encountered during the drilling and well installation process. If NAPL is present, measures should be taken for recovery and surging should not take place to prevent smearing across formation.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site-specific required training, prior to engaging in any field activities. Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

VI. Equipment and Supplies

- Monitoring well keys;
- Bailers (dedicated or disposable) in the scenario in which NAPL is present;
- Submersible Pump with Controller;
- Tubing (disposable or dedicated);
- 12 volt DC power source, (i.e. generator or battery);
- Graduated pails or containers;
- Purge water tank or drum;
- Electronic Water Level Meter (Oil Water Interface probe, if applicable);
- Water Quality Meter; and
- Daily Log and/or field book (see Appendix B).

VII. Groundwater Monitoring Well Predevelopment

1. When drill casing is at the total well depth, check for NAPL (SOP 17).
2. If NAPL is present, recover as much as possible using a disposable bailer.
3. If NAPL is not present, then calculate the volume of water in the casing and then remove the water from casing using a submersible pump. If the casing recharges as much as the pumping rate – remove at least one well volume.
4. Install the well, well sand pack according to SOP 12.
5. Before installing the filter pack and annular seal with the casing still at the top of the sand pack at depth, lower a submersible pump and follow steps 6 through 8 (do not raise and lower pump across the well screen if NAPL is present).
6. Removal at least three well volumes.
7. Check depth of sand pack to make sure settling has not occurred.
8. If the sand pack has settled, then add additional sand to the proper level.
9. Continue with well installation.

VIII. Groundwater Monitoring Well Development

NOTE: Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

1. The monitoring well must have been installed 48 hours prior to development for proper cure of the annular seal.
2. Check for the presence of NAPL (SOP 17).
3. If NAPL is present, recover as much as possible using a disposable bailer and in Step 7 – do not raise and lower pump across screen.

4. Measure depth to water and total depth and calculate well volume.
5. Ensure pump is clean, if not decontaminate pump (SOP 7).
6. Attach pump to tubing and lower pump to the approximated depth of the top of screen.
7. Lower the pump down the screen and repeat in reverse raising the pump to the top of the screen until groundwater becomes less turbid if not already clear. During this process start the pumping at a low rate (about 100 to 200 mL/min) and increase to at least 10 times towards the end.
8. If the turbidity does not improve – increase the pumping rate.
9. Continue pumping taking the below groundwater quality measurements every well volume (following modified table from Ohio EPA).

Parameter	Stabilization
pH	± 0.1
Specific Conductance	± 3%
Temperature	± 1° C
Turbidity	± 10% (when turbidity is greater than 10 NTUs)
Oxidation-Reduction Potential (ORP)	± 10 mv
Dissolved Oxygen (DO)	± 0.3 mg/L

10. The well is properly developed when the above parameters have stabilized over three well volumes and sediment in well is ≤ 0.1 feet.
11. If the well goes dry, stop pumping immediately. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping when sufficient water has recharged the well.
12. If the parameters have not stabilized, then the well is considered developed when:
 - another method is tried,
 - well construction is verified to be correct,
 - turbidity is within $\pm 10\%$ over 3 successive well volumes,
 - conductivity and pH have stabilized, and
 - sediment in well is ≤ 0.1 feet.

IX. Data and Record Management

Well development activities will be documented in a proper field notebook (SOP 18). Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original field logs to ensure accuracy.

XI. References

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, 2010.
<http://www.epa.state.oh.us/ddagw/tgmbew.aspx>

SOP 14

Low Flow Sampling

Motors Liquidation Company

Moraine, Ohio

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Approval Signatures



Prepared by: _____
Trey Fortner

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Jason Manzo

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I. Scope and Application

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and collect groundwater samples. Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter.

II. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. All personnel are also required to have experience with groundwater sampling by low-flow methodology.

III. Equipment List Specific to this activity, the following materials (or equivalent) will be available:

- Site Plan, well construction records, prior groundwater sampling records (if available).
- Sampling pump, which may consist of one or more of the following:
 - o Submersible pump,
 - o Peristaltic pump, or
 - o Bladder pump.
- Appropriate controller and power source for pump;
- Tubing;
- Electronic Water-level meter;
- Water-quality (temperature/pH/specific conductivity/ORP/dissolved oxygen) meter and flow-through measurement cell;

- Appropriate water sample containers (supplied by the laboratory);
- Appropriate blanks (trip blank supplied by the laboratory);
- 0.45-micron disposable filters (if field filtering is required);
- Decontamination equipment (SOP 7); and
- Groundwater sampling log (Appendix B).

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers.

VI. Procedure

1. Calibrate field instruments according to manufacturer procedures for calibration.
2. Measure initial depth to groundwater prior to placement of pumps (SOP 16).
3. Prepare and install pump in well: Slowly lower pump, tubing, and leads into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of tubing and leads while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.
4. Connect the pump to other equipment. If using a bladder pump, the discharge water line should be connected to the bottom inlet port on the flow-through cell connected to the water quality meter. Connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin

the gas flow. Turn on the pump controller if an on/off switch is present and verify that all batteries are charged and fully operating before starting pump.

5. Measure the groundwater level again (SOP 16) with the pump in the well before starting the pump. Start pumping the groundwater at 200 to 500 milliliters (mL) per minute. The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement) and the water level should stabilize. The water level should be monitored every 3 to 5 minutes during pumping if the well diameter is of sufficient size to allow such monitoring. Care should be taken not to break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to groundwater. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition. If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

During purging, monitor the field indicator parameters (e.g., temperature, specific conductance, and pH) every 3 to 5 minutes (or as appropriate). Field indicator parameters will be measured using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log (SOP 18). The well is considered stabilized and ready for sample collection when the specific

conductance and temperature values remain within 3%, and pH remains within 0.1 units for three consecutive readings collected at 3- to 5-minute intervals. If the field indicator parameters do not stabilize within 30 minutes of the start of purging the well can be sampled.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

6. Complete the sample label and cover the label with clear packing tape to secure the label onto the container (SOP 2).
7. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others.
8. If sampling for total and filtered metals, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container. When the container is full, tightly screw on the cap.
9. Secure with packing material and store at 4°C in an insulated transport container (SOP 2).

10. Record on the groundwater sampling log or bound field logbook or PDA the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Appendix B).
11. Turn off the pump or air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing and leads from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
12. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.
13. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.
14. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody (SOP 2).
15. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate (SOP 7).

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client.

VIII. Data Recording and Management

Field logs or PDA files and chain-of-custody records will be transmitted to the ARCADIS TM/PM at the end of each day unless otherwise directed by the TM/PM.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.
- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well) see SOP 15.
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook (SOP 2).
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination (SOP 7).

IX. Quality Control and Quality Assurance

Duplicate groundwater samples will be collected at a rate specified in the QAPP to ensure accuracy when sampling.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA Region II. 1998. Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling.

SOP 15

Equipment Blank Collection

Motors Liquidation Company

Moraine, Ohio

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Approval Signatures



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Trey Fortner

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Joseph Rumschlag

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Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for collecting equipment blanks, sometimes referred to as rinse blanks, which are used for validated data collected using non-disposable sampling equipment. If disposable and/or dedicated sampling equipment is used, this SOP is not applicable as it is assumed that there is no chance for cross-contamination between sampling locations and samples.

II. Summary of Method

Equipment blanks are collect by rinsing decontaminated, no-dedicated sampling equipment with laboratory grade deionized (DI) water, collecting the rinse water in sample containers, and submitting the samples for laboratory analysis. The resulting data are used to validate samples collected during a given environmental investigation.

III. Health and Safety Considerations and Cautions

Care should be taken when handling sample containers with preservatives which could be harmful. Preserved containers could off-gas when opened and/or be caustic. Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions. Appropriate personal protective equipment (PPE) must be worn by all field personnel within the designated work area.

IV. Interferences

If the equipment to be used is not correctly decontaminated, the equipment blank sample could indicate the presence of contaminants. This could lead to questionable data collected during a given field program.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any required site specific or client training requirements. ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

VI. Equipment and Supplies

The following materials will be available, as required, when collecting equipment blank samples:

- Decontaminated sampling equipment (SOP 7),
- Laboratory grade DI water,
- Appropriate sample containers and forms,
- Daily Log and/or field notebook (Appendix B); and
- Nitrile gloves.

VII. Equipment Blank Sampling Procedures

Equipment blank from a split-spoon sampler

1. Ensure that the split-spoon sampler has been appropriately decontaminated.
2. Don clean nitrile gloves.
3. Set the equipment up so that it will be possible to pour the laboratory grade DI water down the center of the inside of the split-spoon sampler, or other deconned equipment, and into the laboratory prepared sample containers.
4. Slowly pour the laboratory grade DI water down the center of the inside of the split-spoon and into the sample container.
5. Once the sample container is filled, seal the sample and label it with the appropriate ID, time, date, and requested analysis.
6. Place the sample in an ice-filled cooler and fill out the sampling information in the daily log and/or logbook. In addition, the Chain-of-Custody should be completed with the appropriate sample information (SOP 2).

Repeat steps 1-6 above, as necessary, with additional non-dedicated sampling equipment at the frequency prescribed in the Quality Assurance Project Plan (QAPP).

VIII. Data and Record Management

Sample identification, equipment used (if appropriate), sample date and time will be recorded in the field notebook, and/or the boring log (SOP 17). The sample will also be identified on an appropriate chain-of-custody form, for submittal to an analytical laboratory for analysis.

IX. Quality Control and Quality Assurance

Equipment blanks will be collected on the interval as set forth in the QAPP. After the equipment blank sample data is received from the laboratory, it will be reviewed and used for data validation purposes.

X. References

None.

SOP 16

Water Level Measurements

Motors Liquidation Company

Moraine, Ohio

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Trey Fortner

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Joseph Rumschlag

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Jason Manzo

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I. Scope and Application

This standard operating procedure (SOP) is for accurately measuring the depth to water in a monitoring well and the total depth of a monitoring well using an electronic water level meter. The purpose of this procedure is to provide uniformity of method so that accurate water level data are always generated. The collection of accurate water level and total depths is critical for determining the center of well screens and the direction of water flow.

II. Summary of Method

Water level and total depth measurements are collected using an electronic water level probe attached to a tape graduated in hundredths of feet.

III. Health and Safety Considerations and Cautions

- Care should be taken when lowering and removing the water level meter from the well as to not run the tape along a jagged surface, doing this could lead to removal of the insulation around the tape and create a short circuit in the meter rendering it useless.
- Prior to unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).
- When removing the well caps, there is potential for the release of harmful vapors, the well should be off-gassed using a pressure release valve, if installed, and the air should be monitored for potential harmful landfill gases. The site-specific health and safety plan must be reviewed before performing field activities.

IV. Interferences

- If the groundwater is not allowed to equilibrate before a reading is measured an artificially high or low reading could be recorded. Allowing sufficient time for the water to equilibrate will allow for accurate readings.
- If the water level meter is not decontaminated correctly between wells it is possible for cross-contamination to occur.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any site-specific training prior to engaging in field activities.

VI. Equipment and Supplies

- Electronic water level meter,
- Water sampling log and/or depth to water form (Appendix B),
- Daily Log and/or field logbook (Appendix B); and
- Decontamination equipment.

VII. Water Level Measurement Procedures

1. Check that the water-level indicator battery is functional.
2. Decontaminate the probe and tape (Refer to SOP 7).
3. Ensure that the monitoring well to be measured is correctly identified.
4. Remove cap from well and check for the reference mark. Allow sufficient time for groundwater within the well to equilibrate to atmospheric pressure.
5. Slowly lower the probe into the center of the well until a contact with the groundwater surface is indicated, either by audible alarm and/or light, and note depth measurement to 0.01 feet from the reference mark.
6. Mark and hold the tape at the contact point and repeat the measurement to ensure groundwater has equilibrated.
7. Turn off the power and sound the well (i.e., lower the tape to the bottom of the well). Record the depth to 0.01 feet.

8. Retract the tape by winding onto the spool, wiping with a disposable paper towel with distilled water as it comes out of the well. Decontaminate the retracted tape and probe (SOP 7).

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

None.

SOP 17

NAPL Measurements

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures



Prepared by: _____
Trey Fortner

Date: November 5, 2010



Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010



Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is for accurately measuring the thickness of light NAPL (LNAPL) and the thickness of dense NAPL (DNAPL) in a monitoring well. The purpose of this procedure is to provide uniformity of method so that accurate NAPL thickness data are always generated and that correct intervals are targeted for sampling or well construction. In addition, because this SOP describes water-level measurement from surveyed measurement points, this SOP can be followed, to obtain water level measurements from surveyed measurement points on the monitoring wells.

II. Summary of Method

Measurements to depth to products, water levels, and total depths in wells which exhibit NAPLs are collected by lowering an oil-water interface probe with a tape graduated in hundredths of feet.

III. Health and Safety Considerations and Cautions

When opening the wells they should be vented first to allow any gases to escape.

- Care should be taken when lowering and removing the oil-water interface probe from the well as to not run the tape along a jagged surface, doing this could lead to removal of the insulation around the tape and create a short circuit in the meter rendering it useless.
- The oil-water interface probe should be grounded because the NAPL is typically flammable and/or explosive.

IV. Interferences

- If the water is not allowed to equilibrate before a reading is collected an artificially high or low reading could be recorded if there is a vacuum in the well. Allowing sufficient time for the water to equilibrate will allow for accurate readings.
- If the water level meter is not decontaminated correctly between wells it is possible for cross-contamination to occur.

- The oil/water interface probe can become coated with LNAPL, leading to an artificial thickness reading.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course, associated 8-hour refresher courses, and the any site-specific required training prior to engaging in any field activities. Individuals conducting fluid level measurements will have been trained in the proper use of the instruments, including their use for measuring fluid levels and the bottom depth of wells.

VI. Equipment and Supplies

- Oil-water interface probe;
- Photoionization Detector (PID);
- Any appropriate PPE as required by the Site Specific HASP;
- Water sampling log and/or depth to water form (Appendix B);
- Daily Log and/or field notebook (Appendix B); and
- Decontamination equipment.

VII. Measurement Procedures

The detailed procedure for obtaining fluid level depth measurements is as follows. Field notes on logs will be treated as secured documentation and indelible ink will be used. As a general rule, the order of measuring should proceed from the least to most contaminated monitoring wells, based on available data

1. Check that the oil-water interface battery is functional.
2. Decontaminate the probe and tape (SOP 7).
3. Ensure that the well to be measured is correctly identified.

4. Unlock well, vent cap by releasing the pressure valve, remove cap and let stand until water equilibrates in the well. Monitor concentrations of the gases in the well with appropriate air monitoring equipment and record the values on the daily field log and/or log book and the water sampling log.
5. Allow sufficient time for groundwater within the well to equilibrate to atmospheric pressure.
6. Locate a measuring reference point on the well casing. If one is not found, initiate a reference point at the highest discernable point on the inner casing (or outer if an inner casing is not present) by notching with a hacksaw, or using an indelible marker. All down-hole measurements will be taken from the reference point established at each well on the inner casing (on the outer only if an inner casing is not present).
7. Lower the probe into the center of the well until a contact with the LNAPL (typically a solid beep) or water surface (typically an intermittent beep) is indicated, either by audible alarm or light, and note depth to 0.01 feet.
8. Mark and hold the tape at the contact point and repeat the measurement.
9. If LNAPL is encountered (Step 5), continue to slowly lower the probe until water is contacted (typically indicated by change from intermittent to a solid beep). Calculate and record the thickness of the LNAPL. It should be noted that this can be difficult due to the fact that the LNAPL might coat the probe.
10. Continue to slowly lower the probe through the water column until DNAPL is detected (typically indicated by a change back to intermittent beep) or until the bottom of the well is reached.
11. If DNAPL is encountered, continue to slowly lower the probe until the bottom of the well is reached. Record the depth of the bottom of the well to 0.01 feet. Calculate and record the thickness of DNAPL.

12. Turn off power and retract the tape by winding onto the spool, wiping with a disposable paper towel with distilled water as it comes out of the well.

Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.

If field forms are input or tabulated electronically after the field program, they should be compared to the original field forms to ensure accuracy.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

None.

SOP 18

Field Book Entry Procedures

RACER

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures

A handwritten signature in blue ink, appearing to read 'Trey Fortner', written over a horizontal line.

Prepared by: _____
Trey Fortner

Date: November 5, 2010

A handwritten signature in blue ink, appearing to read 'Joseph Rumschlag', written over a horizontal line.

Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010

A handwritten signature in blue ink, appearing to read 'Jason Manzo', written over a horizontal line.

Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) covers the entries needed in a field log book for environmental investigations. This SOP does not address all of the entries that may be needed for a specific project, and does not address health and safety, equipment decontamination, field parameter measurements, sample preservation, chain-of-custody, or laboratory analysis.

II. Summary of Method

This SOP will assist field personnel in identifying the proper procedures need to document activities needing recorded during a field investigation.

III. Health and Safety Considerations and Cautions

Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions.

IV. Interferences

Poor handwriting can lead to misinterpretation of written information, as best as practical, care should be taken when handwriting data. Where possible and appropriate, electronic data capturing devices should be considered.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any required site specific or client training requirements.

VI. Equipment and Supplies

- Daily log and/or field log book.
- Ball point (medium point) pen with blue or black ink. A fine point Sharpie pen may be used if the ink does not bleed through the page and become visible on back side of the page. If weather conditions prevent the use of a pen, indicate so in the log and use an alternate writing instrument. A write-in-the-rain™ pen can also be utilized in adverse weather conditions.

- Zip-lock baggie or other weather-proof container to protect the field log book from the elements.

VII. Field Log Book Entry Procedures

- Print legibly. Do not use cursive writing.
- The name of the project, project number and project location should be written in indelible ink on the outside of the field log book.
- On the inside of the front cover, write "If Found, Please Return to ARCADIS" and include the appropriate address and phone number, the name of the person to which the book is assigned, and the name of the project manager.
- Reserve the first page of the book for a Table of Contents.
- Reserve the last five (5) pages of the book for important contacts, notes, reminders, etc.
- Each day of field work, the following should be recorded in the field log book as applicable:
 - a) Project Name.
 - b) Date and time arrived.
 - c) Work Site Location.
 - d) Names of people on-site related to the project including ARCADIS employees, visitors, subcontractor employees, agency personnel, client representative, etc.
 - e) Describe the work to be performed briefly, and list the equipment on-site.
 - f) Indicate the health and safety (H&S) level to be used.
 - g) Record instrument calibrations and checks.
 - h) Record time and general content of H&S briefing.

- i) Describe the weather conditions, including temperature, precipitation, and wind speed and direction.
- j) List periodic time entries in the far left hand column of each page.
- k) Minimize unused space on each page.
- The tailgate meeting must be recorded in the log book and the tailgate form completed (see HASP). If health and safety monitoring is performed, record the time and results of initial and follow-up monitoring.
- Note factual observations including collection of QA/QC samples, delays, well damage, accidents, work plan deviations, instrument problems, and problem resolutions.
- Describe work performed and how documented such as photographs, sample core logs, water sampling logs, etc.
- Describe bases for field decisions including pertinent conversations with visitors, regulators, or project personnel.
- Note final instrument calibrations and checks.
- Sign the log book at the end of each day at a minimum. Draw a line to the end of the page to indicate no further entries on that page. Sign and date the bottom of each page if possible.
- If an entry to the log book is changed, strike out the deleted text or item with a single line such that the entry remains legible, and initial and date the change. Such changes should only be made by the same person that made the initial entry.
- Field log book entries must be made in the field at the site, not at a later time at a different location. Supplemental entries to the log book may be made at a later date. The supplemental entry must be clearly identified as such and the entry must be signed and dated as described in this SOP.
- Problems noted in the field log book must be brought to the attention of the project manager and task manager in a timely fashion. Problems may be

reported in person, on the telephone, or in a written daily log form. If daily logs are prepared and you will not be able to personally give the daily log to the project manager, send the daily log via FAX or overnight courier to the project manager and task manager.

VIII. Data and Record Management

Each page of the field log book should be scanned for electronic/digital archiving at periodic intervals. This will ensure that copies of the field notes are available in the event the field book is lost or damaged, and that field data can be easily disseminated to others without the risk of physically sending the field log book. Field log books that are full should be archived with the project files, and readily retrievable.

IX. Quality Control and Quality Assurance

None.

X. References

None.

SOP 19

Compositing or Homogenizing Samples

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

Approval Signatures

A handwritten signature in blue ink, appearing to read 'Trey Fortner', written over a horizontal line.

Prepared by: _____
Trey Fortner

Date: November 5, 2010

A handwritten signature in blue ink, appearing to read 'Joseph Rumschlag', written over a horizontal line.

Reviewed by: _____
Joseph Rumschlag

Date: November 5, 2010

A handwritten signature in blue ink, appearing to read 'Jason Manzo', written over a horizontal line.

Approved by: _____
Jason Manzo

Date: November 5, 2010

I. Scope and Application

This standard operating procedure (SOP) is to be used when composting/homogenizing solid and semisolid samples as outlined below.

II. Summary of Method

This SOP will assist field personnel in identifying the proper procedures need to composite solid or semi-solid samples for analysis.

III. Health and Safety Considerations and Cautions

Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions. Appropriate personal protective equipment (PPE) must be worn by all field personnel within the designated work area. Air monitoring may be required during certain field activities as required in the Site Health and Safety Plan.

IV. Interferences

- The field crew must be aware of the potential chemicals of concern (COCs), and equipped with a variety of sample homogenizing equipment. The field crew must take care not to use equipment that may react with suspected COCs. For example, stainless steel implements should not be used to homogenize strongly acidic materials.
- Soil, sediment, sludge and other solid/semisolid materials that are easily mixed should be thoroughly homogenized. Excessive, vigorous mixing should be avoided as COCs can be mobilized/liberated posing a health and safety risk and diminishing the representativeness of the sample.
- Implements used for compositing/homogenizing should be thoroughly decontaminated between samples. A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of equipment/supplies that are to be shipped.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any

field activities along with any required site specific or client training requirements. ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work.

VI. Equipment and Supplies

The following materials will be available, as required, when compositing or homogenizing samples:

- Personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- Stainless steel, plastic, glass or ceramic spoon (or disposable equivalent);
- Stainless steel, plastic, glass or ceramic bowl (or disposable equivalent);
- Stainless steel, plastic, glass or ceramic jar/bottle (or disposable equivalent);
- Shovel or trowel;
- Decontamination supplies;
- Digital camera;
- Appropriate sample containers and forms; and
- Field notebook.

VII. Field Log Book Entry Procedures

Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample. The procedure for mixing samples is provided below:

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless steel spoon (or disposable equivalents). When dealing with large sample quantities, use disposable plastic sheeting and a shovel or trowel. Note: When preparing samples for metals analyses, do

not use disposable aluminum (or metal tools or trays other than stainless steel), as it may influence the analytical results.

2. Flatten the pile by pressing the top without further mixing.
3. Divide the circular pile by into equal quarters by dividing out two diameters at right angles.
4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting.
5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite or homogenous sample.
6. Place composite or homogenized sample into specified containers. Remaining material will be disposed of in accordance with project requirements and applicable regulations.

VIII. Data and Record Management

Sample identification, interval depth (if appropriate), sample date and time will be recorded in the daily log or field notebook, and/or the boring log. The sample will also be identified on an appropriate chain of custody form, for submittal to an analytical laboratory for analysis. Consider digital photography to record unusual field conditions or to document compliance (i.e. proper labeling and storage of drums/IDW containers).

IX. Quality Control and Quality Assurance

All materials to be re-used for sample compositing/homogenizing will be decontaminated as appropriate.

X. References

None.

SOP 20

Sub-Slab Soil-Gas Point Installation and Sampling

RACER

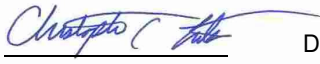
Moraine, Ohio

Rev. #: 1.2

Rev Date: February 10, 2011

Approval Signatures

Prepared by:  Date: July 7, 2010
Mitch Wacksman

Approved by:  Date: July 7, 2010
Christopher Lutes

Modified by:  Date: Revised, February 10, 2011
Mitch Wacksman

Modified by:  Date: Revised, December 3, 2010
Joseph Rumschlag

I. Scope and Application

This document describes the procedures for installing permanent sub-slab sampling points and collecting soil-gas samples using permanent points. Samples from the points are collected in an evacuated 1-liter SUMMA[®]-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of permanent sub-slab soil-gas points and the collection of sub-slab soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For sub-slab soil-gas point installation, drilling with an electric concrete impact drill should be completed only by personnel with prior experience using such a piece of equipment and with the appropriate health and safety measures in place as presented in the JLA. It is possible to encounter high

concentrations of VOCs in sub-slab soil-gas, so the amount of time the borehole remains open should be minimized. For the same reason, when installing sub-slab points in spaces with minimal dilution potential, such as closets, it may be necessary to provide local ventilation. Finally, sub-slab point installation should be completed after any indoor air sampling to avoid cross contamination of the indoor air samples.

IV. Equipment List

The equipment required to install a permanent sub-slab soil-gas point is presented below:

- Appropriate personal protective equipment (PPE; as required by the site specific HASP and the JLA)
- Electric hammer drill (e.g., Bosch®, Hilti®, etc.);
- 5/8-inch and 1 1/2-inch diameter concrete drill bits for impact drill (drill bit length contingent on slab thickness);
- Decontaminated soil-gas point (typically 3-inch stainless steel pipe 9/16-inch OD [1/4-inch NPT threads on one end], 1/4-inch NPT female coupling, stainless steel Swagelok® fitting (or similar) bored through male connector [1/4-inch tube OD x 1/4 inch male NPT]), and stainless steel Swagelok® (or similar) plug for 1/4-inch tube fitting;
- Extra 1/4-inch Swagelok® front and back compression sleeves;
- Tubing cutter with heavy-duty cutting wheel;
- Hand tools, including open-end wrench (typically 9/16-inch), pliers, Channel Lock® pliers, etc.;
- Teflon® tape;
- Quick-setting non-shrink grout powder;
- Modeling clay (VOC free and non-drying);
- Potable water for mixing grout;

- Disposable cups and spoons for mixing grout;
- Spray bottle with potable water;
- Broom and dust pan;
- Paper towels;
- Nitrile gloves;
- Work gloves;
- Knee pads;
- Bottle brush;
- Ground fault circuit interrupter (GFCI);
- Extension cords capable of amperage required for hammer drill;
- Plastic sheeting; and
- Shop vacuum with clean fine-particle filter

The equipment required for sub-slab soil-gas sample collection is presented below:

- 1-liter stainless steel SUMMA[®] canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 30 minutes) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch OD Teflon[®] tubing;
- 1/4-inch Swagelok[®] by 1/8-inch NPT male stainless steel coupling;
- Extra 1/4-inch Swagelok[®] front and back compression sleeves;

- Decontaminated stainless steel Swagelok® or comparable “T” fitting and needle valve for isolation of purge pump;
- Stainless steel duplicate “T” fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);
- Portable vacuum pump capable of producing very low-flow rates (e.g., 50 to 200 mL/min);
- Electric flow sensor (Bios DryCal® or equivalent);
- Tracer gas testing supplies (refer to “Administering Tracer Gas” SOP #21);
- Appropriate-sized open-end wrench (typically 9/16-inch and 1/2-inch);
- Tedlar® bag to collect purge air or length of tubing sufficient to vent it outside the structure;
- Compound pressure/vacuum gauge;
- Portable weather meter, if appropriate;
- Chain-of-custody (COC) form;
- Sample collection log (attached);
- Nitrile gloves;
- Work gloves;
- Field notebook.

V. Procedure

Permanent Sub-Slab Soil-Gas Point Installation

Permanent sub-slab soil-gas points are installed using an electric drill and manual placement of the sub-slab point. After a dry fit, the sub-slab point is inserted into the hole and grouted with a quick-setting, non-shrink grout powder. The soil-gas point is equipped with a plug. The plug is removed and a compression fitting nut and ferrules are used to allow collection of a sub-slab soil-gas sample through Teflon[®] tubing. The sub-slab point and tubing will be purged with a portable sampling pump prior to collecting the sub-slab soil-gas sample. Detailed installation methods are as follows:

1. Complete utility clearance in accordance with ARCADIS Utility Locate SOP with assistance from Ohio Utility Protection Service (OUPS) prior to drilling activities.
2. Assemble the sub-slab sample point assembly. Teflon[®] tape should never be used with Swagelok[®] connections; it should be used on normal NPT threads.
3. Remove, only to the extent necessary any covering on top of the slab (e.g., carpet).
4. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.
5. Advance the 1 1/2-inch drill bit approximately 2 1/2 inches into the slab. This hole is drilled deep enough to permit the top of the sampling point to be set flush with the slab when the 1/4-inch tubing (9/16-inch OD) is inserted into the 5/8-inch hole drilled under Step 6, below. Clean up cuttings with shop vacuum, bottle brush, and dust pan.
6. Drill a 5/8-inch-diameter hole into the concrete slab using the electric drill. Do not fully penetrate the slab at this time. Stop drilling approximately 1 inch short of penetrating the slab. To gage this, a typical concrete slab is 4-6 inches thick. Therefore, stop drilling at 3 inches.
7. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

8. Advance the 5/8-inch drill bit the remaining thickness of the slab and approximately 3 inches into the sub-slab material to create an open cavity.

Note (if possible) from the drill cuttings any evidence for the types of materials in the immediate sub-slab – i.e. moisture barriers, sand, gravel, etc.

9. Use the bottle brush, whisk broom, and dust pan to quickly clean material around and within the hole. The hole should not be left open for any extended length of time to ensure that VOCs below the slab do not migrate into indoor air (plug with clay during clean up). Do not use the shop vacuum to clean up the drill hole after the full thickness of the slab has been penetrated.
10. Using an assembled sub-slab point, test fit the components so that the proper length of 1/4-inch tubing and depth of the 2 1/2-inch hole provides enough space for the coupling. Adjust so that the sample port plug will lie flush with the slab surface and does not create a tripping hazard.
11. If necessary, re-drill the 5/8-inch hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing, or even a piece of heavy wire (e.g., coat hanger).
12. Wrap the sample point assembly with Teflon[®] tape or VOC free modeling clay, to the extent necessary, for a snug fit of the assembly into the 5/8-inch diameter hole and also to prevent migration of cement to the sub-slab. Ensure that Teflon[®] tape or modeling clay do not interfere with the cement that will be used to permanently fix and seal the sample point.
13. Prepare a mixture of VOC-free non-shrink quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.
14. Before cementing in the sub-slab point, moisten the 1 1/2-inch drill hole with the spray bottle to provide better adhesion.
15. Cement in the sub-slab point using the plastic spoon to apply the cement into the annular space between the coupling and the 1 1/2-inch drill hole.

16. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent point.
17. Proceed to sub-slab soil-gas sample collection after waiting a minimum of 24 hours for equilibration following sub-slab point installation.

Sub-Slab Soil-Gas Sample Collection

Once the permanent sub-slab point is installed, the following procedures should be used to collect the sample in a SUMMA[®] canister:

1. Record the following weather information from inside the building being sampled in the field notebook:
 - a. wind speed and direction (if capable with in-field measuring device);
 - b. ambient temperature;
 - c. barometric pressure; and
 - d. relative humidity.
2. Before sampling, remove the sample point plug and attach a compound pressure/vacuum gauge to the end of the sample point to record the pressure gradient occurring between indoors and sub-slab. Record the positive or negative pressure reading in the field notebook. Cap the sample point once the reading is collected.
3. Check all SUMMA[®]-type canisters for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.
4. Remove the brass plug from the SUMMA[®] canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA[®] canister. Do not open the valve on the SUMMA[®] canister. Record in the field

notebook and COC form the flow controller number with the appropriate SUMMA[®] canister number.

5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA[®] canisters using stainless steel Swagelok[®] duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.
6. Complete a “shut in” or “leak down” test prior to sampling each sub-slab soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA[®] canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA[®] canister will be placed on the end of the sample train, effectively producing a closed system. The SUMMA[®] canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively “shut-in” to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.
7. Connect a Swagelok[®] (or comparable) T-fitting to the end of the sample tubing. On one end of the T-fitting connect a short length of Teflon[®] tubing to the assembled sample train (flow control with in-line particulate filter and vacuum gauge and SUMMA[®] canister). On the other end of the T-fitting connect a Swagelok[®] (or similar) two-way valve using a short length of 1/4-inch OD Teflon[®] tubing.
8. Connect the two-way valve and the properly calibrated portable vacuum pump using a length of tubing. Affix a Tedlar[®] bag to the purge pump to capture all purged air. The purged air should be evacuated outside the building.
9. Purge 3 volumes of air from the sub-slab soil-gas point and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing and sample point using the calculation:

$$V_1 + V_2 = V_t$$

where:

$V_1 = \pi r^2 h$ = open space volume of sample tubing

$V_2 = \pi r^2 h$ = open space volume of sample point

V_t = total volume

r = inner radius of sample point or sample tubing

h = height of sample point or length of tubing

10. A tracer-gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around all sub-slab soil-gas points and connections by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP 21 "Administering Tracer Gas," for procedures on tracer gas use.] If unacceptable leaks are detected ($\geq 5\%$ of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement sub-slab point should be installed and sampled. Measure organic vapor and tracer gas levels within the Tedlar[®] bag, as appropriate
11. Close the two-way valve to isolate the purge pump.
12. Open the SUMMA[®] canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.
13. On a floor plan or sketch of the area being sampled, include the following information:
 - Sample location;
 - Locations of heating, ventilation, and air conditioning equipment;
 - Chemical storage areas;
 - Any attached garages or utility areas;
 - Doorways and stairways;

- Any sumps, drains, or other utility perforations;
 - Separate footings sections or buildings constructions; and
 - The nearest street and the direction of north.
14. Take a photograph of the SUMMA[®] canister and surrounding area unless prohibited by the building owner.
 15. Check the SUMMA[®] canister approximately half way through the sample duration and note progress on sample logs.

Termination of Sample Collection

1. Due to the short duration of sampling, field staff should stay with the SUMMA[®] canister throughout sampling.
2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.
3. Record the final vacuum. Stop collecting the sample by closing the SUMMA[®] canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.
4. Disconnect sample tubing from the sample point and replace flush-mount cap.
5. Remove the particulate filters and flow controllers from the SUMMA[®] canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.
6. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA[®] canisters should not be preserved with ice or refrigeration during shipment.
7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.
9. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent sample point. Document with photographs.

Decommissioning of Permanent Sub-Slab Soil-Gas Points

1. Remove, only to the extent necessary any covering on top of the permanent sample point (e.g., carpet).
2. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.
3. Using a hammer, carefully strike the sample point on the top of the plug to dislodge the permanent point from the slab. Repeat until the sample point becomes loose inside the borehole.
4. Remove the sample point from the slab.
5. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.
6. Prepare a mixture of VOC-free, non-shrink, quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.
7. Place cement in 1 1/2-inch borehole using the plastic spoon until the hole is filled and wait until the cement sets.
8. Replace the surface covering (e.g., carpet) if warranted.
9. Document with photos.

VI. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil gas sample.

- When drilling sample collection holes, utilities may be in the area. Always complete utility location, identification and marking before installing sub-slab sample points as required by the ARCADIS Utility Location Policy and Procedure. Be aware that public utility locator organizations frequently do not provide location information within buildings so alternative lines of evidence must be used.
- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.
- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.
- If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative sub-slab soil-gas samples, due to high moisture conditions and/or tight soils, a replacement sub-slab point should be installed, for up to three attempts.
- Field personnel will properly seal the sub-slab point at the slab surface to prevent leaks of atmosphere into the sub-slab point during purging and sampling.
- Quick-setting non-shrink grout and modeling clay or other materials used to seal the hole should only be obtained from an approved ARCADIS source and should not be purchased off the shelf from an unapproved retail source. Data indicate that some modeling clays may contain VOCs that can affect sample results.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA[®] canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches of Hg). Consult your project manager (PM), risk assessor or air sampling expert by phone if the SUMMA[®] canister does not appear to be working properly.
- Ensure that there is still measureable vacuum in the SUMMA[®] after sampling. Sometimes the gauges sent from the lab have offset errors, or they stick.
- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in the http://www.uigi.com/Atmos_pressure.html.
- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.
- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.
- Check the seal around the soil-gas sampling point by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document.
- A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

VII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate sub-slab soil-gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the sub-slab soil-gas point simultaneously.

Trip blank samples will not be used during sub-slab soil-gas sampling. SUMMA[®] canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA[®] canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA[®] canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA[®] canister. The integrity of each SUMMA[®] canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

X. References

CEPA. 2010. Advisory – Active Soil Investigation. California Environmental Protection Agency. March.

OEPA. 2010. Sample Collection and Evaluation of Vapor Intrusion to Indoor Air. Guidance Document for Remedial Response and Voluntary Action Program. Division of Emergency and Remedial Response. May.



Sub-slab/Soil-Gas Sample Collection Log

		Sample ID:	
Client:		Boring Equipment:	
Project:		Sealant:	
Location:		Tubing Information:	
Project #:		Miscellaneous Equipment:	
Samplers:		Subcontractor:	
		Equipment:	
Sampling Depth:		Moisture Content of Sampling Zone):	
Time and Date of Installation:		Approximate Purge Volume:	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA® Canister Information:

Size (circle one):	1 L	6 L
Canister ID:		
Flow Controller ID:		
Notes:		

Tracer Test Information (if applicable):

Initial Helium Shroud:		
Final Helium Shroud:		
Tracer Test Passed:	Yes	No
Notes:		

General Observations/Notes:

Approximating One-Well Volume (for purging):

$V_1 + V_2 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of sample tubing; $V_2 = \pi r^2 h$ = open space volume of sample point; V_t = total volume; r = inner radius of sample point, or sample tubing; h = height of sample point or length of tubing.

SOP 21

Administering Helium Tracer Gas for Leak Checks of Soil-Gas or Sub-slab Sampling Points

RACER

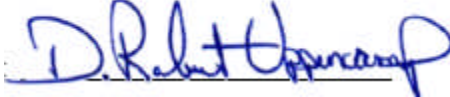
Moraine, Ohio

Rev. #: 2

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Approval Signatures

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I. Scope and Application

When collecting subsurface soil-gas samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil-gas point seal. Without the use of a tracer, verification that a soil-gas sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF₆), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity where the port or sample tubing intersects the surface with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of high concentrations (>5%) of the tracer. A pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the port during the testing.

There are two basic approaches to testing for the tracer gas:

1. Include the tracer gas in the list of target analytes reported by the laboratory; or
2. Use a portable monitoring device to analyze a sample of soil-gas for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar[®] bag, etc. They need not be collected in SUMMA[®] canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the port seals prior to formal sample collection.

During the initial stages of a subsurface soil-gas sampling program, tracer gas samples should be collected at each of the sampling points or in the case of nested points in the shallowest sampling point. If the results of the initial samples indicate that the port seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil-gas points as part of a long-term monitoring program, the port should

be tested prior to the first sampling event. Tracer gas testing of subsequent sampling events is not necessary unless conditions have changed at the site.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

III. Equipment List

The equipment required to conduct a helium tracer gas test are presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan)
- Helium
- Regulator for helium tank
- Shroud (plastic bucket, garbage can, etc)
 - o The size of the shroud should be sufficient to fit over the soil-gas point manhole. It is worth noting that using a smaller shroud obviously uses less helium as well; this may be important when projects require a number of helium tracer tests.
 - o The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two on the side (one for the helium detector probe, and one for the helium line).

- o The shroud ideally encloses the entire sampling train.
- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent)
- Tedlar® bags
- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc).
Although the sealing material is not in direct contact with the sample if no leak occurs, sealing materials with high levels of VOC emissions should be avoided, since they could easily contaminate a sample from a point in which a trace leak occurs.
- Field notebook

IV. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of soil-gas point installation. The helium tracer test can be conducted when using temporary or permanent sample point installs and from inside or outside a facility. However, when using the tracer gas within an indoor area you must provide adequate ventilation because helium is an asphyxiant.

1. Attach Teflon® sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., barbed fitting, Swage-Lok® fitting, ball valve, etc.).
2. Place the shroud over the sample point and tubing.
3. Pull the tubing through hole in top of shroud. Seal opening with modeling clay.
4. Place weight on top of shroud to help maintain a good seal with the ground.
5. Insert helium tubing into hole in side of shroud, seal with modeling clay to prevent leaks.
6. Fill shroud with helium. While filling shroud allow atmospheric air to escape either by leaving a crack with the surface or by providing a release valve on the side of the shroud.

7. Use the helium detector to test level of helium gas from the bottom of the shroud (where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.
8. Purge the sample point through the sample tubing into a Tedlar[®] bag using a hand held sampling pump. The sample pump should be operating at a rate of 50 mL/minute (the purge rate should not exceed the sample collection rate). Use a stand-alone flow sensor to monitor purge flow rate during purge (Bios DryCal or equivalent). Test the air in the Tedlar[®] bag for helium using portable helium detector. If the sample point has been installed properly there should be zero helium in purge air.
9. If > 5% helium is noted in purge air, add more clay or other material to the seal the sample port at the surface and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.
10. Monitor and record helium level in shroud before, during and after tracer test.
11. Monitor and record helium level in purge exhaust.
12. At successful completion of tracer test and sample point purging, the soil-gas sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors!

Care should be taken not to pressurize shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground.

Because minor leakage around the port seal should not materially affect the usability of the soil-gas sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (>5%) of tracer gas are observed in a sample, the port seal should be enhanced to reduce the infiltration of ambient air and the tracer

test readministered. If the problem cannot be rectified, a new sample point should be installed.

VI. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

APPENDIX: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.

- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Special Precautions

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

SOP 22

Indoor Air and Ambient Air Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 9, 2011

Approval Signatures

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I. Scope and Application

This document describes the procedures to collect indoor air and ambient air samples. Samples are collected in an evacuated 6-liter SUMMA[®]-type canister, (evacuated to <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for placing the sampling device and collecting indoor air or ambient air samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading indoor air or ambient air sample collection activities must have previous indoor air or ambient air sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. The following are examples of hazards that are often encountered in conducting indoor air or ambient air sampling:

- In crawl spaces, hazards often include low head room, limited light, poisonous insects, venomous snakes, insulation, electrical and plumbing lines, and sharp debris.

- In residential buildings and neighborhoods unfamiliar pets can pose a hazard. Even though proper permission for sampling may have been secured, it is still possible to encounter persons suspicious of or hostile to the sampling team. Two sampling personnel are required at all times due to these hazards.
- In occupied industrial buildings be aware of the physical hazards of ongoing industrial processes. Examples include moving forklifts and equipment pits.

IV. Equipment List

The equipment required for indoor air or ambient air sample collection is presented below:

- Appropriate PPE (as required by the Health and Safety Plan);
- 6-liter, stainless steel SUMMA[®] canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges (flow controllers are pre-calibrated by the laboratory to a specified sample duration [e.g., 24-hour]). Confirm with lab that flow controller is equipped with an in-line particulate filter and pressure gauge (order an extra set for each extra SUMMA[®] canister, if feasible);
- Appropriate-sized open-end wrenches (typically 9/16-inch);
- Chain-of-custody (COC) form;
- Building survey and product inventory form (example attached);
- Portable photoionization detector (PID) (for use identifying potential background sources during building survey described below);
- Sample collection log (attached);
- Field notebook;
- Camera if photography is permitted at sampling locations;
- Portable weather meter capable of collecting barometric pressure, relative humidity, and temperature, if appropriate;
- Box, chair, tripod, or similar to hold canister above the ground surface; and

- Teflon sample tubing may be used to sample abnormal situations (i.e., sumps, where canisters must be hidden, etc.). In these situations 1/4-inch Swagelok fittings or other methods may be appropriate to affix tubing to canister. Staff should check this before heading out into field.

V. Procedure

Initial Building Survey for Indoor Air Samples (if applicable to project)

1. Complete the appropriate building survey form and product inventory form (attached) as necessary in advance of sample collection. The product inventory should include ingredients of products as well as quantities. A copy of this completed form will be provided to the property owner to discuss potential background sources.
2. Confirm with building occupants that Instructions for Occupants During Indoor Air Sampling Events has been followed, and use of products that may provide interference with sample results has been discontinued and specified products removed to a non-attached structure at least 48-hours before sampling.
3. Identify on a site plan all underground utilities, piping, or conduits coming into or out of the building to be sampled.
4. Survey the area for the apparent presence of items or materials (i.e. foundation cracks) that may potentially produce or emit constituents of concern and interfere with analytical laboratory analysis of the collected sample. Record relevant information on survey form and document with photographs.
5. Record date, time, location, and other relevant notes on the sampling form.
6. Items or materials that contain constituents of concern and/or exhibit elevated PID readings shall be considered probable sources of VOCs. Request approval of the owner or occupant to have these items removed to a structure not attached to the target structure at least 48 hours prior to sampling, if possible.
7. Set a date and time with the owner or occupant to return for placement of SUMMA[®] canisters.

Preparation of SUMMA[®]-Type Canister and Collection of Indoor Air or Ambient Air Sample

1. Record the following information from wherever the sample is being collected (i.e. inside a building for indoor air samples or outside for ambient air samples) on the sampling form (use a hand-held weather meter, contact the local airport or other suitable information source [e.g., weather.gov] to obtain the following information):
 - ambient temperature;
 - barometric pressure;
 - wind speed; and
 - relative humidity.
2. Choose the sample location in accordance with the sampling plan. If a breathing zone sample is required, place the canister on a ladder, tripod, box, or other similar stand to locate the canister orifice 4 to 5 feet above ground or floor surface. If the canister will not be overseen for the entire sampling period, secure the canisters as appropriate (e.g., lock and chain). Canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of “drafts” shall be avoided. Ambient air samples should be placed upwind of the sampling area.
3. Record SUMMA[®] canister serial number and flow controller number on the sampling log and chain of custody (COC) form. Assign sample identification on canister ID tag, and record on the sample collection log (attached), and COC form.
4. Remove the cap from the SUMMA[®] canister. Attach the flow controller with in-line particulate filter and vacuum gauge to the SUMMA[®] canister with the appropriate-sized wrench. Tighten by hand first, then gently with the wrench. Use caution not to over tighten fittings.
5. Open the SUMMA[®] canister valve to initiate sample collection. Record the date and local time (24-hour time notation) of valve opening on the sample collection log, and COC form. Collection of duplicate samples will include collecting two samples side by side at the same time.

6. On a floor plan or sketch of the area being sampled, include the following information:
 - Sample location;
 - Locations of heating, ventilation, and air conditioning equipment;
 - Chemical storage areas;
 - Any attached garages or utility areas;
 - Doorways and stairways;
 - Any sumps, drains, or other utility perforations;
 - Separate footings sections or buildings constructions; and
 - The nearest street and the direction of north.
7. All SUMMA[®]-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches (in) of Hg and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.
8. Record the initial vacuum pressure in the SUMMA[®] canister on the sample log and COC form.
9. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, two SUMMA[®] canisters will be placed side-by-side and allowed to collect a sample during the exact same period of time.
10. Take a photograph of the SUMMA[®] canister and surrounding area, if possible.
11. The SUMMA[®] canister should be checked, if possible, at least once during the 24-hour sampling process and the progress noted on the sampling log.

Termination of Sample Collection

1. Arrive at the SUMMA[®] canister location at least 1-2 hours prior to the end of the sampling interval (e.g., 24-hour), if possible.
2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.
3. Record the final vacuum. Stop collecting the sample by closing the SUMMA[®] canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.
4. Remove the particulate filter and flow controller from the SUMMA[®] canister, re-install brass cap on canister fitting, and tighten with wrench.
5. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA[®] canister does not require preservation with ice or refrigeration during shipment.
6. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with string).
7. Complete COC form and place requisite copies in shipping container. Close shipping container and affix custody seal to container closure. Ship to laboratory via overnight carrier (e.g., Federal Express) for analysis.

VI. Cautions

- Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, keep canisters away from heavy pedestrian traffic areas (e.g., main entranceways, walkways) if possible. If the canisters are not to be overseen for the entire sample duration, precautions should be taken to maintain the security of the sample (e.g., do not place in areas regularly accessed by the public, fasten the sampling device to a secure object using lock and chain, label the canister to indicate it is part of a scientific project, notify local authorities, place the canister in secure housing that does not disrupt the integrity/validity of the sampling event). Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

- If a sub-slab soil-gas sample is collected from a permanent point at the same residence then wait a minimum of 24 hours after the installation of the point before sampling indoor air to minimize cross-contamination from sub-slab soil-gas that may have entered the indoor air during the installation of the point.
- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 2 to 5–inches Hg) remains in the canister when sample collection is terminated.
- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA[®] canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 to 27 inches Hg). Consult your project manager (PM), risk assessor or air sampling expert if the SUMMA[®] canister does not appear to be working properly.
- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum remaining http://www.uigi.com/Atmos_pressure.html.
- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.
- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- A Shipping Determination must be completed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.
- When collecting ambient air samples it is advisable to contact the local police department to inform them of the sampling and the equipment (i.e. SUMMA®) to be used. This will inhibit any false alarms from concerned citizens.

VII. Waste Management

No specific waste management procedures are required.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager. A building survey form and product inventory form (Attachment A) may also be completed for each building within the facility being sampled during each sampling event as applicable.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Indoor air sample analysis will be according to USEPA Method TO-15. This method uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits. The GC/MS system requires a 1-liter gas sample (which can easily be recovered from a 6-liter canister) to provide a 0.5 ppbv detection limit. The 6-liter canister also provides several additional 1-liter samples in case subsequent re-analyses or dilutions are required. This system also offers the advantage of the GC/MS detector, which confirms the identity of detected compounds by evaluating their mass spectra in either the SCAN or SIM mode.

Trip blank samples will not be used during indoor air or ambient air sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be

provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA[®] canister. The integrity of each SUMMA[®] canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.



Building Survey and Product Inventory Form

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: _____

Date/Time Prepared: _____

Preparer's Affiliation: _____

Phone No.: _____

Purpose of Investigation: _____

1. OCCUPANT:

Interviewed: Y / N

Last Name: _____ First Name: _____

Address: _____

County: _____

Home Phone: _____ Office Phone: _____

Number of Occupants/Persons at this Location: _____

Age of Occupants: _____

2. OWNER OR LANDLORD: (Check if Same as Occupant ☐)

Interviewed: Y / N

Last Name: _____ First Name: _____

Address: _____

County: _____

Home Phone: _____ Office Phone: _____



3. BUILDING CHARACTERISTICS:

Type of Building: (circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _____

If the Property is Residential, Type? (circle appropriate response)

Ranch		2-Family 3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other: _____

If Multiple Units, How Many? _____

If the Property is Commercial, Type?

Business Type(s) _____

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _____

Other Characteristics:

Number of Floors _____ Building Age _____

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

4. AIRFLOW:

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow Between Floors



Airflow Near Source

Outdoor Air Infiltration

Infiltration Into Air Ducts

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS: (circle all that apply)

- a. **Above grade construction:** wood frame concrete stone brick
- b. **Basement type:** full crawlspace slab other _____
- c. **Basement floor:** concrete dirt stone other _____
- d. **Basement floor:** uncovered covered covered with _____
- e. **Concrete floor:** unsealed sealed sealed with _____
- f. **Foundation walls:** poured block stone other _____
- g. **Foundation walls:** unsealed sealed sealed with _____
- h. **The basement is:** wet damp dry moldy
- i. **The basement is:** finished unfinished partially finished
- j. **Sump present?** Y / N
- k. **Water in sump?** Y / N / NA

Basement/lowest level depth below grade: _____(feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

Potential Vapor Point Entry	Field Screening Results (ppm)	Comments

Are the basement walls or floor sealed with waterproof paint or epoxy coatings?

Y / N

6. HEATING, VENTILATING, AND AIR CONDITIONING: (circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation Heat pump Hot water baseboard
 Space heaters Steam radiation Radiant floor
 Electric baseboard Wood stove Outdoor wood boiler
 Other _____

The primary type of fuel used is:

Natural gas Fuel oil Kerosene
 Electric Propane Solar
 Wood coal

Domestic hot water tank fueled by: _____

Boiler/furnace located in: Basement Outdoors Main Floor Other _____

Air conditioning: Central Air Window Units Open Windows None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

7. OCCUPANCY:

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):

Basement _____

1st Floor _____

2nd Floor _____

3rd Floor _____

4th Floor _____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:

a. **Is there an attached garage?** Y / N

b. **Does the garage have a separate heating unit?** Y / N / NA

c. **Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?**

Y / N / NA Please specify: _____

d. **Has the building ever had a fire?** Y / N When? _____

e. **Is a kerosene or unvented gas space heater present?** Y / N Where? _____

f. **Is there a workshop or hobby/craft area?** Y / N Where & Type? _____

g. **Is there smoking in the building?** Y / N How frequently? _____

h. **Have cleaning products been used recently?** Y / N When & Type? _____

i. **Have cosmetic products been used recently?** Y / N When & Type? _____

j. **Has painting/staining been done in the last 6 months?** Y / N Where & When? _____

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- k. Is there new carpet, drapes or other textiles? Y / N Where & When? _____
- l. Have air fresheners been used recently? Y / N When & Type? _____
- m. Is there a kitchen exhaust fan? Y / N If yes, where _____
- n. Is there a bathroom exhaust fan? Y / N If yes, where vented? _____
- o. Is there a clothes dryer? Y / N If yes, is it vented outside? Y / N
- p. Has there been a pesticide application? Y / N When & Type? _____
- q. Are there odors in the building? Y / N

If yes, please describe: _____

Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work? Y / N

If yes, what types of solvents are used? _____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N

Date of Installation: _____

Is the system active or passive? Active/Passive

Are there any Outside Contaminant Sources? (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify _____

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): _____

Heavy vehicle traffic nearby (or other mobile sources): _____

A full-page sheet of white graph paper featuring a uniform grid of thin black horizontal and vertical lines. The grid consists of small squares covering the entire area of the page.

First Floor:This image shows a full page of blank graph paper. The grid consists of small, equal-sized squares formed by thin black lines. There are no margins, text, or other markings on the page.

12. OUTDOOR PLOT:

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

This image shows a full page of blank graph paper. The grid consists of small, equal-sized squares formed by thin black lines. There are no margins, text, or other markings on the page.

13. PRODUCT INVENTORY FORM:

Make and Model of field instrument used:

List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/carpet, nail polish/hairspray/cologne).

[illegible]



Indoor Air or Ambient Air Sample Collection Log

		Sample ID:	
Client:		Outdoor/Indoor:	
Project:		Sample Intake Height:	
Location:		Tubing Information:	
Project #:		Miscellaneous Equipment:	
Samplers:		Time On/Off:	
Sample Point Location:		Subcontractor:	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA Canister Information:

Size (circle one):	1 L	6 L
Canister ID:		
Flow Controller ID:		
Notes:		

General Observations/Notes:

SOP 23

Inspection and Vapor Intrusion Mitigation System Design

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: August 9, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt
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Date: April 26, 2011

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Date: May 3, 2011

Approved by: Carolyn Grogan
Carolyn Grogan

Date: May 6, 2011

Revised Date: August 9, 2011

I. Scope and Application

This Standard Operating Procedure (SOP) describes the inspection and design procedures to be carried out prior to the installation of active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The inspection procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2003), United States Environmental Protection (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and provide detailed instructions for completing the building inspection and design for active vapor intrusion mitigation systems.

Site-specific requirements and/or field conditions may require modifications to the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All inspection personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific inspection. Drilling with the concrete core

drill during communication testing should be done only by personnel with prior experience using such equipment.

IV. Equipment List

The equipment required to complete the inspection and design activities active are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Hammer drill
- Wet/Dry vacuum
- Extra vacuum hose
- Micromanometer – The Fluke 922 Airflow Meter / Micromanometer, or equivalent, will be used for this project. Please see the specification sheet attached to this SOP for details.
- Non-shrink grout
- Tubing
- Swagelok fitting
- Modeling clay
- Flashlight
- Tape measure
- Camera
- Field book or inspection form (attached to the end of this SOP)

V. Procedure

Vapor Mitigation System Inspection (US EPA 625 and ASTM E2121-03)

The following definitions that are commonly used in the vapor mitigation system inspection and design process have been provided for clarification purposes:

- Suction point – The location where the proposed vapor intrusion mitigation system will extract sub-slab, sub-membrane, or crawlspace vapors. For example, a suction point could be a perforated polyethylene flex drain in a crawlspace or a polyvinyl chloride (PVC) pipe that is inserted into a vertical or horizontal suction pit. During communication testing, the vacuum should be applied to a point installed in the location of the suction point and identified as EX-1, EX-2, etc.
- Suction pit – The void installed below slab-on-grade or basement slab foundations.
- Sub-slab sample point – The sample locations used to collect sub-slab pressure field extension readings and background differential pressure readings from below the slab foundation. Permanent sub-slab sample points are installed in accordance with SOP 20, Sub-Slab Soil-Gas Point Installation and Sampling, and can also be used for collection of sub-slab samples. Temporary sub-slab sample points are installed to collect sub-slab pressure field extension readings during communication testing and are installed by drilling a small hole through the foundation. After the communication test is performed the holes are abandoned with non-shrink grout. Typically, the temporary sub-slab sample points are replaced with permanent sub-slab sample points during mitigation system installation. The sub-slab sample points should be labeled as SS-1, SS-2, etc.

Conduct a visual survey and hand sketch for the home to identify the unique characteristics of that home that will need to be considered as part of the system design and construction. Identify the following items, and document any preferences that the homeowner expresses.

- a. Identify each separate foundation and its type. Sketch the configuration and note the approximate size of each separate area. Select the proposed suction point location(s) for each foundation and locate on the floor plan.

One suction point should be proposed within each foundation area unless communication between foundations can be demonstrated through completion of a communication test as described below. The following are example suction point locations that are appropriate for a variety of foundation scenarios:

- If a property has a partial basement foundation and a slab-on-grade foundation, two suction points would be proposed (one suction point in the basement foundation and one suction point in the slab-on-grade foundation).
 - If a property has one crawlspace foundation that supports the entire structure, one suction point is appropriate.
 - If a property has one slab-on-grade foundation and one slab-on-grade addition, two suction points should be proposed (one for each foundation) unless communication testing demonstrates pressure field extension to both areas from one suction point.
- b. Include the size and location of crawlspace access doors and the approximate working height within each crawlspace. Note any obstacles that may present a problem for access and if any stored materials will need to be removed. Note whether padding and plywood or other materials will be needed to protect the sheeting and whether the access door will need to be protected from pets or other small animals.
- c. For slab-on-grade foundations, sketch the floor plan of the first floor, and identify locations such as closets or utility rooms that may be candidates for system installation. If a second floor is present, identify any locations where the system piping could be installed through both floor levels within closets or other acceptable locations. Identify any cracks or other openings in the slab that are accessible for sealing.
- d. Sketch the basement floor plan including the identification of finished and unfinished areas, sumps, floor drains not connected to sewers, cracks, wall to floor joint, open block wall cores, plumbing penetrations, and any other areas that may require sealing. Note the presence of stored items that may need to be relocated to access areas for sealing and system installation. Note any significant degradation in the integrity of the floor and/or walls that would require additional sealing measures beyond the standard caulking procedures.

- e. If a sump is present, identify the drains that are connected to the sump and the type of sump pump that is present (pedestal or submersible).
- f. Identify gas fired appliances; such as furnaces and water heaters that may need to be checked for backdrafting.
- g. On the exterior of the home, identify the number of stories, the type and condition of the roof, and any receptors that may need to be avoided when determining the system discharge location.
- h. Identify the location where the piping will exit the structure. Ensure that the pipe can be routed to an appropriate discharge location from this point with minimal or no jogs around windows or other obstructions. The discharge location must be located above the eave of the roof and be at least 10 feet above ground level and at least two feet above or ten feet away from any windows or other openings into the structure or into any adjacent structure. Avoid locating the piping outside of a bedroom, where fan noise could be disturbing to the homeowner.

Fan placement will either be on the exterior piping or within the attic.

- i. Use a micromanometer to measure a background differential pressure at the existing sub-slab sample point at homes with basement and/or slab-on-grade foundations, where an active mitigation system is to be installed, to determine the pre-existing sub-slab pressure that will need to be overcome.
- j. Determine if a communication test is to be conducted to assist with predicting system coverage across the entire slab. Crawlspace scenarios do not require a communication test because there is no slab to test below. Communication testing should be performed if:
 - 1. The suction point will be located greater than 20 feet from the furthest extent of the area it is intended to provide coverage for;
 - 2. Tight soil conditions are suspected based on site geology or previous sample port/point installation (i.e. clay); and/or
 - 3. Footers or other barriers (i.e., utilities or sumps) are identified or suspected based on a visual survey that may prohibit communication across the foundation.

An Inspection and Design Flow Chart and a Communication Test Schematic have been attached to this SOP.

- k. Communication testing may be conducted during a separate visit and will consist of the following.
 - o Drill a one-inch hole through the slab at the proposed suction point location using a hammer drill. Utilize the wet/dry vac for dust control during drilling and use hearing protection.
 - o Install temporary sub-slab sample point(s) on opposite side(s) of the slab by drilling small holes (same diameter as the outside diameter of the tubing to be used) through the slab, inserting tubing, and sealing around tubing with modeling clay. Permanent sub-slab sample points will be installed during system construction per the procedures in the Sub-Slab Soil-Gas Point Installation SOP (SOP 20) that is included within this appendix.
 - o Connect the suction hose of the wet/dry vacuum to the proposed suction point. Connect extra hose to the discharge of the vacuum and route the discharge to the outdoors.
 - o Connect tubing from temporary sub-slab sample point to the positive port of the micromanometer. Record the sub-slab pressure field extension reading, including the positive or negative sign.
 - o If a negative pressure of at least 0.004 in w.c. is not obtained at each sub-slab sample point, seal any openings in the slab and repeat the test.
 - o If after sealing a negative pressure is not obtained at each sub-slab sample point, identify a second suction point location closer to the area that was not being covered, and repeat the test.
 - o After testing is complete, remove the tubing and clay from the temporary sub-slab sample point (s) and fill the suction hole(s) and temporary sub-slab sample point (s) with non-shrink grout.
- l. Test combustion appliances to document any pre-existing backdrafting conditions utilizing the following procedure:

1. Turn on the appliance being tested (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding).
2. Check for flue gas spillage near vent hood.

If backdrafting is occurring the owner will be advised of the situation. The necessary repairs must be completed by the owner prior to any vapor control work. Note that high efficiency appliances do not require backdraft testing and can be identified by the presence of PVC vent pipes.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during inspection of vapor intrusion mitigation system. All necessary PPE will be worn during visual inspection and communication testing.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

IX. Data Recording and Management

ARCADIS will keep records of all measurements and notes taken during the inspection, and the information gathered will be used to create a property specific work plan. A detailed inspection form will be completed for each building.

X. Quality Assurance

ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

XI. References

ASTM Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches, October 2008.

FLUKE®

Fluke 922

Airflow Meter/ Micromanometer

Technical Data



Today's HVAC technicians need a simple solution for diagnosing ventilation issues. The Fluke 922 makes airflow measurements easy by combining pressure, air flow, and velocity into a single, rugged meter. Compatible with most pitot tubes, the Fluke 922 allows technicians to conveniently enter their duct shape and dimensions for maximum measurement accuracy.

The Fluke 922 Airflow Meter helps you:

- Monitor air pressure across key HVAC components
- Ensure proper air flow balance
- Promote good indoor air quality
- Maintain a comfortable environment

Use the Fluke 922 to:

- Measure pressure drops across filters and coils
- Match ventilation to occupant loads
- Monitor indoor vs. outdoor pressure relationships and manage the building envelope
- Perform duct traversals for accurate airflow readings

Features:

- Powerful meter provides differential and static pressure, air velocity and flow readings
- Rugged design built for field use
- Easy to use without sacrificing performance
- User-defined duct shape and size for maximum airflow accuracy
- Convenient colored hoses help you properly diagnose pressure readings
- Bright, backlit display for clear viewing in all environments
- Min/Max/Average/Hold functions for easy data analysis
- Auto power off saves battery life



Fluke 922 Airflow Meter Specifications

Feature	Range	Resolution	Accuracy
Operating Specifications			
Air Pressure	± 4000 Pascals ± 16 in H ₂ O ± 400 mm H ₂ O ± 40 mbar ± 0.6 PSI	1 Pascal 0.001 in H ₂ O 0.1 mm H ₂ O 0.01 mbar 0.0001 PSI	± 1 % + 1 Pascal ± 1 % + 0.01 in H ₂ O ± 1 % + 0.1 mm H ₂ O ± 1 % + 0.01 mbar ± 1 % + 0.0001 PSI
Air Velocity	250 to 16,000 fpm 1 to 80 m/s	1 fpm 0.001 m/s	± 2.5 % of reading at 2000 fpm (10.00 m/s)
Air Flow (Volume)	0 to 99,999 cfm 0 to 99,999 m ³ /hr 0 to 99,999 l/s	1 cfm 1 m ³ /hr 1 l/s	Accuracy is a function of velocity and duct size
Temperature	0 °C to 50 °C 32 °F to 122 °F	0.1 °C 0.1 °F	± 1 % + 2 °C ± 1 % + 4 °F
General Specifications			
Operating Temperature	0 °C to +50 °C (+32 °F to +122 °F)		
Storage Temperature	-40 °C to +60 °C (-40 °F to +140 °F)		
Operating Relative Humidity	0 % to 90 %, non-condensing		
IP Rating	IP40		
Operating Altitude	2000 m		
Storage Altitude	12000 m		
EMI, RFI, EMC	Meets requirements for EN61326-1		
Vibration	MIL-PREF-28800F, Class 3		
Max Pressure at Each Port	10 PSI		
Data Storage	99 readings		
Warranty	2 years		
Power	Four AA batteries		
Typical Battery Life	375 hours without backlight, 80 hours with backlight		



Optional accessories



PT12
Pitot Tube, 12 in



TPAK
ToolPak™



Fluke 922 comes complete with the following:
Fluke 922 Airflow Meter, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Soft Carrying Case



Fluke 922/Kit comes complete with the following:
Fluke 922 Airflow Meter, 12 in. pitot tube, ToolPak™, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Hard Carrying Case

Ordering Information

Fluke-922 Airflow Meter
Fluke-922/Kit Airflow Meter with 12 in Pitot Tube
PT12 Pitot Tube, 12 in

Fluke. Keeping your world up and running.®

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**Vapor Intrusion Mitigation System
Inspection and Design Form**

Property Address: _____ Temperature (Ambient): _____ °F
Tenant's Name: _____ Temperature (House): _____ °F
Owner's Name: _____ Barometric Pressure: _____ "Hg
Owner's Address (If Different from Property Address): _____ Weather Conditions: _____

Inspector(s) Name(s): _____

Date and Time: _____

Foundation Type(s): Slab Basement Crawlspace Crawlspace Height: _____

Cracks or Other Areas to be Sealed: Yes No NA

List: _____

Open Block Cores to be Sealed: Yes No NA

List: _____

Sump to be Sealed: Yes No NA Sump Diameter: _____

If Yes, Pedestal Pump, Submersible Pump, or None: _____

Existing Lid to be Reused: Yes No NA

Drain Seals Needed: Yes No

Diameter of Drains: _____ How Many? _____

Backdraft Test Completed on Furnace: Pass Fail NA - High Efficiency

Backdraft Test Completed on Water Heater: Pass Fail NA - Electric or Direct Vent

Reason Backdraft Test not Performed? _____

Failing Backdrafting Condition Reported to Homeowner: Yes No NA

Building Height: 1-Story 2-Story Other _____

Will Roof be Penetrated: Yes No

Roof Type: Metal Shingle Other _____

Piping to be Installed through or Outside House? _____

Fan will be Located on Exterior or in Attic? _____

Verify Discharge Location will Meet Required Clearance from any Openings into Home or Adjacent Home: Yes No

Suction Point Location and Communication Testing Determination

Are there Multiple Foundation Types? Yes No (Each foundation type will need to be mitigated)

If Yes, Indicate Dimensions of Each Foundation: _____

Does the Structure have any Additions? Yes No (Additions should be considered a separate foundation)

Is the Suction Point Located Greater than 20 Feet from the Furthest Extent of the Area it is Intended to to Provide Coverage?

Yes No (If yes, communication testing should be completed)

Are there Footers or other Barriers that may Impede Communication across Slab? Yes No

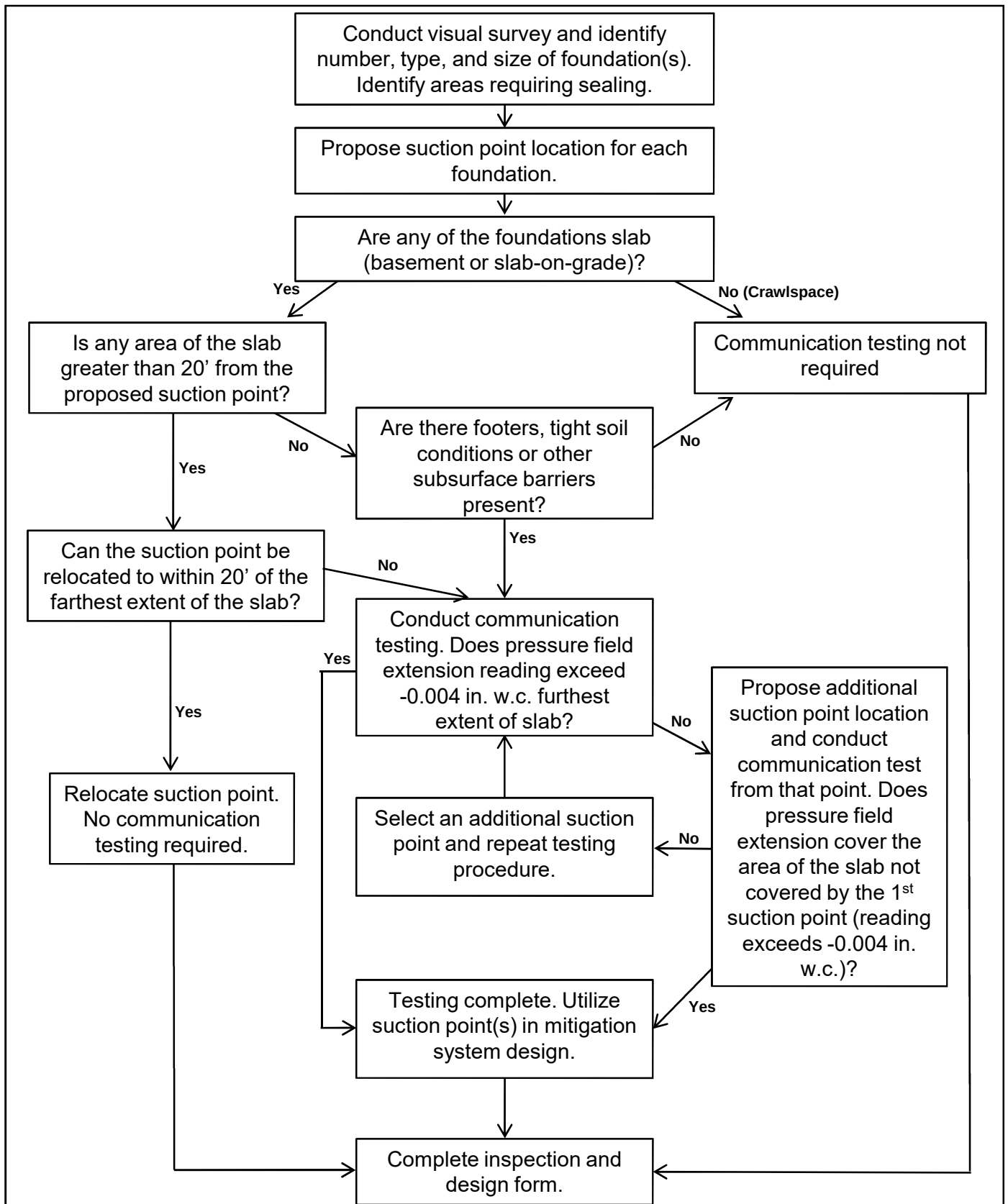
(If yes, communication testing should be completed)

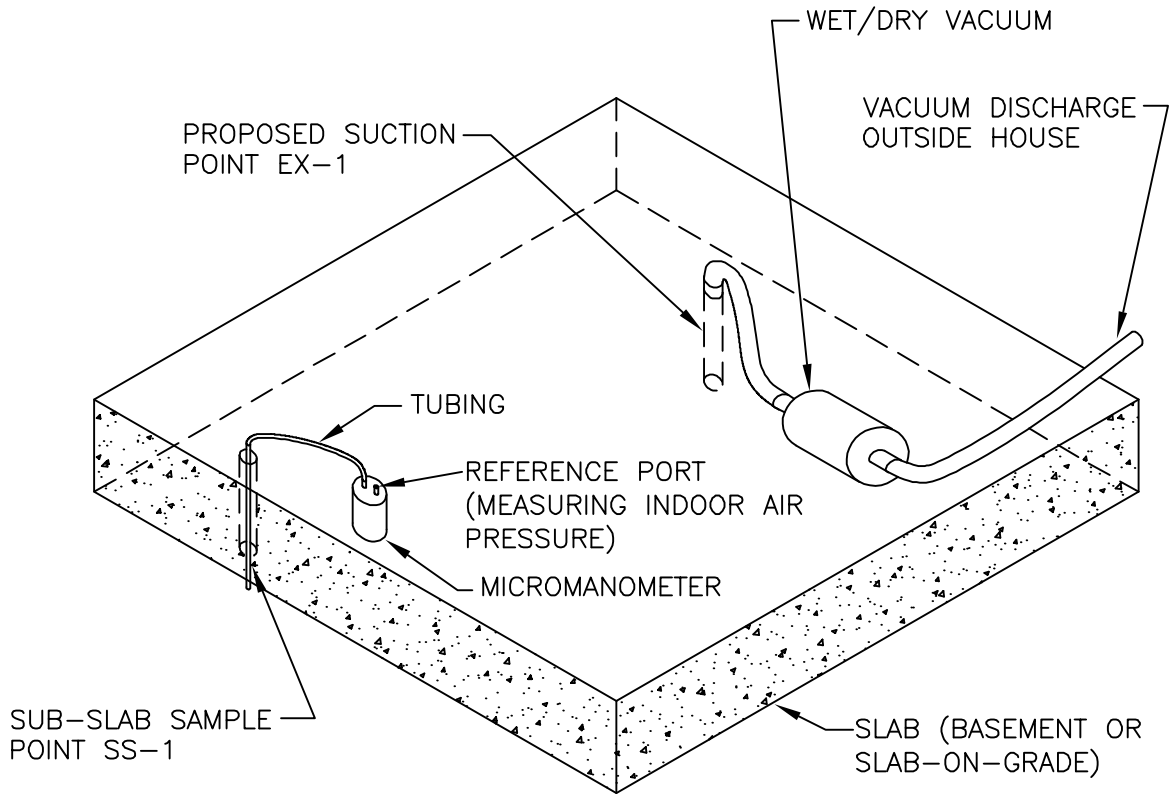
Communication Testing to be Completed: Yes No NA

If Communication Testing is not Completed, Reason Why: _____

Background Sub-Slab Pressure: Point ID: _____ Pres: _____ Point ID: _____ Pres: _____

See Back for Communication Test Results





NOT TO SCALE

RACER
 MORAIN, OHIO
 OH000294.2011

COMMUNICATION TEST SCHEMATIC SOP 23



FIGURE
2

SOP 24

Vapor Intrusion Mitigation System Installation

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 26, 2011

Revised: September 12, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: May 3, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 26, 2011
Rachel Saari



Modified by: _____ Date: September 12, 2011
Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to install active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The active mitigation system should be designed to depressurize the sub-slab, sub-membrane (crawlspace sealed with reinforced, polyethylene sheeting), or inaccessible crawlspace and prevent the entry of soil vapors into the structure. The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and materials and provide detailed instructions for the installation of active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination of the mitigation system installation with the installation contractor and the oversight of the vapor intrusion mitigation system installation activities. ARCADIS personnel leading the mitigation system installation activities will have previous vapor intrusion mitigation system installation oversight experience.

III. Health and Safety Considerations

Installation materials and equipment must be carefully handled to minimize the potential for injury. All installation personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Intrusive methods required for the vapor mitigation system installation (i.e., drilling with a concrete core drilling machine) should be done only by personnel with prior experience of using such equipment. Process pipe installation should be done only by personnel with prior experience and the appropriate training for working at heights. The inline fan shall be wired by a licensed electrician to an independent disconnect switch and to a breaker with sufficient capacity. Installation requirements will be outlined below.

IV. Equipment and Materials List

The equipment and materials required to install active vapor mitigation systems for structures with each of the three different foundation types: basement, crawlspace, and slab-on-grade, or any combinations of these three are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Concrete core drilling machine
- Extension and step ladders
- Drill
- Hand tools
- Lighting
- Vent piping 3 or 4-inch schedule 40 polyvinyl chloride (PVC) pipe, PVC primer, and PVC cement
- Elbows, couplings, pipe supports, and other fittings
- Sealant (silicone and polyurethane caulk)

- 6-mil polyethylene sheeting or 3-mil cross-laminate polyethylene sheeting (crawlspace)
- Untreated 1-inch by 2-inch wood strips, airtight gaskets and mechanical fasteners
- Perforated polyethylene drain tile (crawlspace)
- Backer rod, expandable foam, non-shrink mortar, grouts, etc.
- Roof flashing
- Intumescent fire stops (fire wall penetrations)
- Drain seals and/or water traps
- In-line fan
- Manometer
- Disconnect switch
- Audible alarm

V. Procedure

Active Mitigation System with Basement Foundation Installation (US EPA 625 and ASTM E2121-03)

The following steps will detail installation of an active mitigation system with a basement foundation for the given project.

1. Confirm gathered Information about the Structure: Review floor map to include rooms, crawlspaces, floor drains, cracks, pipe penetrations, plumbing rough-ins, and other openings requiring sealing. Identify any sump pits, drain tile, block walls, or baseboard drainage (see SOP 23 in this Appendix).
2. Backdrafting Check: Prior to system installation, test all combustion appliances and document pre-existing conditions (see SOP 23 in this Appendix).

3. Sealing Potential Vapor Intrusion Routes: Seal all cracks and openings in the basement walls and/or the floor slab to reduce pathways for vapors to enter the structure. Ventilate the structure during caulking activities to prevent the buildup of vapors as necessary. All surfaces to be sealed will be cleaned prior to applying sealant using a wet/dry vacuum. Wire brush may be necessary to loosen dirt or debris prior to vacuuming. Surfaces must be clean, dry, and free of all dirt debris, oil, and grease prior to sealing. Sealing will be conducted utilizing the following methods.
 - a. Cracks/Openings: All cracks greater than a 1/2-inch wide will be filled with closed cell foam backer rod prior to applying sealant. Backer rod should be approximately 25 percent larger than the width of the crack. Backer rods should be installed using a roller or flat sided tool to prevent puncture of the rods during installation. Cracks will be sealed with polyurethane caulk by forcing the caulk into the crack and smoothing at or slightly below the floor/wall surface to create a complete seal to each edge of the crack.
 - b. Sumps: Sumps will be sealed by installing solid lids with seals around all protrusions through the lid. Lids will be sealed to the floor using a non-permanent caulking, such as silicone, or through the use of an air-tight gasket and mechanical fasteners to allow the opening of the lid for pump maintenance. A view port may also be included in the lid to enable routing inspection of pump performance without repeated removal of the lid.
 - c. Drains: Drains installed through sump lids, through crawlspace liners, or through basement floors (not connected to sewer) will be sealed by installing a drain seal consisting of a one way valve which allows water to drain out, but no air to travel up through them or a trapped drain. If a trapped drain is utilized it should be capable of holding a minimum of 6-inches of standing water to minimize the potential for drying out.
 - d. Open Block Wall Cores: They will be sealed by filling the top portion of the cores with expanding foam.
 - e. Other openings will be evaluated and sealed using polyethylene sheeting, non-shrink grout, mortar, concrete, or expanding foam.

- f. Based on specific construction details of each property, other sealing methods may be required.
4. Confirm the Selection and Spacing of Suction Point: Confirm the selection and spacing of the suction points per the design drawing for the structure. The number and spacing of the suction point is based upon diagnostic testing reflective of the properties of soil underneath the building.
5. Confirm Pipe Routing & Fan Placement: These are determined based on design drawing for the structure. Confirm the exterior facade of the property and termination point location with the design drawing.
6. Installation of Suction Pit: Confirm all known utility lines near the proposed suction pit location. Use a portable coring tool to core through the basement slab. Remove approximately 1 cubic foot of soil from below the slab. Insert the 3 or 4"-inch PVC vent piping through the slab and seal the opening with polyurethane caulk.
7. Installation of Pipe: Vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction point through the sill plate of the structure and up the exterior of the structure, or routed through the interior of the structure through the attic to the rooftop discharge location per the design drawings. All joints in the PVC piping will be sealed using PVC cement. All of the piping runs will slope back towards the suction point. Extraction piping designed to run along the exterior of the structure will exit the structure at the level of the floor joists. Sealing will be performed around this penetration through the structure. The exterior run of piping will be attached to the side of the structure using clamps. Penetration through the roof and installation of flashing at this penetration will be performed as necessary. For additional pipe installation requirements refer to ASTM E2121 section 7.3.2.
8. Installation of Inline Fan: The Inline fan will be installed within the vent piping on the exterior of the structure when possible. The fan will be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building. The fan will be wired through a local disconnect switch to the structure's electric panel. A padlock will be installed on the disconnect switch to prevent unintentional shut down of the fan. The associated breaker on the panel will be labeled to indicate it is connected to the fan. For additional fan installation requirements refer to ASTM E2121 section 7.3.3.

9. Installation of Manometer: A manometer will be installed on the vent piping within the basement to confirm on-going system operation within the desired range.
10. If an audible alarm is required, a pressure switch will be installed in the system piping. The switch will be calibrated to alarm if the vacuum within the pipe is outside of the normal operating range.

Active Mitigation System with Slab-On-Grade Foundation Installation

Installation procedures for active mitigation systems with slab-on-grade foundations are the same as the procedures for basement foundations with the following exceptions:

1. The suction pit will be installed through the slab and the vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction pit up through the interior of the structure and through the attic to the rooftop discharge location per the design drawings. The in-line fan will be installed within the vent piping inside the attic of the structure.

Active Mitigation System with Crawlspace/Dirt Floor Foundation Installation

Installation procedures for active mitigation systems with crawlspace foundations are the same as the procedures for basement foundations with the following exceptions:

1. Accessible crawlspaces will be sealed using reinforced, polyethylene sheeting. Adjacent sheets will be overlapped by one foot and sealed with polyurethane caulking. Sheeting will be sealed to the perimeter of the crawlspace and around any protrusions using polyurethane caulking and tape as necessary. Sheeting will be secured to the crawlspace walls using 1-inch by 2-inch (thick by wide) wood strips (non-treated) and concrete anchors. Where moisture is a concern aluminum strips can be used. Exterior crawlspace walls will be sealed as necessary with polyurethane caulking or by extending the sheeting up the exterior walls and securing at the top. Crawlspace access openings may also be covered to prevent pets or other small animals from entering and damaging the sheeting.
2. For accessible crawlspaces, concrete will also be considered to seal dirt floor areas where significant foot traffic (i.e., daily) is expected. If the dirt floor is only periodically used (weekly or less) plastic sheeting protected with foam padding and plywood will be considered.

3. For accessible crawlspaces, the suction point will be installed under the crawlspace sheeting. The suction point will consist of a tee connected to a perforated polyethylene drain tile. The drain tile will create the necessary collection area and prevent the sheeting from being pulled into the vent pipe.
4. Inaccessible crawlspaces will be sealed by identifying and sealing openings from the crawlspace to the first floor with appropriate materials (e.g., polyurethane caulking, expanding foam, and/or polyethylene sheeting). Cracks within the crawlspace foundation walls will be sealed with polyurethane caulking. Larger openings in the foundation will be sealed with expanding foam or covered with sheet metal, sealed with polyurethane caulk, and anchored to the foundation with screws.
5. For inaccessible crawlspaces, a PVC pipe will be inserted into the crawlspace wall and used as the suction point. A screen will be attached to the end of the pipe to prevent small animals from entering the system. Polyurethane caulk will be used to seal the area where the pipe enters the crawlspace.

VII. Safety and Health Hazards (ASTM E2121-03 Section 6.0)

ARCADIS will comply with all OSHA, state and local standards or regulations relating to worker safety and occupational exposure while installing vapor intrusion mitigation systems. In addition to OSHA standards and NIOSH recommendations, the following requirements specifically applicable to the safety and protection of mitigation workers while installing vapor intrusion mitigation system will be met.

- ARCADIS or the mitigation system installation subcontractor will advise the workers of the potential hazards of the materials and supplies used, exposure to contaminants, and the importance of protective measures when working in areas of elevated contaminant concentrations.
- ARCADIS or the mitigation system installation subcontractor will ensure that appropriate safety equipment and applicable material safety data sheets are available at the job site during mitigation activities.
- Work areas shall be ventilated as necessary to reduce worker exposure to contaminants, dust, or other airborne pollutants.
- Vapor mitigation work shall not be conducted in any work area suspected of containing friable asbestos-containing material, or where work would render

non-friable asbestos-containing material friable, until a determination has been made by a properly trained or certified person that such work will be undertaken in a manner which complies with applicable asbestos regulations, including those of EPA and OSHA.

- Vapor mitigation work shall not be conducted in any work areas with the potential for exposure to mold or other types of infestations or any other conditions determined to cause an unnecessary safety risk until measures have been taken to eliminate these conditions.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

X. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. The Construction Quality Assurance Manager will complete an As-Built Drawing/Specifications List (attached to this SOP). The construction of the system and details pertaining to the operation of the system will be included in the As-Built Drawing/Specifications List.
2. ARCADIS will provide the property owner with an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) that includes the following :
 - a. A description of the mitigation system installed and its basic operating principles.
 - b. A description of the proper operating procedures of any mechanical or electrical systems (manometer, in-line fan, etc.) installed, including manufacturer's operation and maintenance instructions.
 - c. Contact information to be used if the system failure warning device indicates system degradation or failure or other system maintenance is found to be needed.

- d. Contact information for questions about operation of the mitigation system.

XI. Quality Assurance (ASTM E2121-03 Section 7.6)

Upon installation of active mitigation systems in structures with basement or slab-on-grade foundations, a measurement of a negative pressure below the slab of at least 0.004 inches of water column (in. w.c.) will indicate that the active system is successfully depressurizing the sub-slab area. Measurements will be taken on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab.

Upon installation of the mitigation system, an ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c. They will then mark the operating differential pressure on the manometer and will show the owner how to read the manometer installed on the system piping. If at any time the system is not functioning within the range marked on the monitoring device or the owner notices damage to the system, they will be encouraged to call the phone number listed on the system label. ARCADIS will also provide an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) to each owner with contact information for any necessary troubleshooting and repairs. All repairs will be made at no cost to the owner.

A post-installation proficiency sampling will be completed approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air (basement, accessible crawlspace, and first floor) is in compliance with the USEPA Regional Screening Levels at a 1×10^{-5} risk level (Action Levels). The sampling will be performed in accordance with the Indoor Air and Ambient Air Sampling SOP (SOP 22) included in this Appendix. Property owners will be provided with a letter to notified them of the sampling results and explain that the results are less than or greater than the Action Levels.

If sampling results are not in compliance with the Action Levels, ARCADIS personnel will evaluate the performance of the active mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). Following completion of the system modifications, an additional post-installation proficiency sampling event

will be completed within 30 days. Additional quality assurance measures will be outlined in the Operation and Maintenance SOP.

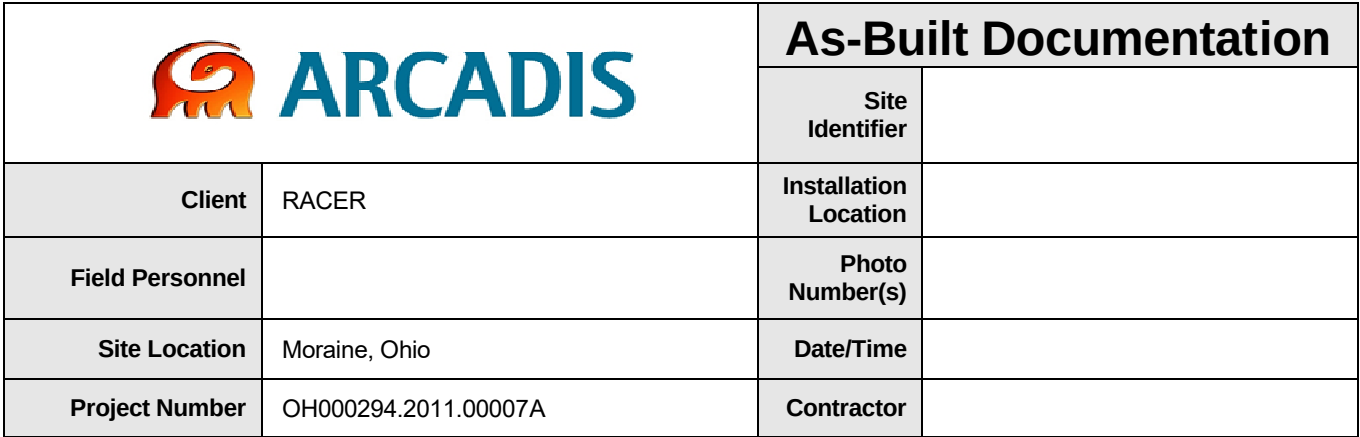
XII. References

American Society for Testing and Materials (ASTM) Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

United States Environmental Protection Agency (U.S. EPA), Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches. October 2008.



Vapor Intrusion Mitigation System Inspection and Design Form Attached:	Yes	or	No
Design Drawings Attached:	Yes	or	No

[illegible][illegible]

Vapor Intrusion Mitigation System Installation Checklist

Address Inspected: _____	Property ID #: _____
Tenant's Name: _____	Owner's Name: _____
Owner's Address (If Different from Property): _____	Make and Model of Fan: _____
Inspector's Name: _____	Date Installed: _____
Date: _____	
Time: _____	

System Pressures	SS-	SS-	SS-	FAN
Observed Pressure Field Extension Reading (in w.c.)				
Required Pressure Field Extension Reading (in w.c.)	-0.004	-0.004	-0.004	Between 1 and 4
Difference (in w.c.)				

1.0 Systems Installation and Interior Piping Requirements

	Yes	No	NA
1.1 Is all system piping Schedule 40 PVC of not less than 3-inch diameter?	_____	_____	_____
1.2 Are all system piping connections permanently sealed? (Exceptions include installation of fan and sump cover)	_____	_____	_____
1.3 Does the system piping avoid attachment to or support from existing pipes, ducts, conduits, or any other kind of equipment?	_____	_____	_____
1.4 Does the system piping avoid blocking windows and doors or access to installed equipment?	_____	_____	_____
1.5 Are supports for system piping installed at least every 6 feet on horizontal runs?	_____	_____	_____
1.6 Are vertical runs secured above or below the points of penetration through floors, ceilings, and roof, and at least every 8 feet?	_____	_____	_____
1.7 Are suction point pipes supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits?	_____	_____	_____

2.0 General Sealing Requirements

	Yes	No	NA
2.1 Is the suction point piping penetration through the slab and/or polyethylene sheeting properly sealed using polyurethane caulk or equivalent?	_____	_____	_____
2.2 Are accessible openings around utility penetrations through the foundation walls and slab, test holes, sub-slab sample points, and any other openings in slabs properly sealed using polyurethane caulk or equivalent?	_____	_____	_____
2.3 Are openings/cracks sealed where the slab meets the foundation wall using polyurethane caulk or equivalent?	_____	_____	_____
2.4 Was backer rod used when sealing cracks greater than ½ inch wide?	_____	_____	_____
2.5 Are drain seals properly installed?	_____	_____	_____
2.6 Is the sump pit installed with an impermeable cover and sealed with O-ring or silicone caulking?	_____	_____	_____
2.7 Are open block cores sealed?	_____	_____	_____
2.8 Is crawlspace sheeting sealed to foundation walls, at overlapping pieces, and at penetrations?	_____	_____	_____
2.9 Is crawlspace sheeting protected from damage?	_____	_____	_____
2.10 Is piping penetration through the siding sealed?	_____	_____	_____
2.11 Is piping centered within roof flashing?	_____	_____	_____

3.0 Electrical Requirements

	Yes	No	NA
3.1 Is the power supply to the fan hard-wired with an electrical disconnect within line of sight and within 4 feet of the fan?	_____	_____	_____
3.2 Is the padlock in place on the disconnect switch?	_____	_____	_____
3.3 Is the electrical service panel labeled to indicate the circuit breaker powering the fan?	_____	_____	_____

4.0 Monitors and Labeling Requirements

	Yes	No	NA
4.1 Does the suction point have a manometer to measure vacuum?	_____	_____	_____
4.2 Is the manometer clearly marked to indicate the initial pressure reading?	_____	_____	_____
4.3 Is a system description label placed on the mitigation system or other prominent location?	_____	_____	_____
4.4 Is the label legible from a distance of at least 3 feet and does it display the following information: Purpose of the system ("Vapor Intrusion Mitigation"), name, address, and phone number of the contact person?	_____	_____	_____
4.5 Was backdraft testing successfully completed after system installation?	_____	_____	_____
4.6 Is the audible alarm operational?	_____	_____	_____

5.0 System Vent Discharge Point Requirements

	Yes	No	NA
5.1 Is the vent pipe discharge vertical and upward, outside the structure, at least 10 feet above ground level, and at least 12 inches above the surface of the roof?	_____	_____	_____
5.2 Is the discharge of the vent pipe 10 feet or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure or any adjacent structure, if the vapor discharge point is not at least 2 feet above the top of such openings?	_____	_____	_____
5.3 Is the outside vent piping fastened to the structure of the building with hangers, strapping, or other supports that will secure it adequately (every 8 feet and within 2 feet of the discharge)?	_____	_____	_____
5.4 Is vent stack piping ID at least as large as the largest used in the manifold piping? Manifold piping to which two or more suction points are connected shall be at least 4 inch ID. (3x4 inch aluminum downspout is an acceptable deviation)	_____	_____	_____
5.5 If metal roof, is piping protected from snow damage?	_____	_____	_____
5.6 Is exterior piping painted to protect from UV damage?	_____	_____	_____

6.0 Fan Installation Requirements

	Yes	No	NA
6.1 Is the fan installed in a configuration that avoids condensation buildup in the fan housing?	_____	_____	_____
6.2 If the fan is mounted on the exterior of buildings, is it rated for outdoor use or installed in a weather proof protective housing?	_____	_____	_____
6.3 Does the system operate without unacceptable noise or vibration?	_____	_____	_____

7.0 Design Drawing and As-Built Drawing Requirements

	Yes	No	NA
7.1 Was the system installed per all requirements of the property-specific work plan?	_____	_____	_____
7.2 Were deviations from the property-specific work plan documented and approved by the U.S. EPA?	_____	_____	_____

8.0 Notes & Comments (List any deviations from the property-specific work plan.)**9.0 Required Corrective Actions**

SOP 25

Vapor Intrusion Mitigation System Operation and Maintenance

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 27, 2011

Revised: September 12, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 27, 2011
Rachel Saari

Modified by: Carolyn Grogan Date: September 12, 2011
Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for operation and maintenance (O&M) of active vapor intrusion mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The O&M procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008); United States Environmental Protection Agency (U.S. EPA) 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993); and U.S. EPA Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010).

The following sections list the necessary equipment and materials and provide O&M instructions for the active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination and oversight of the vapor intrusion mitigation system O&M activities. ARCADIS personnel leading the O&M activities will have previous vapor intrusion mitigation system O&M oversight experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All O&M personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of potential hazards associated with the job site and the specific O&M.

IV. Equipment and Materials List

The equipment required for O&M of active vapor intrusion mitigation systems is presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Micromanometer
- Flashlight
- Inspection form (included at the end of this SOP)
- Camera

V. Procedure

Annual Operation and Maintenance (US EPA Region 5 Vapor Intrusion Handbook, U.S. EPA 625, and ASTM E2121-03)

Inspections will be conducted by ARCADIS to ensure that it is functioning properly. The inspections will cover the following items:

1. The manometer reading will be recorded and checked against the operating value recorded at the completion of the system installation to ensure the system is operating in the design range.
2. The sub-slab pressure field extension readings will be recorded at the sub-slab points that were installed during system construction. The recorded values will be compared to the values recorded at the completion of the system installation.
3. The condition of the fan and disconnect switch lock will be recorded.
4. The condition of the system piping, fittings, and pipe supports will be recorded.
5. The condition of the foundation sealing including crawlspace sheeting will be recorded.
6. Confirmation that the system O&M manual is present will be recorded.
7. Any changes to the building structure or areas in need of additional sealing will be recorded.

If any deficiencies are found, corrective actions will be undertaken as soon as possible and at a minimum within 30 days of discovery.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during the O&M of vapor intrusion mitigation systems. All necessary PPE will be worn during annual inspection.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e. tubing) should be collected by field personnel for proper disposal.

IX. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. ARCADIS will keep records of all mitigation work performed and maintain those records for three years.
2. Health and safety records shall be maintained for a minimum of 20 years.
3. ARCADIS will provide clients with information that includes the following:
 - a. Inspection forms
 - b. Documentation of corrective actions completed

X. Quality Assurance

After corrective actions have been implemented, manometer readings and sub-slab pressure field extension readings will be recorded as necessary to document the corrective actions have been successfully implemented.

XI. References

ASTM Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

Sub-Slab, Sub-Membrane, and Crawlspace Depressurization Systems - Annual O&M Inspection Form

Property Identification Number: _____ Temperature (Ambient): _____ °F
Tenant's Name: _____ Temperature (House): _____ °F
Owner's Name: _____ Barometric Pressure: _____ "Hg
Owners Address (If Different from Property): _____ Weather Conditions: _____

Inspector Name: _____
Date: _____
Time: _____

System Inspection

Is Fan Operating?	Yes	No	NA
Any Unusual Fan Noises?	Yes	No	
Are Vent Piping and Piping Joints Intact?	Yes	No	
Any Caulking Required Around Piping Penetrations?	Yes	No	
Is System Padlock Intact (System ON/OFF Switch)?	Yes	No	NA
Is O&M Manual Present?	Yes	No	
Any Areas In Need of Additional Sealing?	Yes	No	

List Areas to be Sealed: _____
List Any Necessary System Repairs: _____

Tenant Observations

Any Change in Fan Noise or Vibration?	Yes	No	
Have you Turned the Fan OFF for Any Period of Time?	Yes	No	NA

Reason? _____

Is Differential Pressure in the Manometer Outside of Normal Operating Range?	Yes	No	NA
Is the System Manometer Steady?	Yes	No	NA
Have You or the Owner Made any Changes to the Basement or Other Foundation?	Yes	No	

Is So, What Were the Changes: _____

Measurements

Sample Point ID	Post Install Pressure (in w.c.)	Inspection				Post Repair (If Necessary)		
		Date	Time	Pressure (in w.c.)		Date	Time	Pressure (in w.c.)
Manometer								

Comments (Any Repairs Made While Visiting, etc.):

Repairs

Additional Sealing Completed:

Date:

System Repairs Completed:

Date:

Note: The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

SOP 26

Groundwater Sampling Using a Direct-Push Sampling System

RACER

Moraine, Ohio

Rev. #: 3

Rev Date: April 14, 2011

Approval Signatures



Prepared by: _____
Trey Fortner

Date: March 11, 2010

Revised: August 20, 2010



Reviewed by: _____
Jason Manzo

Date: March 11, 2010

Revised: August 20, 2010



Modified by: _____
Joseph Rumschlag

Date Revised: April 14, 2011

I. Scope and Application

This document describes the procedures to collect groundwater at the water table through a retractable stainless steel well screen via a Direct-Push Sampling System. Groundwater samples are collected following low-flow sampling procedures and are analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method 8260.

The following sections list the necessary equipment and provide detailed instructions for the installation of temporary well screen using direct-push technology and the collection of groundwater samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Drilling with a direct-push drilling rig or hollow stem auger rig should be done only by personnel with prior experience using such equipment.

IV. Equipment List

The equipment required to install multiple nested soil-gas ports is presented below:

- Direct Push Drilling Equipment
- Paperwork
- SP16 Screen Point (4 slot and supplied by driller)
- PPE

- Submersible Pump
- Buckets
- Caution Tape and Posts
- Plastic Sheeting
- Pens and Markers
- Sample Bottles
- Cooler
- Tubing (dual size if using a bladder pump)

The direct-push unit utilizes a protected screen sampler that can sample up to approximately 4 feet of water column. To retrieve groundwater samples at the working depth of the unit a submersible pump will be used. Unlike most well points, the unit remains completely sealed by a drive point at the end of the sample tube while it is pushed or driven to the desired sampling depth.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

V. Procedure

At Field Office:

A. Acquire Necessary Equipment

At Sampling Location:

1. Don appropriate PPE.
2. Establish exclusion zone with barricade tape.
3. Place plastic sheeting near work area.
4. After checking to ensure that all parts have been decontaminated, assemble groundwater sampler. All parts must fit tightly. Damage could occur during probing if threaded assemblage is not tight.
5. Drive the well point with the attached probe rods to the water table using manual probe rod driver or hydraulically-powered unit.
6. After the probe rods are driven approximately 2 feet below the water table, expose screen. Lower submersible pump and tubing down through the center of the rods into screened zone. Follow appropriate low-flow methodology for stabilization and transfer water sample to appropriate sample containers.
7. Record all details of sample collection on appropriate field forms.

8. Collect samples into appropriate bottles. Label each bottle with the following information: date, time of sampling, sample ID, analytical method, sampler initials and method of preservation. Print all information accurately and legibly. Complete chain-of-custody forms.
9. Place samples in containers as needed and pack with ice in coolers (when appropriate) as soon as possible.
10. Disassemble the sampler and remove all parts. Decontaminate equipment.
11. Personnel decontamination.

Submit samples to Sample Custodian with chain-of-custody forms and submit all paperwork

VI. Quality Assurance

One duplicate sample must be collected per 20 samples.

A trip blank must accompany each cooler of VOC samples that is shipped during the project.

SOP 27

Subsurface Soil-Gas Point Installation and Sampling

RACER

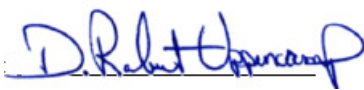
Moraine, Ohio

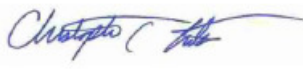
Rev. #: 5

Rev Date: October 11, 2011

Approval Signatures

Prepared by:  Date: Revised, August 20, 2010
Mitch Wacksman

Reviewed by:  Date: May 20, 2008
Robert Uppencamp

Approved by:  Date: Revised, October 13, 2009
Christopher Lutes

Modified by:  Date: Revised, August 20, 2010
Trey Fortner

Modified by:  Date: Revised, October 11, 2011
Joseph Rumschlag

I. Scope and Application

This document describes the procedures to collect subsurface soil-gas samples using temporary single or nested soil-gas points. Using nested soil-gas points allow for the generation of discrete data as a function of depth and time. Samples from the points are collected in an evacuated PAC250 SUMMA[®]-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of temporary single or nested soil-gas points (using direct-push technology or a hollow stem auger) and the collection of soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading subsurface soil-gas sample collection activities must have previous subsurface soil-gas sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For subsurface soil-gas point installation, drilling with a direct-

push drilling rig or hollow stem auger rig should be done only by personnel with prior experience using such of equipment.

IV. Equipment List

The equipment required to install multiple nested soil-gas points are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Appropriate drill rig to reach necessary sample depth (hollow stem auger, direct-push rig, etc.)
 - Hollow stem auger rig with interconnecting augers. The inner diameter of typical augers ranges from 2.25-inches to 7.75-inches; the auger size should be chosen to reflect the number of nested ports that will be installed inside the boring.
 - Direct-push rig (e.g., Geoprobe[®]) equipped with interconnecting 4-foot lengths of steel drive rods (1.25-inch diameter to 4-inch diameter depending on the number of ports to be installed).
- Stainless steel sample screens (one per sample depth)
- 0.25 inch outside diameter (OD) x 0.17-inch inside diameter (ID) tubing (Teflon)
- Decontaminated (cleaned) brass valve or needle valve (one per sample depth to match sample tubing)
- Sand
- Granular bentonite (Benseal[®], Volclay[®] Crumbles, or equivalent)
- Down hole measuring device
- Deionized, distilled, or potable water (for hydration of bentonite)
- Aluminum tags for labeling sample depths

- Flush mount well cover
- Photoionization Detector (PID) (with a lamp of 10.6 or 11.7 eV)
- Kneeling pad (as necessary)

The equipment required for soil-gas sample collection from nested soil-gas points are presented below:

- Stainless steel PAC 250 SUMMA[®] canisters (order at least one extra, if feasible)
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 4 minutes, 30 minutes, 8 hours, 24 hours) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible).
- Swage-Lok (or similar) fittings
- Stainless steel Swage-Lok (or similar) “T” fitting (if collecting duplicate [i.e., split] samples)
- Portable vacuum pump capable of producing very low flow rates (e.g., 50 milliliters per minute [mL/min]). Purging flow rate should be selected based on expected soil type (see below)
- Electric flow sensor (Bios DryCal or equivalent) to monitor purge rate
- Tracer gas testing supplies if applicable (refer to SOP 37 for “Administering Tracer Gas”)
- PID
- Landtec GEM[™] 500 if field monitoring methane

- Appropriate-sized open-end wrench (typically $\frac{9}{16}$ -inch and $\frac{1}{2}$ -inch)
- Portable weather meter capable of collecting barometric pressure, relative humidity, wind speed, and temperature, if appropriate
- Chain-of-custody (COC) forms
- Sample collection logs
- Field notebook

V. Procedure

Single or Nested Soil-Gas Monitoring Point Installation

The procedure used to install the single or nested soil-gas points will vary based upon the method of boring installation. In most situations a temporary well casing will need to be installed to keep the down hole formation from collapsing during point installation. The following steps will detail installing nested soil-gas points through a temporary well casing.

If the nested soil-gas points will be installed at shallow depths, or the formation is thought to be stable enough to not collapse, a temporary well casing may not be necessary to facilitate the installation of the sample points. Either way, the steps for installing the sample points are nearly identical. These following steps should be discussed with the drilling subcontractor and altered based on the methods chosen for a given project.

1. Advance boring to bottom of deepest sampling interval and install a temporary well casing. Soil-gas points will not be installed in groundwater or the capillary fringe. Moisture conditions and/or other observations (such as depth to water in nearby monitoring wells) should be recorded on the soil-gas collection log, as indicated.
2. Fill in 2 inches of sand pack below the soil-gas point and measure to make sure that the total depth is correct for the stainless steel sample screen to be installed.

3. Cut a length of sample collection tubing slightly longer (e.g., 4 to 5 feet) than the collection depth. Attach a 6-inch stainless steel sample screen to one end of the sample collection tubing and lower the screen and attached tubing through the boring.
4. Assure that the sample screen has reached the bottom of the boring and record this depth.
5. Begin simultaneously filling in the area around the sample screen with clean sand and retracting the temporary well casing. The casing should be lowered back down onto the sand every few inches to compact the sand around the screen. Sand should be introduced to cover the sample screen (6 inches deep) then to extend another six inches above the screen for a total of 14 inches of sand.
6. With the proper sand pack in place begin slowly introducing granular bentonite to the boring while gradually retracting the well casing. A minimum of 12 inches of dry granular bentonite should be added followed by a minimum of 12 inches of hydrated bentonite to 2 inches below the next sample depth. This dry bentonite interval will help ensure water does not reach the sand pack around the sample screen.
7. Properly label the sample tubing with a permanent label to designate the sample number and screen depth with a metal tag.
8. Affix a Swagelok[®] or equivalent fitting and valve to the end of the tubing. Use caution to not interchange fittings from different manufacturers as this may result in a compromised seal and possible leakage.
9. Fill in 2 inches of sand pack above the hydrated bentonite for below the shallow soil-gas point and measure to make sure that the total depth is correct for the stainless steel sample screen to be installed.
10. Cut a length of sample collection tubing slightly longer (e.g., 4 to 5 feet) than the collection depth. Attach a stainless steel sample screen to one end of the sample collection tubing and lower the screen and attached tubing through the boring.

11. Assure that the sample screen has reached the bottom of the boring and record this depth.
12. Begin simultaneously filling in the area around the sample screen with clean sand and retracting the temporary well casing. The casing should be lowered back down onto the sand every few inches to compact the sand around the screen. Sand should be introduced to cover the sample screen then to extend another six inches above the screen .
13. Repeat steps 6 through 8.
14. When installing the shallowest (last) sample point, bentonite should be emplaced all the way to the ground surface or bottom of the vault (if applicable) for a minimum of 5 feet of bentonite to ensure no short circuiting with the ambient air.
15. With all temporary single or nested points installed and labeled, a well cover may be installed.
 - a. For permanent installations, the well cover should be rated for whatever type of traffic it may encounter in the future. For interior installations a brass clean-out cover available from a plumbing supply store may provide adequate protection. For exterior installations in high traffic areas a heavy duty groundwater well cover may be appropriate.
 - b. For a temporary installation, a well cover is generally not necessary as the tubing will be removed within several days.
16. All soil-gas points should be allowed to sit and equilibrate for a minimum of 48 hours before proceeding to soil-gas sample collection (CEPA, 2010).

Soil-Gas Sample Collection

The following steps should be used to collect a soil-gas sample from each of the single or nested points installed using the above procedure.

1. Record the following information in the field notebook, if appropriate (contact the local airport or other suitable information source [e.g., site-specific measurements, weatherunderground.com] to obtain the information):

- a. wind speed and direction (if capable with in-field measuring device);
 - b. ambient temperature;
 - c. barometric pressure; and
 - d. relative humidity.
2. Connect a properly calibrated portable vacuum pump to the sample tubing.
 3. Purge 3 volumes of air from the soil-gas point screen and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing, sample screen, sand pack and dry bentonite seal using the calculation:

$$V_1 + V_2 + V_3 = V_t$$

where:

$V_1 = \pi r^2 h$ = open space volume of soil-gas screen

$V_2 = \pi r^2 h$ = open space volume of sample tubing

$V_3 = \pi r^2 h \rho$ = estimated volume of sand pack and dry bentonite open pore space

V_t = total volume

r = inner radius of soil-gas screen, borehole, or sample tubing

h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal

ρ = porosity of sand pack and dry bentonite (40%)

4. All SUMMA[®]-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.
5. If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative soil-gas samples, due to high moisture conditions

and/or tight soils, a replacement probe should be installed approximately 5 feet from the original location, for up to 3 attempts.

6. A “shut in” test will be performed prior to sampling each soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA[®] canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA[®] canister will be placed on the end of the sample train, effectively creating a closed system. The SUMMA[®] canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively “shut-in” to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.
7. A tracer gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around the all soil-gas points by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP “Administering Tracer Gas,” for procedures on tracer gas use.] If unacceptable leaks are detected ($\geq 5\%$ of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement probe should be installed and sampled approximately 5 feet from the original location.
8. Remove the brass plug from the SUMMA[®] canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA[®] canister. Do not open the valve on the SUMMA[®] canister. Record in the field notebook and COC form the flow controller number with the appropriate SUMMA[®] canister number.
9. Connect the Teflon[®] sample collection tubing to the flow controller and the SUMMA[®] canister valve.
10. Open the SUMMA[®] canister valves. Record in the field notebook and/or sample log (attached) the time sampling began, canister vacuum (as noted on the vacuum gauge), sampling flow rate specified from the laboratory, canister number, and flow controller number.

11. Take photographs of the SUMMA[®] canister and surrounding area; as appropriate.
12. Steps 2-10 should be repeated for each of the nested soil-gas points; samples can be collected concurrently.

Termination of Sample Collection

1. Due to the short duration of the soil-gas samples, field staff should stay at the SUMMA[®] canister location through the entire sampling interval.
2. Record the final canister vacuum. Stop collecting the sample by closing the SUMMA[®] canister valves. The canister should have a minimum amount of vacuum (approximately 5-inches of Hg or slightly greater).
3. Record the date and time of valve closing in the field notebook, sample collection log, and COC form.
4. Close the valve on the nested soil-gas sample tubing.
5. Once all the nested samples have been collected, be sure the well cover (if applicable) is properly re-installed and secured.
6. Remove the particulate filters and flow controllers from the SUMMA[®] canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.
7. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA[®] canisters should not be preserved with ice or refrigeration during shipment.
8. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).
9. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.

10. In accordance with standard operating procedures, equipment decontamination procedures, chain-of-custody procedures, and equipment calibration and maintenance procedures should be strictly followed.

VI. Soil-Gas Monitoring Point Abandonment

If the single or nested soil-gas points were installed in a temporary manner, and the soil-gas samples have been collected, the soil-gas monitoring points will be abandoned by pulling up the sample tubing. Since the boring is filled with bentonite and sand, no additional abandonment steps are necessary. Ensure that the boring location and surrounding area are returned to as close to their original appearance as possible.

VII. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a single or nested soil-gas sample.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.
- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.
- Care should be taken to ensure that nested ports are installed at the target sample depths. Sampling personnel should work closely with the driller to ensure this is implemented.
- When introducing granular bentonite to the boring, the material should be introduced slowly and hydrated properly. Consult the bentonite manufacturer's instructions on the bag to determine the proper amount of to be used. When hydrated properly bentonite forms a thick clay mass that

remains moist. The hydration step is crucial in the installation process and if not done properly the integrity of the bentonite seal can be compromised.

- Installing a layer of dry bentonite directly above the sand pack will help ensure water does not reach the sand pack around the sample screen.
- It is important to record the canister pressure, start and stop times and ID on a proper field sampling form. Often SUMMA[®] canisters are collected with a 24 hour averaging period. You should observe and record the time/pressure at the start, and then again one or two hours after starting the sample collection. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches). Consult your Project Manager (PM), risk assessor or air sampling expert by phone if the SUMMA[®] canister does not appear to be working properly.
- Ensure that there is still measureable vacuum in the SUMMA[®] after sampling. In some cases the gauges sent from labs may have large offset errors, or they malfunction (stick). For the most precise pressure readings consider using a separate, more sensitive, device to do checks at the beginning and end of the sampling period. If this is used, it must be tested beforehand to confirm that it does not introduce contaminants to the can during pressure checks.
- If possible, have equipment shipped a day or two before the sampling date so that all materials can be checked.
- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.
- Soil-gas sampling should not proceed within 5 days following a significant rain event (1/2-inch of rainfall or more).

A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

IX. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

X. Quality Assurance

Duplicate samples will be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 20 air samples (5%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate soil gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the soil-gas probe simultaneously.

Trip blank samples will not be used during soil gas sampling. SUMMA[®] canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA[®] canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA[®] canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA[®] canister. The integrity of each SUMMA[®] canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

XI. References

ASTM – “Standard Guide for Soil Gas Monitoring in the Vadose Zone”, D5314-92.

Hayes, H. C., D.J. Benton and N. Khan “Impact of Sampling media on Soil Gas Measurements”
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ITRC “Vapor Intrusion Pathway: A Practical Guide”, January 2007, Appendix F: “regulators
Checklist for Reviewing Soil Gas Data”.

New York State Department of Health (NYSDOH). 2005. DRAFT “Guidance for
Evaluating Soil Vapor Intrusion in the State of New York” February 23, 2005.

Nicholson, P, D. Bertrand and T. McAlary. “Soil Gas Sampling in Low-Permeability Materials”
Presented at AWMA Specialty Conference on Vapor Intrusion, Providence RI, Sept.
2000.



Sub-slab/Soil-Gas Sample Collection Log

		Sample ID:	
Client:		Boring Equipment:	
Project:		Sealant:	
Location:		Tubing Information:	
Project #:		Miscellaneous Equipment:	
Samplers:		Subcontractor:	
		Equipment:	
Sampling Depth:		Moisture Content of Sampling Zone):	
Time and Date of Installation:		Approximate Purge Volume:	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA® Canister Information:

Size (circle one):	250 mL	1L
Canister ID:		
Flow Controller ID:		
Notes:		

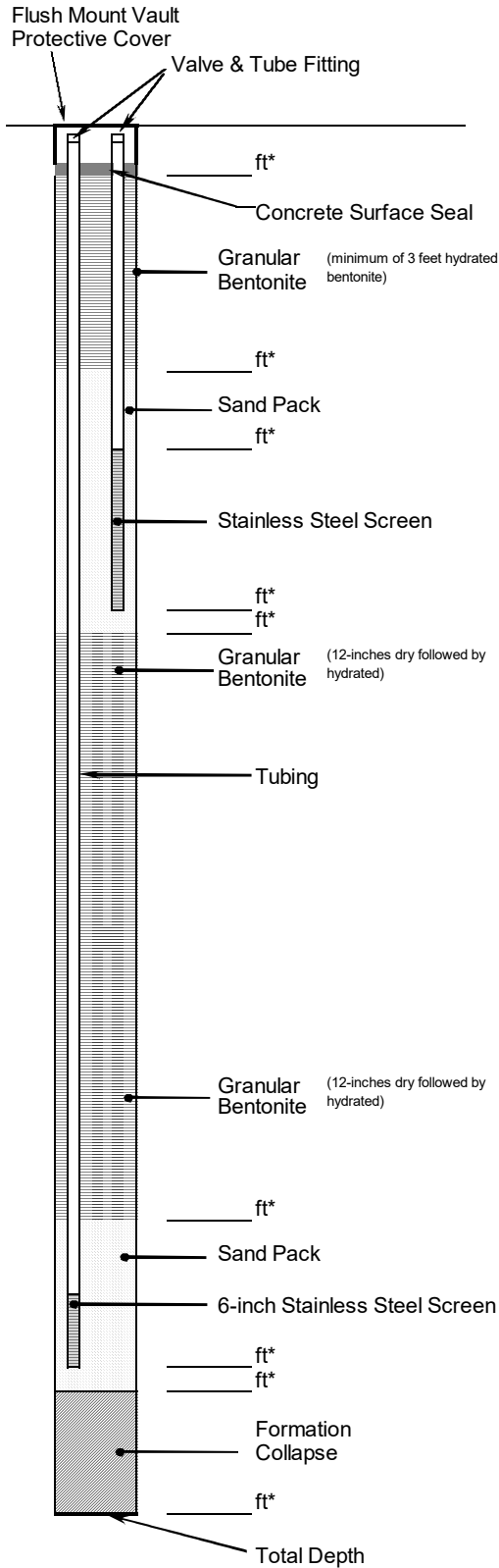
Tracer Test Information (if applicable):

Initial Helium Shroud:		
Final Helium Shroud:		
Tracer Test Passed:	Yes	No
Notes:		

General Observations/Notes:

Approximating One-Well Volume (for purging):

$V_1 + V_2 + V_3 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of soil-gas screen; $V_2 = \pi r^2 h$ = open space volume of sample tubing; $V_3 = \pi r^2 h \rho$ = estimated open pore space for sand pack and dry bentonite seal; V_t = total volume; r = inner radius of soil-gas screen, borehole, or sample tubing; h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal; ρ = porosity of sand pack and dry bentonite seal (40%).



* Depth in Feet Below Land Surface

Project: _____ Point: _____

City: _____

County: _____ State: _____

Survey Coordinates:

Northing: _____

Easting: _____

Land-Surface Elevation (surveyed): _____ feet
(above mean sea level)

Historic Maximum Groundwater Elevation: _____ feet
(above mean sea level)

Groundwater Encountered During Drilling: _____ feet bls

Installation Dates: _____

Weather Conditions at Installation: _____

Drilling Contractor: _____

Driller: _____

Drilling Method: _____

Screen Construction: Type: Stainless Steel - 6 inches
Diameter: 0.4375-inch OD, 0.3125-inch ID
Type: Stainless steel - 60 inches
Diameter: 0.5-inch ID

Tubing Construction: Type: Teflon®
Diameter: 0.25-inch OD, 0.17-inch ID

Volume Calculation (mL):	Shallow	Deep
V_1	_____	_____
V_2	_____	_____
V_3	_____	_____
V_t	_____	_____

Remarks: _____

Prepared by: _____

$V_1 + V_2 + V_3 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of soil-gas screen;
 $V_2 = \pi r^2 h$ = open space volume of sample tubing; $V_3 = \pi r^2 h \rho$ = estimated open pore space for sand pack and dry bentonite seal; V_t = total volume; r = inner radius of soil-gas screen, borehole, or sample tubing; h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal; ρ = porosity of sand pack and dry bentonite seal (40%).

OD - outer diameter 12-inches = 1 foot
ID - inner diameter 1 cubic inch = 16.39 mL
bls - below land surface $\pi = 3.1416$

SOP 28

Air Monitoring using an ORION Plus MultiGas Portable Gas Meter

RACER

Moraine, Ohio

Rev. #: 1

Rev Date: April 20, 2011

Approval SignaturesA handwritten signature in black ink, appearing to read "Kevin Patton".

Prepared by: _____ Date: 10/23/2007
Kevin Patton

A handwritten signature in blue ink, appearing to read "Joseph Rumschlag".

Reviewed by: _____ Date: 4/20/2011
Joseph Rumschlag

A handwritten signature in blue ink, appearing to read "Jason Manzo".

Approved by: _____ Date: 4/20/2011
Jason Manzo

I. Scope and Application

This standard operating procedure describes a methodology for correctly calibrating and using the ORION Plus MultiGas portable gas monitor, manufactured by MSA, Inc. This instrument monitors oxygen (O₂), carbon monoxide (CO), hydrogen sulfide (H₂S), and methane (CH₄). These gases are typically present in landfills and need to be monitored when performing subsurface exploration or groundwater monitoring (if necessary) at landfills as their presence could produce oxygen deficient or explosive atmospheres. The ORION Plus MultiGas portable gas monitor is intrinsically safe for use at landfills.

II. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

III. Equipment List

- ORION Plus MultiGas portable gas meter
- Daily field log or logbook
- ORION Plus MultiGas portable gas meter owner's manuals (attached)
- Calibration gases
- Water sample trap

V. Health and Safety Considerations and Cautions

Performing subsurface investigations or groundwater monitoring at landfills involves dangers related to explosive or oxygen-deficient atmospheres. Air monitoring must be performed using properly functioning equipment.

VI. Procedure

NOTE: The following is a generalized description summary of the procedures to be followed when using the ORION Plus MultiGas portable gas meter. Detailed procedures are presented in the attached Operation Manuals and should be referenced.

1. Ensure that the portable gas meter has sufficient battery power.
2. Turn the unit on and allow pump to start.
3. Once gas readings are displayed, verify the pump is operating correctly by plugging the free end of the sampling line or probe, ensure that the audible

alarm sounds indicating the pump is blocked.

4. Once you have verified the pump is working, press clear to return to readings and reactivate the pump.
5. Connect the water sample trap and hose to the unit.
6. Turn the “pump” button to “on” and the unit should begin logging data.
7. When monitoring ambient air for field health and safety purposes, continuously check the unit to ensure that the power is on and the values are in the accepted range.
8. Periodically record the data from the monitor in the field log book and/or daily log.
9. If collecting a reading from a landfill well, carefully lift the cap slightly and extend the tube in the well. If performing ambient air monitoring for health and safety purposes, the unit should be held in the breathing zone.

Record the maximum value in the field log book and/or daily log. This information should also be recorded on the sampling log for the boring/well.

VIII. Data Recording and Management

Any data related to the calibration and use of the unit should be recorded in a field log book and/or daily log. If the readings are related to the sampling of a well they should be recorded on the sampling log for the given well.

IX. Quality Assurance

If field forms and lab data are input or tabulated electronically after the field program, they should be compared to the original field forms to ensure accuracy.

X. References

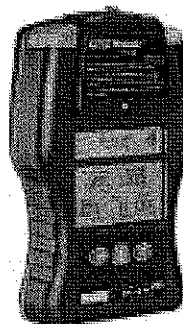
MSA ORION Plus MultiGas Detector, Operating Manual, MSA North America; Part number 10078576 (attached).

MSA Orion® *plus*
The Safety Company MultiGas Detector

Operating Manual

**Detector multigas
Orion® *plus*
Manual de Operación**

**Détecteur multi-gaz
Orion® *plus*
Mode d'emploi**



In North America, to contact your nearest stocking location, dial toll-free 1-800-MSA-2222
To contact MSA International, dial 1-412-967-3354 or 1-800-MSA-7777

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Manufactured by/Fabricado por/Fabriqué par

MSA NORTH AMERICA

P.O. Box 427, Pittsburgh, Pennsylvania 15230

(L) Rev 1

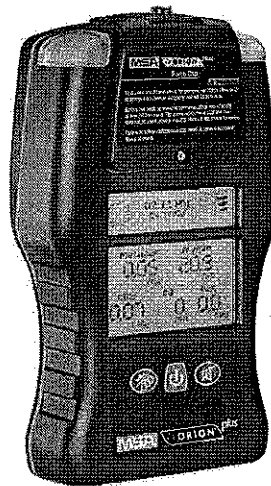
IMZ001-029-N

10078576



Orion[®] *plus* MultiGas Detector

Operating Manual



In North America, to contact your nearest stocking location, dial toll-free 1-800-MSA-2222
To contact MSA International, dial 1-412-967-3354 or 1-800-MSA-7777

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Manufactured by

MSA NORTH AMERICA

P.O. Box 427, Pittsburgh, Pennsylvania 15230

(L) Rev 1

IMZ001-029-N

10078576

WARNING

THIS MANUAL MUST BE CAREFULLY READ BY ALL INDIVIDUALS WHO HAVE OR WILL HAVE THE RESPONSIBILITY FOR USING OR SERVICING THE PRODUCT. Like any piece of complex equipment, this instrument will perform as designed only if it is used and serviced in accordance with the manufacturer's instructions. OTHERWISE, IT COULD FAIL TO PERFORM AS DESIGNED AND PERSONS WHO RELY ON THIS PRODUCT FOR THEIR SAFETY COULD SUSTAIN SEVERE PERSONAL INJURY OR DEATH.

The warranties made by Mine Safety Appliances Company with respect to the product are voided if the product is not used and serviced in accordance with the instructions in this manual. Please protect yourself and others by following them. We encourage our customers to write or call regarding this equipment prior to use or for any additional information relative to use or repairs.

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Chapter 1, Instrument Safety and Certifications

The Orion plus Multigas Detector is for use by trained and qualified personnel. It is designed to be used in air when performing a hazard assessment.

The Orion plus Multigas Detector can be equipped to detect:

- Combustible gases and certain combustible vapors
- Oxygen-deficient or oxygen-rich atmospheres
- Specific toxic gases for which a sensor is installed.

WARNING

Safety Limitations and Precautions

Carefully review the following warnings, safety limitations and precautions before placing this instrument in service:

- The Orion plus Multigas Detector is designed to detect (in air only) combustible gases and vapors and specified toxic gases for which a sensor is installed.
- Perform the following checks before each day's use to verify proper instrument operation:
 - Gas response check (see Calibration section)
 - Calibrate if the readings are not within the specified limits.
 - Check pump for proper operation (see "Verifying Pump Operation" section). Have pump serviced if necessary.
- Check calibration more frequently if the unit is subjected to physical shock or high levels of contaminants. Also, check calibration more frequently if the tested atmosphere contains the following materials, which may desensitize the combustible gas sensor and reduce its readings:
 - Organic silicones
 - Silicates
 - Lead-containing compounds
 - Hydrogen sulfide exposures over 200 ppm or exposures over 50 ppm for one minute.
- A combustible gas reading of "100" indicates the atmosphere is

above 100% LEL and an explosion hazard exists. In such cases, the instrument LockAlarm feature activates. Move away from contaminated area immediately.

- Do not use the Orion plus Multigas Detector to detect combustible dusts or mists.
- Do not use the Orion plus Multigas Detector to test for combustible or toxic gases in the following atmospheres as this may result in erroneous readings:
 - Oxygen-deficient or oxygen-rich atmospheres
 - Reducing atmospheres
 - Furnace stacks
 - Inert environments
 - Atmospheres containing combustible airborne mists or dusts.
- Do not use the Orion plus Multigas Detector to test for combustible gases in atmospheres containing vapors from liquids with a high flash point (above 100°F) as this may result in erroneously low readings.
- Do not block pump inlet as this may cause inaccurate readings. Do not press on the face of the sensors, as this may damage them and cause erroneous readings. Do not use compressed air to clean the sensor holes, as the pressure may damage the sensors.
- Allow sufficient time for unit to display an accurate reading. Response times vary based on the type of sensor being used (see Chapter 7, "Performance Specifications"). Additionally, when using a sampling pump, allow a minimum of 0.7 seconds per foot of sample line to allow the sample to be drawn through to the sensors.
- Keep the probe tip above liquid surfaces; otherwise, liquid may enter the system and block the sample flow, causing inaccurate readings and/or internal damage.
- All instrument readings and information must be interpreted by someone trained and qualified in interpreting instrument readings in relation to the specific environment, industrial practice and exposure limitations.
- Replace alkaline cells or recharge NiMH battery-pack in non-hazardous areas only. Use only battery chargers listed in this manual; other chargers may damage the battery pack and the unit. Dispose of batteries in accordance with local health and safety regulations.

- Do not alter this instrument or make any repairs beyond those specified in this manual. Only MSA-authorized personnel may repair this unit; otherwise, damage may result.

Certifications

Tests completed by MSA verify that the Orion plus Multigas Detector meets applicable industry and government standards as of the date of manufacture.

Electronic Interference

- This instrument generates, uses, and can radiate radio frequency energy. Operation of this instrument may cause interference, in which case, the user may be required to correct.
- This device is test equipment and is not subject to FCC technical regulations. However, it has been tested and found to comply with the limits for a Class A digital device specified in Part 15 of the FCC regulations.
- This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the CRTC.
- There is no guarantee that interference will not occur. If this instrument is determined to cause interference to radio or television reception, try the following corrective measures:
 - Reorient or relocate the receiving antenna
 - Increase separation between the instrument and the radio/TV receiver
 - Consult an experienced radio/TV technician for help.

Chapter 2, Quick Start

It is your responsibility to know how to use the Orion plus Multigas Detector. When used properly, this unit will alert you to the presence of:

- combustible gases and vapors
- atmospheres that are rich or deficient in oxygen
- specific toxic gases if equipped with the appropriate sensor.

These conditions are displayed clearly and simultaneously on the face of the instrument. See Chapter 3, FIGURE 3-3 for an explanation of the flags, numbers and button operation of the Orion plus Multigas Detector.

Turning ON the Orion plus Multigas Detector

1. Push the ON-OFF button to turn ON the Orion plus Multigas Detector with an installed battery pack:
 - The instrument then performs a Self-test where the:
 - instrument details are displayed
 - audible alarm sounds
 - alarm lights illuminate
 - display backlight illuminates.

Once the Self-test is complete, the instrument:

- requests that a Fresh Air Setup be performed
- is ready for use after this Fresh Air Setup procedure is performed or rejected.

Moving Through the Orion plus Multigas Detector Pages

To access instrument features and informational pages:

- Push the PAGE button (See Chapter 3, FIGURE 3-3).

The Pages appear in the following order:

- **Minimum**
Shows minimum value recorded since last instrument turn-ON for the oxygen sensor only.

- **Maximum**
Shows peak value recorded since last instrument turn-ON.
- **TWA**
Shows Time Weighted Average for installed toxic gas sensors.
- **STEL**
Shows Short Term Exposure Limit for installed toxic gas sensors.

To return the instrument to the Measure page:

- Push the RESET button.
 - The instrument automatically returns to the Measure page after a 20-second delay on any page.

Turning OFF the Orion plus Multigas Detector

To turn OFF the Orion plus Multigas Detector:

- Push and hold the ON-OFF button for five seconds.
 - Hourglass displays to indicate instrument turn-OFF.

Chapter 3, Using the Orion plus Multigas Detector

Turning ON the Orion plus Multigas Detector

Installing the Battery Pack (FIGURE 3-1)

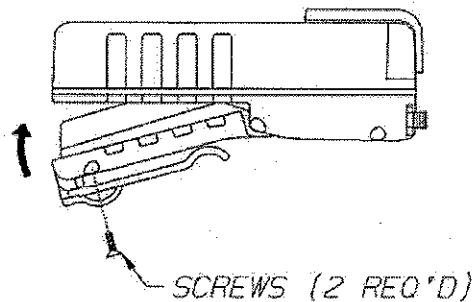


Figure 3-1. Battery Pack Installation

1. Slide the battery pack toward the top of the instrument.
2. Swing the battery pack up and into the body of the instrument.
3. Secure the battery pack by installing the two screws in the bottom two corners of the battery pack and instrument.

NOTE: The screws must be snug to ensure that the battery pack properly seals to the instrument. Do not over-tighten.
4. Once the battery pack is installed, the Orion plus Multigas Detector turns ON.

⚠ WARNING

A calibration check must be performed after switching battery packs to assure accuracy of readings.

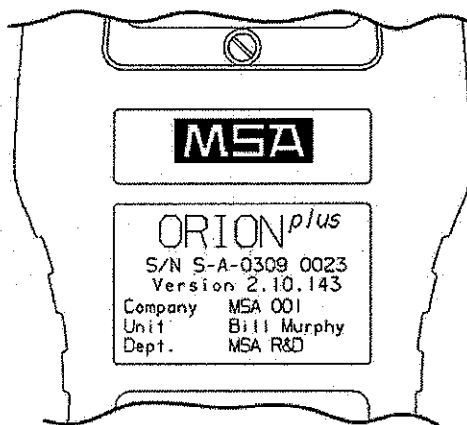


Figure 3-2 Startup Screen

The instrument now performs the following Self-test where the:

- Instrument details are displayed
- Audible alarm sounds
- Alarm lights illuminate
- Display backlight illuminates
- Internal instrument diagnostic occurs
(any detected internal errors appear on the display) and all pre-set alarms are displayed.

When the Self-test ends:

- The instrument offers the FAS option to zero the instrument
 - If the FAS is declined or no buttons are pressed, the instrument enters the Measure mode
- Gas concentrations appear on the display.

Fresh Air Setup Option

(for automatic zero adjustment of the Orion plus Multigas Detector sensors)

NOTE: The Fresh Air Setup (FAS) has limits. If a hazardous level of gas is present, the Orion plus Multigas Detector ignores the

FAS command and goes into alarm.

⚠ WARNING

Do not activate the Fresh Air Setup unless you are certain you are in fresh, uncontaminated air; otherwise, inaccurate readings can occur which can falsely indicate that a hazardous atmosphere is safe. If you have any doubts as to the quality of the surrounding air, do not use the Fresh Air Setup feature. Do not use the Fresh Air Setup as a substitute for daily calibration checks. The calibration check is required to verify span accuracy. Failure to follow this warning can result in serious personal injury or death.

Persons responsible for the use of the Orion plus Multigas Detector must determine whether or not the Fresh Air Setup option should be used. The user's abilities, training and normal work practices must be considered when making this decision.

1. Turn ON the Orion plus Multigas Detector.
 - Once the instrument self check is complete, the instrument offers a Fresh Air Setup option.
2. To perform a Fresh Air Setup, push the display indication YES (RESET) button.
3. To immediately skip the FAS, push the NO (PAGE) button.
 - If no buttons are pushed, the Orion plus Multigas Detector enters the Measuring mode.

Understanding the Display (see FIGURE 3-3)

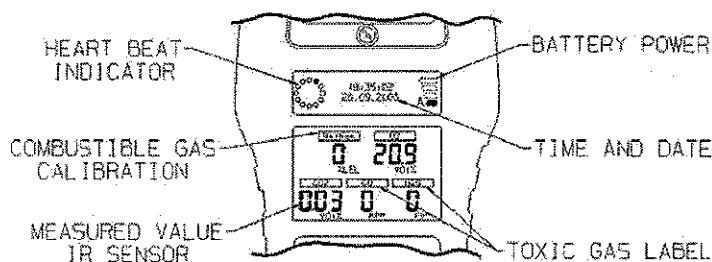


Figure 3-3. Heartbeat, Time & Date, and Battery Life Indicator

- The Heartbeat Indicator circles continuously to notify the user the instrument is ON and operating when Heartbeat is activated.

Time & Date indicator (see FIGURE 3-3)

- The current time (24-hour format) and date (MM/DD/YEAR) continuously displays in the upper portion of the screen.

Battery Life Indicator (see FIGURE 3-3)

- The battery condition icon continuously displays in the upper portion of the screen, regardless of the selected page.
- As the battery charge dissipates, segments of the battery icon go blank until only the outline of the icon remains.

Battery Warning

- A Battery Warning indicates that a nominal 20 minutes of operation remain before instrument batteries are completely depleted.

NOTE: Duration of remaining instrument operation during Battery Warning depends on:

- Ambient temperatures (The battery warning is likely to be shorter in colder temperatures, particularly with alkaline batteries)
 - Whether the battery warning is reset (it comes ON again every five minutes).
- When the Orion plus Multigas Detector goes into Battery Warning:
 - Battery Life indicator flashes
 - Alarm sounds
 - Alarm lights flash.
- To silence the Battery Warning, push the RESET button.
- The Orion plus Multigas Detector continues to operate until the instrument is turned OFF or battery shutdown occurs.

Battery Shutdown

When the batteries can no longer operate the instrument, the instrument goes into Battery Shutdown mode:

- Battery Indicator remains ON

- Alarm sounds continuously
- Alarm lights flash
- No other pages can be viewed
- After approximately five minutes, the unit automatically turns OFF.

⚠ WARNING

When Battery Shutdown condition sounds, stop using the instrument; it can no longer alert you of potential hazards since it does not have enough power to operate properly. You must:

1. Leave the area immediately.
2. Turn OFF the instrument if it is ON.
3. Report to the person responsible for maintenance.
4. Replace or recharge the battery pack.

Failure to follow this procedure, could result in serious personal injury or death.

For Alkaline Battery packs, replace batteries when the "Battery Low" or "Battery Shutdown" alarms occur. When replacing alkaline batteries, replace ALL batteries with fresh ones at the same time. Do not mix new and partially-discharged batteries. If the batteries are improperly replaced or improperly mixed, the "Battery Low" and "Battery Shutdown" alarms may fail to function, which could result in serious personal injury or death.

Do not use rechargeable batteries in Alkaline Battery Packs. The Alkaline battery warning and alarm setpoints are not optimized for rechargeable batteries. The low battery warning and alarm could occur too quickly to be noticed. Using rechargeable batteries in the Alkaline battery pack could result in serious personal injury or death.

NOTE: The instrument recognizes the type of installed battery pack (rechargeable NiMH or alkaline) and automatically adjusts the low battery warning and alarm setpoints.

⚠ CAUTION

During "Battery Low" condition, prepare to exit the work area since the instrument could go into "Battery Shutdown" at any time, resulting in loss of sensor function. Depending on the age of the batteries, ambient temperature and other conditions, the instrument "Battery Low" and "Battery Shutdown" times could be shorter than anticipated.

⚠ WARNING

Recharge or replace the batteries when the "Battery Low" or "Battery Shutdown" conditions occur.

Do not reuse a NiMH battery without recharging, even if the battery regains some charge after a period of non-use.

Verifying Pump Operation

1. Turn ON the Orion plus Multigas Detector.
 - The pump motor starts fast and then slows down as the instrument adjusts the power to run the pump.
2. Once gas readings are displayed, plug the free end of the sampling line or probe.
 - The pump motor shuts down and an alarm sounds.
 - The 'Heartbeat' stops circling and displays a "P" in the circle
 - A clear message appears in the display with 'on-line' instructions
 - The readings on the display may change.
3. When the pump inlet, sample line or probe is blocked, the pump alarm must activate. If the alarm does not activate:
 - a. Check the pump, sample line, and probe for leaks.
 - b. Once leak is fixed, recheck pump alarm by blocking the flow.
4. Check the pump before each day's use.

⚠ WARNING

Do not use the pump, sample line, or probe unless the pump alarm activates when the flow is blocked. Lack of an alarm is an indication that a sample may not be drawn to the sensors, which could cause inaccurate readings. Failure to follow the above can result in serious personal injury or death.

⚠ WARNING

Never let the end of the sampling line touch or go under any liquid surface. If liquid is sucked into the instrument, readings will be inaccurate and the instrument could be damaged.

5. Press the RESET button to reset the alarm and restart the pump.

During operation, a pump alarm may occur when the:

- Flow system is blocked
- Pump is inoperative
- Sample lines are attached or removed.

To Clear an Alarm

1. Correct any flow blockage.
2. Press the RESET button.
 - The Pump will now restart.

Response Check

The gas response check is simple and should complete in about one minute.

- Perform this response check before each day's use.
1. Turn ON the Orion plus Multigas Detector in clean, fresh air.
 2. Verify that readings indicate no gas is present.
 3. Attach the regulator to the cylinder.
 4. Connect the tubing to the regulator.
 5. Open the regulator valve.
 - The flow rate of the regulator is 0.25 lpm.
 6. Attach the other end of tubing to the Orion plus pump inlet fitting.
 - The reading on the Orion plus Multigas Detector display should be within the limits stated on the calibration cylinder or limits determined by your company.
 - If necessary, change the cylinder to introduce other calibration gases.
- The Orion plus Multigas Detector also offers an option for a 'silent' response check with no audible and visual alarms triggered. For the 'silent' check, enter the 'Setup' mode (see Chapter 4, "Changing Instrument Settings") and, in the 'Calibration' menu, select the 'Calibration check' option.

Measuring Gas Concentrations

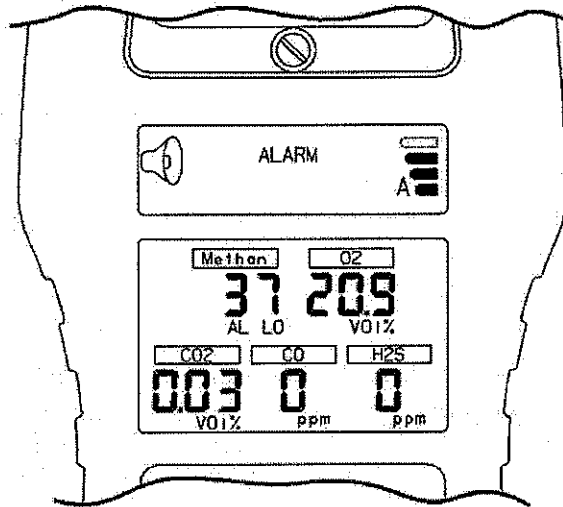


Figure 3-4. Instrument in LEL Alarm

The Orion plus Multigas Detector can be equipped to detect combustible gases in the atmosphere.

- Alarms sound when concentrations reach:
 - Low Alarm Setpoint, High Alarm Setpoint or
 - 100% LEL (Lower Explosive Limit).
- When the combustible gas indication reaches the Low Alarm Setpoint, the:
 - Alarm sounds and Alarm lights flash
 - Lo Alarm indication and % LEL label (located above the concentration) flashes; all other non-alarming gas readings move to the background.
- To silence the alarm, press the RESET button.

NOTE: The alarm will stay silent if the alarm condition has cleared.

- When the combustible gas indication reaches the High Alarm Setpoint, the:
 - Alarm sounds and Alarm lights flash at a higher frequency

- High Alarm indication and % LEL label (located above the concentration) flashes; all other non-alarming gas readings move to the background.
- To silence the alarm, press the RESET button.

NOTE: This alarm cannot be reset with RESET button until the condition is cleared.

- When the combustible gas indication reaches 125% LEL, the:
 - LockAlarm circuit locks the combustible gas reading and alarm
 - Alarm sounds
 - Alarm lights flash
 - Overrange message appears on the display.
- This alarm cannot be reset with the CHANGE/RESET button.

⚠ WARNING

If the overrange LEL alarm condition is reached, you may be in a life-threatening situation; there is enough gas in the atmosphere for an explosion to occur. In addition, any rapid up-scale reading followed by a declining or erratic reading can also be an indication that there is enough gas for an explosion. If either of these indications occur, leave and move away from the contaminated area immediately. Failure to follow this warning can result in serious personal injury or death.

- After moving to a safe, fresh-air environment, reset the alarm by turning OFF the instrument and turning it ON again.

Oxygen Measurements

The Orion plus Multigas Detector can be equipped to detect the amount of oxygen in the atmosphere.

- Two conditions, depending on setpoints, can trigger the alarm:
 - Too little oxygen (deficient)
 - Too much oxygen (enriched).
- When the alarm setpoint is reached for either of the above:
 - Alarm sounds and Alarm lights flash
 - Hi or Lo Alarm indication and % O₂ label above the concentration flashes; all other non-alarming gas readings move to the background.

Toxic Gas Measurements

The Orion plus Multigas Detector can be equipped to detect specific toxic gases.

When the Low alarm setpoint is reached for any toxic gas:

- Alarm sounds and Alarm lights flash
- Lo Alarm indication and gas label above the concentration flashes; all other non-alarming gas readings move to the background.

To silence the alarm, press the RESET button.

NOTE: The alarm will stay silent if the alarm condition has cleared.

When the toxic gas indication reaches the High Alarm Setpoint, the:

- Alarm sounds and Alarm lights flash at higher frequency
- Hi Alarm indication and gas label (located above the concentration) flashes; all other non-alarming gas readings move to the background.

NOTE: This alarm cannot be reset with the RESET button until the condition is cleared.

WARNING

If the Oxygen or Toxic Gas alarm condition is reached while using the instrument as a personal or area monitor, leave the area immediately; the ambient condition has reached a preset alarm level. If using the instrument as an inspection device, do not enter the area without proper protection. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

Viewing Optional Displays

- Press the PAGE button to move to Minimum Readings (MINIMUM).
 - This page shows the lowest level of oxygen recorded by the Orion plus Multigas Detector since Turn-ON.

Peak Readings (MAXIMUM)

- The Maximum flag appears in the upper portion of the display to show the highest levels of gas recorded by the Orion plus Multigas Detector since:
 - Turn-ON
 - Short Term Exposure Limits (STEL)
 - The STEL flag appears in the upper portion of the display to show the average exposure over a 15-minute period.
- When the amount of gas detected by the Orion plus Multigas Detector is greater than the STEL limit, the:
 - Alarm sounds and Alarm lights flash
 - STEL flag flashes.
- The STEL alarm is calculated over a 15-minute exposure. Calculation examples are as follows:

Assume the Orion plus Multigas Detector has been running for at least 15 minutes.

- 10-minute exposure of 35 PPM
5-minute exposure of 5 PPM:

$$\frac{(10 \text{ minutes} \times 35 \text{ PPM}) + (5 \text{ minutes} \times 5 \text{ PPM})}{15 \text{ minutes}} = 25 \text{ PPM}$$

Assume the Orion plus Multigas Detector was turned on five minutes ago.

- 5-minute exposure of 15 PPM:

$$\frac{(5 \text{ minutes} \times 15 \text{ PPM}) + (10 \text{ minutes} \times 0 \text{ PPM})}{15 \text{ minutes}} = 5 \text{ PPM}$$

Time Weighted Average (TWA)

- The TWA flag appears in the upper portion of the display to show the average exposure since the TWA reading was reset.
- When the amount of gas detected by the Orion plus Multigas Detector is greater than the eight-hour TWA limit, the:
 - Alarm Sounds and Alarm Lights Flash
 - TWA flag flashes.

The TWA alarm is calculated over an eight-hour exposure. Calculation examples are as follows:

- 1-hour exposure of 50 PPM:

$$\frac{(1 \text{ hour} \times 50 \text{ PPM}) + (7 \text{ hours} \times 0 \text{ PPM})}{8 \text{ hours}} = 6.25 \text{ PPM}$$

- 12-hour exposure of 100 PPM:

$$\frac{(12 \text{ hours} \times 100 \text{ PPM})}{8 \text{ hours}} = 150 \text{ PPM}$$

NOTE: The accumulated reading is always divided by eight hours.

WARNING

If the STEL or TWA alarm condition is reached while using the instrument as a personal or area monitor, leave the contaminated area immediately; the ambient gas concentration has reached the preset STEL or TWA alarm level. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

Turning OFF the Orion plus Multigas Detector

Push and Hold the ON-OFF button for five seconds.

- Gas readings end and the Hourglass displays.

NOTE: Releasing the ON-OFF/PAGE button before the five seconds elapse returns the instrument to the Measure page.

Chapter 4, Setting up the Multigas Detector

Power Systems

- The Orion plus Multigas Detector is supplied with a NiMH battery pack or an optional replaceable cell, alkaline battery pack.
- See TABLE 4-1 for nominal run times by battery type.

Table 4-1.
Approximate Battery Run Times (20°C)

BATTERY TYPE	HOURS (WITH PUMP)
NiMH	10
Alkaline	6

In colder temperatures, battery output may be severely reduced. See TABLE 4-2 for capacity reductions expected for alkaline batteries at these temperatures.

Table 4-2.
Capacity Reductions
Expected for Batteries at Colder Temperatures

TEMPERATURE	AA ALKALINE
21°C (70°F)	None
0°C (32°F)	25%
-10°C (14°F)	60%

Battery Pack Removal

To remove the battery pack from the Orion plus Multigas Detector:

1. Remove the two screws from the bottom corner of the battery pack.
2. Gently pull out the pack by lifting the bottom out of its recess; then, slide it down.

Battery Charging (NiMH Battery Pack Only)

Charge the Orion plus Multigas Detector NiMH battery packs by using the Orion plus Fast Charger supplied with the instrument.

⚠ CAUTION

Use of any charger, other than the Fast Charger supplied with the instrument, may damage or improperly charge the batteries.

- The Orion plus Multigas Detector must be turned OFF, or the battery pack must be removed from the instrument, prior to charging.
- The charger is capable of charging a completely depleted pack in two hours in normal, room-temperature environments.

NOTE: Allow very cold battery packs to stabilize for 1/2-hour at room temperature before attempting to charge.

To Charge the Battery Pack

- Align and connect the charger cable plug and battery pack charging jack using the white alignment markers located on the charger plug and the back of the battery pack or use the charger cradle.
- Charger status is indicated by the LED color:
 - **Amber**
The charge is pending; LED remains amber until the pack is ready to be charged.
 - **Red**
Charging is in process.
 - **Green**
Charging is complete; the pack is fully charged and ready for use.

- **Red Flashing**
Failure mode; remove battery pack from charger.
- **LED OFF**
No battery pack is connected.

To Charge the Battery Pack (Vehicle Charger P/N 10034276)

- Connect the:
 - input cable assembly to the automobile lighter and
 - input to the charger assembly.
- Align and connect the charger cable plug and battery pack charging jack by using the white alignment markers located on the charger plug and the back of the battery pack.
- Charger status is indicated by the LED color:
 - **Yellow**
Charge pending/Fault
 - **Solid Red**
Charging is in process
 - **Solid Green**
Charge complete.

Once battery pack is charged, it:

- Can be disconnected from the charger
- Is ready for immediate use.

Alkaline Battery Pack

- The Orion plus Multigas Detector Replaceable battery pack can be used as a:
 - Full-time battery pack or
 - Backup power source.
- See TABLE 4-3 for batteries approved for use in the Orion plus alkaline battery pack.

Table 4-3.
Batteries Approved for use in the Orion plus Alkaline Battery Pack

BATTERY	UL	EUROPE	AUSTRALIA
DURACELL MN1500	•	•	•
VARTA 4006	•	•	
Energizer E91	•		•

To Replace the Batteries

1. Remove battery pack from the instrument by removing the two screws located in the bottom corners of the battery pack.
2. Gently lift the pack out of its recess and pull it out.
3. Using the supplied hex key, loosen the single screw that holds the plastic battery cover to the battery pack.
4. Remove the plastic cover, exposing the replaceable batteries.
5. Remove the depleted batteries.

NOTE: Follow local regulations regarding battery disposal.

6. Install the new batteries, observing the direction of the positive (+) battery terminal. The instrument will not operate if cells are reversed.
7. Replace the plastic battery cover and tighten the screw.
8. Re-install the battery pack on the instrument.

Changing Instrument Settings

- Many of the Orion plus Multigas Detector options can be set using the buttons on the front of the instrument.
 - The MSA Orion plus LINK software can be used to set most of the instrument selections, including some that cannot be changed from the instrument's front panel buttons.
1. To access instrument Setup mode, simultaneously press the PAGE and RESET buttons until "Password" appears on the display.
 2. Enter the following sequence:
 - PAGE, ON/OFF, RESET, ON/OFF, PAGE
 - You are now in the Setup menu, on the top menu "calibration"; there are five top menus which can be accessed using the scroll (PAGE/RESET) and OK (ON/OFF) buttons

- See TABLE 4-4 for available selections and methods for changing these selections.

Table 4-4.
Available Instrument Selections and Methods
for Changing Selections

OPTION	Orion plus FRONT-PANEL BUTTONS	ORION PLUS LINK
Viewing alarm set-points	•	•
Changing alarm set-points	•	•
Setting Datalog Intervals	•	
Setting calibration	•	
Password Change		•
Setting Date/Time	•	
Set Contrast	•	
Set Language (English/German)	•	•
Add Remote Sensors		•

Chapter 5, Instrument Setup and Calibration

⚠ WARNING

Attention! Special conditions with toxic gases!

If the instrument is to be checked or calibrated for toxic gases, prerequisites are required; otherwise, incorrect calibration would result in incorrect instrument operation.

Toxic gases (e.g., chlorine, ammonia, ozone) have the property of diffusing into rubber and plastic tubes so the volume of test gas available in the instrument would no longer be sufficient to correctly perform instrument calibration.

For this reason, when calibrating the instrument with toxic gases, certain prerequisites are required:

- a special pressure reducer
- short connection tubes between the pressure reducer and the instrument (approximately one inch)
- connection tubes made from a material which does not absorb the test gases (e.g., Teflon).

NOTE: If using normal tubes and pressure reducers, expose them to the relevant test gas for an extended time period.

For example:
for chlorine, allow the entire contents of a test gas cylinder to flow through the tubes and the pressure reducer.

Calibrating the Orion plus Multigas Detector

The Orion plus Multigas Detector is equipped with a password-accessible autocalibration feature to prevent unauthorized access to calibration. This autocalibration function will only operate with configurations shown in TABLE 5-1.

The Autocalibration sequence resets, instrument zeroes, and adjusts sensor calibration for known concentrations of calibration gases.

Table 5-1. Autocalibration and Required Calibration Cylinders

SENSORS	EXPECTED GAS CONCENTRATION	FIVE GAS CYLINDER	FOUR GAS CYLINDER
	58 Liters	P/N 10050744	P/N 804770
	34 Liters	P/N 10058022	P/N 711058
Combustible	58% LEL	●	●
Oxygen	15%	●	●
Carbon Monoxide	300 ppm	●	●
Hydrogen Sulfide	10 ppm	●	●
Carbon Dioxide	2.5% Vol	●	

To Calibrate the Orion plus Multigas Detector

1. Turn ON instrument and verify that battery is sufficiently charged.
2. To access Instrument Setup mode, simultaneously press the PAGE and RESET buttons until "Password" appears on the display.

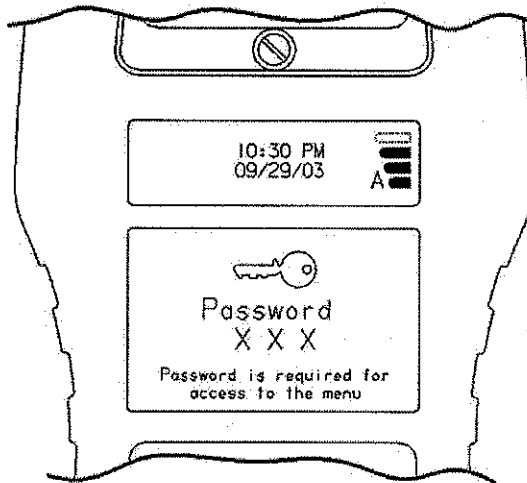


Figure 5-1. Password Screen

3. Enter the following sequence:
 - PAGE, ON/OFF, RESET, ON/OFF, PAGE.
 - User is now:
 - in the Setup menu
 - at the top Menu, "calibration".
 - There are five top menus accessible by using the:
 - Scroll (PAGE, RESET) and
 - OK (ON/OFF) buttons.
 - The five top menus in the Setup menu are:
 - Calibration
 - Alarm Setup
 - Instrument Setup
 - Turn Off Instrument
 - Go Back to Measurement.

Calibration Mode

4. To enter this page, press OK by scrolling with the PAGE and RESET buttons.
5. It is now possible to access the following sub-menus:
 - Calibration Multiple Sensors
 - 5 sensor calibration (see TABLE 5-1)
 - 4 sensor calibration (see TABLE 5-1)
 - Calibration Single Sensor
 - Fresh Air Setup
 - Calibration Check
 - Go Back to Previous Menu.

NOTE: The procedure is similar for all menus.

- The following describe the 4 sensor calibration procedure.

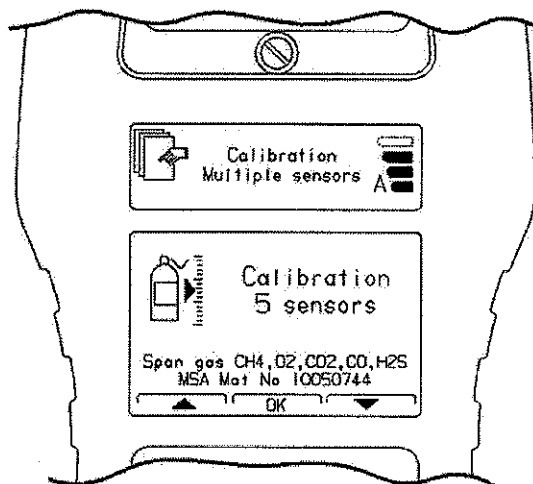


Figure 5-2. Multi Sensor Calibration Screen

Calibration Multiple Sensors

1. Access with OK; choose (PAGE, RESET) for:
 - 5 sensor calibration (see TABLE 5-1) or
 - 4 sensor calibration (see TABLE 5-1)
2. Access with OK.
 - Instrument displays list of required gases and concentrations.
3. Press NEXT for zero Calibration.
 - Instrument displays 'Apply Fresh Air'.

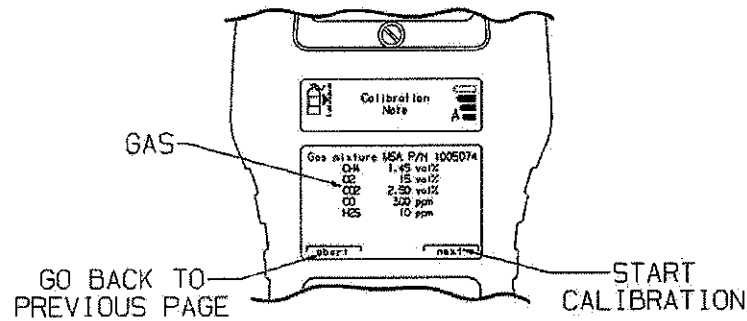


Figure 5-3. Gas Mixture Screen

4. Press:
 - ABORT to cancel
 - MEASURE to return to Measure mode
 - REPEAT to start FAS again
 - MENU to return to 4 sensor calibration
 - NEXT to perform FAS.
5. Press:
 - VALUE to see gas Value instead of gas Flag
 - ABORT to cancel FAS.
6. Press:
 - MEASURE to return to Measure mode
 - REPEAT to start FAS again
 - MENU to return to 4 sensor calibration.
 - If FAS is successful, instrument displays "Apply Span gas".
7. Press:
 - ABORT to cancel.
8. Press:
 - MEASURE to return to Measure mode
 - REPEAT to return to "Apply Span Gas"

- MENU to return to 4 sensor calibration
- NEXT to perform Calibration.

9. Press:

- VALUE to see gas Value instead of gas Flag
- ABORT to cancel Calibration.

10. Press:

- MEASURE to return to Measure mode
- REPEAT to start 4 sensor Calibration again
- MENU to return to 4 sensor calibration.
 - If Calibration is successful, the instrument asks for confirmation.
 - If Calibration is not successful, user can:
 - REPEAT or
 - ABORT.

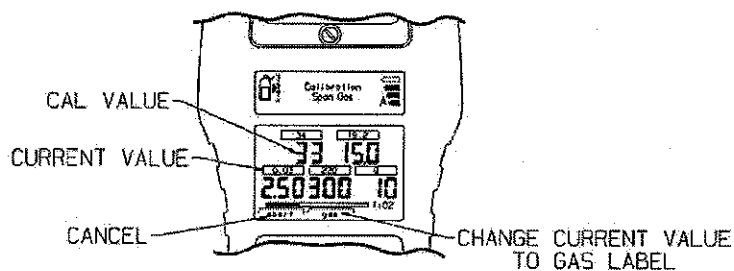


Figure 5-4. Calibration Page

Calibration Single Sensor

1. Access with OK.
2. Press NEXT and follow a procedure similar to that previously given under "Calibration Multiple Sensors".

NOTE: After performing FAS, the unit will ask for Span gas; the calibration value can be adjusted in this mode.

Calibration Table

ORION Plus Echam sensor Calibration				Zero gas: Clean Fresh Air	
Sensor	Range	Time Zero gas	Time Span gas	Cal gas Concentration	Display Read out
O2 Oxygen	0-25 Vol%	-	90 s	Clean Fresh Air (20.9 Vol % O2)	20.9 Vol%
CO Carbon Monoxide	0-300 ppm	60 s	90 s	10058022 / 1005823 (58L) 300 ppm CO	300 ppm
H2S Hydrogen Sulfide	0-200 ppm	60 s	90 s	10058022 / 1005823 (58L) 10 ppm H2S	10 ppm
NH3 Ammonia	0-100 ppm	60 s	240 s	711078 (34L) 25 ppm NH3 in N2	25 ppm
Cl2 Chlorine	0-10 ppm	60 s	180 s	805740 (58L) 10 ppm Cl2 in N2	10 ppm
SO2 Sulfur Dioxide	0-20 ppm	60 s	120 s	711070 (34L) 10 ppm SO2 in N2	10 ppm
NO2 Nitrogen Dioxide	0-20 ppm	60 s	180 s	711068 (34L) 10 ppm NO2 in Air	10 ppm
PH3 Phosphine	0-5 ppm	60 s	90 s	711068 (34L) 0.5 ppm PH3 in N2	0.5 ppm
ClO2 Chlorine Dioxide	0-1 ppm	60 s	180 s	711062 (34L) 2 ppm Cl2 / N2	0.5 ppm
O3 Ozone	0-1 ppm	60 s	240 s	711062 (34L) 2 ppm Cl2 / N2	2.4 ppm
HCN Hydrogen Cyanide	0-30 ppm	60 s	180 s	711072 (34L) 10 ppm HCN / N2	10 ppm
COCl2 Phosgene	0-1 ppm	60 s	240 s	711062 (34L) 2 ppm Cl2 / N2	0.8 ppm

ORION Plus IR sensor Calibration				Zero gas: Clean Fresh Air	
Sensor	Range	Time Zero gas	Time Span gas	Cal gas Concentration	Display Read out
CO2 Carbon dioxide	0 - 10 Vol%	60 s	90 s	10058022 / 1005823 (58L) 2.5 Vol % CO2	2.5 Vol%
CO2 Carbon dioxide	0 - 50 Vol%	60 s	90 s	10081803 10% CO2 in N2	10 Vol%
C3H8 Propane	0 - 100 % LEL	60 s	90 s	493579 100L 0.6 Vol % C3H8 in Air	29% LEL
C3H8 Propane	0 - 25 Vol %	60 s	90 s	10081805 / 15% Propane in N2 10075802 / 8Vol% C4H10 -> 11	15% 11.0 Vol%
C3H8 Propane	0 - 100 Vol %	60 s	90 s	10075803 / 8Vol % C3H8 -> 8 10075802 / 8Vol% C4H10 -> 11	8.0 Vol% 11.0 Vol%
C4H10 n-Butane	0 - 25 Vol %	60 s	90 s	10075802 / 8 Vol% C4H10 in N2	8.0 Vol%
C4H10 n-Butane	0 - 100 Vol %	60 s	90 s	10081604 / 15% Butane in N2	15 Vol%
CH4 Methane	0 - 25 Vol %	60 s	90 s	2.5 % Vol CH4	2.5% Vol
CH4 Methane	0 - 100 Vol %	60 s	90 s	711014 (58L) 100 Vol % CH4 in N2	100 Vol%

Alarm Setup Mode

NOTE: Accessing the Instrument Setup mode leads you to the main Calibration mode page.

1. To access the 'Alarm Setup' page:
 - Press the scroll buttons (PAGE, RESET).
 - Press OK.
 - User is now in the 'Setup Alarm Lo' page.

'Setup Alarm Lo' Page

2. Press:
 - ABORT to cancel setup
 - REPEAT to return to 'Setup Alarm Lo' page
 - NEXT to access the main 'Alarm Setup' page
3. CHANGE setpoints with the PAGE and RESET buttons.
4. Confirm settings with the ON/OFF button.
 - NEXT will lead you to 'Setup Alarm Hi' page.

'Setup Alarm Hi' Page

5. In the 'Setup Alarm Hi' page, press:
 - ABORT to cancel setup
 - REPEAT to return to 'Setup Alarm Lo' page
 - NEXT to access the main 'Setup TWA Alarms' page
6. CHANGE setpoints with the PAGE and RESET buttons.
7. Confirm settings with the ON/OFF button.
 - NEXT leads to 'Setup TWA Alarms' page.

'Setup TWA Alarms' Page

- In 'Setup TWA Alarms', display asks 'Activate TWA Alarms?'
8. Press:
 - ABORT to cancel setup
 - REPEAT to return to 'Setup Alarm Lo' page

- NEXT to access the main 'Alarm Setup' page
 - NO to Deactivate STEL and TWA Alarms
 - YES to save this setting and move to 'Alarm Setup' page.
9. In 'Alarm Setup' page press:
- NO to cancel
 - REPEAT to return to 'Setup Alarm Lo' again
 - NEXT to access the main 'Alarm Setup' page
 - YES to activate and move to 'Setup Alarm STEL' page.

'Setup Alarm STEL' Page

10. In 'Setup Alarm STEL', press:
- NO to cancel
 - REPEAT to return to 'Setup Alarm Lo' again
 - NEXT to access the main 'Alarm Setup' page
11. CHANGE the STEL setpoints with the PAGE and RESET buttons.
12. Confirm the settings with the ON/OFF button.
- NEXT will lead you to the 'Setup TWA Alarms' page.
13. In the 'Setup Alarm TWA', press:
- ABORT to cancel setup
 - REPEAT to return to 'Setup Alarm Lo' page
 - NEXT to access the main 'Alarm Setup' page
14. CHANGE the TWA setpoints with the PAGE and RESET buttons.
15. Confirm the settings with the ON/OFF button.
- NEXT leads to the question 'Save alarm setup?'
16. Press:
- YES to save
 - NEXT to access the main 'Alarm Setup' page
 - NO to cancel the setup
 - REPEAT to restart 'Setup Alarm Lo'
 - NEXT to access the main 'Alarm Setup' page.

Instrument Setup Menu

NOTE: Accessing the Instrument Setup mode leads you to the main Calibration mode page.

1. To access the Instrument Setup page:
 - Press the scroll buttons (PAGE, RESET).
 - Press OK.
 - User is now in the 'Instrument setup' page.
 - the instrument displays the 'Time Setup' sub-menu

'Time Setup' Sub-Menu

2. Press:
 - OK to enter the Time Setup page
 - display asks, 'change time?'
3. Press:
 - NO to cancel and return to 'time Setup' page
 - YES to change
 - OK to confirm setting.
 - Display asks 'Save new time?'
4. Press:
 - YES to save and return to the 'Time setup' page
 - NO to cancel and return to the 'Time Setup' page
 - REPEAT to change time and date again.
 - 'Language' is the next sub-menu under 'Instrument Setup'

'Language' Sub-Menu

5. Press OK to enter the Language sub-menu.
 - The display shows 'English'.
6. Press:
 - ABORT to return to the 'English' page
 - STORE to save and return to the 'Calibration' page
 - CHANGE to change to the 'Deutsche' page.

7. Press:

- 'SPEICHERN' to store
- 'ANDERN' to go back to 'English'
- 'ABBRUCH' to return to 'Language'
 - 'Heartbeat' is the next sub-menu under 'Instrument Setup'.

'Heartbeat' Sub-Menu

7. Press:

- OK to enter the Heartbeat sub-menu
 - The display shows 'Heartbeat ON'
- OFF to:
 - Turn OFF the confidence beep and
 - Flash every 60 seconds
- NEXT to return to 'Heartbeat' page
- ABORT to return to 'Heartbeat' page
 - 'Contrast Setup' is the next sub-menu under Instrument Setup'.

'Contrast Setup' Sub-Menu

8. Press:

- OK to enter the Contrast Setup sub-menu.

NOTE: Contrast automatically adjusts with temperature changes. However, low temperatures may cause poor display contrast; this can be manually adjusted in the Setup mode.

'Data Logging Interval' Sub-Menu

9. Press OK to enter the 'Data Logging Interval' sub menu

10. To change the interval to a setting between 15 seconds and 10 minutes, use the (PAGE, RESET) scroll buttons.

11. Press OK to confirm setting.

- 'Data Logging Interval' is the next sub-menu under 'Instrument Setup'.
- Use arrows to change settings; press OK to confirm settings

between 15 seconds, 30 seconds, 60 seconds, two minutes, five minutes, and 10 minutes.

- 'Go back to Previous Menu' is the next sub-menu under 'Instrument Setup'.

'Go back to Previous Menu'

13. To return to the previous menu:

- Press OK to confirm or
- Scroll with PAGE, RESET between previous sub-menus.

Turn OFF Instrument (Main Menu)

- Press OK to turn OFF the instrument
- Scroll with PAGE, RESET between other menus.

Go Back to Measurement (Main Menu)

- Press OK to return to the Measuring page
- Scroll with PAGE, RESET between other menus.

Setting the Instrument Using the ORION Link Software

NOTE: The computer must be fitted with an Infrared Adaptor IrDA RS 232 (e.g. iFoundry IFSYS-8001A) and the corresponding software.

1. If not already done, connect the infrared adaptor to the computer and install the driver (see drivers and installation instructions for the infrared adaptor).

NOTE: .NET-Framework by Microsoft® software must be installed on the computer.

2. If not already done, install the .NET-Framework by Microsoft software on the computer (software and installation instructions are on the supplied CD-ROM).
3. Install the ORION Link software on the computer (software and installation instructions are on the supplied CD-ROM).

Connecting Instrument to the PC

1. Turn ON the computer and open the ORION Link software.
2. Turn ON the instrument and wait until it is in the Measuring mode.
3. Locate the instrument about 1 inch away from the infrared adaptor (with input spigot pointing toward the infrared sensor when viewing the instrument from the rear).

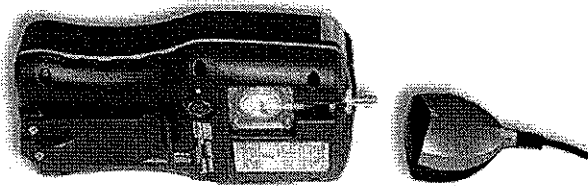


Figure 5-5. Attaching the Infrared Adaptor to the Instrument

4. On the Start screen of the ORION Link software, select CONNECT INSTRUMENT.
5. On the window that opens, select the:
 - interface (COM1, COM2 or others) connected to the infrared adaptor (FIGURE 5-6)
 - scope of information:
 - Instrument information
 - Sensor data and settings
 - Stored event data (over a specific time period)
 - Stored measured values (over a specific time period)

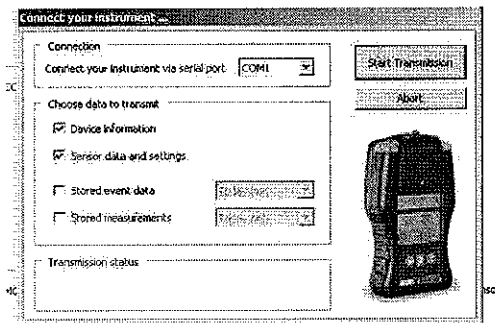


Figure 5-6. Connecting the Instrument

6. Connect the instrument by clicking on the **CONNECT INSTRUMENT** button.
 - The following Welcome screen appears:

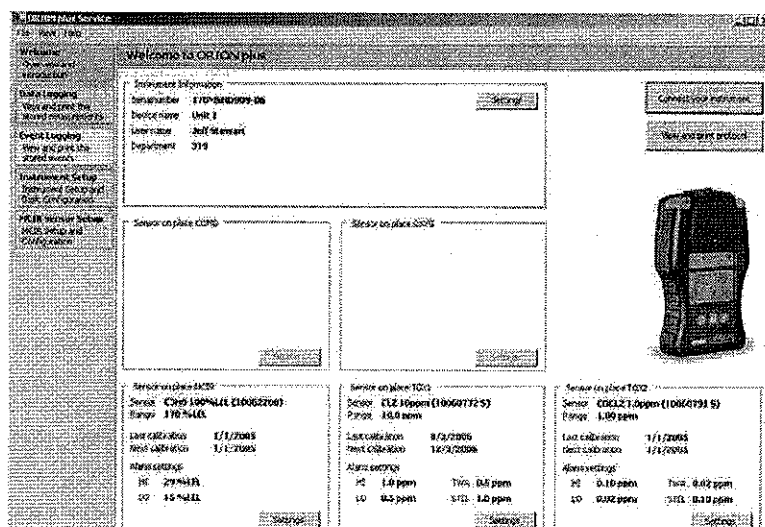


Figure 5-7. Welcome to ORION plus

- The **CONNECT INSTRUMENT** button can be used to reestablish an interrupted connection.
- The **CREATE PROTOCOL** button can be used to store all the instrument data.
- FIGURE 5-7 displays the:
 - instrument data
 - information concerning individual sensors.
- After pressing the **SETTINGS** button, the user can change:
 - settings for each sensor individually (if the required areas are adjustable)
 - alarm settings for installed sensors.

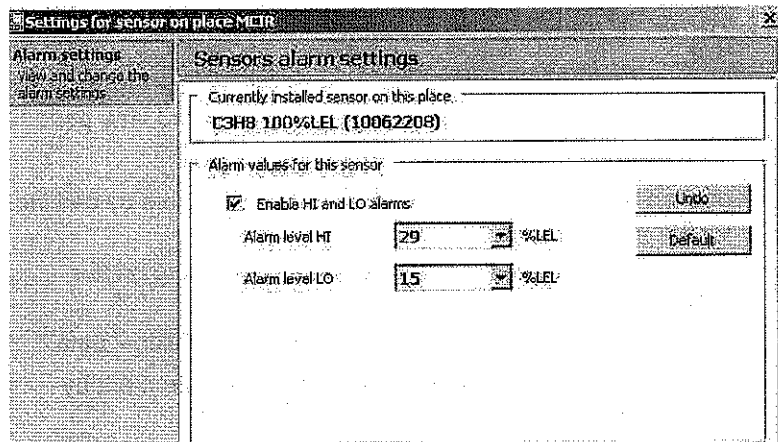


Figure 5-8. Alarm Settings

- The FIGURE 5-8 screen shows the:
 - sensors
 - alarm thresholds for these sensors.
- By selecting the options you can activate or deactivate the alarm.
 - This can only be done for *both* alarm thresholds *together*.
- The alarm thresholds:
 - can be changed to suit the user's requirements and
 - transmitted to the instrument by closing the window.
- By clicking on the relevant button the user can:
 - cancel the changes made or
 - set the values to a standard setting.
- By using the buttons in the navigation bar (FIGURE 5-7) the user can access other program areas, such as:
 - Data storage – display and store the instrument data
 - Event storage – display and store the event data
 - Instrument settings – instrument settings and configuration
 - MCIR settings – MCIR settings and configuration.

NOTE: The program areas, instrument settings and MCIR settings are only accessible with valid authorization.
For access to the area MCIR settings, the corresponding sensor must be installed.

Data Log

- In this window, the user can:
 - view all stored measurement data for the selected time period
 - view instrument data
 - convert and store the measurement data as a table by clicking on the STORE TABLE button
 - delete all the stored measurement data by clicking on the DELETE DATA button
- NOTE: It is not possible to delete selected individual data.
- re-establish an interrupted connection to the instrument by pressing the CONNECT INSTRUMENT button.

Event Log

- In this window, the user can:
 - view all stored measurement data for the selected time period
 - view instrument data
 - convert and store the measurement data as a table by clicking on the STORE TABLE button
- re-establish an interrupted connection to the instrument by pressing the CONNECT INSTRUMENT button.

Area Instrument Settings

Orion Area Service

File View Help

Welcome Overview and Introduction

Data Logging
View and modify the standard data logging.
Event Logging
View and print the standard event.

Instrument Setup and Basic Configuration

Instrument Information

Serial Number: 1704540309-06
Device Name: Built 1
User Name: Jeff Stewart
Company: 319

Instrument Serial Number

Serial Number: 1704540309-06
Manufacturer No: 1704540309

Sensor Installation

Place CO2H
Place CO2G
Place MGR: MGR Sensor Type 001
Place T001: CLZ L001 (10000772 5)
Place T002: COCLA L001 (10000991 5)

Sensor Configuration for...

☐ Sensor on place CO2H ☐ Sensor on place T001
☐ Sensor on place CO2G ☐ Sensor on place T002
☐ Sensor on place MGR

Event and Data Storage

☐ Clear all logging memory ☐ Clear event logging memory

Reset to default settings

Reset all settings to their default values.
This procedure will erase all stored up and stored data.

Common Settings

☐ Show 1st stage in log on startup screen
☐ Display flow range at comb. sensor 8.0 and 6.000

Figure 5-9. Instrument Settings and Configuration

- This window provides extended instrument settings and configuration.
- Certain functions are only accessible by the group of persons authorized by MSA.
- The available options are:
 - Display and modify the instrument information
 - Display the instrument serial number
 - Install the sensors
 - Reset the sensors
 - Delete the data and event storage .
- To reset all instrument data to the factory setting, click on the RESET button.

- By clicking on the SETTINGS button in the area instrument information (FIGURE 5-11), the "Instrument Settings" window appears:

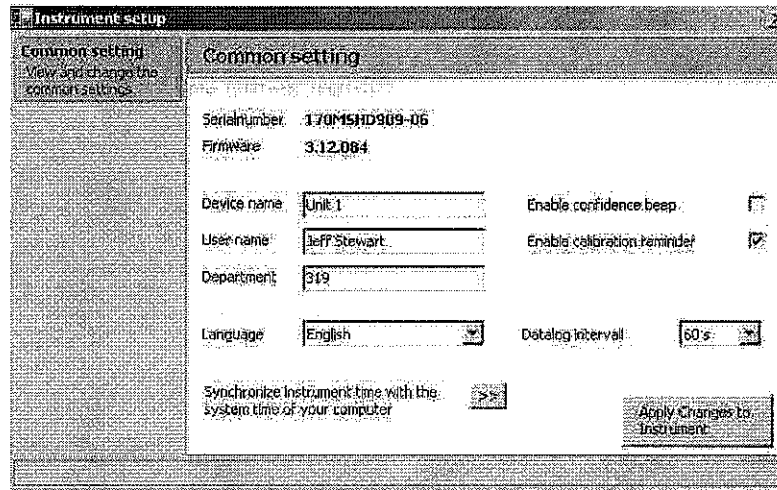


Figure 5-10. Instrument Settings

- This window displays the instrument serial number and additional information applicable to the instrument:
 - Instrument name
 - User, Department
 - Language and
 - Data storage interval.
- The user can:
 - change the information on the input masks provided for this purpose.
 - activate or be reminded by a sound when instrument calibration is required.
- All data is transmitted to the instrument by clicking on the TRANSMIT CHANGES button, .
- After the changes are transmitted, the instrument performs a REBOOT (automatically switches OFF and ON again).

Chapter 6, Warranty, Maintenance, and Troubleshooting

MSA Portable Instrument Warranty

1. Warranty-

ITEM	WARRANTY PERIOD
Chassis and electronics	Two years (MSA will support product for five years after production ends)
Sensors	Varies (see TABLE 7-2)
Pump and drive unit	Two years
Rechargeable batteries	Two years

This warranty does not cover fuses. Certain other accessories not specifically listed here may have different warranty periods. This warranty is valid only if the product is maintained and used in accordance with Seller's instructions and/or recommendations. The Seller shall be released from all obligations under this warranty in the event repairs or modifications are made by persons other than its own or authorized service personnel or if the warranty claim results from physical abuse or misuse of the product. No agent, employee or representative of the Seller has any authority to bind the Seller to any affirmation, representation or warranty concerning this product. Seller makes no warranty concerning components or accessories not manufactured by the Seller, but will pass on to the Purchaser all warranties of manufacturers of such components. **THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, AND IS STRICTLY LIMITED TO THE TERMS HEREOF. SELLER SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.**

2. **Exclusive Remedy-** It is expressly agreed that Purchaser's sole and exclusive remedy for breach of the above warranty, for any tortious conduct of Seller, or for any other cause of action, shall be the repair and/or replacement at Seller's option, of any equipment or parts thereof, which after examination by Seller is proven to be defective. Replacement equipment and/or parts will be provided at no cost to Purchaser, F.O.B. Seller's Plant. Failure of Seller to successfully repair any nonconforming product shall not cause the remedy established hereby to fail of its essential purpose.

3. **Exclusion of Consequential Damages-** Purchaser specifically understands and agrees that under no circumstances will seller be liable to purchaser for economic, special, incidental or consequential damages or losses of any kind whatsoever, including but not limited to, loss of anticipated profits and any other loss caused by reason of nonoperation of the goods. This exclusion is applicable to claims for breach of warranty, tortious conduct or any other cause of action against seller.

Cleaning and Periodic Checks

As with all electronic equipment, the Orion plus Multigas Detector will operate only if it is properly maintained.

▲ WARNING

Repair or alteration of the Orion plus Multigas Detector, beyond the procedures described in this manual or by anyone other than a person authorized by MSA, could cause the instrument to fail to perform properly. Use only genuine MSA replacement parts when performing any maintenance procedures described in this manual. Substitution of components can seriously impair instrument performance, alter intrinsic safety characteristics or void agency approvals.

FAILURE TO FOLLOW THIS WARNING CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

Cleaning and Routine Care

Periodically clean the Orion plus Multigas Detector case with a soft damp cloth.

1. Remove the sensor cover plate, sensor membrane, and sensor cover gasket (see Chapter 8, FIGURE 8-1)
2. Clean sensor plate holes with a paper clip, wire, or similar device. The holes may also be cleaned with oil-free compressed air.
3. Replace sensor membrane with a new one.

▲ WARNING

Do not attempt to clean the sensor cover plate while it is in place; sensor damage may occur. The tops of sensors are very fragile; do not touch or apply pressure to the tops of any sensors. If a sensor is damaged, it can cause the unit to give false readings. The sensor cover plate contains

holes for four sensors. In instruments with less than four sensors, some of the holes are permanently blocked with special sealing membranes. Do not puncture these membranes; erroneous gas readings can result.

Checking The Pump Inlet Filter

Orion plus Multigas Detectors ordered with the internal pump contain a filtering system to protect the pump from particles and water in the sample air. If the filter becomes clogged, the sample flow may be blocked, or an extra load may be placed on the pump; therefore, check the filter regularly.

The frequency of checks should depend on amount of pump usage and concentration of particles allowed to enter the pump. In dirty applications, replace the dust filter every 200 hours.

Replacing the Filters

⚠ CAUTION

When replacing external dust and water filters, prevent any dust or dirt around the filter housing from entering the pump housing. Dust or dirt in the pump unit may impede pump operation.

Dust and Water Filter (see FIGURE 8-2 and TABLE 8-2)

1. Remove the four screws (24) from the clear filter housing (23) on the back of the instrument.
2. Remove fibrous filter (21) from the recess on filter housing.
3. Carefully install the new filter in the filter housing recess.
4. Re-install the filter housing.

NOTE: When replacing filter, carefully handle new filter by the edges only, as it is easily torn. Install filters in correct order.

4. Replace the O-ring, being sure to press gently down on top of the water filter.
5. Replace the cover and screws.

Probe Filter

- The MSA sampling probe contains a filter to:
 - block dust and dirt
 - block the passage of water.
- If the probe tip is accidentally submerged in water, the filter prevents the water from reaching the internal pump. The filter is not designed to stop other liquids, such as gasoline or alcohols.

To Replace the Probe Filter

1. Grasp the probe handle by the base and guard.
2. Push the cap section toward the other two and turn clockwise. The spring pushes the sections apart.
3. Grasp and spin the wand clockwise while pulling to disengage.
4. Remove the water trap filter (P/N 801582) and replace.

Storage

- When not in use, store your Orion plus Multigas Detector in a safe, dry place between -5° and 40°C (23° and 104 °F).
- The Orion plus Multigas Detector with the NiMH rechargeable battery pack can be stored on charge indefinitely.

WARNING

After storage, always recheck instrument calibration before use. During storage, sensors may drift or become inoperative and may not provide warnings of dangers to the health and lives of users.

Shipment

1. Remove battery pack before shipment. When returning the Orion plus Multigas Detector for repairs, disconnect the normally used battery pack from unit, and include it in the container.

2. Pack the Orion plus Multigas Detector in its original shipping container with suitable padding. If the original container is unavailable, an equivalent container may be substituted. Seal instrument in a plastic bag to protect it from moisture. Use sufficient padding to protect it from the rigors of handling. Damage due to improper packaging or damage in shipment is not covered by the instrument's warranty.

Troubleshooting

The Orion plus Multigas Detector will operate reliably for years when cared for and maintained properly. If the instrument becomes inoperative, it typically displays the error message with corrective action in clear language. You may return nonoperative instruments to MSA for repair.

- **Instrument Division
Repair and Service Department
1000 Cranberry Woods Drive
Cranberry Township, PA 16066-5207
1-800-MSA-INST**

To contact MSA International, please call:

- **1-412-967-3000 or 1-800-MSA-7777.**

Table 6-1. Troubleshooting Guidelines

PROBLEM	ACTION
Does not turn ON	Recharge (if applicable) or replace battery. See Chapter 6
Battery pack does not hold charge	Replace battery. See Chapter 6
Sensor does not calibrate	Replace sensor. See Chapter 6
IR Sensor Error	If temperature too cold, allow instrument to stabilize within normal temperature range before turning ON. If Error remains, contact the MSA Repair Center
Pump alarm	Check for leaks/blocks, replace dust and water filters. See Chapter 3
Sensor missing	Check installation of sensor/replace sensor. See Chapter 6
RAM Error	Contact MSA
ROM Error	Contact MSA
Memory Error	Contact MSA
Battery type not recognized	Change the battery pack or have the instrument checked by MSA
Device restarts automatically	If this occurs repeatedly, arrange for service by MSA
▲ or ▼ next to the measurement unit	Measurement above or below measuring range; calibration required
Fresh Air Setup error	Supply fresh air (not measuring gas) and repeat; if error recurs, calibration is required
Test gas error	Check the gauge on test gas regulator. Set the correct test gas concentration; if message recurs, replace the sensor
In all of the above cases and for any other problems, the Orion plus Multigas Detector may be returned to MSA for repairs.	

Repair Procedures

Battery Pack Replacement

Remove the Battery Pack

1. Remove the two battery mounting screws on the back of the instrument.
2. Pull out the battery pack by gripping it at the edge of the battery pack case and pulling it away from the unit.

Replace the Battery Pack

3. Insert the front of the battery pack under the lip on the case and snap the bottom of the battery pack into the case.

4. Install and tighten the battery mounting screws.

Sensor Replacement

1. Verify that the instrument is turned OFF; remove battery pack.
2. Remove pump cover by removing the screw with a 1/16" hex key.
3. Remove the sensor cover screws and cover.
4. Gently lift out sensor to be replaced; properly dispose of sensor.

NOTE: Sensor positions cannot be changed. Each sensor location is identified by a label in the bottom of each sensor well. When replacing a sensor, ensure that the gas type printed on the sensor label matches the sensor identification label in the instrument.

5. If replacement sensor is equipped with a shorting plate, clip or wire attached to its pins, remove plate, clip or wire before inserting the replacement sensor.
6. Carefully align the new sensor contact pins with the sockets on the printed circuit board.
7. Press the new sensor into place.
8. Replace the sensor gasket and sensor cover.
9. Re-install the screws to hold down the sensor cover.

NOTE: Any repair beyond this manual (IR sensor, Main board, etc.) requires special training and can only be performed by qualified and authorized repair centers.

⚠ WARNING

Verification of calibration response is required (some toxic sensors require more than five hours to stabilize); otherwise, the instrument will not perform as required, and persons relying on this product for their safety could sustain serious personal injury or death.

Chapter 7, Performance Specifications

Table 7-1. Certifications

HAZARDOUS LOCATIONS	US	UL 913 for Class 1, Div. 1, Groups A, B, C, and D
	CANADA	CSA C22.2 No. 157 for Class 1, Div. 1, Groups A, B, C, and D
	EUROPE	EN 50 014/ EN 50 018/ EN 50 019/ EN 50 020 EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C
	AUSTRALIA	AS/NZS 60079-11 Ex ia IIC -20°C to +50°C
EMC/RFI	US	47 CFR, part 15
	EUROPE	EN 50270 Type 2 EN 61000-6-3
	AUSTRALIA	C-tick emissions (CSPR11)
PERFORMANCE	CANADA	CSA C22.2 No. 152 for Methane only
	EUROPE	IEC 529 IP54 min., EN 50 271/ EN 50 054 EN 50 057/ EN 50 104 EN 45 544
	AUSTRALIA	AS/NZS 61779 -1/61779-4
SAFETY	EUROPE	CE: LVD (low voltage directive), EN61010-1 for chargers and accessories requiring greater than 50 VAC or 75 VDC
ATEX	EUROPE	EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C Directive 94/9/CE
		BVS 03 ATEX E 270X II2G EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C

Table 7-2. Instrument Specifications

TEMPERATURE RANGE	Normal	0 to 40°C
	Extended*	-20 to 50°C
WARM-UP TIME	two minutes	
*NOTE: Extended temperature range indicates that gas readings may vary slightly if calibrated at room temperature. For optimal performance, it is recommended that the instrument be calibrated at temperature of use.		
MEASUREMENT METHODS	COMBUSTIBLE GAS	Catalytic Sensor
	OXYGEN	Electrochemical Sensor
	TOXIC GASES	Electrochemical Sensors/IR Sensor
WEIGHT	410 g (instrument with battery pack)	
DIMENSIONS	165 x 92 x 66 mm (L x B x H)	
BATTERY TYPE	Rechargeable NiMH battery pack	
BATTERY LIFE	NiMH: 11 h	
CHARGING TIME	≤ 3 h with the MSA Fast Charger (100-250 VAC)	
WARM UP TIME	2 minutes	
TEMPERATURE RANGE	-20°C to +50°C, Storage from -5°C to +40°C	
HUMIDITY RANGE	15 - 90% rel. humidity, non condensing, short term 5% - 95% rel. humidity	
ATMOSPHERIC PRESSURE RANGE	800 to 1200 HPa	
FLOW RATE	0.2 to 0.5 l/min	
DUST AND SPRAY PROTECTION	IP 54	
WARRANTY	2 years for housing, electronics, rechargeable batteries and pump 2 years for IR, LEL, O ₂ , H ₂ S, CO, HCN, SO ₂ , Cl ₂ sensors; 1 year for NH ₃ , NO ₂ and PH ₃ sensors; 6 months for ClO ₂ , COCl ₂ , and O ₃	

Table 7-3.
Measurable Gases, Displays and Resolution

MEASURABLE GASES*	DISPLAY	RESOLUTION	RESPONSE TIME AT 20°C
20 mm SENSORS			
Combustible gases	0 - 100% LEL	1% LEL	$t_{50} \leq 10$ s methane ≤ 15 s propane $t_{90} \leq 26$ s methane ≤ 35 s propane
O ₂	0 - 25 % Vol.	0.1 % Vol.	≤ 10 s
CO	0 - 999 ppm	1 ppm	= 45 s
H ₂ S	0 - 200 ppm	1 ppm	= 20 s
HCN	0 - 50 ppm	1 ppm	$t_{50} < 30$ s
Cl ₂	0 - 10 ppm	0.1 ppm	$t_{50} < 10$ s / $t_{90} < 30$ s
NH ₃	0 - 100 ppm	1 ppm	$t_{50} < 20$ s / $t_{90} < 60$ s
SO ₂	0 - 20 ppm	0.1 ppm	$t_{90} \leq 35$ s
NO ₂	0 - 20 ppm	0.1 ppm	$t_{90} \leq 25$ s
ClO ₂	0 - 1 ppm	0.02 ppm	$t_{50} < 20$ s / $t_{90} < 120$ s
PH ₃	0 - 5 ppm	< 0.05 ppm	$t_{90} 30$ s
O ₃	0 - 1 ppm	0.02 ppm	$t_{50} < 30$ s / $t_{90} < 60$ s
COCl ₂	0 - 1 ppm	0.02 ppm	$t_{50} < 60$ s / $t_{90} < 120$ s
IR SENSORS			
HC, Butane	0-25 % Vol.	0.1 % Vol.	
HC, Propane	0-25 % Vol.	0.1 % Vol.	
CH ₄ , Methane	0-100 % Vol.	1 % Vol.	
C ₃ H ₈ , Propane	0-100 % Vol.	1 % Vol.	
C ₃ H ₈ , Propane	0-100 % LEL	1 % LEL	
CO ₂	0 - 10 % Vol.	0.01 % Vol.	
CO ₂	0 - 5 % Vol.	0.01 % Vol.	
CO ₂	0 - 50 % Vol.	0.1 % Vol.	

* The gases can only be measured when the appropriate sensors are used.

**Table 7-4.
Sensor Cross-Sensitivity**

INPUT→ OUTPUT↓	20.9 % Vol O ₂	300 ppm CO	20 ppm H ₂ S	5 % Vol CO ₂	33 % LEL CH ₄	20 ppm Cl ₂	50 ppm NH ₃
O ₂ /	20.9	20.9	20.9	20.9	20.9	20.9	20.9
30 % Vol	% Vol	% Vol	% Vol	% Vol	% Vol	% Vol	% Vol
CO/							
300 ppm	0 ppm	300 ppm	0 ppm	0 ppm	0 ppm	2 ppm	23 ppm
H ₂ S/							
200 ppm	0 ppm	0 ppm	20 ppm	0 ppm	0 ppm	9 ppm	0 ppm
CO ₂ /							
5% Vol	0 % Vol	0 ppm	0 ppm	5 % Vol	0 ppm	0 ppm	0 ppm
Comb/							
100 LEL	0 LEL	0 LEL	0 LEL	0 LEL	33 % LEL	0 LEL	0 LEL
Cl ₂ /							
20 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	20 ppm	0 ppm
NH ₃ /							
100 ppm	0 ppm	0 ppm	2 ppm	0 ppm	0 ppm		50 ppm
SO ₂ /							
20 ppm	0 ppm	4 ppm	0 ppm Fi (200 ppmh)	0 ppm	0 ppm	-140 ppm*	0.25 ppm
NO ₂ /							
100 ppm	0 ppm	≤ 0.1 ppm	≤ 40 ppm	0 ppm	0 ppm	200 ppm	≤ 0.25 ppm
PH ₃ /							
5 ppm	0 ppm	1.5 ppm	0 ppm	0 ppm			
ClO ₂ /							
1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	6 ppm	
O ₃ /							
1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	24 ppm	-1.5 ppm
HCN/							
50 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm
COCl ₂ /							
1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	8 ppm	0.15 ppm

* This sensor combination should not be selected.

INPUT → OUTPUT ↓	20 ppm SO ₂	100 ppm NO ₂	5 ppm PH ₃	1 ppm ClO ₂	1 ppm O ₃	50 ppm HCN	1 ppm COCl ₂
O ₂ /	20.9	20.9	20.9	20.9	20.9	20.9	20.9
30% Vol	% Vol	% Vol	% Vol	% Vol	% Vol	% Vol	% Vol
CO/							
300 ppm	1 ppm	-6 ppm				0.5 ppm	
H ₂ S/							
200 ppm	0.2 ppm	-7 ppm				0.5 ppm	
CO ₂ /							
5% Vol	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm
Comb/							
100 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL
Cl ₂ /							
20 ppm	-2.5 ppm	20 ppm		0.5 ppm	0.12 ppm	-0.5 ppm	
NH ₃ /							
100 ppm							
SO ₂ /							
20 ppm	20 ppm	-500 ppm					
NO ₂ /							
100 ppm	≤ -2.5 ppm	100 ppm					
PH ₃ /							
5 ppm	4 ppm		5 ppm				
ClO ₂ /							
1 ppm		37 ppm		1 ppm	0.06 ppm	-2.1 ppm	
O ₃ /							
1 ppm	-0.2 ppm	60 ppm		1.5 ppm	1 ppm		
HCN/							
50 ppm	0 ppm Fi	-7.3 ppm		-2 ppm	-0.04 ppm	50 ppm	
COCl ₂ /							
1 ppm	0 ppm	10 ppm		-3 ppm	0 ppm	0 ppm Fi	1 ppm

IR X- Sensitivity Table

IR Sensor 0-25 Vol % Methan		
Test Gas	% LEL	% VOL CH4 Display
12.5 Vol % Methane	NA	12.5
Propane	50	25.2
Butane	50	25.8
Nonane	50	26.0
Hexane	50	32.8
Pentan	50	Over Range
Methanol	50	Over Range
Benzene 65/95	50	Over Range
JP8	20	1.5
Ethanol	50	24.3
Toluene	50	2.0
Aceton	50	2.1
Ethylacetat	50	5.6

IR Sensor / 0-100 % LEL Propane		
Test Gas	% LEL	% LEL C3H8 Display
20 Vol % Methane	NA	44.0
Propane	50	50.0
Butane	50	54.0
Nonane	50	48.0
Hexane	50	53.0
Pentan	50	62.0
Methanol	50	61.0
Benzene 65/95	50	66.0
JP8	20	7.0
Ethanol	50	55.0
Toluene	50	13.0
Aceton	50	10.0
Ethylacetat	50	21.0

IR Sensor / 0 - 100 % LEL Butane		
Test Gas	% LEL	% LEL C4H10 Display
20 Vol % Methane	NA	66.0
Propane	50	52.0
Butane	50	50.0
Nonane	50	36.0
Hexane	50	45.0
Pentan	50	55.0
Methanol	50	62.0
Benzene 65/95	50	55.0
JP8	20	6.0
Ethanol	50	55.0
Toluene	50	11.0
Aceton	50	12.0
Ethylacetat	50	27.0

Environment and Oxygen Sensor Readings

A number of environmental factors may affect the oxygen sensor readings, including changes in pressure, humidity and temperature. Pressure and humidity changes affect the amount of oxygen actually present in the atmosphere.

Pressure Changes

The Orion plus oxygen sensor is designed to compensate for ambient pressure changes in the area of instrument operation. If pressure changes rapidly (e.g., stepping through airlock) the oxygen sensor reading may temporarily shift, and possibly cause the detector to go into alarm. While the percentage of oxygen may remain at or near 20.8%, the total amount of oxygen present in the atmosphere available for respiration may become a hazard if the overall pressure is reduced to a significant degree.

Humidity Changes

If humidity changes to any significant degree (e.g., going from a dry, air conditioned environment to outdoor, moisture laden air), oxygen levels can change up to 0.5%. This is due to water vapor in the air displacing oxygen, thus reducing oxygen readings as humidity increases. The oxygen sensor has a special filter to reduce the affects of humidity changes on oxygen readings. This effect will not be noticed immediately, but slowly impacts oxygen readings over several hours.

Temperature Changes

The oxygen sensor has built-in temperature compensation. However, if temperature shifts dramatically, the oxygen sensor reading may shift. Zero the instrument to within 30°C of the temperature-of-use for the least effect.

Chapter 8, Replacement and Accessory Parts

Table 8.1. Accessory Parts List

PART	PART NO.
Protective Jacket, Orange Nylon	10020486
Protective Rubber Boot, Black	10022036
Protective Rubber Boot, Red (North American-approved instrument only)	10025665
Leather Carrying Case	10020485
Calibration Kit Model RP with 0.25 lpm Regulator	477149
Calibration Gas - 100 Liters, 58% LEL pentane simulant / 15% O ₂ ; 300 ppm CO / 2.5% Vol. CO ₂	10059149
Calibration Gas - 58 Liters, 58% LEL pentane simulant / 15% O ₂ ; 300 ppm CO and 10 ppm H ₂ S / 2.5% Vol. CO ₂	10050744
Econocal, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O ₂ /2.5% Vol. CO ₂	10058023
Econocal, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O ₂ /10 ppm H ₂ S/2.5% Vol. CO ₂	10058022
Gas Miser Regulator, Model RP	710288
Regulator, .25 LPM, Model RP	467895
Regulator, Combination, .25 LPM, Model RP	711175
Battery Charger, NiMH, A.C.	10020551
Battery Charger, NiMH, Vehicle	10034276
Battery Pack, NiMH (10031091 Pack with Charging Adapter)	10073663
Battery Pack, Alkaline	10031092
Belt Clip	10025664
Sampling Line, 1.5 m Teflon, PTFE conductive	10074535
Sampling Line 5 m Teflon, PTFE conductive	10021927
Calibration Gas - 58 Liters, 58% LEL pentane simulant / 15% O ₂ ; 300 ppm CO and 10 ppm H ₂ S	804770
Calibration Gas, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O ₂ and 10 ppm H ₂ S	711058
Calibration Gas, 34L, 300 ppm CO, 1.45% CH ₄ , 15% O ₂ , 10 ppm H ₂ S, 2.5% CO ₂ , N ₂ Balance	10058022
Calibration Gas, 34L, 300 ppm CO, 1.45% CH ₄ , 15% O ₂ , 2.5% CO ₂ , N ₂ Balance	10058023
Calibration Gas, 34L, 10 ppm HCN, N ₂ Balance	711072
Calibration Gas, 58L, 10 ppm Cl ₂ , N ₂ Balance (to calibrate Cl ₂ sensor)	806740
Calibration Gas, 34L, 2 ppm Cl ₂ , N ₂ Balance (to calibrate O ₃ /COCl ₂ /ClO ₂ sensor)	711082
Calibration Gas, 34L, 25 ppm NH ₃ , N ₂ Balance	711078
Calibration Gas, 34L, 10 ppm SO ₂ , air Balance	711070
Calibration Gas, 34L, 10 ppm NO ₂ , air Balance	711068

PART	PART NO.
Calibration Gas, 34L, 0.5 ppm PH ₃ , N ₂ Balance	711088
Calibration Gas, 10% CO in N ₂	10081603
Calibration Gas, 15% Butane in N ₂	10081604
Calibration Gas, 15% Propane in N ₂	10081605
Calibration Gas, 58L, 50% Vol Methane, N ₂ Balance	10075804
Calibration Gas, 58L, 100% Vol Methane	711014
Calibration Gas, 100L, 0.6% Vol Propane	493579
NiMH Battery with PCBA connector	10073663
Connector, PCBA and nut	10074534
Charger and Cradle	10073666
Upgrade Kit (Cradle, PCBA connector and nut)	10073664
Charging Cradle	10073668
Alkaline Battery pack	10031092
Vehicle Battery Charger	10034276
Assembly Kit for IR Sensor	10080043

Table 8-2. Replacement Parts List

FIGURE 8-1 OR 8-2 ITEM NO.	PART/COMPONENT	PART NO.
1	Pump Cap Assembly, includes screw P/N10025551	10025539
2	Pump Cap Screw	10025551
3	Case Screws	10022921
4	Sensor Cover	10022105
6	Sensor Cover Gasket, Coated	10061454
7	Oxygen Sensor	10025940
8	Toxic Sensor 1	
9	Combustible Sensor	10024247
10	Toxic Sensor 2	
11	Sensor Gasket	10022331
12	Front Case Assembly Keypad	10046364
13	Pump Cap Assembly, includes gasket P/N 10022102	10025539
14	Pump Cap Gasket	10022102
15	Display Assembly	10046366
16	Printed Circuit Board Assembly, Main	10045993
17	IR Sensor	
18	Case Gasket	10022100
19	Pump and Drive Replacement Kit	10031093
21	PTFE filter and Water filter, package of five	10064531

RACER Trust
Moraine, Ohio

SOP 29 - EXTRACTION STEP TEST

Rev #: 0.0

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APPROVAL SIGNATURES

Prepared by:

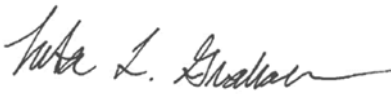


Everett H. Fortner III, PG

03/08/2017

Date:

Reviewed by:



Trika Graham

03/08/2017

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

In a step test, the test well is pumped at several successively higher flow rates (generally 3 to 4) and the drawdown for each flow rate, or step, is recorded in the test well and, if applicable, in nearby observation wells. This testing is used to evaluate the test well specific capacity, establish the test well baseline performance, estimate the test well maximum sustainable yield, and provide an understanding of long-term sustainable flow rate ranges. All steps are generally performed in uniform duration with recovery recorded after the final step.

The initial step flow rate will be approximately half of the expected median flow rate. The understanding of expected flow rate ranges can be determined based on the conceptual site model, analytical calculations, groundwater zone grain size analysis or from the initial test well specific capacity during development. At the conclusion of the first test period (i.e., after approximately 1 hour of pumping with a stable drawdown), the pumping rate is increased based on field observations and estimated maximum or desired maximum yield. The process (steps) are repeated for 3 to 4 cycles, or until a desired maximum flow rate or unsustainable flow rate is established (i.e., the in-well water level rapidly falls, cascades, to the pump

intake after the start of pumping). In the case of an unsustainable drawdown that is encountered for the final step flow rate, it may be necessary to draw back the flow rate on the final step to determine the maximum sustained yield. Following the final step, pumping will cease and recovery will be monitored to within 95% of static water level conditions.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Fuel cans
- Generator – with hot fill capability if needed
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow

- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
 - o Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
 - o Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
 - o To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
 - o For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
 - o For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
 - o In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
 - o Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
 - o Sufficient background water levels should be recorded (approximately 8 to 12 hours).
 - o Logarithmic or head-change settings should not be used to log data, only linear.
 - o Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.
- Data Recording and Management
 - o All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each

reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.

- o Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidentally lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
 - o Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
 - o Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
 - o Make sure all equipment that enters the test well (pump, water-level meter, pressure transducer) is decontaminated before use. If testing multiple wells, start with the least contaminated and progress to the most contaminated.
- Weather
 - o Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in more cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test well and establish a background monitoring phase. Make sure to record everything in military time.
2. Install pressure transducers for background monitoring phase:
 - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
 - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
 - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
 - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
 - Fill out pressure transducer deployment field log.
3. Set up at the test well pumping system in accordance with the work plan and technical staff. Set up pumping equipment (i.e. downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization). Ensure that a check valve or a ball valve at the top of the well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can be specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. As with all pumping tests, it is critical that the flow rate be held steady. Set the desired flow rate as soon as possible after starting the pump or adjusting (stepping) the flow rate.
4. After at least 8 to 12 hours of background data collection, set to linear logging under non-overwriting recording mode recording at the rate of 1 seconds.
5. Start test, turn pump on, and complete step testing at 3 to 4 flow rates. At least three steps should be performed on each well (typically 33%, 67%, and 100% of anticipated maximum flow rates). However, wells where high yields are expected, a lower maximum flow rate may be determined based on the design flow rate specifications. Each flow rate will be maintained for approximately 1-hour or when stability is apparent before stepping up to the next flow rate. A sustained drawdown (i.e., stable, non-changing) should be observed prior to starting the next test step (i.e., adjusting the flow rate). *Note: A stabilized water level means little or no measurable change over time—use less than 0.03 ft of change over a 10-minutes period as a general guide. This can be monitored in real-time using a laptop connected to the transducer in the pumping test well.*
6. When a step flow rate exceeds the maximum yield (i.e. water-level in the well drops to pump intake), the flow rate will be stepped back incrementally to establish a maximum sustainable flow rate. This may include stepping the flow rate back to the previous step sustained rate. In either case, the final maximum flow rate needs to be maintained for approximately 1-hour before pump is shut off and recovery monitoring commences.
7. Record the manual depth-to-water measurements in the test well with the following sequence (record time along with depth-to-water measurement):
 - every 10 seconds for the first minute,

- every 30 seconds for the next three minutes,
 - every minute for the next 15 minutes, and
 - every 15 minutes for the remainder of the step.
 - Repeat for each step.
8. As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).
 9. Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step, and after pump shut off.
 10. Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the drawdown before increasing the flow rate. If stabilization is apparent before the 1-hour duration, confirm with technical staff to proceed to next step.
 11. After the maximum sustained or end desired design flow rate is achieved and maintained, turn off pump and commence recovery monitoring. Recovery will be monitored to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as described above (again, as time allows, record depth-to-water measurements in the observation wells during the recovery phase of the test).
 12. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.
 13. Water-IDW. Follow the work plan for water-IDW management, treatment, and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE, and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations, and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust
Moraine, Ohio

SOP 30 - EXTRACTION CONSTANT RATE TEST

Rev #: 0.0

Rev Date: March 8, 2017



APPROVAL SIGNATURES

Prepared by:

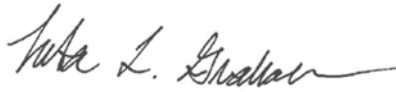


Everett H. Fortner III, PG

03/08/2017

Date:

Reviewed by:



Trika Graham

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2 SCOPE AND APPLICATION

A reliable and commonly used method of evaluating aquifer characteristics is by controlled aquifer extraction constant rate tests using a test well and observation wells. Extraction constant rate tests provide results that are more representative of bulk average aquifer characteristics than those predicted by single well tests. Important aquifer characteristics which may be estimated include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers.

In general, an extraction constant rate test is a pumping test set at a constant flow rate completed over longer periods of time (usually 2 to up to 4 days). In addition, data collected within an observation well network can provide data to calculate horizontal and vertical hydraulic gradients that supports the understanding of hydraulic influence.

Proper design of an extraction constant rate test requires a general understanding of the hydrogeologic system so that a suitable work plan can be made. The design incorporates known Site information from the conceptual site model and from any previous hydraulic testing. Factors such as aquifer thickness,

level of confinement, step testing, and known permeability range will aid in estimating the duration of the test. Unconfined aquifers will have a longer duration test at 48 to over 72 hours to record late time gravity drainage response. All of this information will aid in the design factors for the work plan such as: number of observation wells, depth and spatial placement of observation wells; duration of background measurements, flow rate(s); frequency of water-level measurements; and duration of the test.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Weather station
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Generator – with hot fill capability if needed

- Fuel cans
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
 - o Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
 - o Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
 - o To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
 - o For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
 - o For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
 - o In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
 - o Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
 - o Sufficient background water levels should be recorded (at least 3 to 5 days).
 - o Logarithmic or head-change settings should not be used to log data, only linear.
 - o Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.

- Data Recording and Management
 - o All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
 - o Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidentally lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
 - o Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
 - o Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
 - o Make sure all equipment that enters the test well (pump, water-level meter, pressure transducer) is decontaminated before use. If testing multiple wells, start with the least contaminated and progress to the most contaminated.
- Weather
 - o Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in most cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.

- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test well and establish a background monitoring phase. Make sure to record everything in military time.
2. Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).
3. Install pressure transducers for background monitoring phase:
 - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
 - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
 - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
 - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
 - Fill out pressure transducer deployment field log.
4. Set up at the test well pumping system in accordance with the work plan and technical staff. Set up pumping equipment (i.e. downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization). Ensure that a check valve or a ball valve at the top of the well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. As with all pumping tests, it is critical that the flow rate be held steady. Set the desired flow rate as soon as possible after starting the pump.
5. Within the later portion of the background monitoring phase and at least 24 hours before testing, prepare a shakedown of test equipment. A shakedown test is a trial test period to ensure that all equipment is functional and is working within specifications for the main test. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade and the protective lid not closed. The shakedown should include the following:
 - Set up generator (hot fill) with grounding rod and GFCI protection
 - Have sufficient fuel containers for fill
 - Verify down-hole test well equipment depth (pump, check and/or top ball valve, and pressure transducer).
 - Verify pressure transducer operation

- Test pump at various flow rates and at the flow rate specified for the test
 - Check piping effluent pressure and piping for leaks
 - Flow controls (valve operation – always operate pump with some back pressure)
 - Flow meter function and manual volume estimate verification
 - Check operation of modular treatment system (if applicable)
6. After the shakedown and background monitoring phase is complete, measure water-levels from the specified network and download/re-program the pressure transducers in all wells to start recording (linear – non-overwriting) 2 hours before planned testing start with the below schedule.
 - First 2 hours and then first 30 minutes of testing set at 1 second interval
 - Next 2 hours set at 5 second interval
 - Remainder of test set at 30 second interval
 7. Start test, turn on pump, and set flow rate as quickly as possible to be approximate to the design flow rate.
 8. Record the manual depth-to-water measurements in the test well with the following sequence (record time along with depth-to-water measurement):
 - every 10 seconds for the first minute,
 - every 30 seconds for the next three minutes,
 - every minute for the next 15 minutes, and
 - every 15 minutes for the remainder of the test.
 9. Periodically (every 2 to 4 hours), record manual depth to water measurements from the observation well network during test (record time and depth-to-water measurement).
 10. Flow meter readings (instantaneous) should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 30 minutes thereafter. Totalizer flow readings should be recorded before test start and during each instantaneous flow meter recording.
 11. If flow rate adjustments are necessary, record each on the field form. However, the flow rate should be maintained as close as possible to the start for the duration of the test.
 12. Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the drawdown and late time aquifer response. Unconfined aquifer systems require longer duration of pumping to record the aquifer gravity drainage response. Duration should be maintained and stabilization apparent before shutting down the test. Confirm with technical staff to proceed with shut down after all responses have been verified.
 13. After the testing response has been verified, shut down the pump and monitor recovery to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as during the start of the test.
 14. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.
 15. Water-IDW. Follow the work plan for water-IDW management, treatment and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust
Moraine, Ohio

SOP 31 – Injection Step Testing for DGR™ Systems

Rev #: 0.0

Rev Date: March 14, 2017



APPROVAL SIGNATURES

Prepared by:

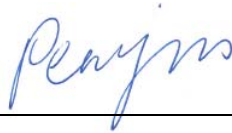


Everett H. Fortner III, PG

03/14/2017

Date:

Reviewed by:



Peng, Jin, PhD, PE

03/14/2017

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The approach to an injection step test for dynamic groundwater recirculation (DGR™) systems is to evaluate injection flow rate well capacity (under gravity fed conditions – no applied pressure) using successively higher flow rates (generally 3 to 4). This testing is used to establish the test well injection baseline performance, estimate the test well maximum injection flow rate, and provide an understanding of long-term sustainable injection flow rate ranges. All steps are generally performed in uniform duration with recovery recorded after the final step. Large-volume injection testing may still be necessary to confirm full-scale injection rates. This information aids in design of the recirculation test and full-scale DGR™ design elements.

The understanding of expected flow rate ranges can be determined based on the conceptual site model, analytical calculations, groundwater zone grain size analysis, or from the initial test well extraction tests. The initial injection step flow rate can be estimated by using 25% to 33% of the maximum sustainable extraction flow rate of the test well. The duration of each step is expected to be 1 hour; however, both duration and subsequent injection step flow rates will be adaptive based on initial step results. The

injections will be completed by pumping stored, treated water within piping to a manifold at the well head. Flow rate and well head pressure at the manifold will be closely monitored and recorded.

The response of in-well water-levels (both test well and observation wells) should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter, if accessible. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements. Following the final step, injection will cease and recovery will be monitored to within 95% of static water level conditions.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Injection manifold, piping, pressure gauges, flow meter, and transfer injection pump
- Buckets, drums, and tanks
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for injection test and decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Generator – with hot fill capability if needed
- Fuel cans
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed

5 CAUTIONS

- Pressure Transducers/Data Loggers
 - o Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
 - o Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the static water level (approximately 15 feet).
 - o To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
 - o For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
 - o For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
 - o In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
 - o Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
 - o Sufficient background water levels should be recorded (at least 8 to 12 hours).
 - o Logarithmic or head-change settings should not be used to log data, only linear.
 - o Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.
- Data Recording and Management
 - o All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
 - o Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. Always back up data on a laptop computer and/or a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
 - o Flow meters should come with calibration certificate and confirmed in the field during test start up.

- Equipment Care
 - o Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
 - o Make sure all equipment that enters the test wells (water-level meter, pressure transducer) is decontaminated before use.
- Weather
 - o Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in more cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

- Measure water-levels and total well depth in all applicable observation wells and test wells and establish a background monitoring phase. Make sure to record everything in military time.
- Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).
- Install pressure transducers for background monitoring phase:
 - o Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
 - o The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.

- o The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
 - o The pressure transducer will be attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
 - o Fill out pressure transducer deployment field log.
- Set up injection equipment in accordance with work plan and technical staff direction (i.e. injection pump, manifold, downhole test well equipment, piping, and flow meters).
- After at least 8 to 12 hours of background data collection, reprogram pressure transducers to linear logging under non-overwriting recording mode recording at the rate of 1 seconds.
- Start test, turn on injection well pump and complete step testing at 3 to 4 flow rates. At least three steps should be performed on each well and maintained for approximately 1-hour or when stability is apparent before stepping up to the next flow rate. A sustained rise in water-level (i.e., stable, non-changing) should be observed prior to starting the next test step (i.e., adjusting the flow rate). Note: A stabilized water level means little or no measurable change over time—use less than 0.03 ft of change over a 10-minute period as a general guide. This can be monitored in real-time using a laptop connected to the transducer in the test well.
- As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).
- Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step, and after pump shut off.
- If flow rate adjustments are necessary, record each on the field form. However, the flow rates for the injection should be maintained as close as possible to the start for the duration of the test.
- As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).
- Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step and after pump shut off.
- Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the water-level rise before increasing the flow rate. If stabilization is apparent before the 1-hour duration, confirm with technical staff to proceed to next step.
- After the maximum sustained or end desired design injection flow rate is achieved and maintained, turn off pump and commence recovery monitoring. Recovery will be monitored to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as described above (again, as time allows, record depth-to-water measurements in the observation wells during the recovery phase of the test).

- Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.
- Water-IDW. Follow the work plan for water-IDW management, treatment and discharge

8 WASTE MANAGEMENT

Rinse water, PPE, and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust
Moraine, Ohio

SOP 32 - RECIRCULATION TEST FOR DGR™ SYSTEMS

Rev #: 0.0

Rev Date: March 14, 2017



APPROVAL SIGNATURES

Prepared by:



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03/14/2017

Date:

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03/14/2017

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

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2 SCOPE AND APPLICATION

The approach to a recirculation test for dynamic groundwater recirculation (DGR™) systems is to collect observed response to injection balanced by extraction using a single injection well and a single extraction well, along with observation wells. The observed responses will provide information on changes in horizontal and vertical hydraulic gradients and evaluate hydraulic connection between the injection and extraction well. This information aids in full-scale DGR™ design elements.

Proper design of a recirculation test requires a general understanding of the hydrogeologic system so that a suitable work plan can be made. The design incorporates known Site information from the conceptual site model and from any previous testing that includes extraction and injection testing. All of this information will aid in the design factors for the work plan such as: number of observation wells, depth and spatial placement of observation wells; duration of background measurements, injection/extraction flow rate(s); frequency of water-level measurements; and duration of the test.

Extraction and injection step testing should preclude a recirculation test in order to properly design the flow rates for injection and extraction.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Injection and extraction flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as injection equipment, submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Weather station
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Injection manifold, piping, pressure gauges, flow meter, and transfer injection pump
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Fluorescein dye, sample bottles, visual dye standards, and AquaFluor Handheld Fluorometer
- Graduated cylinders (50 mL and 1L)
- Scale to measure weight of dye to the nearest 1 gram
- Field forms
- Waterproof marker
- Low-flow submersible pump, controller, and tubing (for observation well dye verification)
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Generator – with hot fill capability if needed
- Fuel cans

- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
 - o Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
 - o Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
 - o To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
 - o For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
 - o For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
 - o In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
 - o Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
 - o Sufficient background water levels should be recorded (at least 12 to 24 hours).
 - o Logarithmic or head-change settings should not be used to log data, only linear.
 - o Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.

- Data Recording and Management
 - o All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
 - o Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidentally lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
 - o Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
 - o Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination (see SOP X)
 - o Make sure all equipment that enters the test wells (pump, water-level meter, pressure transducer) is decontaminated before use.
- Weather
 - o Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in most cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test wells and establish a background monitoring phase. Make sure to record everything in military time.
2. Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).
3. Install pressure transducers for background monitoring phase (12 to 24 hours):
 - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
 - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
 - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
 - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
 - Fill out pressure transducer deployment field log.
4. Set up injection and pumping equipment (i.e. injection manifold, downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization [if applicable]). Ensure that a check valve or a ball valve at the top of the extraction test well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The extraction pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can be specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. It is critical that the flow rates be held steady as best as possible for both injection and extraction. Set the desired flow rate as soon as possible after starting the pump.
5. Within the later portion of the background monitoring phase and at least 24 hours before testing, prepare a shakedown of test equipment. A shakedown test is a trial test period to ensure that all equipment is functional and is working within specifications for the main test. The shakedown should include the following:
 - Set up generator (hot fill) with grounding rod and GFCI protection
 - Have sufficient fuel containers for fill
 - Verify down-hole extraction test well equipment depth (pump, check and/or top ball valve, and pressure transducer).
 - Verify pressure transducer operation
 - Verify injection manifold and transfer pump set up
 - Test injection transfer pump at various flow rates and at the flow rate specified for the test (use water with no dye applied for shakedown)
 - Test pump at various flow rates and at the flow rate specified for the test
 - Check piping pressures and check for any leaks
 - Flow controls (valve operation – always operate pump with some back pressure)
 - Flow meters function and manual volume estimate verification
 - Check operation of modular treatment system (if applicable)

6. After the shakedown and background monitoring phase is complete, measure water-levels from the specified network and download/re-program the pressure transducers in all wells to start recording (linear – non-overwriting) 2 hours before planned testing start with the below schedule.
 - First 2 hours and then first 30 minutes of testing set at 1 second interval
 - Next 2 hours set at 5 second interval
 - Remainder of test set at 30 second interval
7. Prepare injection water (treated or potable) with fluorescein dye concentration at 40 ppm. The dye will be used to help with qualitative visual confirmation of recirculation.
 - Prior to drilling, measure the proper weight of powdered dye for mixing with injection water – 75 grams of fluorescein dye will be added to every 500 gallons of water to yield on average tracer concentration of approximately 40 ppm.
 - If the injection water “batch” is larger or smaller than 500 gallons, the same ratio of dye to water will be used.
 - Measure the mass of the dye using a scale with an accuracy of +/- 1 gram.
 - Add the dye to the injection water batch tank(s) while using a utility pump to mix the tracer with the injection water.
 - Collect four 40 mL unpreserved VOA vials from each tank of injection water – label all four of these vials “W-1” for the first batch of injection water, “W-2” for the second batch, etc.
 - Photograph the “W” samples from each batch of injection water with adequate, consistent light, against a white background.
 - Keep all of the dyed injection water (“W”) samples in a cooler to keep them dark, to inhibit photodegradation.
 - The pH injection water source should be measured. A pH value below approximately 5 standard units results in reduced fluorescence of the fluorescein.
8. Start the test by turning on the extraction well pump and injection well transfer pump simultaneously and set flow rates as quickly as possible to be approximate to the test design flow rates.
9. Record the manual depth-to-water measurements in the extraction test well with the following sequence (record time along with depth-to-water measurement):
 - every 10 seconds for the first minute,
 - every 30 seconds for the next three minutes,
 - every minute for the next 15 minutes, and
 - every 15 minutes for the remainder of the test.
10. Periodically (every 2 to 4 hours) record manual depth to water measurements from the observation well network during test (record time and depth-to-water measurement).
11. Flow meter readings (instantaneous) should be recorded once every minute for the first 10 minutes. Continued recording flow rates from the flow meters documented on the field form every 30 minutes thereafter. Totalizer flow readings should be recorded before test start and during each instantaneous flow meter recording.
12. If flow rate adjustments are necessary, record each on the field form. However, the flow rates for the injection and extraction should be maintained as close as possible to the start for the duration of the test.
13. Set up low-flow sampling pump into specified observation well(s) at mid-screen. Set flow rate to a flow rate between 300 to 800 mL per minute. Collect groundwater samples in 40 mL unpreserved VOA vials every 30 minutes from the designated observation well(s) and extraction test well to

verify presence of tracer dye. If present, use field fluorometer to measure dye concentration and save samples in cooler on ice and label with well ID, date, and time.

14. Data evaluation will be real time. A plot from the direct read pressure transducer of the test wells will be evaluated during the test to ensure stabilization. Maximum duration of the test will be determined by the technical staff and may be up to 24 hours.
15. After the testing response has been verified, shut down the pumps and monitor recovery to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as during the start of the test.
16. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.
17. Water-IDW. Follow the work plan for water-IDW management, treatment and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None.

APPENDIX C

Field Forms



DAILY LOG

Project No.: _____ Page _____ of _____

Site Location: _____

Prepared By: _____

[illegible]

GROUNDWATER SAMPLING LOG

Page ____ of ____

Project No. _____ Well ID _____ Date _____

Project Name/Location _____ Weather _____

Measuring Pt. _____ Screen _____ Casing _____ Well Material _____ PVC
Description _____ Setting (ft-bmp) _____ Diameter (in.) _____ SS

Static Water _____ Water Column/
Level (ft-bmp) _____ Total Depth (ft-bmp) _____ Gallons in Well _____

MP Elevation _____ Pump Intake (ft-bmp) _____ Purge Method: _____ Sample
Method _____

Pump On/Off _____ Volumes Purged _____ Centrifugal _____
Submersible _____
Other _____

Sample Time: Label _____ Replicate/
Start _____ Code No. _____ Sampled by _____
End _____

Time	Minutes Elapsed	Rate (gpm) (mL/min)	Depth to Water (ft)	Gallons Purged	pH	Cond. (mMhos) (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C) (°F)	Redox (mV)	Appearance	
											Color	Odor

Constituents Sampled	Container	Number	Preservative

Well Casing Volumes

Gallons/Foot	1" = 0.04	1.5" = 0.09	2.5" = 0.26	3.5" = 0.50	6" = 1.47
	1.25" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65	

Well Information

Well Location: _____	Well Locked at Arrival: Yes / No
Condition of Well: _____	Well Locked at Departure: Yes / No
Well Completion: Flush Mount / Stick Up	Key Number To Well: _____

SOIL BORING LOG

Boring No.: _____

Sheet : 1 of _____

Project Name: _____	Date Started: _____	Logger: _____
Project Number: _____	Date Completed: _____	Editor: _____
Project Location: _____	Weather Conditions: _____	

Depth (feet)	Blow Counts	Sample ID & Time	Recovery (in.)	PID (ppm)	USCS Class.	Description	Construction Details
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Drilling Co.: _____ Driller: _____ Drilling Method: _____ Drilling Fluid: _____ Remarks: _____ _____ _____	Sampling Method: _____ Sampling Interval: _____ Water Level Start: _____ Water Level Finish: _____ Converted to Well: ☐ Yes ☐ No Surface Elev: _____ North Coord: _____ East Coord: _____

SOIL/SEDIMENT/SLUDGE SAMPLING LOG

Project/		Date	_____
Site Location	_____	Project No.	_____
Sample No.	_____	Coded	_____
Time	_____	Replicate No.	_____
Sampling Began	_____	Time	_____
		Sampling Ended	_____

Sampling Method and Material: _____

From	To	Soil/Sediment/Sludge Description

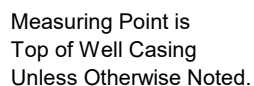
OTHER (OVA; HNu; etc.) _____

Constituents Sampled	Container Description	Preservative
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Remarks _____

Sample Personnel _____

(Unconsolidated)



Prepared by



ID#:

CHAIN OF CUSTODY & LABORATORY
ANALYSIS REQUEST FORM

Page ____ of ____

Lab Work Order #

Send Results to:	Contact & Company Name:		Telephone:		Preservative								Keys Preservation Key: A. H₂SO₄ B. HCL C. HNO₃ D. NaOH E. None F. Other: _____ G. Other: _____ H. Other: _____ Container Information Key: 1. 40 ml Vial 2. 1 L Amber 3. 250 ml Plastic 4. 500 ml Plastic 5. Encore 6. 2 oz. Glass 7. 4 oz. Glass 8. 8 oz. Glass 9. Other: _____ 10. Other: _____ Matrix Key: SO - Soil W - Water T - Tissue SE - Sediment SL - Sludge A - Air NL - NAPL/Oil SW - Sample Wipe Other: _____
	Address:		Fax:		Filtered (✓)								
	City State Zip		E-mail Address:		# of Containers								
	Project Name/Location (City, State):		Project #:		Container Information								
	Sampler's Printed Name:		Sampler's Signature:		PARAMETER ANALYSIS & METHOD								
Sample ID		Collection Date Time		Type (✓) Comp Grab		Matrix		REMARKS					
Special Instructions/Comments: ☐ Special QA/QC Instructions(✓):													
Laboratory Information and Receipt				Relinquished By		Received By		Relinquished By		Laboratory Received By			
Lab Name:		Cooler Custody Seal (✓)		Printed Name:		Printed Name:		Printed Name:		Printed Name:			
☐ Cooler packed with ice (✓)		☐ Intact ☐ Not Intact		Signature:		Signature:		Signature:		Signature:			
Specify Turnaround Requirements:		Sample Receipt:		Firm:		Firm/Courier:		Firm/Courier:		Firm:			
Shipping Tracking #:		Condition/Cooler Temp: _____		Date/Time:		Date/Time:		Date/Time:		Date/Time:			

CHAIN-OF-CUSTODY SEAL • CHAIN-OF-CUSTODY SEAL



ARCADIS



CHAIN-OF-CUSTODY SEAL • CHAIN-OF-CUSTODY SEAL

Sample Label

 ARCADIS		SAMPLE I.D.	
PROJECT #		DATE	
SAMPLE TYPE ☐ Soil/Sediment ☐ Water	COLLECTION MODE ☐ Composite ☐ Grab	TIME	
ANALYSIS			
SAMPLER		PRESERVATIVE	

INJECTION TEST FIELD LOG



Date: _____

Test Area:

Weather:

Injection Well/Zone:

Site: _____

Personnel:

INJECTION SOLUTION CHARACTERISTICS

Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
15	15	15	15	15	15
16	16	16	16	16	16
17	17	17	17	17	17
18	18	18	18	18	18
19	19	19	19	19	19
20	20	20	20	20	20
21	21	21	21	21	21
22	22	22	22	22	22
23	23	23	23	23	23
24	24	24	24	24	24
25	25	25	25	25	25
26	26	26	26	26	26
27	27	27	27	27	27
28	28	28	28	28	28
29	29	29	29	29	29
30	30	30	30	30	30
31	31	31	31	31	31
32	32	32	32	32	32
33	33	33	33	33	33
34	34	34	34	34	34
35	35	35	35	35	35
36	36	36	36	36	36
37	37	37	37	37	37
38	38	38	38	38	38
39	39	39	39	39	39
40	40	40	40	40	40
41	41	41	41	41	41
42	42	42	42	42	42
43	43	43	43	43	43
44	44	44	44	44	44
45	45	45	45	45	45
46	46	46	46	46	46
47	47	47	47	47	47
48	48	48	48	48	48
49	49	49	49	49	49
50	50	50	50	50	50
51	51	51	51	51	51
52	52	52	52	52	52
53	53	53	53	53	53
54	54	54	54	54	54
55	55	55	55	55	55
56	56	56	56	56	56
57	57	57	57	57	57
58	58	58	58	58	58
59	59	59	59	59	59
60	60	60	60	60	60
61	61	61	61	61	61
62	62	62	62	62	62
63	63	63	63	63	63
64	64	64	64	64	64
65	65	65	65	65	65
66	66	66	66	66	66
67	67	67	67	67	67
68	68	68	68	68	68
69	69	69	69	69	69
70	70	70	70	70	70
71	71	71	71	71	71
72	72	72	72	72	72
73	73	73	73	73	73
74	74	74	74	74	74

Volume of Water (gal):

Concentration of Reagent (mg/L):

Concentration of Dye (mg/L):

INJECTION LINE READINGS

[illegible]

MANUAL WATER LEVEL RECORD, FOR PUMPING TEST

MEASUREMENTS IN OBSERVATION WELL #:

Sheet: of

Job Name: _____

Location:

Well Diameter: _____ Pumped Well: _____

Step No. _____

Measure Point: _____ Distance from Pumped Well: _____

Start Date: _____

[illegible]

PHASE 1 DGR™ PILOT TEST OPERATION AND MAINTENANCE LOG

Field Personnel:

Test:

Weather:

[illegible]

Phase 1 DGR™ Pilot Test
PRESSURE TRANSDUCER LOG

Personnel: _____

Test: _____

Weather: _____

Pressure Transducers											
Well ID	Transducer Serial Number	Program Start Date and Time	Recording Interval	Approximate Deployment Depth (ft bTOC)	DEPLOYMENT			RETRIEVAL/DOWNLOAD			Download File Name (GM-16-01012017-00:00)
					Date	Time	DTW (ft bTOC)	Date	Time	DTW (ft bTOC)	
<i>Barologger</i>											
GM-16											
EW-1											
EW-2											
W-3-S											
W-4-S											
RZ-4I											
GM-63											
GM-64											
RMW-93											
RMW-94											

NOTES:

ft bTOC - feet below top of casing.

[illegible]

Well ID



Date _____

Site: _____

Job Number: _____

[illegible]

Notes