Proactive by Design

CONCEPTUAL SITE MODEL and REMEDIAL INVESTIGATION WORK PLAN

Former House Street Disposal Area
Wolverine World Wide, Inc.
Rockford, Michigan

November 27, 2017
File No. 16.0062335.52

PREPARED FOR:
Wolverine World Wide, Inc.

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File No. 16.0062335.00

Ms. Abigail Hendershott
Acting District Supervisor – Remediation and Redevelopment Division
Michigan Department of Environmental Quality
350 Ottawa Avenue NW #10
Grand Rapids, MI 49503

Re: Remedial Investigation Work Plan
Former House Street Site
1885 House Street, Plainfield Township, Michigan

Dear Ms. Hendershott:

On behalf of Wolverine World Wide, Inc. (Wolverine), Rose & Westra, a Division of GZA GeoEnvironmental, Inc. (R&W/GZA), prepared this Remedial Investigation Work Plan related to the presence of per– and poly-fluoroalkyl substances (PFAS) at the Former House Street Site (Site). The Work Plan and attached documents were prepared in response to certain requests included in MDEQ's November 2, 2017 letter[1] to Wolverine and Wolverine's ongoing investigation. Specifically, this letter addresses Requests D and F related to the Wolverine Former House Street Site in MDEQ's November 2, 2017 letter, and provides a proposed Work Plan and a conceptual site model (CSM), respectively.

As requested, the proposed Work Plan is focused on evaluating the vertical and lateral extent of PFAS, in particular, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). The proposed investigation is based on the CSM, our experience at the Site, and experience at other PFAS-related sites.

R&W/GZA trust that this letter and attachments are responsive to MDEQ requests referenced herein, and look forward to receiving your comments on the proposed Work Plan. Should you have any questions, please do not hesitate to contact the undersigned.

[1] Letter by MDEQ titled "*Wolverine World Wide, Inc. (Wolverine) PFAS Response, House Street, Plainfield Township, and Wolverine Tannery, 123 Main Street, Rockford, Kent County, Michigan*."

Very truly yours,

Rose & Westra, a Division of GZA GeoEnvironmental, Inc.

Jiangeng (Jim) Cai, P.E.
Senior Consultant

Mark A. Westra
Associate Principal

John C. Osborne, P.G.
Consultant Reviewer/Senior Vice President

Attachments: As Stated

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1.0 INTRODUCTION

GZA GeoEnvironmental, Inc. (GZA) has prepared this Report for Wolverine World Wide, Inc. (Wolverine), regarding Wolverine's Former House Street Disposal Area, located at 1855 House Street, NE, Plainfield Township, Kent County, Michigan (Site). This Report has been prepared for submittal to the Michigan Department of Environmental Quality (MDEQ) in response to MDEQ's November 2, 2017 letter, Item D, requesting the development of a Remedial Investigation Work Plan (RIWP) to fully define the vertical and horizontal extent of impacts to groundwater, soils, and surface water by November 27, 2017, and as part of Wolverine's ongoing investigation.

1.1 BACKGROUND

In the 1960's, Wolverine disposed of byproducts from its leather tanning operations at the Site, which was a licensed and regulated disposal facility authorized by the State of Michigan. The disposed byproducts may have contained perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), which are part of a larger group of perfluoroalkyl and polyfluoroalkyl substances (PFAS). PFAS were in 3M's Scotchgard™ applied to some leather manufactured at the tannery. MDEQ Remediation and Redevelopment Division (RRD) files indicated the House Street Site waste disposal license expired in 1978, but it appears no waste was disposed after 1970.

In March 2017, MDEQ informed Wolverine material containing PFAS may have been disposed at the Site. Since April 2017, Wolverine has voluntarily and proactively worked with MDEQ, the Kent County Health Department (KCHD), and Michigan Department of Health and Human Services (DHHS) to establish zones for drinking water well testing, provided alternate (bottled) water service, point of use (faucet) water filters, and point of entry (whole house) filter systems. As of November 2017, six hundred forty-one (641) drinking water samples were collected and analyzed for PFAS in the investigation and expansion areas related to the Site; six hundred forty-one (641) houses were offered alternate water sources; faucet water filters were installed for sixty-six (66) houses; and whole house filter systems were installed, or scheduled to be installed, at approximately 200 houses. GZA has installed groundwater monitoring wells at seven (7) locations on the Site, one monitoring well on the adjoining Michigan Department of Transportation (MDOT) parcel, and is installing monitoring wells at three (3) locations on the US-131 right of way (ROW).

MDEQ requested this RIWP to delineate the extent of PFOA/PFOS in groundwater near the Site.

1.2 SCOPE OF WORK

The scope of work for the development of the RIWP consists of the following components:

1. Development of a conceptual site model (CSM) based on available information to form a hypothesis on the fate and transport of PFOA/PFOS and potential risks from exposure;

2. Identify data gaps;

3. Development of proposed field sampling and analysis plan; and,

4. A quality assurance project plan (QAPP, superseded by MDEQ's subsequent request for a consolidated QAPP)

To develop a CSM, GZA performed the following tasks:

- Evaluate existing literature and historical information;
- Obtain and evaluate source area information;
- Obtain and assess the physical setting of the Site and its vicinity: topology, geology, surface water hydrology, and groundwater;
- Assess the extent of PFOA/PFOS and PFAS impact in groundwater;
- Assess the fate and transport characteristics of PFOA, PFOS, and PFAS; and,
- Evaluate relevant exposure pathways; and,
- Develop a preliminary CSM, which will be further revised with additional data and analysis throughout the lifecycle of the project.

2.0 DEVELOPMENT OF A CONCEPTUAL SITE MODEL

The following sections discuss the information and data reviewed and evaluated, leading to the development of the CSM.

2.1 SITE LOCATION AND TOPOLOGY

The Site is located at 1855 House Street, NE, Plainfield Township, Michigan, Kent County, Michigan. The Site resides in an area of mixed rural and residential land use according to "Plainfield Charter Township Zoning Map," dated April 13, 2015.

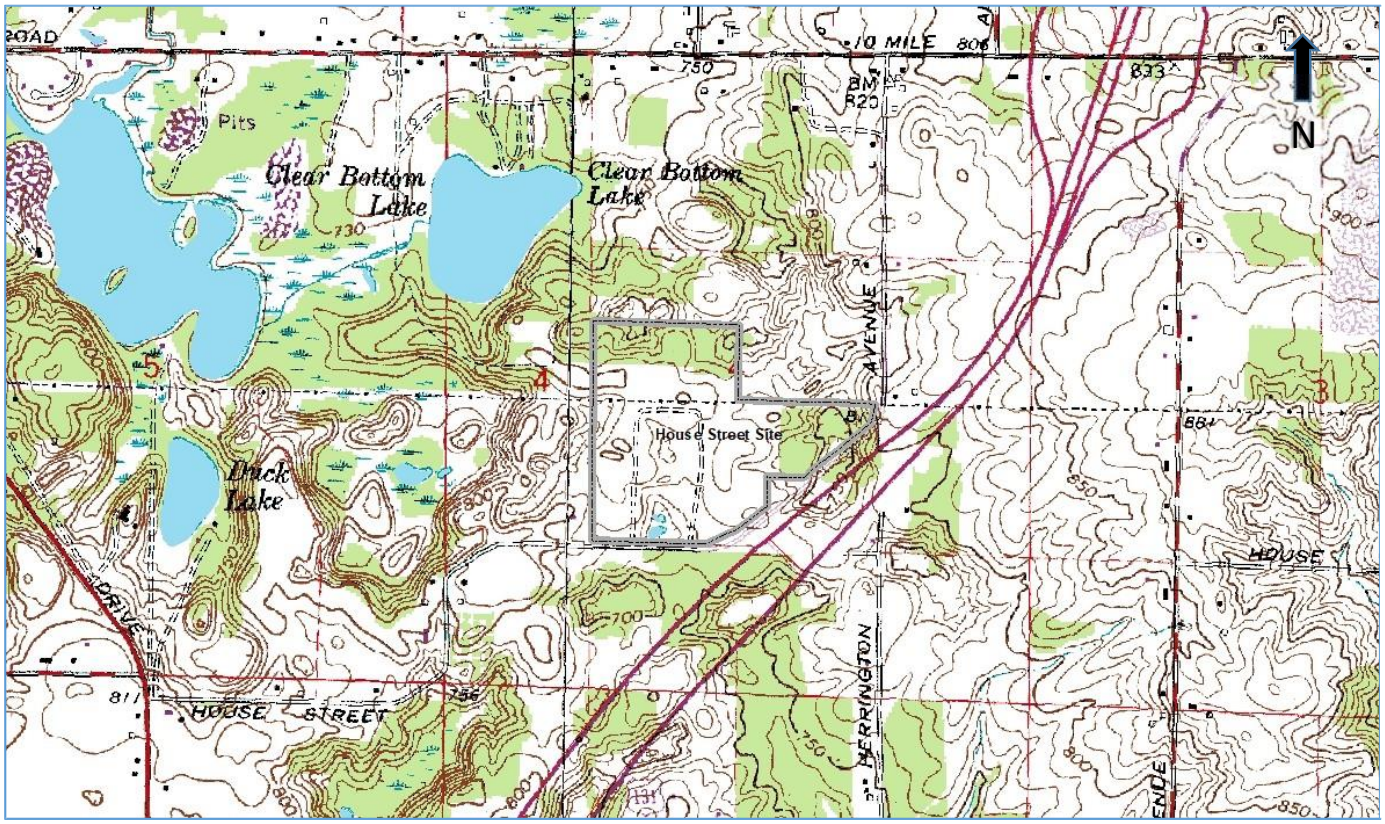


Figure 1 - USGS Topography Map

As shown in Figure 1, a clipped topography map from the United States Geological Survey (USGS) topography map, the Site is located immediately northwest of US Highway – 131, with ground surface elevations ranging from 740 feet to 800 feet across the Site. The terrain is generally hilly in the region. Ground surface elevations for the area east of the Site ranges from 800 to more than 900 feet; ground surface elevations for the west to southwest of the Site ranges from 800 to 820 feet, with lower terrains to the northwest and southeast. Figure No. 2 provides a regional view of the topography based on USGS's Digital Elevation Model (DEM) geographic information system (GIS) file downloaded from the Michigan Geographical Digital Library (MGDL)[1], overlaid with GIS data for surface water features (Center for Shared Solutions and Technology Partnerships, 2014). The Site is flanked by higher ground to the northeast and southwest, but ground surface dips to the northwest toward the Clear Bottom Lake and Freska Lake, and to the southeast toward the Rogue River.

[1] http://www.mcgi.state.mi.us/mgdl/

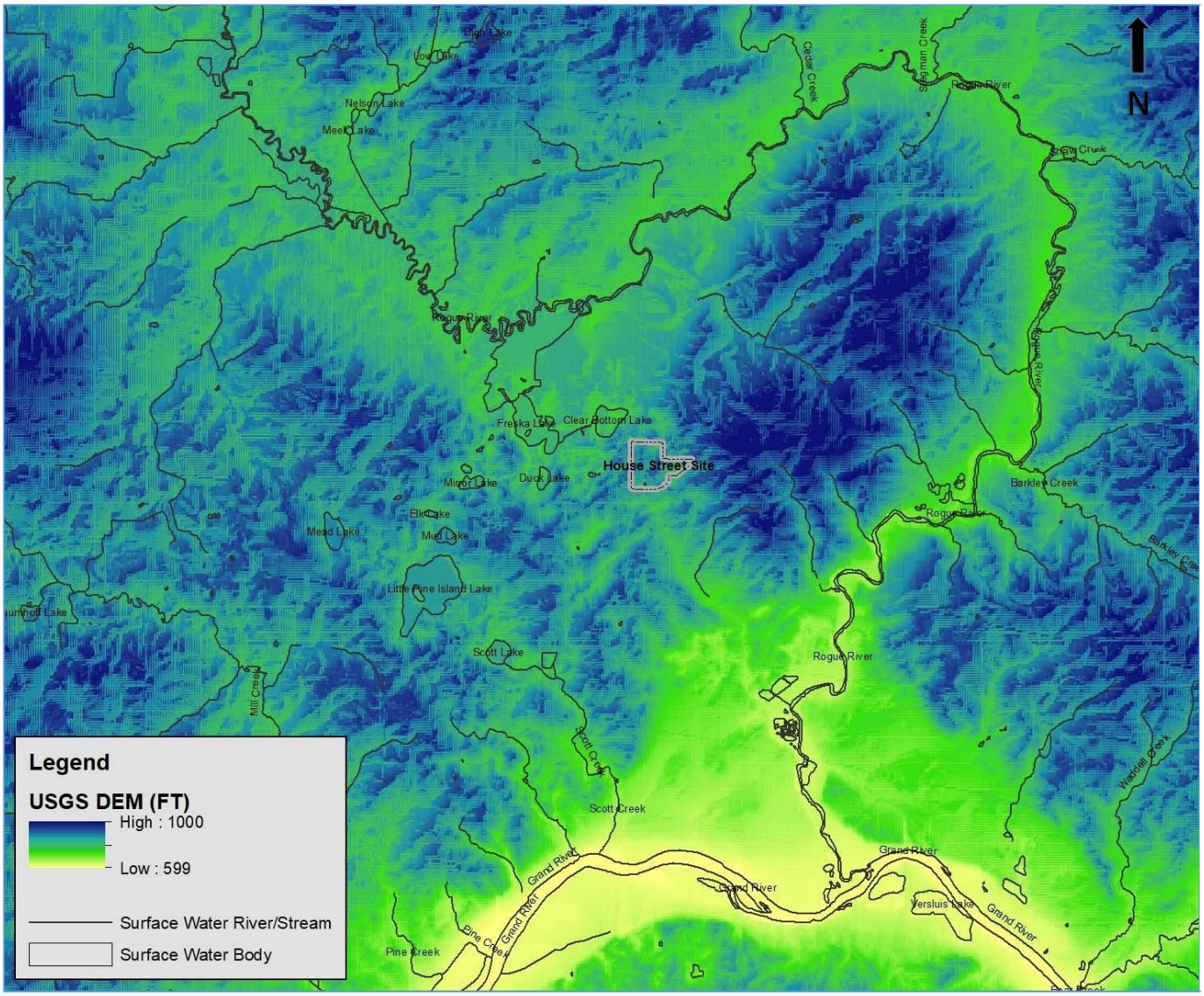


Figure 2 - USGS DEM and Surface Water Features

2.2 HYDROLOGY

Based on the Michigan's Major Watersheds – Sub-basins GIS data (Michigan Department of Environmental Quality, 2011) downloaded from MGDL, the Site is situated within the Rogue River Basin (Basin No. 14F), which is part of the Lower Grand River watershed (HUC 0405006). The Rogue River basin consists of 12 sub-basins, three of which are near the Site area, as shown in Figure 3. The Site is situated on the water divide of two sub-basins: HUC 405006040080 and HUC 405006040120, both draining to the Rogue River, which discharges to the Grand River. The Site is also near sub-basin HUC 45006050050, which is part of the Grand River basin.

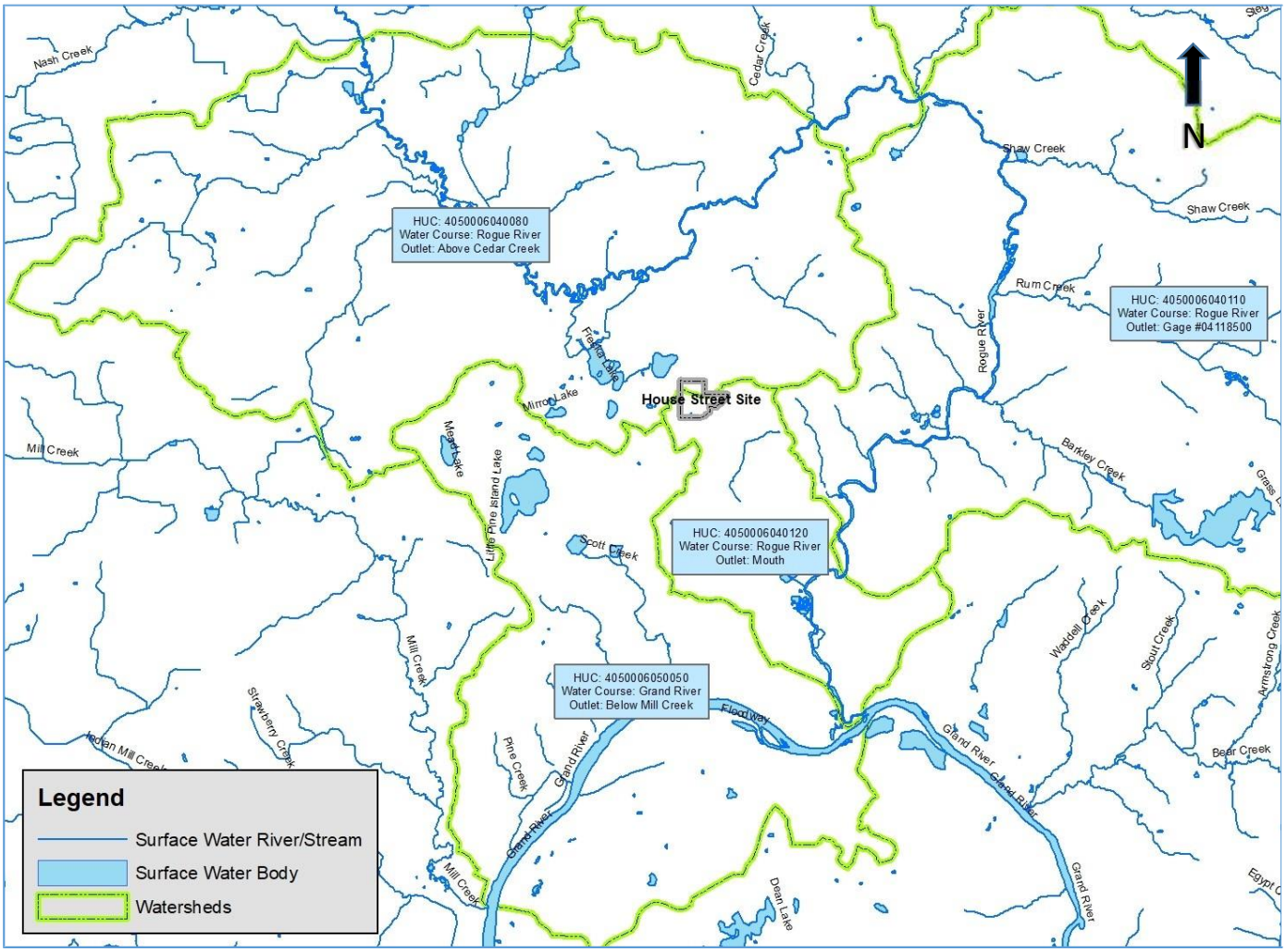


Figure 3 - Major Watersheds Near the Site

Based on the 2016 climate data report for Grand Rapids, Michigan, downloaded from National Oceanic and Atmospheric Administration (NOAA), the mean annual precipitation for the record period of 80 years is approximately 36 inches. Streamflow data at the USGS Gaging Station No. 04118500, located at Rockford, Michigan, the discharge point of sub-basin HUC 405006040110 (See Figure 3), from 1989 to 2016, were downloaded and reviewed with the use of USGS Groundwater Toolbox software. Annual baseflow rates were estimated and plotted with the annual total streamflow rates in Figure 4.

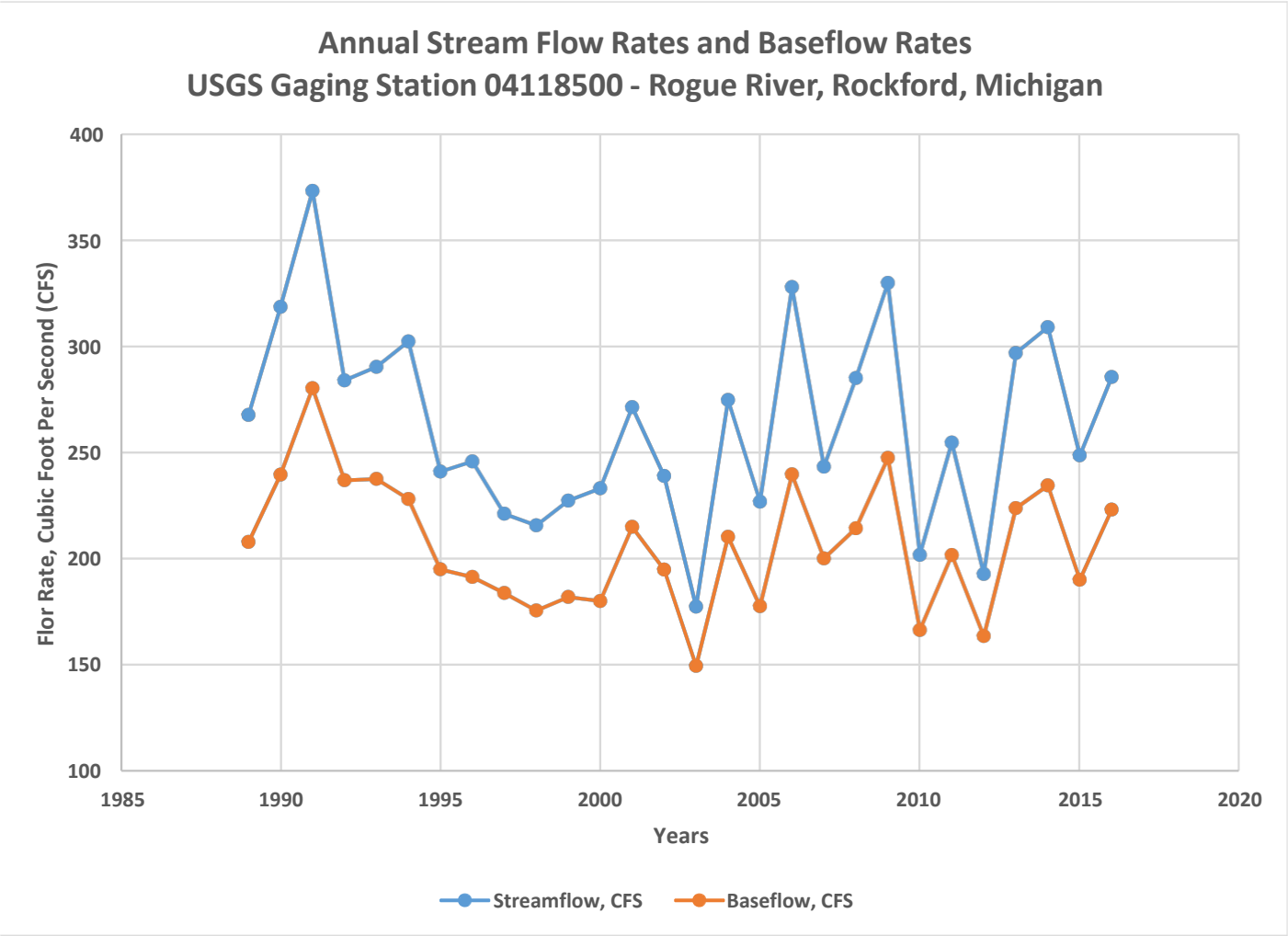


Figure 4 -Annual Streamflow and Baseflow Rates, the Rogue River, Rockford, Michigan

From 1989 to 2016, the average annual streamflow rate is approximately 260 cubic feet per second (CFS), and the average baseflow rate approximately 210 CFS. The gaging station measures the flow for the sub-basin, HUC 405006040110, a drainage area of approximately 234 square miles according to the USGS record. The equivalent streamflow, baseflow, and runoff, expressed in inches are as follow:

Table 1 - Average Annual Streamflow, Baseflow, and Runoff, Sub-basin (HUC 405006040110)

Parameters	Average
Total Streamflow Rates (1989 – 2016)	15.3 inches
Base Flow Rates (1989 – 2016)	12.0 inches
Runoff (1989 – 2016)	3.3 inches

Baseflow represents the amount of groundwater flow discharging to the surface water. Assuming 100 percent of groundwater recharge to the aquifer is discharged to the river as baseflow, the base flow rate for the sub-basin represents approximately 12 inches of annual recharge (This assumption does not consider groundwater inflow and outflow between this aquifer and other adjacent aquifers vertically and horizontally.).

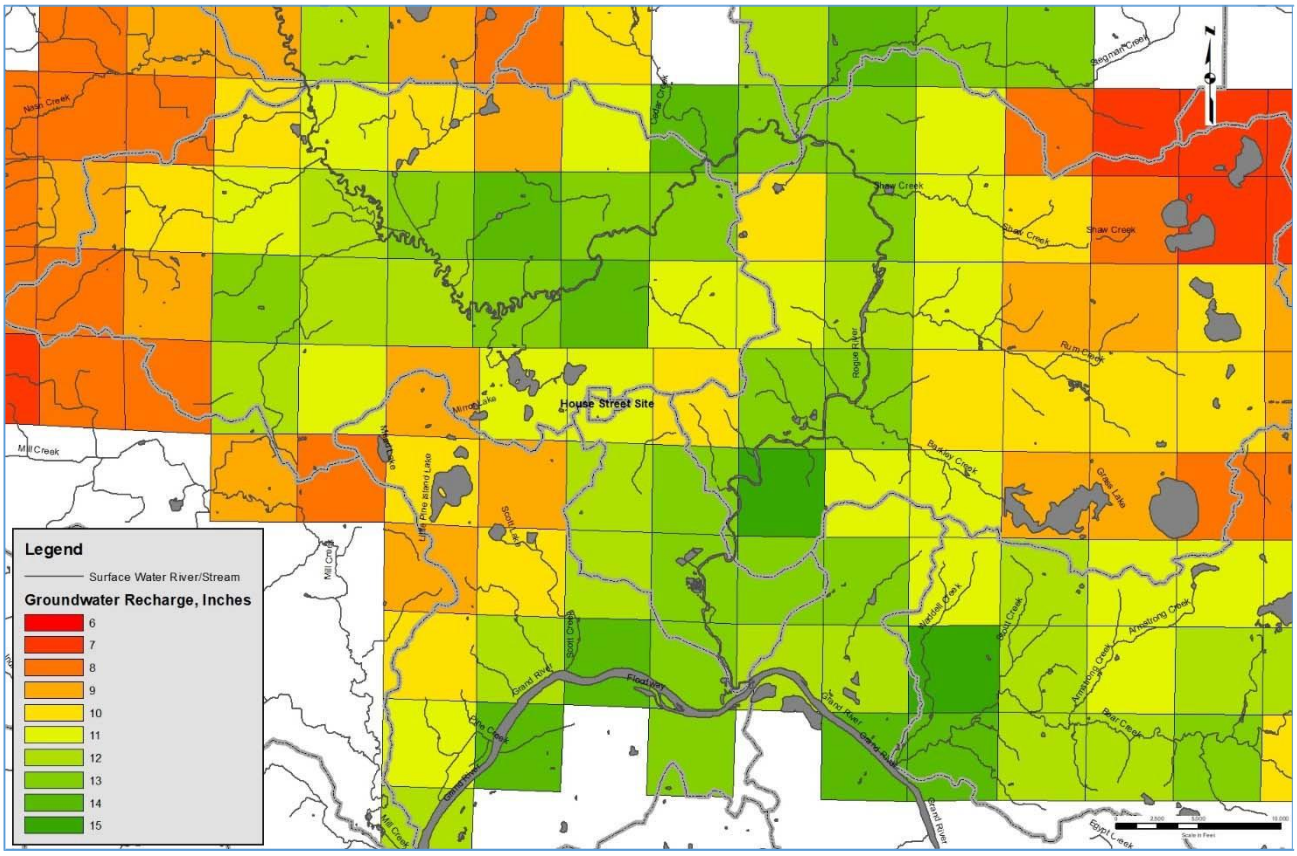


Figure 5 - Estimated Groundwater Recharge, Inches

Based on the State-wide GIS data for the estimated annual groundwater recharge (Groundwater Inventory and Mapping Project, 2005) downloaded from MGDL (See Figure 5), groundwater recharge in the region varies from 7 to 15 inches, with an average of approximately 11 inches; groundwater recharge in the cells immediately around the Site ranges from 9 to 14 inches; and groundwater recharge at the Site is approximately 11 inches.

Based on the National Wetland Inventory for Kent County GIS data (U.S. Fish & Wildlife Service, 1994) downloaded from MGDL, wetlands are present near the Rogue River southeast of the Site and northwest of the Site.

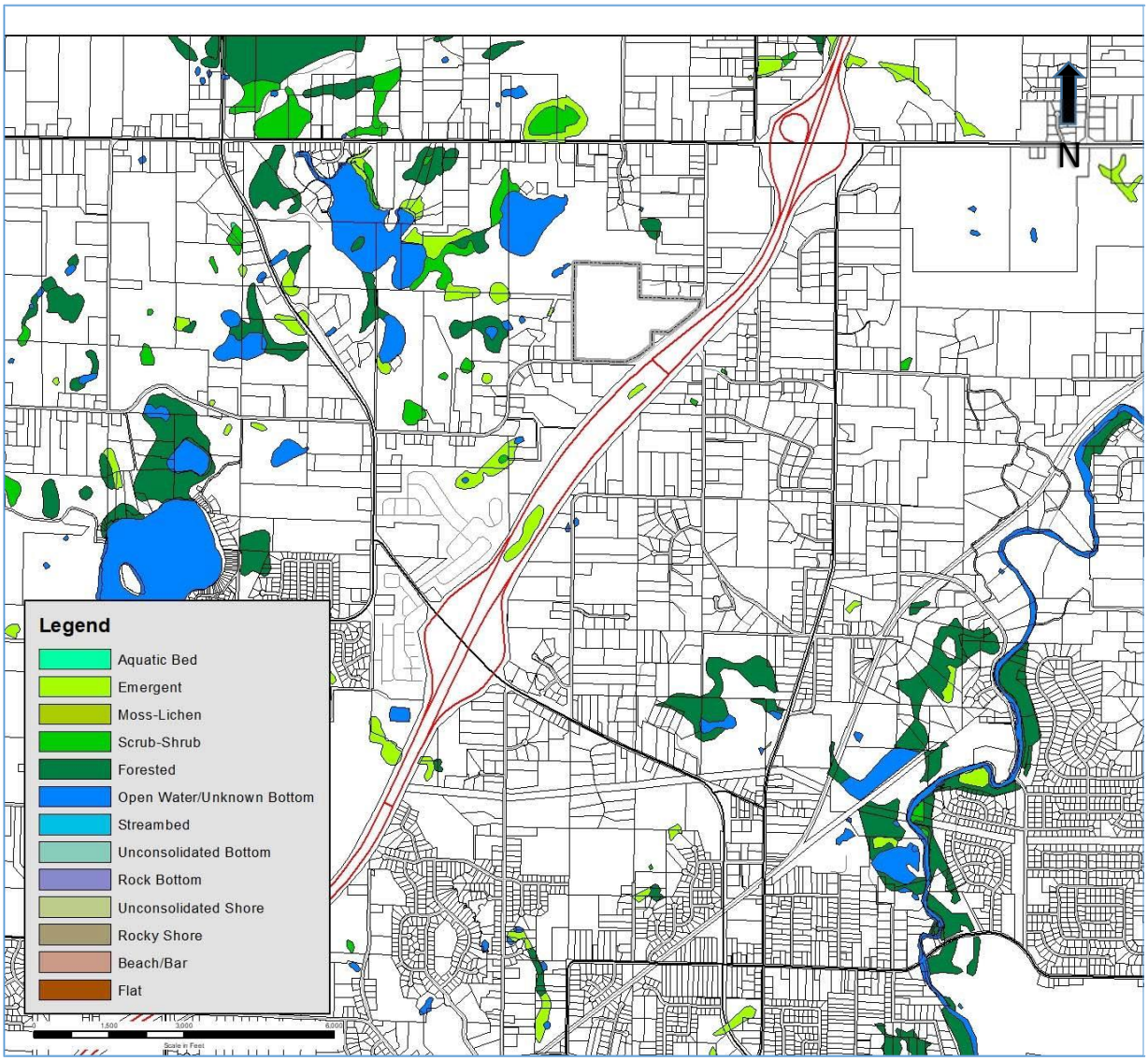


Figure 6 - National Wetland Inventory

2.3 GEOLOGY AND HYDROGEOLOGY

Several literatures and GIS data sources were reviewed to understand the regional geology. The primary sources of geological information are listed below:

- Summary of Hydrogeologic Conditions by County for the State of Michigan (Apple & Reeves, 2007);
- Water Resources of Grand Rapids Area, Michigan (Stramel, Wisler, & Laird, 1954);
- Hydrogeologic Atlas of Michigan: U.S. Environmental Protection Agency Underground Injection Control Program, Tech. rep., 35 plates, scale 1:500,000 (Western Michigan University, 1981);
- Quaternary Geology of Michigan (GIS Data) (Michigan Natural Features Inventory and MI Dept of Natural Resources, 1998), which was based on the Quaternary Geology of Southern Michigan and Quaternary Geology of Northern Michigan (Farrand & Bell, 1982);
- Bedrock Geology (GIS Data) (Michigan Department of Environmental Quality (MDEQ) - Geologic Survey Division, 1987);
- Wellogic -Statewide Wells (GIS Data) (Groundwater Inventory and Mapping Project, 2005).

2.3.1 Regional Quaternary Geology

Based on our literature review, overburden geology in Kent County consists of a thick sequence of Pleistocene glacial deposits. The thickness of glacial deposits ranges from 11 to 800 feet in Kent County, however, the majority of glacial deposits range from 200 to 400 feet in thickness (Western Michigan University, 1981). The glacial deposits in the county include till, outwash, and lacustrine deposits. Till occurs in end moraines and ground moraines (till plains), and are interspersed on the surface throughout the county (Stramel, Wisler, & Laird, 1954). The ground moraine (till plain) and end moraine belong to the unstratified group of deposits. Till is composed of fine to coarse-grained material, including silt, sand, gravel, and boulders; however, the majority of the till in Kent County is medium-grained (Farrand and Bell, 1982). The outwash and lake deposits belong to the stratified group of glacial deposits. Outwash is the most permeable of the glacial deposits, and consists of sand and gravel. Thin layers of lacustrine deposits were in the Grand Rapids area (Stramel, Wisler, & Laird, 1954). In the area, lacustrine deposits consist of clay and fine-grained sand, and may be underlain by sand and gravel.

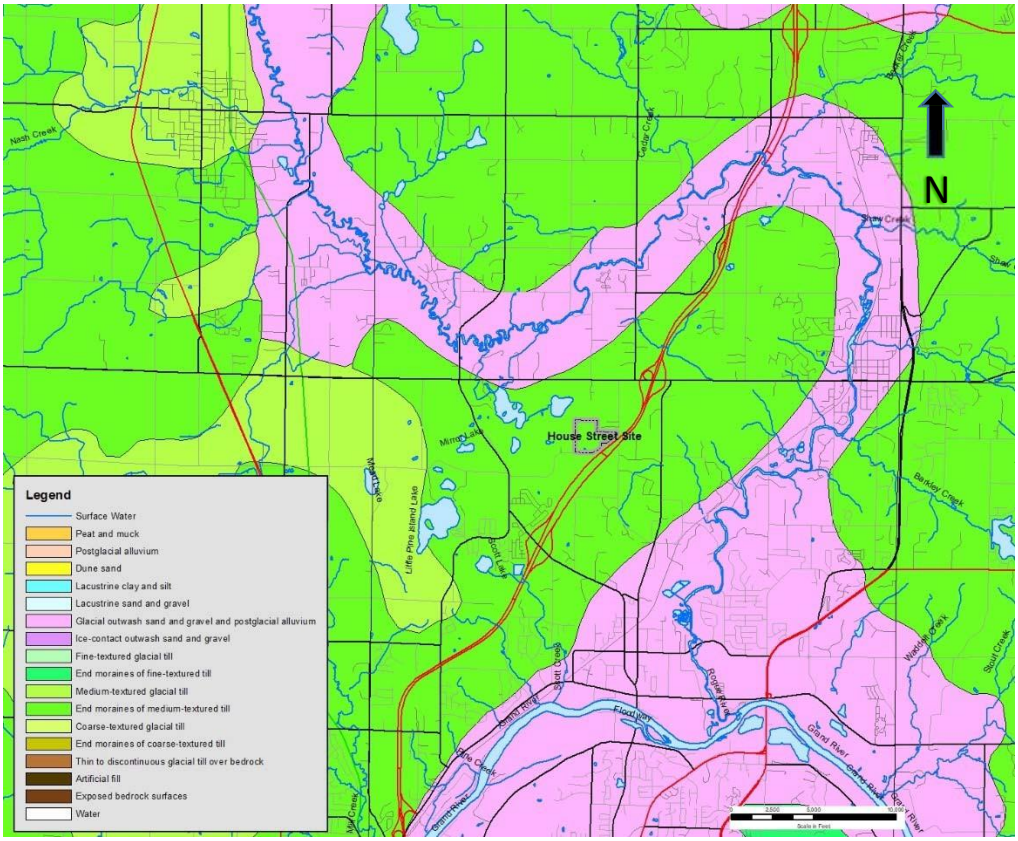


Figure 7 - Quaternary Geology at the Site and Vicinity [Based on Quaternary Geology of Michigan (GIS Data) (Michigan Natural Features Inventory and MI Dept of Natural Resources, 1998)]

As indicated in Figure 7, end moraines of medium-textured till are present at the Site and its vicinity; medium-textured glacial tills are present in the area west of the Little Pine Island Lake; glacial outwash sand and gravel and postglacial alluvium are present in the area along the water courses of the Rogue River and the Grand River.

2.3.2 Regional Bedrock Geology

Bedrock underlies the glacial drift. In the Grand Rapids area, bedrock beneath the drift are, from oldest to youngest, the Marshall formation, the Michigan formation, and the Bayport limestone, all of Mississippian age; the Parma sandstone and a very small area of outcrop of Saginaw formation, both of Pennsylvanian Age (Stramel, Wisler, & Laird, 1954). The regional dip is to the northeast. See Figure 8.

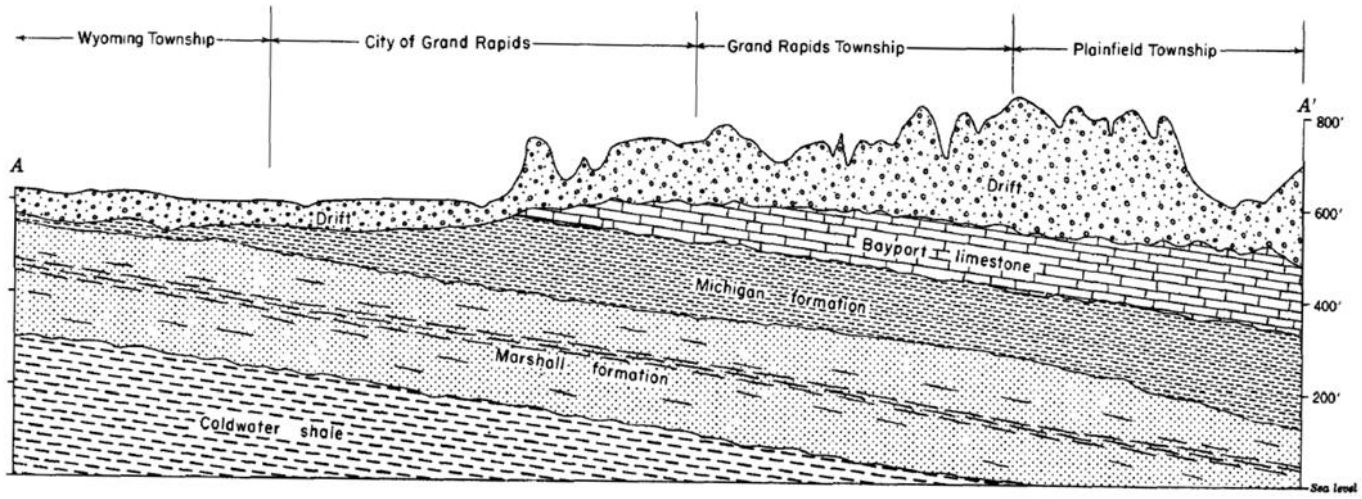


Figure 8 - Geological Cross, South to North from Wyoming Township to Plainfield Township (Stramel, Wisler & Laid, 1954)

The Jurassic "red beds" form the bedrock surface that underlie the glacial deposits in portions of Kent County. The "red beds" are often poorly consolidated or unconsolidated and consist primarily of clay, mudstone, siltstone, sandstone, shale, and gypsum. The "red beds" are of low permeability and are considered a confining unit. However, locally in the county, the "red beds" have been documented to supply small quantities of water (Apple & Reeves, 2007).

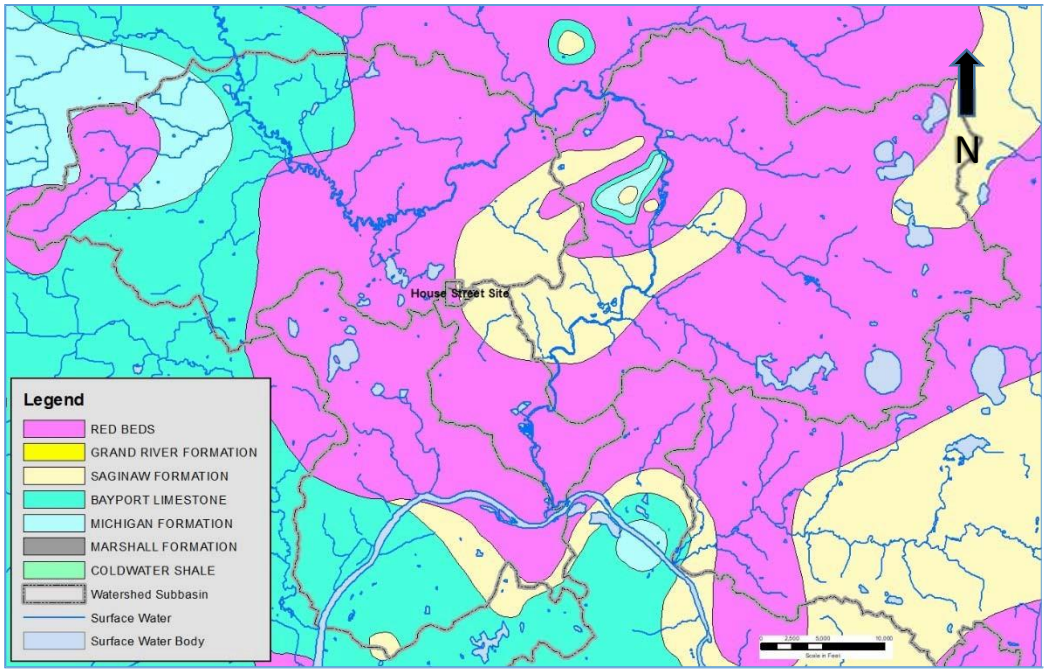


Figure 9 - Bedrock at the Site and Vicinity

Based on Bedrock Geology (GIS Data) (Michigan Department of Environmental Quality (MDEQ) - Geologic Survey Division, 1987) downloaded from MGDL, red beds are present in most of the Site area and its vicinity with some small areas of Saginaw Formation outcrop; Bayport Limestone and Michigan Formation are present to the southwest of the area (See Figure 9).

2.3.3 Well Logic Data Interpolation – Soil Stratigraphy

To determine regional geologic conditions, the Wellogic -Statewide Wells GIS Data for Kent County (Groundwater Inventory and Mapping Project, 2005) was downloaded from the MGDL to evaluate for glacial lithologies and top of bedrock surface. Geostatistical interpolation using kriging algorithm was utilized to create an approximate bedrock surface. The area of geostatistical modeling is focused on the area surrounded by the Rogue River to the north, northeast and east, the Grand River to the south, and the sub-basin divide to the west (See Figure 10).

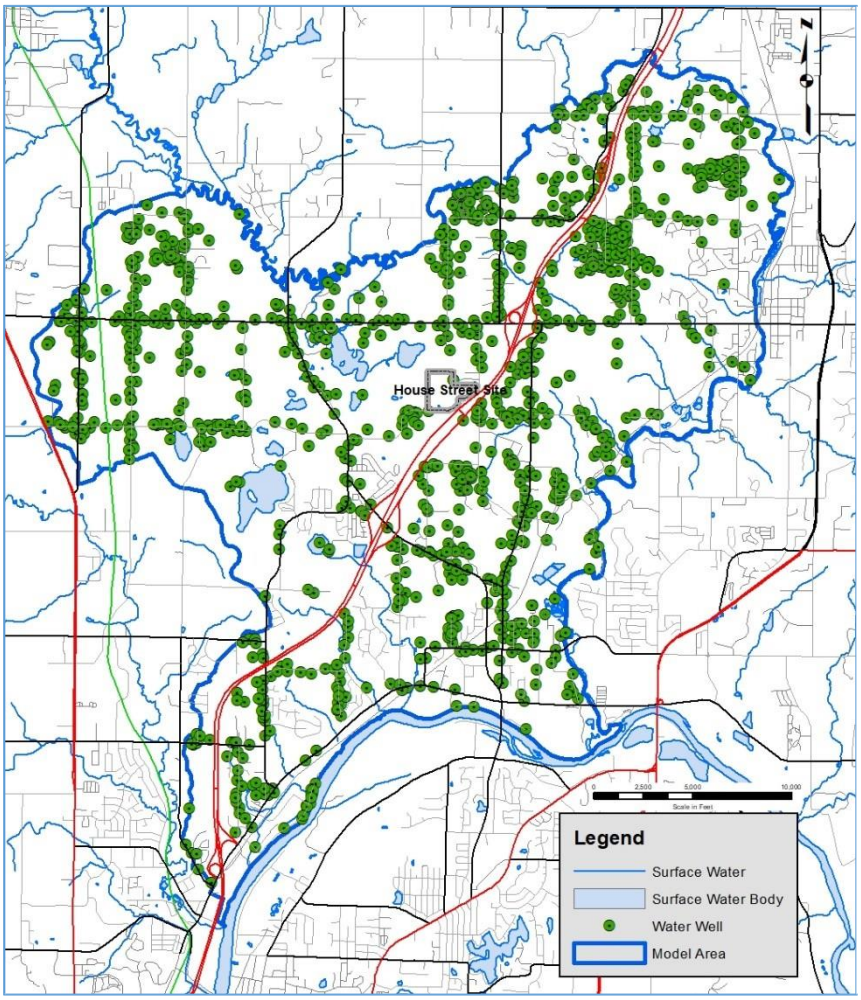


Figure 10 - Water Wells in the Model Area

To simplify the soil descriptions in the well logs, primary lithology was classified in the Wellogic GIS data file as follows:

AQ = aquifer material	MAQ = marginal aquifer material
CM = confining material	PCM = partially confining material

Upon review of the lithology data, the primary lithology in the Wellogic GIS data file was utilized for geostatistical analysis, but with some modifications: various bedrock lithology and classifications were grouped as one single class – bedrock; fine-grained materials, such as clay or silt, which were in some cases classified as PCM, were grouped as CM for geostatistical modeling. Boreholes with unknow lithology descriptions were excluded. The following

tables provides a summary of the modified classifications and lithology descriptions from the Wellogic GIS data. In addition, for posting material legend, each modified class is provided with a generalized soil description.

Modified Class	Generalized Soil Description for Each Class	Primary Lithology from Wellogic Data
AQ	Sand or Gravel	Boulders; Cobbles; Gravel; Gravel & Boulders; Gravel & Cobbles; Gravel & Sand; Gravel & Stones; Sand; Sand & Boulders; Sand & Cobbles; Sand & Gravel; Sand & Stones; Stones
MAQ	Clayey Sand or Gravel	Gravel & Silt; Gravel Clay Sand; Loam; Sand & Silt; Sand Clay Gravel; Sand Clay Silt; Sand Gravel Clay; Silt Sand Gravel
PCM	Sandy Clay	Clay & Boulders; Clay & Cobbles; Clay & Gravel; Clay & Sand; Clay & Stones; Clay Gravel Sand; Clay Gravel Stones; Clay Sand Gravel; Gravel & Clay; Sand & Clay
CM	Clay or Silt	Clay; Clay & Silt; Hardpan; Silt; Silt & Clay
Bedrock	Bedrock	Granite; Gypsum; Limestone; Limestone & Sandstone; Sandstone; Sandstone & Limestone; Shale; Shale & Limestone; Shale & Sandstone

The soil classified as MAQ and PCM represents a mixture of fined grained soil, sand, gravel or cobbles, likely belonging to the till material described previously. The soil classified as CM represents fined grained soil, clay or silt, likely belonging to either the lacustrine deposit or till of fine-textured. The soil classified as AQ represents sand, gravel, cobbles, likely belonging to the outwash group.

A cross section through several boreholes from northwest to southeast was created as shown in Figure 11 (the borehole colors symbolize the soil materials of the borehole top layers), and the cross section is shown in Figure 12.

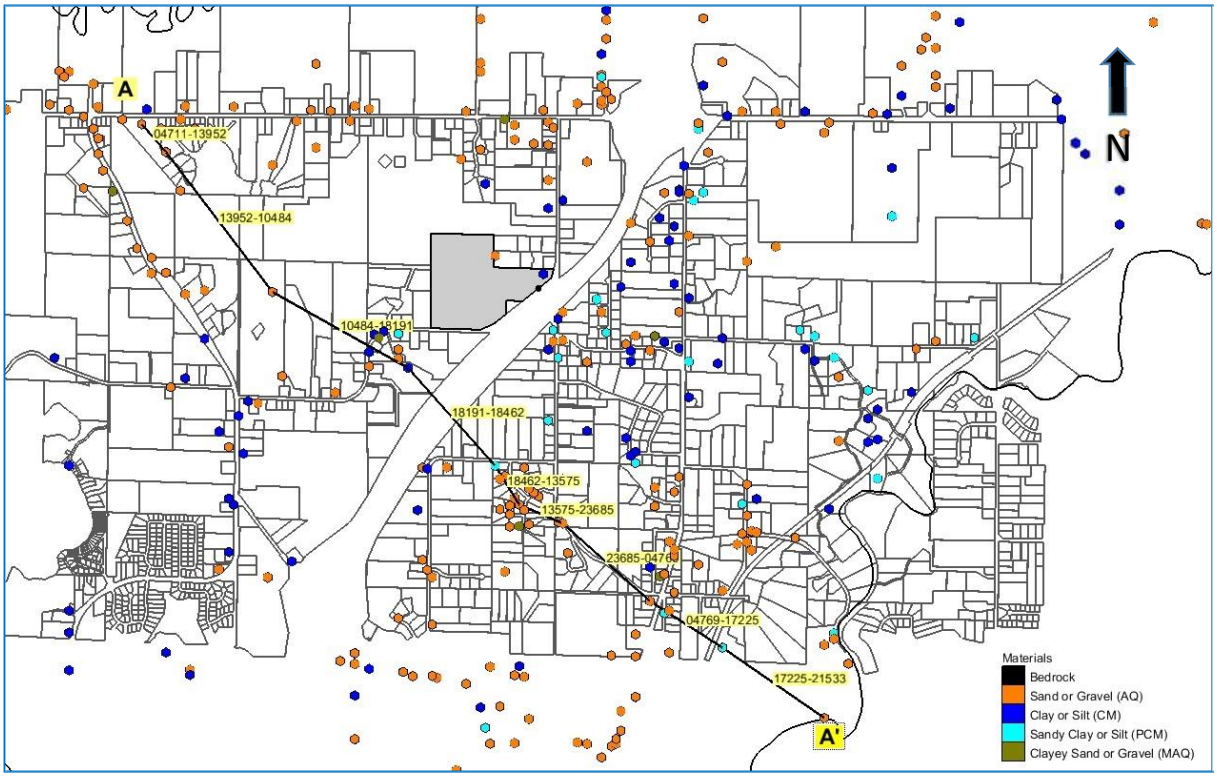


Figure 11 - Borehole Cross Section Location

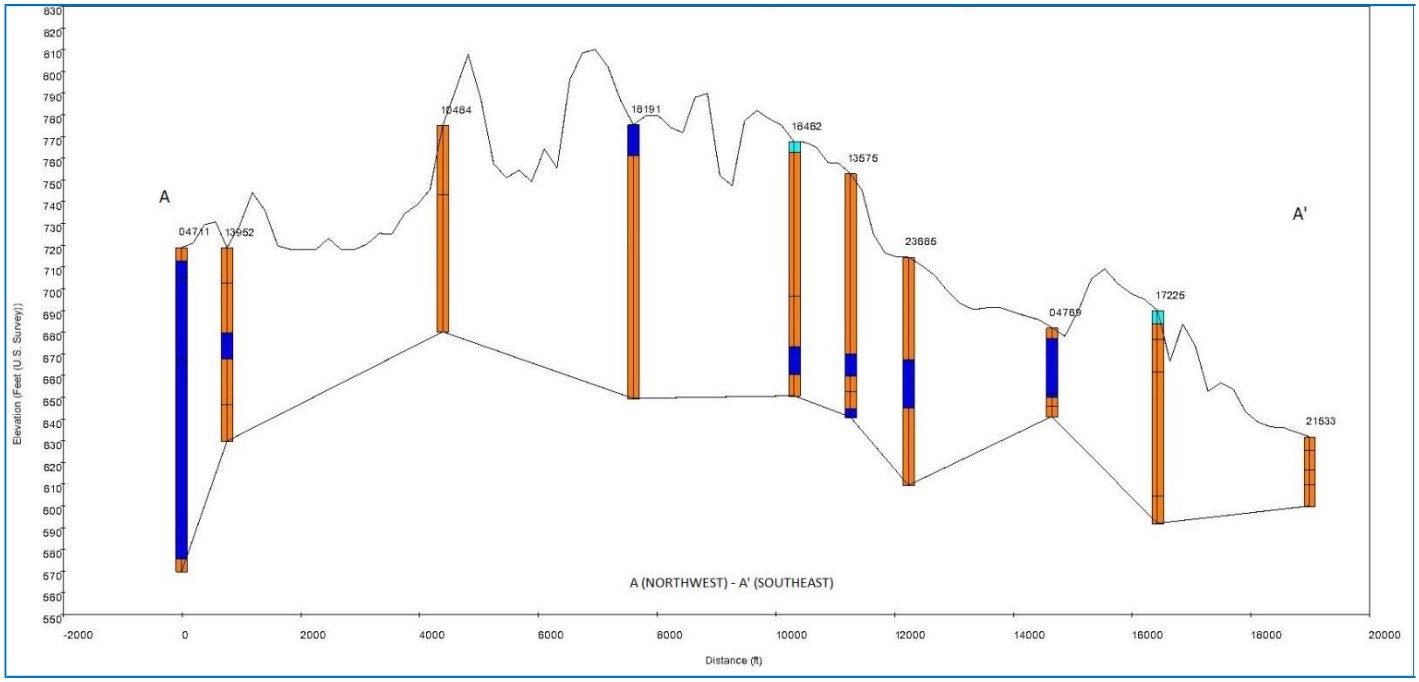


Figure 12 - Borehole Cross-Section (Northwest - Southeast)

The borehole cross section indicates a thick stratum of clay material at the northwest area, the presence of clay materials in several boreholes, and the presence of sand or gravel aquifer material in all the 10 boreholes.

The top of each lithology from each borehole, termed "contact", was assigned a horizon identification number based on their distributions horizontally and vertically. The horizons were used to create a material surface, representing top elevations of the stratum, using kriging algorithm for the model area, and the interpolated horizon surfaces were used to crease solids. A three-dimensional view of the solids is shown in Figure 13, and Figure 14 provides cross-sections of the interpolated solid.

As shown in Figure 13 and Figure 14, CM, PCM and MAQ materials are interspersed throughout the model area. Relatively thick stratums of CM, PCM materials are present in northwest areas (northwest ends of Sections A and B), northeast areas (Sections D, E and F) and southwest area (southwest ends of Section 1 and Section 2). AQ materials are present throughout the model area, with relatively greater thickness in southeast areas, as shown on southeast portions of Sections A and B, and the area running northwest to southeast through the Site (Section C).

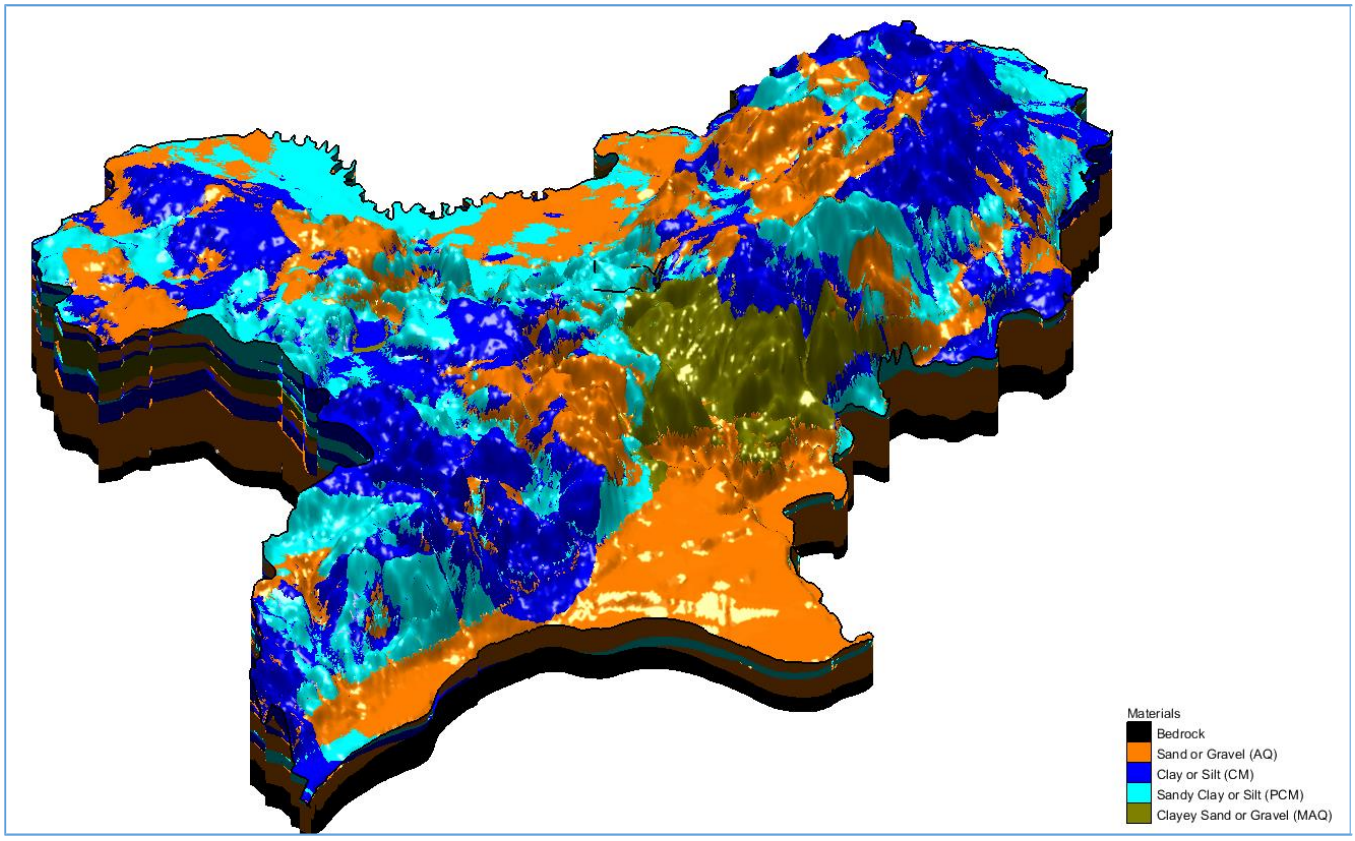


Figure 13 - Overburden Soil Solid

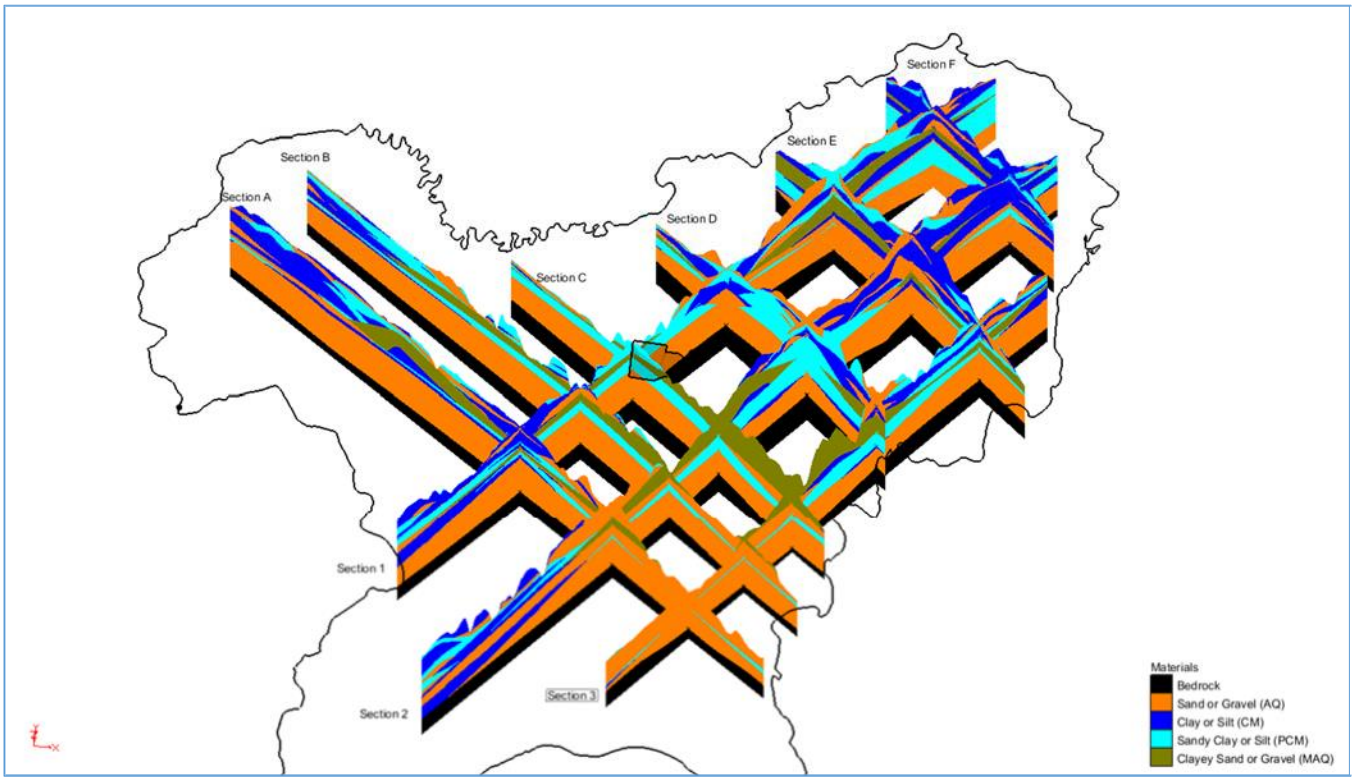


Figure 14 - Cross-Sections of the Interpolated Solid

2.3.4 Wellogic Data Interpolation – Top of Bedrock Elevation

Based on the recorded depth to top of bedrock in the Wellogic data file and the ground surface elevation data from USGS DEM GIS data downloaded from MGDL, the top of bedrock elevations were estimated, and elevation contours interpolated for the model area (See Figure 15).

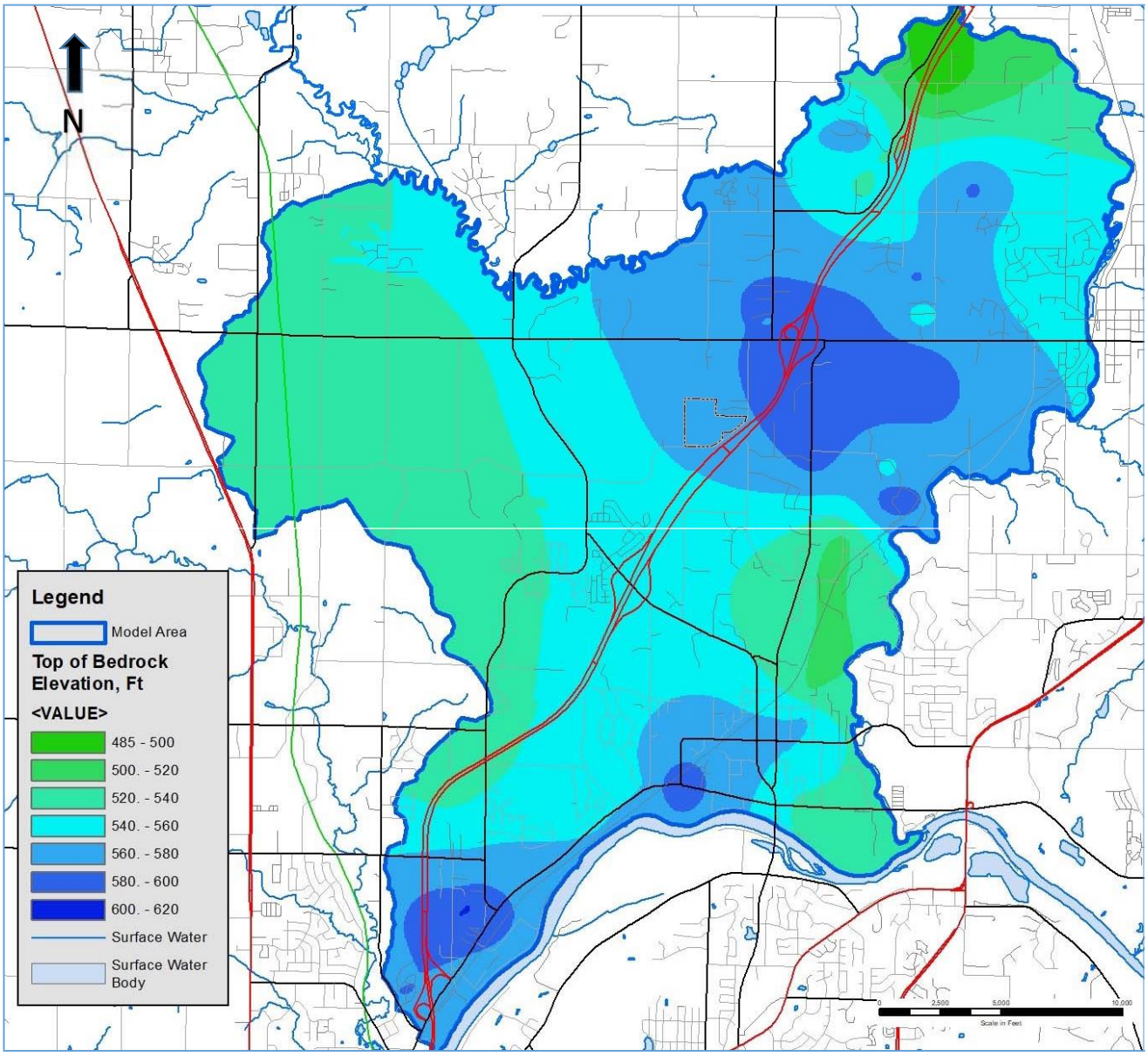


Figure 15 - Top of Bedrock Elevation Contours (Interpolated from Wellogic Data)

Top of bedrock elevations are greater than 540 feet in most of the model area, likely representing the areas of the "red beds" or outcrop Saginaw Formation; top of bedrock elevations in the remaining areas are less than 540 feet, likely representing the areas of Bayport Limestone or Michigan Formation. Top of bedrock elevations at the Site and its immediate vicinity range from 540 to 580 feet.

2.3.5 Regional Hydrogeology

This section discusses regional hydrogeology, consisting of groundwater flow direction, estimated hydraulic conductivity and transmissivity, and estimated groundwater velocity.

2.3.5.1 Groundwater Flow Direction

Based on the static water level data and the ground surface elevation data from USGS Digital Elevation Model (DEM) GIS data downloaded from MGDL, the regional groundwater elevations were estimated, and groundwater contours

interpolated for the model area. Groundwater flows from areas of relatively high groundwater elevations to lower elevations depicted in the following diminishing color order: red (highest elevations), orange, yellow, lighter green to darker green (lowest elevation). As shown in Figure 16, the groundwater flow pattern generally follows the topology in the region. Overall groundwater discharges to the Rogue River and the Grand River. Groundwater water elevations northeast of the Site and west of the Site are relatively high, causing groundwater flows from these two areas toward the Site. According to Figure 16, most of the groundwater at the Site area is expected to flow southwest for a relatively short distance, approximately 1,000 to 2,000 feet, then flow southeast toward the Rogue River. From the Site southeastward to the Rogue River, groundwater elevations change from approximately 720 feet at the Site to 630 feet near the southeast portion of the Rogue River, over a flow path line of approximately 12,000 feet, with an estimated hydraulic gradient of approximately 0.0075 foot/foot.

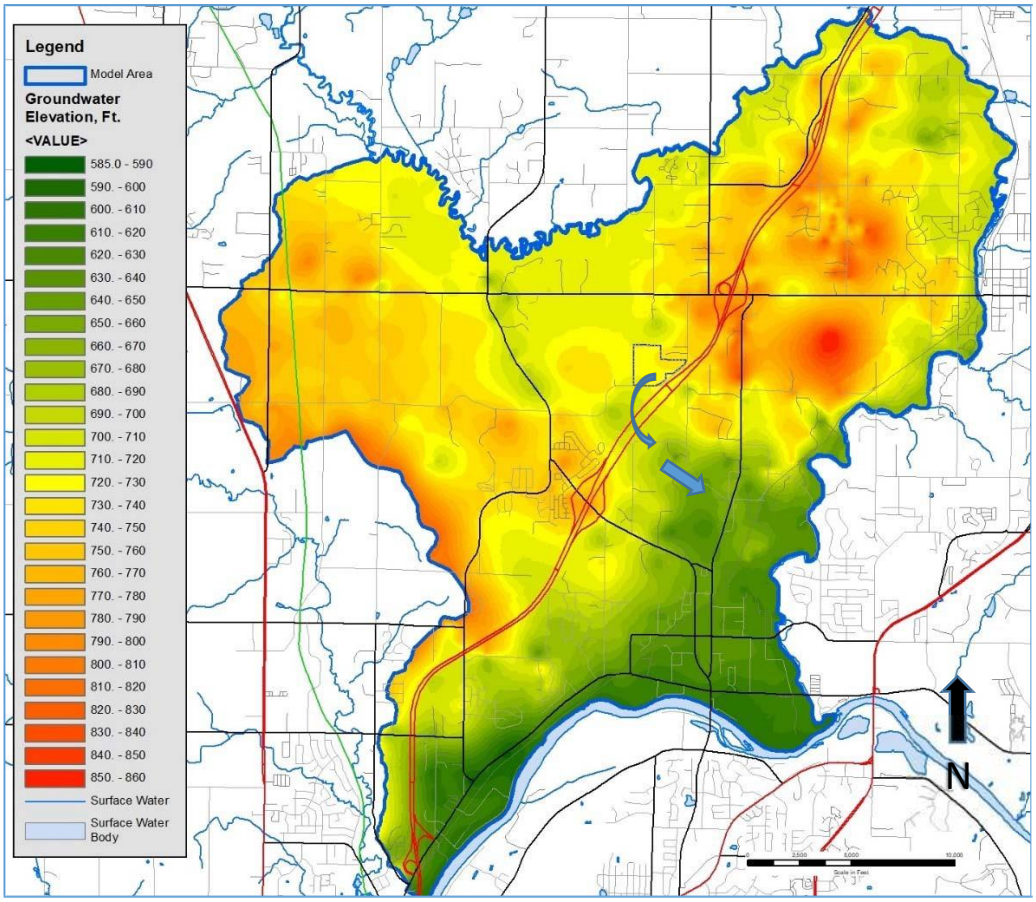


Figure 16 - Groundwater Contours Interpolated from Wellogic Water Level Data

From the Site to the north or northwest toward the Rogue River, the groundwater elevations change from approximately 720 to 718 feet over a possible flow path line of approximately 7,000 to 10,000 feet. The estimated hydraulic gradient ranges from approximately 0.0002 to 0.0003 foot/foot, which is very flat, indicating little groundwater, if any, flows to the north or northwest.

2.3.5.2 Estimated Hydraulic Conductivity and Transmissivity

Based on GIS data, Glacial Deposits -Estimated Transmissivity (Groundwater Inventory and Mapping Project, 2005), downloaded from MGDL, the estimated glacial transmissivity distribution is plotted for the model area (See Figure 17). According to the metadata, the transmissivity was estimated by multiplying the aquifer thickness by the estimated hydraulic conductivity for each well location, and then interpolated using a kriging algorithm. The hydraulic conductivity for each well location was estimated from the lithology index of each stratum, which was

based on the percentages of AQ, MAQ and PCM. As indicated in Figure 17, the transmissivity for most of the model area ranges from 900 to 5,000 square foot per day (ft^2/d).

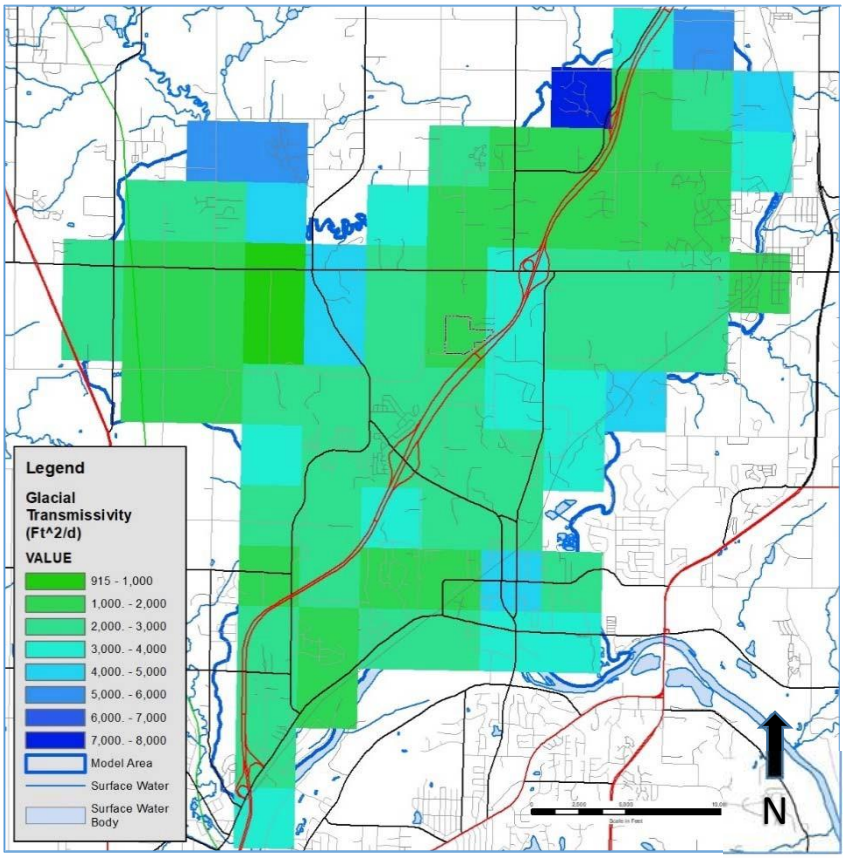


Figure 17 - Estimated Glacial Drift Transmissivity (ft^2/day)

Figure 18 provides a map of estimated horizontal hydraulic conductivity, which was interpolated from the estimated hydraulic conductivity values at individual well location. Based on the metadata, the estimated hydraulic conductivity is likely a geometric mean of the hydraulic conductivity values for the various stratums in the entire saturated zone at each well location. Areas with lower hydraulic conductivity value indicate the presence of fine-grained soil in the saturated zone while areas with higher hydraulic conductivity generally indicates good aquifer materials, such as outwash sand and gravels.

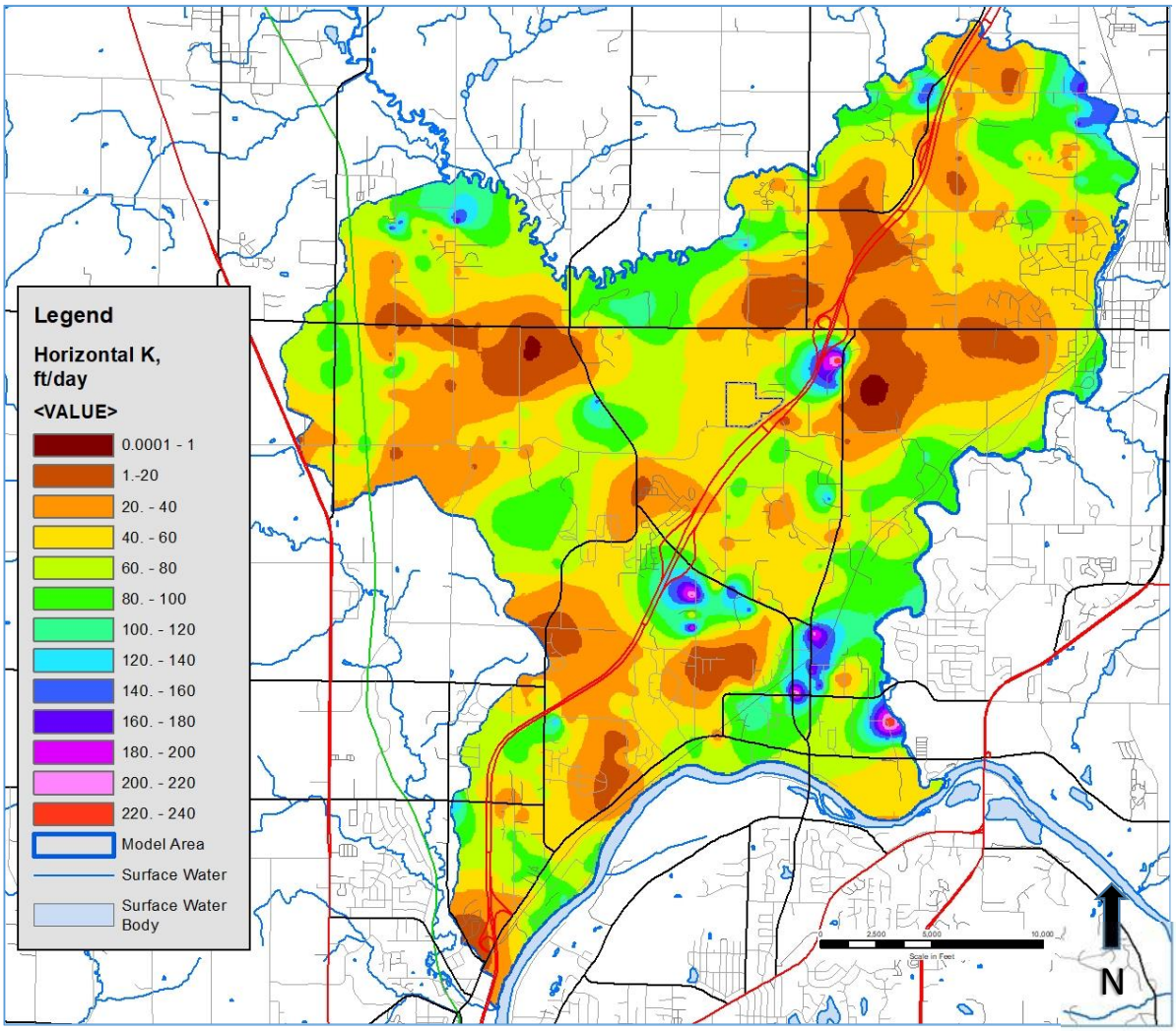


Figure 18 - Estimated Horizontal Hydraulic Conductivity (ft/d)

As shown in Figure 18, hydraulic conductivity varies from 20 to 120 feet per day (ft/d) for most of the model area, with a few small areas of lower or greater values. For the area from the Site to the southeast portion of the Rogue River, the hydraulic conductivity ranges from 40 to 80 ft/d.

2.3.5.3 Estimated Groundwater Seepage Velocity

Based on the estimated hydraulic gradient from the Site to the southeast toward the Rogue River, 0.0075 ft/ft, the range of hydraulic conductivity from 40 to 80 ft/d, and a literature effective porosity value of 0.3, the groundwater seepage velocity from the Site to the southeast portion of the Rogue River is estimated to range from approximately 1 ft/d to 2 ft/d, or 360 feet per year (ft/yr) to 730 ft/yr.

2.4 PROPERTIES OF PFOS AND PFOA

This section provides a summary of our literature review of the properties of PFOA and PFOS. The following sources were reviewed:

- US Environmental Protection Agency (USEPA) Fact Sheet, PFOA & PFOS Drinking Water Health Advisories (USEPA, 2016);

- USEPA Fact Sheet, Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) (USEPA, 2014);
- Perfluorinated Chemicals (PFCs): Perluorooctanoic Acid (PFOA) & Perfluorooctane Sulfonate (PFOS) Information Paper ((The Association of State and Territorial Solid Waste Management Officials (ASTSWMO), 2015); and,
- Assessment, Management and Remediation for PFOS and PFOA, Part 1 through Part 5 (CRC CARE, 2017).

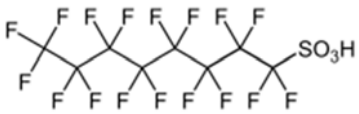
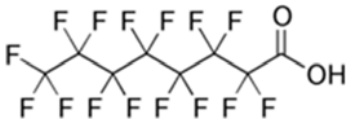
2.4.1 Overview of History and Use

PFOA and PFOS are man-made fluorinated organic chemicals that are part of a larger group of chemicals, PFASs, which are stable chemicals with varying length carbon chains. PFAS are used in a wide variety of industrial and commercial products such as textiles and leather products, metal plating, the photographic industry, photolithography, semi-conductors, paper and packaging (including food contact), coating additives, cleaning products and pesticides. Because of their unique lipid- and water-repellent characteristics, PFAS are used as surface-active agents in various high-temperature applications and as a coating on surfaces that contact with strong acids or bases. PFOS and PFOA can be formed by environmental microbial degradation or by metabolism in larger organisms from a larger group of PFAS. PFOA and PFOS have been the most extensively studied PFAS. USEPA has published health advisories of 70 ng/L (ppt) for the combined concentrations of PFOS and PFOA. Therefore, our review is focused on PFOS and PFOA.

2.4.2 Physical and Chemical Properties

As shown in Table 2, due to the strength of the carbon-fluorine bonds, PFOS and PFOA are stable chemicals. PFOS and PFOA are moderately soluble in water, and are stable to hydrolysis in the environment as demonstrated by their persistence in groundwater and surface waters. As the reported organic-portioning coefficient (Koc) indicates, they have been found to partition from the groundwater column into organic matter rich sediments and soil particles due to their propensity to sorb to natural organic matter. PFOA is relatively less strongly adsorbed than PFOS. Both PFOS and PFOA have low volatility.

Table 2 - Physical and Chemical Properties of PFOS and PFOA

Property	PFOS	PFOA
Molecular structure		
Appearance at normal temperature and	White powder	White powder/waxy white solid
Molar weight (gram/mol)	538	414
Vapor pressure	3.31 x 10^{-4} Pa (20 °C)	0.1 kPa (20 °C) 10 mmHg (25 °C) 4.2 Pa (25 °C)
Water solubility at 25 °C (mg/L)	550 to 570 (purified) 370 (freshwater) 25 (filtered sea water)	9.5 x 10^{3} (purified)
Melting point (°C)	>400	45 – 50
Octanol-water partition	Not Measurable	6.30

Property	PFOS	PFOA
Organic-carbon partition coefficient	2.57 – 4.2	2.06 – 3.7
Henry's Law constant (atm-	3.05 x 10^{-9}	Not measurable
Air-water partition	<2 x 10^{-6}	Not available
Source: (USEPA, 2014)		

2.4.3 Fate and Transport in the Environment

Due to their stability and persistence, PFOS and PFOA can be transported long distances and transferred between different media. PFOS and PFOA can be transported to surface waters and groundwater as a result of runoff and leaching.

Mobility of PFOS and PFOA in water is partially influenced by the degree of sorption to sediments or soils during transport. Sorption can remove a portion of the PFOS and PFOA from aqueous solution, and hence reduce the total contaminant mass migration velocity relative to water velocity. The partitioning of PFOS and PFOA between water, soil and sediment is complex, with numerous factors influencing partitioning such as the strength of bonds, solubility, solution ionic composition, organic content, pH and presence of other contaminants such as hydrocarbons.

PFOS and PFOA have also been shown to be persistent in the aquatic environment with potential to adsorb to particulate matter. PFOS has a very low Henry's Law Constant which indicates that volatilization from water to air is unlikely. Considering the above characteristics, the following transport and migration mechanisms should be considered during the development of a Site specific CSM:

- Leaching from soil to groundwater (and surface water);
- Groundwater discharge into surface water bodies; and,
- Adsorption to sediments.

2.4.4 Regulatory Guidelines

The following table provides a summary of USEPA and MDEQ regulatory guidelines:

Regulatory Guidelines	PFOS	PFOA
USEPA Health Advisory Levels for Drinking Water	70 ng/l (combined)	
Proposed Part 201 Residential Groundwater Screening Level Protective of Drinking Water (August 2017)	70 ng/l (combined)	
Proposed Part 201 Residential Soil Screening Level Protective of Drinking Water (August 2017)	1,400 ng/kg	59,000 ng/kg
Proposed Part 201 Residential Soil Screening Level Protective of Direct Contact (August 2017)	2,100,000 ng/kg	2,100,000 ng/kg

2.5 EXTENT OF IMPACT

This section discusses the Site investigation data collected to date and the current understanding of the extent of PFAS.

2.5.1 Site Source Characterization

R&W/GZA interpreted historical aerial photographs downloaded from Kent County GIS data portal. Potential historical disposal areas were identified and indicated in Sheet No. 1.

2.5.2 Subsurface Exploration and Well Installation

GZA retained Stearns Drilling Company of Dutton, Michigan (Stearns) to perform subsurface exploration and monitoring well installation. Stearns utilized a hollow-stem auger to perform soil borings at seven locations, SB-1 through SB-7, at the Site. A 4.25-inch inside diameter auger was advanced, and split-spoon soil samples were collected at 2-foot intervals from the ground surface to the borehole terminal. To date, 10 permanent monitoring wells were installed at these seven locations. Shallow and deep well clusters were installed at soil boring locations SB-1, SB-3, and SB-5. Soil boring logs and monitoring well construction details are provided in **Appendix A**.

Monitoring wells were constructed of 2-inch diameter PVC, with a 5-foot wire-wrapped PVC screen, and threaded joints. The screened intervals were backfilled with a filter sand pack to approximately 2 to 4 feet above the top of the screen. An approximately 2-foot-thick bentonite seal was then installed, and the balance of the boring was backfilled with cement/bentonite grout. The wells were finished with well caps and lockable steel protective covers set in concrete.

The monitoring wells were developed by surging and pumping with a submersible pump. Following well development, the new monitoring wells were surveyed. Surveyed elevations included top of well casing, ground surface elevation, and top of protective casing. The following table summarizes well construction and survey data.

Table 3 - Summary of Monitoring Well Construction and Survey Data

Borehole Name	Well Number	Top of Casing Elevation	Ground Surface Elevation, Ft.	Screen Depth Interval, Ft.	Depth to the Bottom of well, Ft.
SB-1	MW-1S	790.73	788.7	68.4-73.1	75.0
SB-1	MW-1D	791.01	788.8	170.1-174.7	175.0
SB-2	MW-2S	799.66	797.6	78.5-83.1	83.4
SB-3	MW-3P	790.07	787.5	19.0-24.0	25.0
SB-3	MW-3S	790.62	788.1	69.7-74.6	75.1
SB-4	MW-4S	784.88	782.3	71.1-75.7	76.0
SB-5	MW-5P	781.45	778.9	17.1-21.8	22.3
SB-5	MW-5S	781.61	778.8	61.9-66.6	67.1
SB-6	MW-6S	772.76	770.3	57.1-61.8	62.3
SB-7	MW-7S	791.09	788.9	70.1-74.7	75.0

2.5.3 Groundwater Flow at the Site

Static water levels at the Site monitoring wells were measured in September 2017 and October 2017 (See Table below).

Table 4 - Groundwater Elevations, September 2017 and October 2017.

Well ID	Groundwater Elevation, FT, 9/22/2017	Groundwater Elevation, FT, 10/20/2017
MW-1S	726.54	726.28
MW-1D	726.49	726.23
MW-2S	724.57	724.39
MW-3P	Not Encountered	Not Encountered
MW-3S	723.74	723.53
MW-4	723.42	723.19
MW-5P	757.82	757.74
MW-5S	723.50	723.28
MW-6S	723.66	723.40
MW-7S	725.12	724.81

Groundwater elevation contours were developed from the October 2017 elevation data for the Site groundwater monitoring wells and shown in the following figure. As indicated in the figure, groundwater flows to the southwest across the Site area. The Site groundwater elevation data and flow direction are consistent with the regional groundwater contour map.

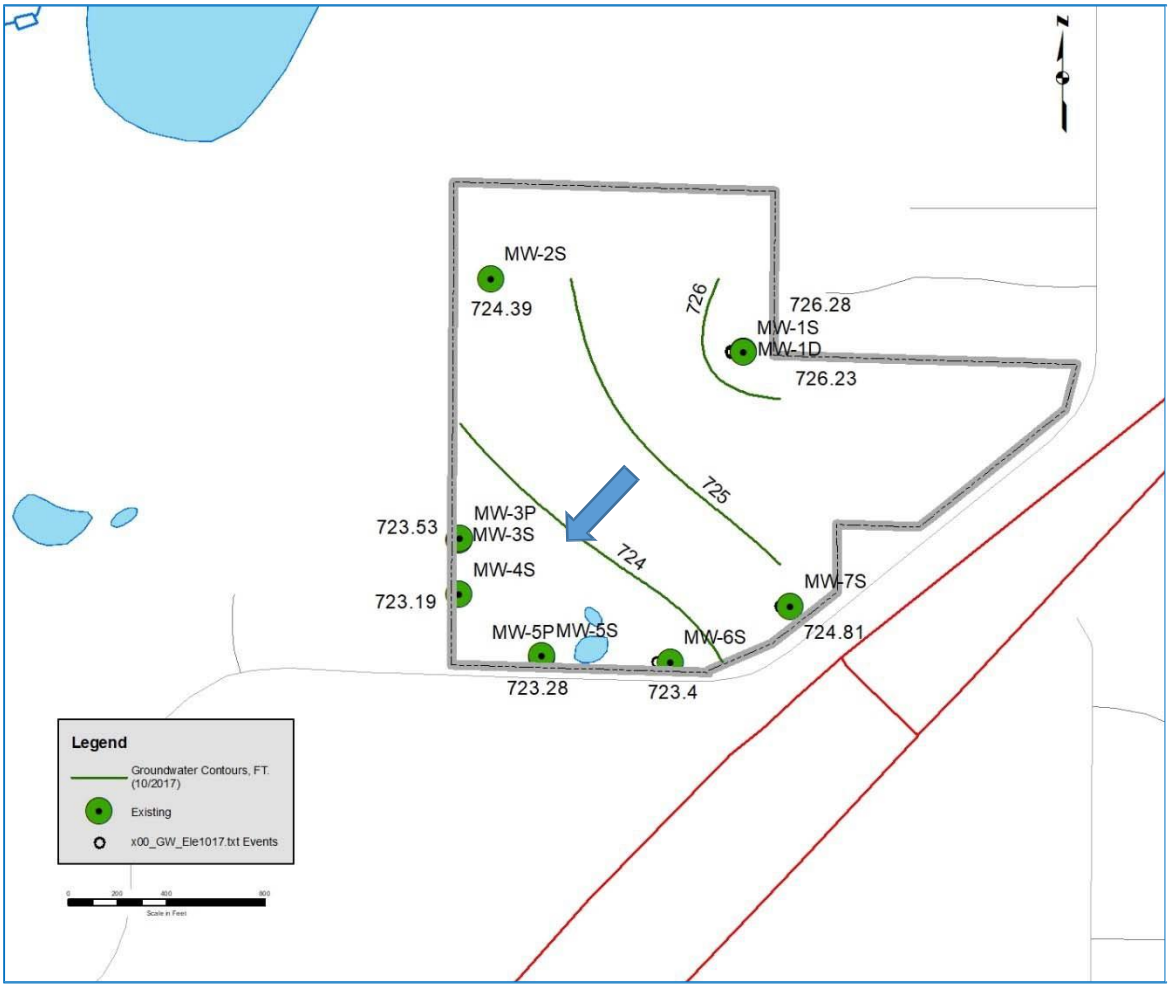


Figure 19 - Site Monitoring Wells and Groundwater Contours, Ft.

2.5.4 Groundwater Sampling and Analysis

GZA collected groundwater samples following the "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells," by U.S. EPA, Region I, Revision 3, dated January 19, 2010 (USEPA Region I, 2010). GZA personnel used a Geotech® portable pneumatic bladder pump or a Solinst® portable double valve pneumatic pump to purge and sample the monitoring wells. Turbidity, dissolved oxygen (DO), specific conductance, pH, oxidation-reduction potential (ORP), temperature, drawdown measurements, and purging rate were recorded at five-minute intervals during well purging. Drawdown induced by purging was kept low in accordance with the procedure, and the pump intake was positioned within the middle portion of the screen. The groundwater monitoring wells were considered stabilized and ready for sample collection after field parameters stabilized over three consecutive readings as shown in the following table and in accordance with U.S. EPA's low flow sampling procedure.

Parameter	Stabilization Criteria
pH	± 0.1 pH units (S.U.)
Temperature	± 3%
Specific Conductance	± 3%
ORP	± 10 millivolts (mV)
Turbidity	± 10% (when turbidity is greater than 5 Nephelometric Turbidity Unit [NTUs]); or < 5 NTUs over three consecutive readings
DO	± 10% (when DO > 0.5 milligrams per liter [mg/L]); or <0.5 mg/L over three consecutive readings

Upon stabilization of the field parameters, groundwater samples were collected by placing the tubing outlet near the bottom of laboratory-supplied sample containers. Immediately following sample collection, each sample was labeled with the project name, project number, location, well name, sample number, collection date, and collector's initials and placed on ice inside a cooler. The collected groundwater samples were transported under chain-of-custody protocol to ALS Kelso laboratory. The groundwater samples were using USEPA Method 3535A and analyzed for PFAS using Method PFC/537M - Perfluorinated Sulfonic Acids and Perfluorinated Carboxylic Acids by HPLC/MS/MS. A summary of the groundwater analytical data is included as **Table A**.

2.5.5 Drinking Water Well Sampling Data

A total of 641 water wells were sampled to date, among them 629 residential water wells, 11 non-residential wells, and 1 irrigation well. As of November 22, 2017, the analytical results of approximately 610 samples have been received. A summary of the combined concentrations of PFOS and PFOA is provided in **Table B**. The majority of the water well logs are not in the Wellogic GIS data file. To plot the data as a point feature, the parcel centroids were used for the coordinates of the water wells. The following figure shows the ranges of the detected combined concentrations of PFOS and PFOA.

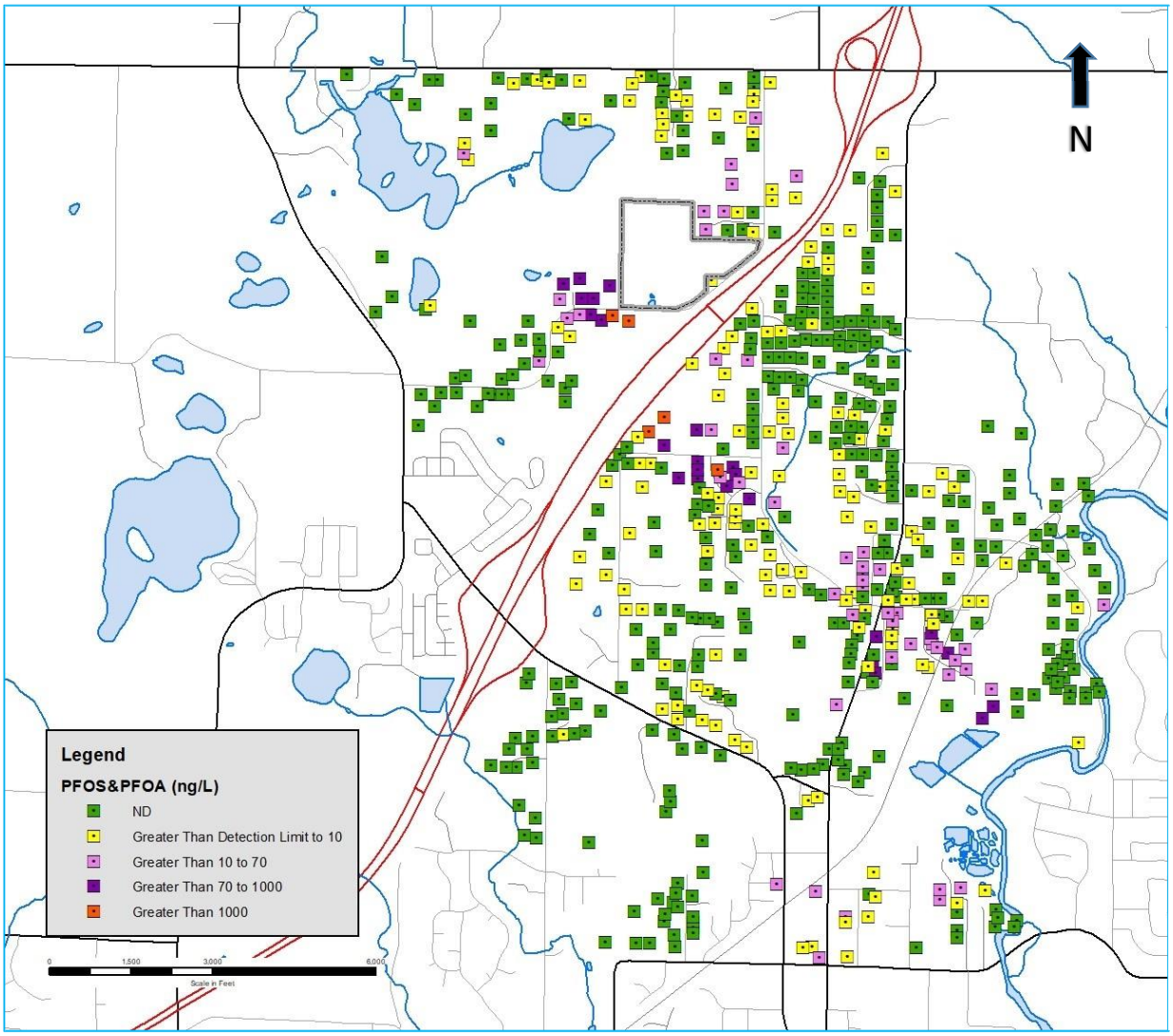


Figure 20 - Water Well PFOS and PFOA Data, ng/L

For the water wells with available well construction information from Wellogic GIS data, the following wells were detected with PFOS and PFOA greater than 70 ng/L, providing depth of vertical PFOS and PFOA impact in groundwater.

Table 5 - Available Well Screen Depth and Elevation Information for Wells Detected with PFOS / PFOA Concentrations Greater Than 70 ng/L

Well ID	Well Depth, Ft	Top of Screen Elevation, Ft	Bottom of Screen Elevation, Ft	PFOS&PFOA Concentration, ng/L
	97	690	685	2220.0
	117	705	696	179.0
	143	593	585	398.0
	98	600	592	88.8
	130	669	659	130.0
	184	603	598	2080.0
	202	571	566	300.0

Well ID	Well Depth, Ft	Top of Screen Elevation, Ft	Bottom of Screen Elevation, Ft	PFOS&PFOA Concentration, ng/L
	135	589	584	200.0
	165	598	593	670.0

As indicated in the above table, the deepest detection of PFOS and PFOA concentrations greater than 70 ng/L occurs at elevations from approximately 560 to 580 feet, near the top of bedrock.

2.5.6 Extent of PFOS and PFOA Impact in Groundwater

Based on the groundwater analytical data and the water well data, the extent of PFOS and PFOA concentrations greater than 10 ng/L is estimated and plotted below.

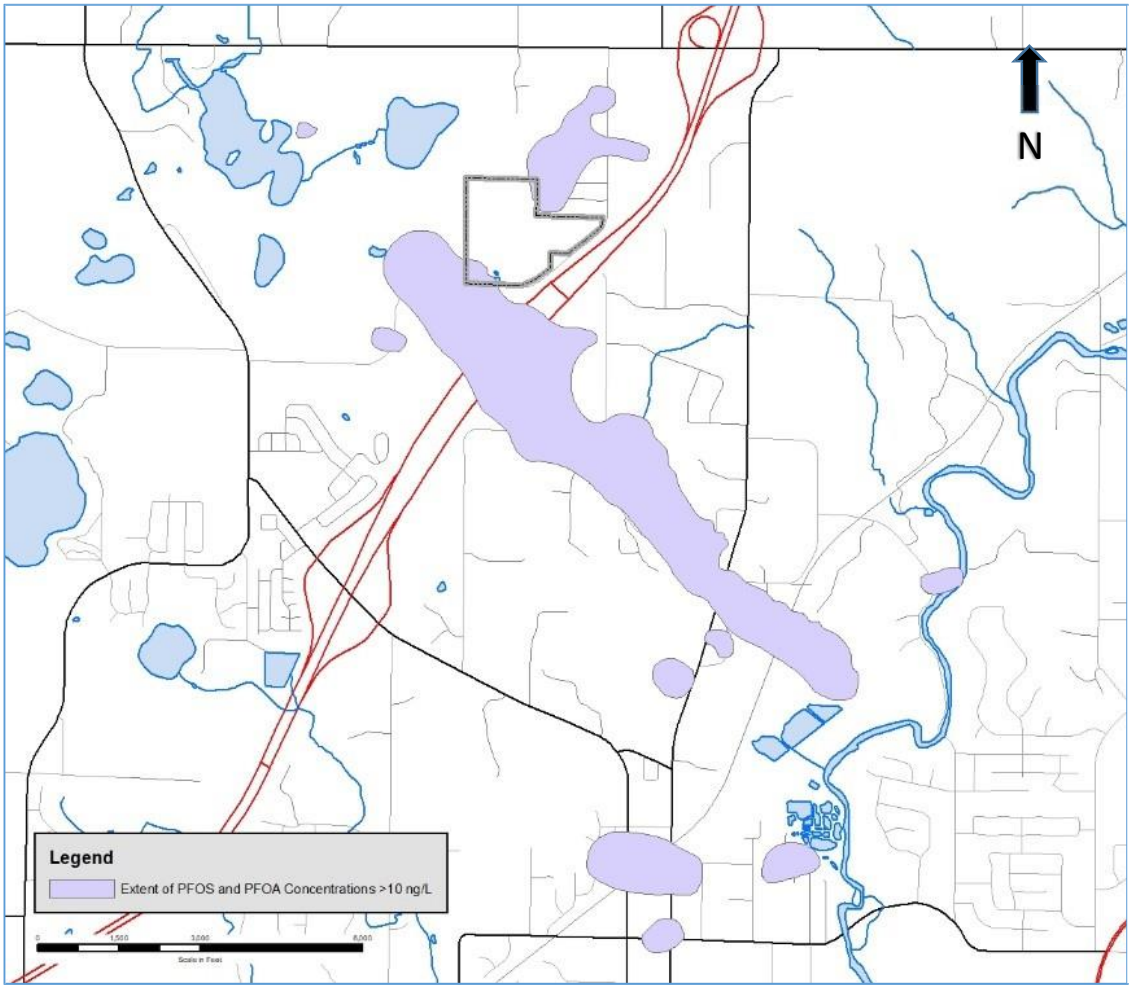


Figure 21 - Approximate Extent of PFOS and PFOA at Concentrations Greater Than 10 ng/L

2.6 SITE SPECIFIC CSM

Based on our literature review and data evaluation, GZA has developed a preliminary understanding of the source, transport mechanism and exposure pathways.

PFOS and PFOA containing waste may have been disposed of at the Site. PFOS and PFOA leached from unsaturated soil into groundwater in dissolved phase. Even though fine-grained soil is present in lacustrine deposits or unstratified moraines, the fine-grained soil stratum is not continuous, and PFOS and PFOA migrated to the water-bearing sand and gravel aquifer. Surface runoff carrying PFOS and PFOA containing soil and water was unlikely because the aerial photos and the existing topography indicate the waste was buried.

Groundwater generally flows to the southwest for approximately 1,000 to 2,000 ft away from the southwest corner of the Site, and then changes to southeasterly toward the Rogue River. Based on the regional groundwater flow configuration, the flow path appears to coincide with a groundwater discharge corridor formed by flow from the northeast and southwest sides of the flow path. The hydraulic gradient along this flow path is approximately 0.0075, which is relatively high for sand and gravel aquifer, and the groundwater seepage velocity was estimated to range from 360 ft/yr to 730 ft/yr. With the relatively fast groundwater seepage velocity and the flow pattern, the transport of PFOS and PFOA is expected to be primarily advective, driven by the bulk groundwater flow. Lateral hydrodynamic dispersion is expected to be relatively limited due to the presence of groundwater flow from either sides of the flow path and the relatively fast groundwater seepage velocity longitudinally. Due to the low partitioning coefficients for PFOS and PFOA and generally low fraction organic carbon in subsurface soil, the retardation factor is expected to be small, only slightly greater than 1. Biodegradation of PFOS and PFOA is not expected due to the stability of the chemicals and the generally long half-lives.

Situating on a groundwater divide, some groundwater is likely to flow from the Site to the northwest toward Clear Bottom and Freska Lakes which ultimately discharge northwesterly to the Rogue River. The hydraulic gradient is, however, very flat, estimated to ranges from approximately 0.0002 to 0.0003 foot/foot, indicating very little groundwater flows to the north or northwest.

Due to their low Henry's Law constant, volatilization of PFOS and PFOA is negligible.

Potential receptors for PFAS-containing groundwater are residents who use groundwater as their primary water sources. In addition, the PFAS-containing groundwater is likely to reach groundwater discharge such as the Rogue River. The following table provides a summary of the relevant exposure pathways and USEPA or MDEQ screening levels for preliminary risk assessments.

Table 6 - Potential Exposure Pathways

Primary Media	**Transport Mechanism**	**Secondary Media/Tertiary Media**	**Receptors**	**Exposure Route**	**USEPA/MDEQ Screening Levels for Relevant Exposure Pathway**
Waste and PFAS-Containing Soil at the Site	Leaching	Groundwater	Humans	Oral Ingestion (as Drinking Water)	USEPA Health Advisory
		Groundwater Discharge to Surface Water	Humans	Incidental Ingestion, Dermal Contact (Non-Drinking)	MDEQ Part 201 Groundwater Surface Interface (GSI)

Primary Media	Transport Mechanism	Secondary Media/Tertiary Media	Receptors	Exposure Route	USEPA/MDEQ Screening Levels for Relevant Exposure Pathway
		Groundwater Discharge to Surface Water	Aquatic Organisms	Ingestion	Generic or Mixing-Zone Based GSI Criteria.

2.7 IDENTIFICATION OF DATA GAPS

Based on our data evaluation and the preliminary CSM discussed above, GZA has identified the following data gaps, which are expected to be useful to characterize the impacted groundwater and refine the CSM for risk management or remediation.

1. Source soil characterization: Additional unsaturated zone soil sampling at the suspected disposal areas will provide further information at the source areas for risk assessment and risk management decisions.

2. Groundwater elevations: The preliminary CSM related to groundwater flow was based on water well static water level data from Wellogic GIS data. Water level data collected from surveyed groundwater monitoring wells over various seasons provide more accuracy. The groundwater elevation data collected from surveyed monitoring wells can be used to better evaluate groundwater flow pattern southwest of the Site, and southeast of the Site.

3. Horizontal and vertical extent of PFOS and PFOA in groundwater: The currently estimated extent of groundwater impact was based on data from the water wells, many of which do not have well construction details. Therefore, additional groundwater sampling is needed to further define the horizontal and vertical extent of PFOA/PFOS in groundwater.

4. Groundwater venting to surface water: The water well sampling data suggest PFAS-containing groundwater has reached the Rogue River to the southeast. It is important to install monitoring wells at several locations near the Rogue River to evaluate the discharge flow rate and concentrations at these areas.

3.0 SAMPLING AND ANALYSIS PLAN

Based on the above review, the proposed sampling and analysis plan for the Site is described in this section.

3.1 PROPOSED SITE SOURCE CHARACTERIZATION

GZA interpreted historical aerial photographs from Kent County GIS, and identified several suspected historical disposal areas. To further characterize the source area soil, GZA proposes ten (10) soil borings at the Site. The following sections provide a summary of the subsurface exploration and sampling to be performed at the Site.

Subsurface Exploration

GZA retained Stearns to perform additional subsurface exploration commencing November 27, 2017. Stearns will use advance 4.25-inch inside diameter, hollow-stem augers and split-spoon soil sampler. The soil samples will be collected continuously from the ground surface to at least 5 feet below any evidence of waste material or 20 feet

below grade, whichever is deeper. Refer to Figure B for the 10 proposed source area boring locations. Actual locations will be determined in the field based on site access and the estimated disposal area locations.

GZA will make visual, tactile, and olfactory observations of recovered soil, checking for the presence of noticeable hazardous substances or petroleum in the soil and for volatile organic compounds (VOCs) using a MiniRAE 2000 Photo Ionization Detector (PID). The PID will be calibrated in accordance with the manufacturer's instructions with a mixture of 100 parts per million (ppm) isobutylene in air. The PID field screening results are presented in ppm by volume (total concentration as isobutylene) in the head space (air) over the soil being tested.

Waste and Soil Sampling and Analysis

One waste sample (if encountered) and one unsaturated soil sample will be collected from each location. The soil samples will be collected 3 to 5 ft. below any waste encountered. These samples will be transferred to pre-cleaned and preserved (if appropriate) containers supplied by the laboratory. The samples will be labeled, stored on ice, and transported under chain-of-custody protocol to the laboratories.

Aliquots for PFAS analysis will be submitted to a laboratory accredited by the Department of Defense and/or the National Environmental Laboratory Accreditation Program for most PFAS analytes by Environmental Protection Agency (EPA) Method 537 Rev. 1.1, modified. We anticipate using either Eurofins Lancaster Laboratories Environmental, LLC (ELLE) of Lancaster, Pennsylvania or ALS Environmental of Kelso, Washington.

A minimum list of the PFAS compounds analyzed via the above-referenced method and the associated method reporting limit (MRL) pertaining to soil analysis is provided as follows:

Compound	CAS Number	MRL (ng/g)
Perfluoro-octanesulfonate	1763-23-1	1.0
Perfluorobutanesulfonate	375-73-5	1.0
Perfluorobutanoic Acid	375-22-4	1.0
Perfluoroheptanoic Acid	375-85-9	1.0
Perfluorohexanesulfonate	355-46-4	1.0
Perfluorohexanoic Acid	307-24-4	1.0
Perfluorooctanoic Acid	335-67-1	1.0
Perfluoroheptanesulfonate	375-92-8	1.0
Perfluoropentanoic Acid	2706-90-3	1.0
Perfluorodecanoic Acid	335-76-2	1.0
Perfluorododecanoic Acid	307-55-1	1.0
Perfluorononanoic Acid	375-95-1	1.0
Perfluorotridecanoic Acid	72629-94-8	1.0
Perfluoroundecanoic Acid	2058-94-8	1.0
Perfluorotetradecanoic Acid	376-06-7	1.0

The laboratories may report additional PFAS compounds if their Standard Operating Procedures have been validated for the additional analytes.

QA/QC measures for PFAS-specific analyses will include the following:

- (1) Trip (field) blank
- (1) Field sample duplicate
- (1) Equipment rinsate blank

Laboratory-provided PFAS-free deionized water will be used for the equipment rinsate and trip blanks.

Aliquots for volatile organic compounds (VOCs; US EPA Method 8260), semivolatile organic compounds (SVOCs; US EPA Method 8270), the MDEQ 10 metals (using US EPA 6000 and 7000-series methods; arsenic, barium, cadmium,

chromium (total), copper, lead, mercury, selenium, silver, and zinc) and hexavalent chromium (US EPA Methods 3060A and 7196A or 7197) will be transported to Bio-Chem Laboratories, Grand Rapids, Michigan for testing.

3.2 GROUNDWATER INVESTIGATION

R&W/GZA proposes installing nine additional off Site monitoring wells (PMW-16, PMW-17, PMW-18, PMW-19, PMW-20, PMW-21, PMW-22, PMW-23 and PMW-2) in the approximated locations shown on Figure 22, which are subject to approval of the respective landowners and accessibility of the drilling rig. PMW-9 through PMW-11 are currently being installed. PMW-12 through PMW-15 have been previously proposed to MDEQ and, pending access agreements, are scheduled to start the week of December 4, 2017.

The objectives of the proposed monitoring network are to provide groundwater elevation data for the evaluation of groundwater flow at and near the estimated extent of impact, and to further define the horizontal and vertical extent of impact.

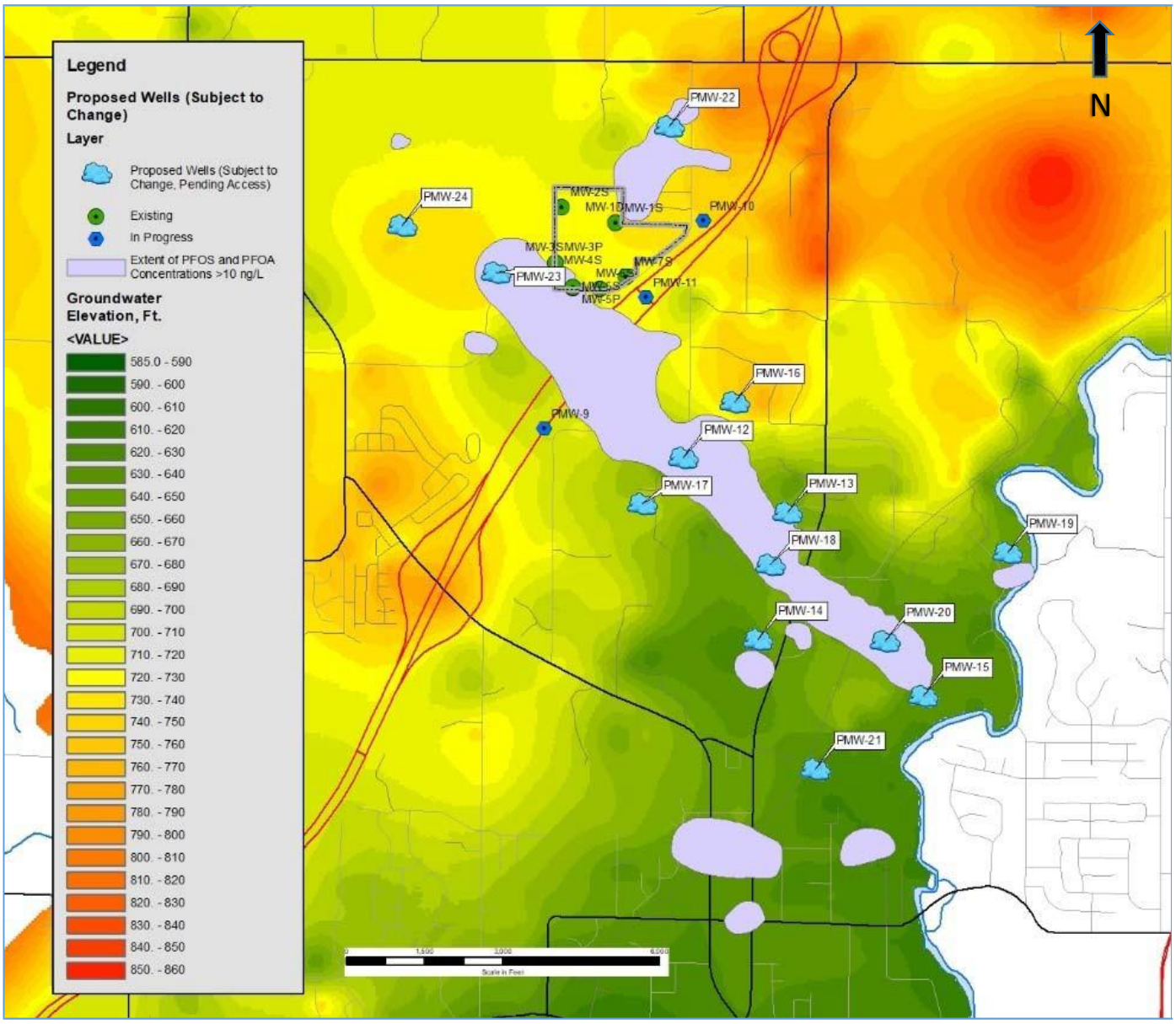


Figure 22 - Proposed Groundwater Monitoring Wells

- PMW-12, PMW-15, PMW-16, PMW-20 and PMW-23 are intended to provide vertical distribution of PFOA/PFOS along the plume centerline;
- PMW-9 and PMW-11, PMW-13 and PMW-14, and PMW-15 and PMW-16 are proposed to delineate the extent of PFOA/PFOS along various transects;
- PMW-19 and PMW-21, along with PMW-15, are proposed to provide groundwater elevation and PFOS/PFOA distribution approaching the Rogue River;
- PMW-22, along with PMW-10 and the existing monitoring wells, are used to provide groundwater elevation data and PFOS/PFOA distribution immediately northeast of the Site; and,
- PMW-23 and PMW-24 are proposed to provide groundwater elevation data and PFOS/PFOA distribution immediately west or northwest of the source area.

GZA will retain Stearns to perform the drilling, sampling and well installation. Hollow stem auger drilling rig will be utilized. A GZA representative will be present on-Site to observe and document the field work.

3.2.1 Vertical Profiling Boreholes

Groundwater vertical profiling will be performed in the southeastern portion of the study area at proposed boreholes PMW-15, PMW-19, and PMW-21.

The driller will drill the boreholes to an elevation of approximate 560 feet or to a depth where a confining stratum is encountered. The drilling depth will be determined based on field observation results and communications with the project team. Split spoon soil samples will be collected at an interval of approximately 10 feet in the unsaturated zone above the capillary fringe; and at an interval of approximately 5 feet in the saturated zone. Depending on the ground surface elevations, the depth of boreholes will range from approximately 120 feet to 150 feet.

Groundwater vertical profiling will be performed with the use of a temporary well consisting of PVC casing and a 10-foot-long PVC screen. A submersible pump with dedicated poly tubing will be used to purge and sample the temporary well. Groundwater samples will be collected at an interval of 20 feet from the groundwater table to the end of boring. After drilling to the desired depth, the sampling will be performed as follows:

- A screen section is placed at the bottom of the boring;
- The auger is pulled up approximately 10 feet to expose the screen to the targeted zone of the formation and allow sand to collapse around the screen;
- The sampling pump and piping components are placed in the well and positioned at the well screen position;
- The temporary well is purged using low-flow methods and field indicator parameters are measured;
- A low-flow sample is obtained for analysis; and,
- The pump and piping assembly are removed.

Groundwater samples collected from the vertical profiling will be submitted for laboratory analysis. Based on the analytical results, two to three monitoring well screens will be positioned at the vertical interval where relatively high

PFOS and PFOA concentrations are detected and where the screen positions are beneficial for the monitoring and delineation of vertical distribution.

3.2.2 Perimeter Boreholes (PMW-13, PMW-16, PMW-17 and PMW-24)

For the perimeter boreholes, the primary objective is to provide groundwater elevation data and horizontal extent of PFOA/PFOS in groundwater. The well screens for these wells will be set at the same screen interval as their nearby centerline well or adjacent water wells where PFOS and PFOA were detected. The driller will drill the boreholes to the target screen elevations or where a confining stratum is encountered. The drilling depth will be determined based on field observation results and communications with the project team. Split spoon soil samples will be collected at an interval of approximately 10 feet in the unsaturated zone above the capillary fringe; and at an interval of approximately 5 feet in the saturated zone.

3.2.3 Monitoring Well Installation

Monitoring well installation will be performed in general accordance with ASTM Method D 5092-04, Standard Practice for Design and Installation of Ground Water Monitoring Wells. For the vertical profiling boreholes, the well screen positions will be decided upon receipt of vertical profiling sample analytical data. Depending on the vertical profiling results and nearby water well data, two to three well screens will be installed at each proposed location. The monitoring wells will be installed and constructed of 2-inch diameter PVC, with a 10-foot PVC screen, and threaded joints. The well screen interval will be backfilled with a 20 to 40 filter sand to approximately 2 feet above the top of the screen. A bentonite seal will then be installed, and the balance of the boring will be backfilled with a cement/bentonite grout. The wells will be finished with a well cap and a lockable steel protective cover set in concrete. The construction of each monitoring well will be documented in a monitoring well construction report.

For the perimeter boreholes (See Section 3.2.2), one monitoring well will be installed at each location. The well screen position will be at the same elevation interval as its nearby plume well screen position where relatively high PFOS/PFOA concentration is detected. The well screen positions of its nearby water wells will also be considered and reviewed with the vertical profiling data to determine the best screen position for groundwater monitoring.

3.2.4 Monitoring Well Development

Upon completion of well installation, the monitoring wells will be developed with surging and pumping. As the purged water starts running clear, the purged water will be measured for pH, temperature, conductivity, and turbidity using a hand-held meter. The well will be developed until the three consecutive turbidity readings become less than 25 NTU or the changes in values are less than 10 percent. Field measurement readings, along with time spent on development and volume purged, will be recorded on a well development form. Groundwater purged from monitoring wells will be containerized than will be returned to the monitoring well after development.

3.2.5 Monitoring Well Elevation Survey

Following installation, GZA will retain a professional surveyor to survey the new monitoring wells based on the survey benchmark near the monitoring wells. Surveyed elevations shall include the top of well casing, ground surface elevation, and top of protective casing. Additionally, locations of each monitoring well will be surveyed. Survey tolerances for coordinates will be less than 0.1 foot horizontally; survey tolerances for elevations will be less than 0.01 foot.

3.2.6 Laboratory Analysis of Groundwater Samples

The vertical profiling groundwater samples will be sent to ALS for PFAS analysis using Method PFC/537M. The vertical profiling groundwater samples will be analyzed via 7-day quick turnaround. Groundwater samples will be

transferred to pre-cleaned and preserved containers supplied by the laboratory. Samples will be stored in an ice bath inside of a cooler and kept cool for transport under chain-of-custody protocol to the laboratory.

The remaining groundwater samples will be sent to ALS for PFAS analysis using Method PFC/537M, with standard turnaround time.

4.0 FIELD SAMPLING PROCEDURES

This section describes the field sample procedures, including soil sampling and groundwater sampling.

4.1 SOIL BORING

The soil borings and the groundwater monitoring well will be installed using a hollow stem auger drill rig. Soil samples will be visually classified in general accordance with ASTM D2488, Standard Practices for Description and Classification of Soils (Visual-Manual Procedures), and the Unified Soil Classification System. The observations will be recorded on boring log forms. Soil generated during drilling and sampling will be containerized for proper disposal. Groundwater purged from monitoring wells will be containerized than will be returned to the monitoring well after development.

4.1.1 Documentation

Information will be recorded in a daily field book and on boring log forms. Where applicable, documentation will include:

- Logs of individual borings noting soil classification, depths, and field PID screening results, and relevant drilling information;
- Drilling and sampling personnel;
- Field conditions;
- Drilling, testing, and sampling equipment;
- Well development; and,
- Well installation information.

4.1.2 Decontamination

The sampling tools will be thoroughly washed with detergent, rinsed with potable water, and rinsed with distilled water prior to each use. Drilling equipment will be steam cleaned prior to the start of activities between test boring locations, and at the completion of work.

4.1.3 Quality Assurance/Quality Control

Boring logs will be reviewed and edited by the GZA's Project Manager (PM) for consistency. Each boring will have a unique identification number and sample depths will be clearly marked on all sample containers.

The PID will be calibrated using an isobutylene-in-air standard each day prior to use and at the end of the sampling day.

4.2 SAMPLING PROCEDURES

Sampling procedures to be performed at the Site are described in the following subsections, including sampling methods, handling procedures, and equipment decontamination procedures.

4.2.1 Special Precautions For PFAS Sampling

To minimize PFOS and PFOA contamination from clothing, equipment and other commonly used products, the following special cares will be followed:

Pre-Sampling:

- Clothing will be laundered, clothing will be old, cotton clothes;
- Only natural, unwaterproofed belt and shoes to be worn, if available;
- No cosmetics or personal care items the day of sampling;
- No insect repellent or sunscreen; and,
- No fast food consumption for 48-hours prior to sampling.

Field Equipment:

- Use of pre-labeled HDPE sampling containers without lined caps, with or without Trizma® preservative;
- Field notes will be kept on traditional paper, not water proof paper;
- Ball point pens will be used to label the sample containers and take field notes;
- Regular ice (not blue ice) will be used in the coolers;
- Nitrile gloves will be worn during the sampling process and changed between locations; and,
- An aluminum clip board will be used in conjunction with field notes.

Sampling:

- Just prior to sampling, change nitrile gloves, sample (2 container), and replace container tops;
- Label sample (Ball point pen) and return to in Ziploc bag before placing in cooler on ice;
- Change gloves and collect field blank, if needed, and replace container top; and,
- Label sample and return to ziplocked bag before placing in cooler on ice.

It is required that the sampling personnel Change nitrile gloves before handling containers, after adequate purging of well system, before sampling, after sampling, and before the collection of field blank sample.

4.2.2 Sampling Procedures

The following sampling methods shall be used for each of the media encountered:

- Soil Sampling (See Standard Operating Procedures [SOP] in Appendix B);
- Procedures for Collection and Methanol Preservation of Soil Samples for Volatile Organics (See SOP in Appendix B);
- Groundwater Sample Collection – Monitoring Wells (See SOP in Appendix B); and,
- Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells (See SOP in Appendix B).

Where conditions warrant, the SOP may be altered with the approval of the PM or Principal-in-Charge (PIC) prior to sampling initiation. Any special circumstances or deviations from SOP must be recorded in the field documentation.

After collection in appropriate containers, as discussed in the following sections, samples will be placed in coolers and delivered to the laboratory using courier or overnight delivery services.

4.2.3 Field Instruments, Calibration and Preventive Maintenance

Field meters to be used during sampling typically include pH, temperature and specific temperature and conductance meters and PID's.

All equipment to be used during the field sampling will be examined to verify that it is operating correctly. The equipment will be calibrated according to manufacturer's instructions and specifications. Field notes from previous sampling trips will be reviewed so that any prior equipment problems are not overlooked, and timely repairs are made. The Field Engineer/Geologist will maintain an equipment log documenting instrument malfunctions, repairs, battery charging, replacement dates, and dates of use and personnel. New batteries for contingency replacements will be purchased and kept with the equipment in the field.

All parts of field measuring/monitoring equipment that come in contact with potentially impacted media will be decontaminated after each use using a distilled water rinse and hand wipes.

4.2.4 Sample Containers and Preservatives

Sample containers to be used during this project will be obtained directly from the analytical laboratory. The types of containers to be used will depend on the analytical parameters and sample matrix.

4.2.5 Sample Custody Procedures

Written procedures will be followed to track sample collection, transfer, storage, analysis, and disposal. The primary objectives of these procedures are preservation of sample integrity to create a written record which can be used to trace the possession and handling of sample(s) from the moment of (their) collection to analytical laboratories.

4.2.5.1 Logging of Samples

Accountability for sample custody will begin when the sample is removed from its natural environment. Sample labels, field data records, and chain-of-custody forms will be completed at the time of sampling. The following COC

procedure will be implemented by the Field Engineer/Geologist in accordance with SOP to document sample integrity. Sampling log entries will be made in waterproof ink during sampling.

The COC form will contain information to distinguish each sample from any other sample. This information will include:

- The project for which sampling is being conducted;
- The matrix being sampled (air, groundwater, soil, etc.);
- The sampling date and time;
- The unique sample location number. This number can be cross referenced to appropriate descriptive information found in the field log book or on the field data record sheets;
- The type of sample container and method of sample preservation (Table 2);
- Significant observations made during the sampling process;
- Signature of the person performing the sampling; and,
- Analyses requested for each sample.

Each sample will be assigned a unique identification number, which will be marked on the sample container in waterproof ink. The COC will be forwarded to the laboratory with the samples. As a precaution against this record being lost or altered, the field personnel will retain a copy of the COC form documenting all information up until the first change of sample custody. This record will then be filed with the PM.

Field measurements (e.g., pH, specific conductance, temperature, depth) will be recorded on field data record sheets.

4.2.5.2 Cleaning Materials

Equipment used to sample in more than one location must be cleaned before it is reused. Cleaning materials are identified for each procedure in the appropriate sections of this document. Cleaning materials which can be used without compromising sample integrity must be carried to the Site or purchased locally, and include:

- water;
- distilled water (obtained from a local supplier); and,
- non-phosphate detergent.

4.2.5.3 Packing Materials

All samples must be packed to protect them from physical abuse and breakage during shipment. Glass containers should be packed in compartmented boxes or blister-pack. In addition, the sampling team should have a supply of tape, absorbent pads, plastic bags, packing crates, and labels to minimize potential for breakage, absorb and contain liquids if leakage occurs, and seal and mark shipping containers. All shipping procedures will conform to state and federal Department of Transportation requirements. Special packing requirements for PFAS aliquots were discussed previously.

5.0 DATA QUALITY ASSURANCE PROGRAM

A program-wide quality assurance project plan (QAPP) will be prepared and submitted to MDEQ. The following section provides a summary of the data quality assurance program for this project.

5.1 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

Field quality assurance (QA) and quality control (QC) measures to be taken include the collection of field QC samples and the review of field activities and documentation to assess the quality of data obtained in the field. A summary of these measures is provided in the following subsection.

5.1.1 Field Duplicates

Field duplicate samples will be collected at the Site at a frequency of one duplicate after the collection of 20 field samples per each matrix for each analytical method. A duplicate sample is a second sample collected from a chosen sampling location. Duplicates will be submitted as blind samples to the laboratory. Duplicate samples will be analyzed to check for sampling and analytical reproducibility.

5.1.2 Equipment Blanks

One equipment blank will be taken at a minimum of one per 20 samples per similar matrix, or per day, whichever is more frequent. Equipment blank samples will be collected by pouring distilled water over each piece of decontaminated sampling equipment used for sample collection. Equipment blanks monitor potential cross-contamination from inadequate or incomplete sample equipment decontamination.

5.1.3 Trip Blank

Trip blanks will be collected for each group of 20 or fewer samples or once per day of sampling, whichever is more frequent. Trip blanks will be placed with the volatile samples for shipment.

5.1.4 Matrix Spike/Matrix Spike Duplicates

Matrix Spike/Matrix Spike Duplicates (MS/MSDs) will be collected at a minimum of one per 20 samples per similar matrix from areas suspected with potential impact.

5.1.5 Temperature Blank

A temperature blank will be placed in each sample cooler submitted to the laboratory to monitor proper temperature preservation of the samples upon receipt at the laboratory.

5.1.6 Field Documentation and Review

Field data collection efforts will be documented in a bound field notebook with pre-numbered pages or a pre-printed form to allow PM's to review of all aspects of the work being performed. Field records will include, but not limited to, the following:

- Equipment calibration records, including frequency, conditions, standards, and records reflecting the calibration history of a measurement system;

- Sample collection effort, including personnel conducting the activity, sample number, sample location, equipment used, climatic conditions, documentation of adherence to sampling protocol, and unusual observation;

- COC records, including the following information: the project name; signatures of samplers; the sample number, date and time of collection, and discrete or composite sample designation; signatures of individuals involved in sample transfer; and, if applicable, the air bill or other shipping number;

- Maps and drawings documenting the location of sample collection points and monitoring wells obtained through field survey;

- QC sample documentation will be maintained for the generation of QC samples, such as trip and equipment rinseate blanks, duplicate samples and any field spikes; and,

- Deviations from the Work Plan will be recorded in the field documentation.

- The field activities will be reviewed for the following subjects: completeness of field documentation; identification of valid samples; identification of anomalous field test data; and validation of field analyses.

5.2 LABORATORY QA/QC

The samples will be submitted to a Michigan certified laboratory for the methods and analyses required for this project. The laboratory QC program will also be reviewed prior to the selection of the laboratory. The following elements of the laboratory QC program will be reviewed:

- Method proficiency – laboratory procedures for demonstrating the precision and bias of the method as performed by the laboratory and procedures for determining the method detection limit (MDL);

- Control limits – laboratory procedures for establishing and updating control limits for analysis;

- Laboratory QA/QC practices – laboratory procedures for demonstrating that the laboratory is in control during each data collection activity through laboratory control samples, method blank, matrix-specific bias, matrix-specific precision, and/or matrix specific detection limit; and,

- Data handling procedures – data reduction procedures, practices for verification and validation of data reduction computer programs.

Upon receipt of analytical data, data verification will be performed by review of laboratory data along with field documentation to identify potential data quality issues. Review of laboratory data includes the followings:

- Completeness of laboratory records – This review determines whether all samples and analyses contracted have been processed, and complete records exist for each analysis and the associated QC samples. The results of the completeness check will be documented, and the data affected will be identified.

- Evaluation of Data with respect to MRLs – This review compares analytical results to laboratory MRLs.

- Evaluation of data with respect to control limits – This review compares the results of QC and calibration check samples to control criteria. Data not within control limits will require corrective action. Corrective action reports and the results of reanalysis, if available, will be reviewed; and,

- Review of Holding Time Data - This review compares sample holding times to those required by the analytical methods and notes all deviations.

5.3 DATA VERIFICATION

Data verification will be performed by reviewing the field documentation and laboratory data for completeness and correctness with respect to methods, procedural and contractual requirements. The result of data verification will be documented, and data quality issues will be identified. If necessary, data validation involving analyte-specific and sample-specific review will be performed to identify the samples/data potentially affected and evaluate the data usability with respect to the project objective.

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TABLES

TABLE A

SUMMARY OF GROUNDWATER SAMPLE ANALYSIS - PFAS

WOLVERINE WORLD WIDE, INC.

PLAINFIELD TOWNSHIP, MICHIGAN

WELL ID	USEPA HEALTH ADVISORY	MW-1D	MW-1S	MW-2S	MW-3S	MW-4S	MW-5S	MW-6S	MW-7S
LABORATORY ID		K1711117-004	K1711117-003	K1711117-005	K1711250-001	K1711250-002	K1711250-003	K1711250-004	K1711250-005
SAMPDATE		10/12/2017	10/12/2017	10/12/2017	10/13/2017	10/13/2017	10/13/2017	10/16/2017	10/16/2017
Parameter (ng/L)									
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
N-Ethyl perfluorooctane sulfonamidoethanol	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
N-Methyl perfluorooctane sulfonamide (MeFOSA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
N-Methyl perfluorooctane sulfonamidoethanol	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluorobutane sulfonic acid (PFBS)	NA	<4.2	18	<4.2	370	93	570	<4.2	<4.2
Perfluorobutanoic acid (PFBA)	NA	<8.3	<8.3	<8.3	91	160	140	<8.3	<8.3
Perfluorodecane sulfonic acid (PFDS)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluorodecanoic acid (PFDA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluorododecanoic acid (PFDoDA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluoroheptane sulfonic acid (PFHpS)	NA	<4.2	<4.2	<4.2	32	550	1100	<4.2	<4.2
Perfluoroheptanoic acid (PFHpA)	NA	<4.2	12	<4.2	180	320	710	<4.2	<4.2
Perfluorohexane sulfonic acid (PFHxS)	NA	<4.2	26	<4.2	930	1600	1900	14	6.9
Perfluorohexanoic acid (PFHxA)	NA	<4.2	16	<4.2	390	420	450	<4.2	<4.2
Perfluorononanoic acid (PFNA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	18	<4.2	<4.2
Perfluorooctane sulfonamide (FOSA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluorooctane sulfonic acid (PFOS)	70	<4.2	<4.2	<4.2	22	***2000***	***44000***	<4.2	4.7
Perfluorooctanoic acid (PFOA)	70	<1.7	4.2	<1.7	***380***	***830***	***2800***	9.8	3.3
Perfluoropentanoic acid (PFPeA)	NA	<4.2	<4.2	<4.2	130	170	190	<4.2	<4.2
Perfluorotetradecanoic acid (PFTeDA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluorotridecanoic acid (PFTrDA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2
Perfluoroundecanoic acid (PFUnDA)	NA	<4.2	<4.2	<4.2	<4.3	<4.3	<4.2	<4.2	<4.2

TABLE A
SUMMARY OF GROUNDWATER SAMPLE ANALYSIS - PFAS
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

NOTES:
1. Concentration and criteria units are nano-grams per kilogram or parts per trillion; "< RL" indicates the compound was analyzed for but not detected above the method detection limit; RL = Reporting Limit

2. Italic number with thick line border and highlighted cells or italic chemical indicates that compound was detected above the USEPA Health Advisory for Drinking Water Uses.

3. USEPA Health Advisory Level was obtained from USEPA Fact sheet: PFOA & PFOS Drinking Water Health Advisories, EPA 800-F-16-003, dated November 2016.

4. USEPA Health Advisory Level of 70 ppt was established fro the combined concentrations of PFOA and PFOS.

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	313	K1710940-028	10/6/2017	0.0
	314	K1710940-026	10/6/2017	2.1
	314	K1710940-025	10/6/2017	0.0
	320	K1710940-034	10/6/2017	0.0
	319	K1710940-032	10/6/2017	0.0
	318	K1710940-031	10/6/2017	0.0
	317	K1710940-030	10/6/2017	0.0
	312	K1710940-033	10/6/2017	1.7
	316	K1710940-029	10/6/2017	0.0
	315	K1710940-027	10/6/2017	0.0
	301	K1710940-003	10/5/2017	4.5
	302	K1710610-009	9/29/2017	0.0
	303	K1710610-008	9/29/2017	0.0
	304	K1710940-004	10/5/2017	2.1
	500	K1710940-006	10/5/2017	0.0
	533	K1710940-010	10/5/2017	0.0
	531	K1710610-006	9/29/2017	0.0
	532	K1710940-009	10/5/2017	0.0
	110	K1709831-024	9/14/2017	0.0
	503	K1710423-009	9/26/2017	0.0
	504	K1710423-010	9/26/2017	0.0
	505	K1710771-005	10/4/2017	0.0
	513	K1710423-020	9/26/2017	0.0
	514	K1710423-008	9/26/2017	0.0
	512	K1710771-003	10/4/2017	0.0
	511	K1710423-019	9/26/2017	0.0
	509	K1710771-004	10/4/2017	0.0
	510	K1710423-011	9/26/2017	0.0
	508	K1710423-012	9/26/2017	0.0
	506	K1710610-007	9/29/2017	0.0
	507	K1710940-007	10/5/2017	0.0
	210	K1710611-010	9/29/2017	2.2
	211	K1710611-011	9/29/2017	0.0
	213	K1711956-001	11/1/2017	3.0
	225	K1710693-004	10/2/2017	0.0
	224	K1710693-002	10/2/2017	0.0
	212	K1710693-003	10/2/2017	2.0
	216	K1710611-012	9/29/2017	3.0
	217	K1710693-007	10/2/2017	0.0
	215	K1710693-006	10/2/2017	2.9
	226	K1710693-005	10/2/2017	5.7
	236	K1710423-046	9/27/2017	0.0
	235	K1710423-044	9/27/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	234	K1710423-043	9/27/2017	0.0
	233	K1710423-042	9/27/2017	1.8
	232	K1710423-041	9/27/2017	1.8
	90	K1709831-002	9/14/2017	2.0
	88	K1709831-004	9/14/2017	0.0
	89	K1709967-021	9/18/2017	0.0
	91	K1709967-022	9/18/2017	0.0
	228	K1710423-039	9/27/2017	0.0
	231	K1710693-010	10/2/2017	1.8
	230	K1710423-038	9/27/2017	2.3
	229	K1710423-040	9/27/2017	4.5
	218	K1710771-012	10/4/2017	0.0
	227	K1710693-009	10/2/2017	0.0
	244	K1710693-026	10/3/2017	0.0
	245	K1710423-048	9/27/2017	9.2
	243	K1710423-037	9/27/2017	3.7
	98	K1709967-026	9/18/2017	8.5
	238	K1710423-036	9/27/2017	0.0
	239	K1710423-050	9/27/2017	6.1
	237	K1711956-003	11/1/2017	0.0
	95	K1709967-023	9/18/2017	12.3
	220	K1710693-008	10/2/2017	0.0
	9	K1703984-002	4/19/2017	16.4
	8	K1703984-003	4/19/2017	14.4
	7	K1703984-001	4/19/2017	3.1
	6	K1703984-008	4/19/2017	0.0
	300	K1710423-047	9/27/2017	7.3
	240	K1710423-049	9/27/2017	20.0
	99	K1709967-004	9/15/2017	18.9
	96	K1709967-002	9/15/2017	9.7
	97	K1709967-003	9/15/2017	6.4
	100	K1709967-027	9/18/2017	0.0
	94	K1709967-024	9/18/2017	14.2
	4	K1703984-005	4/19/2017	2.2
	4	K1706136-001	6/12/2017	0.0
	242	K1710940-002	10/5/2017	3.9
	241	K1710693-025	10/3/2017	3.8
	5	K1703984-007	4/19/2017	0.0
	39	K1709007-002	8/23/2017	13.5
	10	K1703984-004	4/19/2017	0.0
	11	K1708712-002	8/16/2017	**164.0**
	13	K1707878-001	7/24/2017	**117.0**
	12	K1707746-002	7/18/2017	**201.0**

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	17	K1707746-004	7/18/2017	**27,600.0**
	17	K1708712-007	8/16/2017	**37,800.0**
	17	K1708712-009	8/17/2017	6.1
	15	K1708712-001	8/16/2017	**98.2**
	15	K1710171-018	9/20/2017	**154.5**
	15	K1710171-017	9/20/2017	0.0
	16	K1707746-017	7/20/2017	15.0
	25	K1707746-008	7/19/2017	0.0
	23	K1708712-003	8/16/2017	3.1
	22	K1708712-004	8/16/2017	46.0
	22	K1710171-016	9/20/2017	57.0
	22	K1710171-015	9/20/2017	0.0
	21	K1707746-015	7/20/2017	12.0
	20	K1707746-014	7/20/2017	**130.0**
	18	K1707746-016	7/20/2017	**1,430.0**
	18	K1708712-006	8/16/2017	**2,020.0**
	18	K1710171-021	9/20/2017	0.0
	18	K1710171-022	9/20/2017	**2,220.0**
	19	K1707746-003	7/18/2017	**179.0**
	24	K1707746-006	7/19/2017	2.4
	14	K1707885-002	7/24/2017	**227.0**
	3	K1703984-006	4/19/2017	0.0
	3	K1706136-002	6/12/2017	9.8
	64	K1709831-023	9/14/2017	0.0
	65	K1710171-002	9/19/2017	0.0
	520	K1710423-006	9/26/2017	10.0
	519	K1710695-027	10/3/2017	0.0
	518	K1710423-017	9/26/2017	0.0
	517	K1710423-007	9/26/2017	0.0
	516	K1710771-001	10/4/2017	0.0
	515	K1710771-002	10/4/2017	0.0
	502	K1710423-013	9/26/2017	0.0
	501	K1710423-014	9/26/2017	0.0
	311	K1710423-015	9/26/2017	0.0
	310	K1710423-018	9/26/2017	0.0
	309	K1710940-023	10/6/2017	0.0
	308	K1710423-016	9/26/2017	4.8
	76	K1709967-015	9/18/2017	0.0
	75	K1709967-016	9/18/2017	0.0
	74	K1709967-017	9/18/2017	0.0
	73	K1709967-018	9/18/2017	0.0
	71	K1710171-023	9/20/2017	0.0
	72	K1709967-009	9/15/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	69	K1709967-010	9/15/2017	0.0
	70	K1709967-012	9/15/2017	0.0
	68	K1709831-025	9/14/2017	1.9
	67	K1709967-019	9/18/2017	0.0
	66	K1709967-011	9/15/2017	0.0
	77	K1710171-001	9/19/2017	4.3
	78	K1709967-014	9/18/2017	3.9
	305	K1710771-008	10/4/2017	2.9
	306	K1710771-007	10/4/2017	0.0
	307	K1710771-006	10/4/2017	1.8
	63	K1710171-019	9/20/2017	3.3
	59	K1710171-013	9/19/2017	0.0
	58	K1710171-004	9/19/2017	4.3
	57	K1710171-005	9/19/2017	0.0
	56	K1710171-006	9/19/2017	27.5
	55	K1709831-021	9/14/2017	25.0
	54	K1710171-007	9/19/2017	5.9
	60	K1710171-003	9/19/2017	3.2
	62	K1709967-007	9/15/2017	0.0
	61	K1709967-008	9/15/2017	0.0
	109	K1709831-022	9/14/2017	2.0
	521	K1710693-024	10/3/2017	0.0
	522	K1710693-023	10/3/2017	0.0
	558	K1710940-013	10/5/2017	0.0
	250	K1711414-006	10/19/2017	0.0
	248	K1711232-002	10/13/2017	0.0
	201	K1710611-005	9/29/2017	0.0
	202	K1710940-001	10/5/2017	0.0
	205	K1711115-006	10/10/2017	0.0
	206	K1710611-008	9/29/2017	0.0
	92	K1709831-019	9/13/2017	4.2
	203	K1710611-007	9/29/2017	0.0
	204	K1710611-006	9/29/2017	2.1
	93	K1709831-001	9/14/2017	20.0
	208	K1710940-019	10/6/2017	0.0
	221	K1711414-001	10/19/2017	0.0
	222	K1710693-001	10/2/2017	2.2
	200	K1710695-022	10/3/2017	0.0
	209	K1710771-014	10/4/2017	4.0
	223	K1710771-013	10/4/2017	0.0
	247	K1710695-011	10/2/2017	0.0
	455	K1711115-013	10/12/2017	0.0
	249	K1711232-003	10/13/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	28	K1708712-005	8/16/2017	0.0
	26	K1709007-001	8/23/2017	0.0
	84	K1709831-016	9/13/2017	0.0
	86	K1709831-017	9/13/2017	0.0
	80	K1709831-018	9/13/2017	0.0
	29	K1707746-005	7/18/2017	11.1
	37	K1707885-003	7/24/2017	0.0
	27	K1707885-001	7/24/2017	0.0
	405	K1710611-004	9/29/2017	0.0
	81	K1709831-012	9/13/2017	0.0
	452	K1710695-008	10/2/2017	0.0
	401	K1710695-006	10/2/2017	2.1
	401	K1710695-007	10/2/2017	2.5
	400	K1710695-005	10/2/2017	0.0
	38	K1707885-005	7/25/2017	0.0
	407	K1710695-031	10/3/2017	0.0
	85	K1709831-014	9/13/2017	0.0
	87	K1709831-015	9/13/2017	0.0
	83	K1709831-013	9/13/2017	0.0
	454	K1710695-009	10/2/2017	0.0
	404	K1710695-003	10/3/2017	0.0
	402	K1710695-001	10/3/2017	0.0
	403	K1710695-002	10/3/2017	0.0
	406	K1710695-010	10/2/2017	0.0
	82	K1709967-001	9/15/2017	0.0
	410	K1710771-015	10/4/2017	0.0
	419	K1710423-026	9/27/2017	0.0
	41	K1709967-005	9/15/2017	0.0
	42	K1707885-006	7/25/2017	3.4
	42	K1711115-008	10/12/2017	0.0
	1206	K1709831-006	9/14/2017	**120.0**
	43	K1709831-005	9/14/2017	**1,960.0**
	44	K1709831-003	9/14/2017	**10,310.0**
	424	K1710423-031	9/27/2017	0.0
	420	K1710423-027	9/27/2017	6.5
	425	K1710423-032	9/27/2017	**86.3**
	408	K1710423-029	9/27/2017	0.0
	409	K1710423-028	9/27/2017	10.0
	31	K1707746-013	7/20/2017	0.0
	32	K1707746-001	7/18/2017	0.0
	30	K1707746-007	7/19/2017	0.0
	421	K1710423-034	9/27/2017	0.0
	422	K1710423-030	9/27/2017	2.5

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	423	K1710423-035	9/27/2017	6.0
	79	K1709967-020	9/18/2017	0.0
	52	K1710771-020	10/4/2017	0.0
	105	K1710171-009	9/19/2017	2.0
	594	K1710693-015	10/3/2017	3.2
	51	K1709967-013	9/15/2017	0.0
	50	K1710171-008	9/19/2017	0.0
	49	K1711115-010	10/12/2017	0.0
	47	K1711414-007	10/19/2017	28.0
	34	K1709007-003	8/23/2017	6.1
	53	K1709831-010	9/14/2017	8.1
	46	K1709831-011	9/13/2017	**147.9**
	561	K1710693-020	10/3/2017	4.2
	106	K1710771-011	10/4/2017	15.6
	562	K1710693-019	10/3/2017	4.9
	565	K1711115-011	10/12/2017	0.0
	33	K1707746-009	7/19/2017	0.0
	48	K1711115-009	10/12/2017	0.0
	563	K1710771-019	10/4/2017	5.1
	564	K1710693-018	10/3/2017	5.0
	107	K1709831-009	9/14/2017	0.0
	559	K1710693-022	10/3/2017	0.0
	560	K1710693-021	10/3/2017	0.0
	593	K1710693-016	10/3/2017	24.0
	592	K1710693-014	10/3/2017	0.0
	101	K1710171-011	9/19/2017	**490.0**
	102	K1710171-012	9/19/2017	**398.0**
	103	K1710171-010	9/19/2017	43.0
	434	K1710423-002	9/27/2017	**169.0**
	433	K1710498-002	9/28/2017	60.0
	432	K1710498-001	9/28/2017	**2,080.0**
	426	K1710498-004	9/28/2017	**670.0**
	427	K1710498-003	9/28/2017	**78.0**
	428	K1710423-053	9/27/2017	**300.0**
	429	K1710423-052	9/27/2017	0.0
	430	K1710423-003	9/27/2017	2.0
	431	K1710423-051	9/27/2017	7.4
	451	K1710695-017	10/2/2017	3.1
	450	K1710695-015	10/2/2017	0.0
	449	K1710695-012	10/2/2017	0.0
	448	K1710695-014	10/2/2017	0.0
	447	K1710695-013	10/2/2017	6.2
	446	K1710695-016	10/2/2017	2.4

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	438	K1710695-019	10/2/2017	0.0
	437	K1710498-007	9/28/2017	2.6
	436	K1710498-006	9/28/2017	2.1
	435	K1710498-005	9/28/2017	3.4
	104	K1709831-008	9/14/2017	**200.0**
	36	K1707746-010	7/19/2017	3.5
	411	K1710423-025	9/27/2017	0.0
	413	K1710423-021	9/27/2017	2.2
	412	K1710423-024	9/27/2017	0.0
	415	K1710940-005	10/5/2017	2.5
	414	K1710423-033	9/27/2017	2.5
	418	K1710423-001	9/27/2017	8.3
	417	K1710423-022	9/27/2017	0.0
	416	K1710423-023	9/27/2017	1.7
	916	K1711614-005	10/24/2017	5.7
	917	K1711614-006	10/24/2017	6.0
	918	K1711716-017	10/26/2017	0.0
	919	K1711716-006	10/26/2017	0.0
	920	K1711716-004	10/26/2017	0.0
	921	K1711844-003	10/31/2017	0.0
	923	K1711716-001	10/26/2017	0.0
	924	K1711716-002	10/26/2017	0.0
	925	K1711716-009	10/26/2017	2.4
	926	K1711716-010	10/26/2017	0.0
	922	K1711716-003	10/26/2017	0.0
	445	K1710498-008	9/28/2017	0.0
	444	K1710695-018	10/2/2017	4.4
	443	K1710498-011	9/28/2017	0.0
	442	K1710498-012	9/28/2017	0.0
	441	K1711414-002	10/19/2017	0.0
	440	K1710498-010	9/28/2017	0.0
	453	K1710498-013	9/28/2017	0.0
	439	K1710498-009	9/28/2017	4.1
	595	K1710693-012	10/3/2017	0.0
	604	K1710498-030	9/28/2017	4.2
	602	K1710498-031	9/28/2017	3.6
	601	K1710498-032	9/28/2017	5.6
	603	K1710610-001	9/29/2017	3.5
	600	K1710693-013	10/3/2017	4.3
	596	K1710771-018	10/4/2017	3.7
	597	K1711956-002	11/1/2017	0.0
	598	K1710610-002	9/29/2017	0.0
	939	K1711716-012	10/26/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	940	K1711716-013	10/26/2017	0.0
	941	K1711658-002	10/25/2017	0.0
	944	K1711658-003	10/25/2017	0.0
	945	K1711716-019	10/26/2017	0.0
	949	K1711716-018	10/26/2017	0.0
	950	K1711716-011	10/26/2017	0.0
	947	K1711716-015	10/26/2017	2.1
	946	K1711716-020	10/26/2017	0.0
	942	K1711716-014	10/26/2017	0.0
	964	K1711612-001	10/24/2017	0.0
	523	K1710498-020	9/28/2017	0.0
	524	K1710940-008	10/5/2017	0.0
	525	K1710498-021	9/28/2017	0.0
	526	K1710498-023	9/28/2017	0.0
	527	K1710498-024	9/28/2017	0.0
	528	K1710771-009	10/4/2017	0.0
	529	K1710498-025	9/28/2017	0.0
	530	K1710498-026	9/28/2017	0.0
	534	K1710695-026	10/3/2017	0.0
	535	K1710695-025	10/3/2017	0.0
	536	K1710498-028	9/28/2017	2.4
	537	K1711232-001	10/13/2017	0.0
	542	K1710771-023	10/4/2017	0.0
	543	K1710695-029	10/3/2017	6.1
	544	K1710695-024	10/3/2017	0.0
	545	K1710693-027	10/3/2017	0.0
	541	K1711115-001	10/10/2017	0.0
	539	K1710498-029	9/28/2017	0.0
	538	K1710498-027	9/28/2017	2.4
	546	K1710940-011	10/5/2017	0.0
	547	K1710940-020	10/6/2017	0.0
	548	K1710940-012	10/5/2017	0.0
	549	K1710498-014	9/28/2017	0.0
	550	K1710771-021	10/4/2017	4.5
	551	K1710695-023	10/3/2017	0.0
	552	K1710695-030	10/3/2017	0.0
	553	K1710771-022	10/4/2017	5.1
	554	K1710695-028	10/3/2017	0.0
	555	K1710498-022	9/28/2017	0.0
	556	K1710771-024	10/4/2017	0.0
	557	K1710498-019	9/28/2017	0.0
	566	K1710610-005	9/29/2017	0.0
	574	K1711115-004	10/10/2017	3.2

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	575	K1710940-016	10/5/2017	3.2
	569	K1711414-003	10/19/2017	0.0
	567	K1710610-004	9/29/2017	0.0
	568	K1710610-003	9/29/2017	0.0
	571	K1710940-015	10/5/2017	0.0
	570	K1710940-014	10/5/2017	2.2
	579	K1710771-016	10/4/2017	2.5
	578	K1710771-017	10/4/2017	0.0
	576	K1710940-017	10/5/2017	5.9
	576	K1711414-004	10/19/2017	3.7
	573	K1711115-012	10/12/2017	2.1
	572	K1711115-005	10/10/2017	0.0
	700	K1711719-020	10/26/2017	0.0
	701	K1711614-001	10/24/2017	5.7
	710	K1711719-001	10/26/2017	0.0
	720	K1711613-001	10/24/2017	0.0
	704	K1711719-013	10/26/2017	0.0
	702	K1711614-002	10/24/2017	5.7
	708	K1711614-003	10/24/2017	5.9
	709	K1711719-014	10/26/2017	0.0
	719	K1711719-015	10/26/2017	0.0
	722	K1711613-002	10/24/2017	1.9
	705	K1711658-013	10/25/2017	0.0
	707	K1711658-012	10/25/2017	0.0
	712	K1711658-005	10/25/2017	0.0
	706	K1711723-006	10/26/2017	0.0
	713	K1711723-007	10/26/2017	0.0
	715	K1711723-005	10/26/2017	0.0
	714	K1711719-010	10/26/2017	0.0
	711	K1711658-009	10/25/2017	0.0
	844	K1711719-012	10/26/2017	0.0
	845	K1711719-011	10/26/2017	0.0
	716	K1711658-004	10/25/2017	0.0
	589	K1710498-018	9/28/2017	64.0
	588	K1710611-001	9/29/2017	11.0
	587	K1710611-002	9/29/2017	20.0
	586	K1710611-003	9/29/2017	34.0
	585	K1711414-005	10/19/2017	0.0
	599	K1710693-011	10/3/2017	5.7
	591	K1710940-022	10/6/2017	11.0
	590	K1710498-016	9/28/2017	21.0
	108	K1709831-007	9/14/2017	35.0
	580	K1711115-003	10/10/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	581	K1711115-002	10/10/2017	0.0
	582	K1710610-010	9/29/2017	0.0
	583	K1710498-017	9/28/2017	32.0
	584	K1710940-021	10/6/2017	0.0
	755	K1711787-003	10/27/2017	0.0
	752	K1711613-005	10/24/2017	0.0
	753	K1711719-019	10/26/2017	0.0
	754	K1711787-001	10/27/2017	3.3
	751	K1711660-001	10/25/2017	3.6
	756	K1711660-011	10/25/2017	3.9
	758	K1711660-012	10/25/2017	5.7
	759	K1711660-013	10/25/2017	0.0
	760	K1711719-017	10/26/2017	0.0
	725	K1711613-004	10/24/2017	0.0
	726	K1711719-016	10/26/2017	0.0
	727	K1711614-004	10/24/2017	6.1
	724	K1711613-003	10/24/2017	2.7
	750	K1711723-009	10/26/2017	0.0
	748	K1711660-015	10/25/2017	0.0
	761	K1711660-014	10/25/2017	0.0
	757	K1711719-018	10/26/2017	2.6
	763	K1711787-005	10/27/2017	2.6
	965	K1711612-007	10/24/2017	0.0
	966	K1711612-006	10/24/2017	0.0
	967	K1711612-005	10/24/2017	15.0
	968	K1711723-008	10/26/2017	4.2
	969	K1711612-011	10/24/2017	0.0
	970	K1711612-010	10/24/2017	7.7
	971	K1711612-009	10/24/2017	0.0
	972	K1711612-012	10/24/2017	0.0
	973	K1711723-010	10/26/2017	0.0
	974	K1711723-011	10/26/2017	0.0
	813	K1711613-006	10/24/2017	0.0
	814	K1711613-009	10/24/2017	**180.0**
	818	K1711660-003	10/25/2017	**71.0**
	815	K1711613-010	10/24/2017	3.5
	817	K1711723-012	10/26/2017	0.0
	811	K1711719-007	10/26/2017	**111.0**
	798	K1711787-002	10/27/2017	19.0
	801	K1711613-011	10/24/2017	4.6
	802	K1711719-006	10/26/2017	8.5
	803	K1711660-005	10/25/2017	2.5
	805	K1711660-002	10/25/2017	52.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	806	K1711660-004	10/25/2017	0.0
	799	K1711719-008	10/26/2017	36.0
	800	K1711719-005	10/26/2017	40.8
	797	K1711661-001	10/25/2017	27.0
	793	K1711661-002	10/25/2017	5.4
	794	K1711661-003	10/25/2017	3.5
	795	K1711844-012	10/31/2017	0.0
	784	K1711787-004	10/27/2017	0.0
	786	K1711661-014	10/25/2017	60.0
	810	K1711661-012	10/25/2017	15.0
	788	K1711661-011	10/25/2017	**88.8**
	785	K1711723-003	10/26/2017	13.0
	787	K1711661-013	10/25/2017	58.0
	796	K1711661-005	10/25/2017	0.0
	792	K1711661-006	10/25/2017	**104.9**
	791	K1711661-007	10/25/2017	64.1
	790	K1711661-008	10/25/2017	35.5
	789	K1711661-009	10/25/2017	58.0
	809	K1711716-025	10/26/2017	2.2
	808	K1711716-024	10/26/2017	3.8
	728	K1711661-021	10/25/2017	0.0
	729	K1711661-020	10/25/2017	0.0
	730	K1711661-010	10/25/2017	0.0
	737	K1711719-023	10/26/2017	0.0
	743	K1711716-030	10/26/2017	0.0
	738	K1711658-014	10/25/2017	0.0
	739	K1711658-007	10/25/2017	0.0
	740	K1711658-010	10/25/2017	17.3
	735	K1711658-006	10/25/2017	0.0
	736	K1711844-010	10/31/2017	0.0
	742	K1711719-022	10/26/2017	0.0
	741	K1711719-021	10/26/2017	2.3
	745	K1711716-031	10/26/2017	0.0
	764	K1711723-002	10/26/2017	2.0
	731	K1711716-026	10/26/2017	5.0
	733	K1711716-028	10/26/2017	0.0
	734	K1711716-029	10/26/2017	0.0
	732	K1711716-027	10/26/2017	0.0
	783	K1711723-004	10/26/2017	0.0
	767	K1711719-002	10/26/2017	0.0
	769	K1711723-026	10/26/2017	0.0
	770	K1711723-027	10/26/2017	0.0
	778	K1711723-018	10/26/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	1205	K1711723-017	10/26/2017	0.0
	775	K1711723-015	10/26/2017	0.0
	771	K1711723-013	10/26/2017	0.0
	779	K1711719-003	10/26/2017	0.0
	768	K1711661-016	10/25/2017	0.0
	776	K1711723-016	10/26/2017	0.0
	774	K1711723-014	10/26/2017	0.0
	1204	K1711844-009	10/31/2017	0.0
	766	K1711719-009	10/26/2017	0.0
	841	K1711658-008	10/25/2017	0.0
	975	K1711612-013	10/24/2017	0.0
	976	K1711660-007	10/25/2017	16.0
	820	K1711846-009	10/30/2017	0.0
	823	K1711660-006	10/25/2017	0.0
	821	K1711723-019	10/26/2017	0.0
	1135	K1711856-004	10/31/2017	0.0
	1133	K1711856-002	10/31/2017	0.0
	1132	K1711856-001	10/31/2017	0.0
	824	K1711660-008	10/25/2017	0.0
	1134	K1711856-007	10/31/2017	0.0
	1136	K1711856-003	10/31/2017	0.0
	829	K1711723-024	10/26/2017	0.0
	830	K1711723-025	10/26/2017	0.0
	831	K1711723-023	10/26/2017	0.0
	835	K1711723-021	10/26/2017	0.0
	837	K1711661-019	10/25/2017	0.0
	842	K1711723-020	10/26/2017	0.0
	838	K1711661-017	10/25/2017	0.0
	834	K1711661-018	10/25/2017	0.0
	827	K1711661-015	10/25/2017	38.0
	833	K1711723-022	10/26/2017	0.0
	826	K1711612-003	10/24/2017	**71.0**
	825	K1711612-004	10/24/2017	**102.8**
	840	K1711723-001	10/26/2017	4.4
	1137	K1711856-011	10/31/2017	5.2
	1126	K1711853-015	10/31/2017	11.4
	1127	K1711853-016	10/31/2017	6.2
	1201	K1711853-004	10/31/2017	7.5
	1138	K1711856-012	10/31/2017	9.1
	1125	K1711853-014	10/31/2017	3.0
	1124	K1711856-013	10/31/2017	0.0
	1121	K1711784-008	10/27/2017	0.0
	1121	K1711784-010	10/27/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	1115	K1711853-011	10/31/2017	69.4
	1111	K1711853-009	10/31/2017	7.2
	1110	K1711853-008	10/31/2017	0.0
	1112	K1711853-010	10/31/2017	18.4
	1116	K1711853-012	10/31/2017	26.0
	1107	K1711853-005	10/31/2017	0.0
	1108	K1711853-006	10/31/2017	0.0
	1108	K1711853-007	10/31/2017	0.0
	1104	K1711853-019	10/31/2017	0.0
	1105	K1711853-018	10/31/2017	0.0
	1106	K1711853-017	10/31/2017	0.0
	1103	K1711853-020	10/31/2017	2.7
	915	K1711784-007	10/27/2017	0.0
	996	K1711849-018	10/30/2017	0.0
	988	K1711846-004	10/30/2017	0.0
	984	K1711787-006	10/27/2017	0.0
	999	K1711784-016	10/27/2017	0.0
	998	K1711784-015	10/27/2017	0.0
	997	K1711784-014	10/27/2017	0.0
	995	K1711784-013	10/27/2017	0.0
	994	K1711846-010	10/30/2017	0.0
	993	K1711784-012	10/27/2017	3.4
	992	K1711784-011	10/27/2017	0.0
	937	K1711716-007	10/26/2017	1.9
	938	K1711614-008	10/24/2017	5.9
	927	K1711844-008	10/31/2017	0.0
	933	K1711716-008	10/26/2017	0.0
	935	K1711844-001	10/31/2017	0.0
	936	K1711614-007	10/24/2017	6.8
	1024	K1711844-004	10/31/2017	0.0
	1026	K1711846-001	10/30/2017	0.0
	982	K1711846-005	10/30/2017	0.0
	1025	K1711846-002	10/30/2017	0.0
	983	K1711846-003	10/30/2017	0.0
	980	K1711846-006	10/30/2017	0.0
	963	K1711716-021	10/26/2017	0.0
	959	K1711614-011	10/24/2017	6.4
	962	K1711614-009	10/24/2017	5.9
	961	K1711614-010	10/24/2017	5.9
	958	K1711614-012	10/24/2017	7.5
	951	K1711614-015	10/24/2017	5.9
	952	K1711614-014	10/24/2017	5.9
	953	K1711716-023	10/26/2017	0.0

TABLE B
SUMMAR OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	954	K1711614-013	10/24/2017	5.9
	955	K1711716-022	10/26/2017	0.0
	977	K1711612-002	10/24/2017	0.0
	978	K1711846-008	10/30/2017	0.0
	979	K1711846-007	10/30/2017	0.0
	1000	K1711856-005	10/31/2017	0.0
	1004	K1711844-006	10/31/2017	0.0
	1005	K1711844-005	10/31/2017	0.0
	1002	K1711856-006	10/31/2017	0.0
	1008	K1711856-014	10/31/2017	3.1
	1007	K1711844-007	10/31/2017	2.1
	1009	K1711856-015	10/31/2017	0.0
	1038	K1711787-011	10/27/2017	0.0
	1028	K1711849-012	10/30/2017	0.0
	1049	K1711787-013	10/27/2017	0.0
	1033	K1711853-013	10/31/2017	0.0
	1035	K1711787-014	10/27/2017	0.0
	1034	K1711849-016	10/30/2017	0.0
	1031	K1711849-007	10/30/2017	0.0
	1037	K1711849-015	10/30/2017	0.0
	1030	K1711849-008	10/30/2017	0.0
	1036	K1711849-010	10/30/2017	0.0
	1029	K1711849-009	10/30/2017	0.0
	1015	K1711849-001	10/30/2017	0.0
	1014	K1711849-017	10/30/2017	0.0
	1032	K1711849-006	10/30/2017	0.0
	1202	K1711856-009	10/31/2017	12.7
	1016	K1711849-002	10/30/2017	0.0
	1017	K1711849-003	10/30/2017	0.0
	1018	K1711849-004	10/30/2017	0.0
	1020	K1711849-011	10/30/2017	0.0
	1023	K1711849-014	10/30/2017	0.0
	1022	K1711849-013	10/30/2017	0.0
	1019	K1711849-005	10/30/2017	0.0
	1203	K1711856-008	10/31/2017	24.0
	1012	K1711853-003	10/31/2017	53.0
	1010	K1711853-001	10/31/2017	2.5
	1011	K1711658-001	10/25/2017	3.6
	908	K1711787-008	10/27/2017	0.0
	913	K1711844-011	10/31/2017	0.0
	912	K1711787-007	10/27/2017	0.0
	907	K1711784-006	10/27/2017	0.0
	906	K1711784-001	10/27/2017	0.0

TABLE B
SUMMARY OF WELL WATER SAMPLING DATA - PFOS/PFOA
WOLVERINE WORLD WIDE, INC.
PLAINFIELD TOWNSHIP, MICHIGAN

PARCEL ID	PARCEL Number	LABORATORY ID	SAMPLE DATE	Sum of PFOS and PFOA, ng/L
	904	K1711784-002	10/27/2017	0.0
	900	K1711784-003	10/27/2017	0.0
	901	K1711784-004	10/27/2017	0.0
	902	K1711784-005	10/27/2017	0.0
	903	K1711716-016	10/26/2017	0.0
	1045	K1711787-009	10/27/2017	0.0
	1042	K1711787-012	10/27/2017	0.0
	1041	K1711787-015	10/27/2017	0.0
	1043	K1711787-010	10/27/2017	0.0

NOTES:

1. Concentration and criteria units are nano-grams per kilogram or parts per trillion; "0" indicates the compound was analyzed for but not detected above the method detection limit.

2. Bold numbers with highlighted cells indicate that compound was detected above the USEPA Health Advisory for Drinking Water Uses, 70 ng/L.

3. USEPA Health Advisory Level was obtained from USEPA Fact sheet: PFOA & PFOS Drinking Water Health Advisories, EPA 800-F-16-003, dated November 2016.

4. USEPA Health Advisory Level of 70 ppt was established fro the combined concentrations of PFOA and PFOS.

FIGURES

RTYLINE

-$-MW-2S

!!a-X

SB-X

Sa-X

JL.

FORMER DISPOSAL PITS BASED ON 1968 AERIAL PHOTOGRAPHY

SB-X

Sa-X

SB-X

®sa-X

FORMER DISPOSAL PITS BASED ON 1968 AERIAL PHOTOGRAPHY

58-X

FORMER DISPOSAL PITS BASED ON 1968 AERIAL PHOTOGRAPHY

SB-X

SUSPECTED FORMER DISPOSAL AREA

SB-X

·W-1D

MW-1S

TYLINE

PROPERTY LINE

.MW-3P

MW-3S

MW-4S

MW-5S

MW-5P

MW-6S

MW-7S

PROPERTY LINE

PROPERTY LINE

PROPERTY LINE

HOUSE STREET

$

SCALE: 1" = 100'

LEGEND

58-X ® – PROPOSED "SOURCE AREA" SOIL BORING LOCATION

-$- = INSTALLED MONITOR WELL LOCATION

DRAWN BY

FILE NO.: 6239552_Source

REVISIONS

NO.	BY	DATE

REVISED IN ACCORDANCE WITH CONSTRUCTION RECORDS

WOLVERINE WORLD WIDE
HOUSE STREET SITE, BELMONT, MICHIGAN
SOURCE AREA INVESTIGATION

ROSE & WESTRA
A DIVISION OF GZA
Grand Rapids, Michigan
GEOTECHNICAL–ENVIRONMENTAL–ECOLOGICAL–WATER–CONSTRUCTION MANAGEMENT

PROJECT NO.
16.0062335.52

SHEET NO.
1 OF 1

APPENDIX A

PREVIOUS SOIL BORING LOGS

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-1/MW-1D
Page: 1 **of** 13
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-5-17/9-5-17
Boring Location:
GS Elev.: 788.80' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/20	0-2	3-4 4-7		Yellowish-brown to brown, SILT, some fine grained Sand, trace Gravel, poorly sorted, dry (ML).	SILT (ML)		PROTECTIVE CASING Backfill/Cement Pad
2	2	24/22	2-4	4-5 8-9		Yellowish-brown to brown, SILT, some fine grained Sand, trace Gravel, poorly sorted, dry (ML). Changing at 2.6 feet to: Yellowish-brown, fine to medium SAND, little Silt, moderately sorted, dry (SM). Changing at 2.7 feet to: Mottled dark yellowish-brown to light grayish-brown, SILT, little Clay, little Sand, trace Gravel, poorly sorted, dry (ML).	2.6' 2.7' SAND (SM) SILT (ML)		
4	3	24/24	4-6	8-6 7-7		Yellowish-red to dark brown, medium to fine grained SAND, some Silt, trace Gravel, moderate sorting, dry (SM). Changing at 4.5 feet to: Mottled dark yellowish-brown to light gray, SILT, little Clay, little fine to medium grained Sand, slightly plastic, cohesive, poorly sorted, dry (ML).	4' SAND (SM) 4.5' SILT (ML)		
6	4	24/24	6-8	3-4 5-5		Mottled dark yellowish-brown to light gray, SILT, little Clay, little fine to medium grained Sand, slightly plastic, cohesive, poorly sorted, dry (ML). Changing at 7.1 feet to: Mottled grayish-brown to dark yellowish-brown, CLAY & SILT, plastic, cohesive, moist (CL).	7.1' CLAY & SILT (CL)		
8	5	24	8-10	4-4 3-5		Mottled grayish-brown to dark yellowish-brown, CLAY & SILT, plastic, cohesive, moist (CL).			
10	6	24/20	10-12	2-4 2-2		Mottled grayish-brown to dark yellowish-brown, CLAY & SILT, plastic, cohesive, moist (CL). Changing at 10.4 feet to: Dark gray to dark grayish-brown, fine to medium grained SAND, trace Silt, moderately sorted, moist (SP). Changing at 11.4 feet to: Dark gray to dark grayish-brown, fine to coarse SAND, trace	10.4' SAND (SP) 11.4' SAND (SW) 12'		

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-1/MW-1D

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-1/MW-1D
Page: 2 **of** 13
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	7	24/24	12-14	5-6 14-16		Gravel, trace Silt, trace Clay, slightly cohesive, poorly sorted, moist to wet (SW). Dark grayish-brown to very dark grayish-brown, CLAY & SILT, trace Gravel, plastic, cohesive, poorly sorted, moist (CL). Changing at 13.6 feet to: Grayish-brown, coarse to medium SAND, trace Gravel, trace Silt, poorly sorted, moist (SP). Changing at 13.7 feet to: Mottled yellowish-brown to light yellowish-brown to dark gray to black, CLAY & SILT, little Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL). Mottled yellowish-brown to light yellowish-brown to dark gray to black, CLAY & SILT, little Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL). Changing at 15.0 feet to: Black, fine to coarse grained SAND, trace Gravel, trace Silt, poorly sorted, moist (SW). Changing at 15.1 feet to: Brownish-yellow, SILT, very well sorted, moist to wet (ML). Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 17.3 feet to: Dark yellowish-brown, fine grained SAND, little Clay, little Silt, slightly to moderately plastic, cohesive, moderately sorted, moist (SC). Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 19.0 feet to: Yellowish-brown, fine grained SAND, little Clay, little Silt, moderately plastic, cohesive, moderately sorted, moist (SC). Changing at 19.3 feet to: Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).	CLAY & SILT (CL)		
13							13.6'		
							13.7' SAND (SP)		
14	8	24/24	14-16	4-12 7-7			CLAY & SILT (CL)		
15							15'		
							15.1' SAND (SW)		
							SILT (ML)		
16	9	24/18	16-18	3-3 5-6			16' SAND (SP)		
17							17.3'		
							SAND (SM)		
18	10	24/20	18-20	2-4 7-9			18' SAND (SP)		
19							19'		
							19.3' SAND (SM)		
							SAND (SP)		
20	11	24/17	20-22	3-6 7-10					
21						Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).			
22	12	24/18	22-24	3-5 6-9		Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).			
23									
24	13	24/23	24-26	5-9 10-14		Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 25.5 feet to: Yellowish-brown, SILT & CLAY, little Silt, slightly plastic, cohesive, well sorted, moist (CL).			
25							25.5'		
							CLAY & SILT (CL)		
							26'		

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-1/MW-1D

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-1/MW-1D
Page: 3 **of** 13
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	14	24/24	26-28	6-8 13-13		Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 26.3 feet to: Yellowish-brown, SILT & CLAY, little Silt, slightly plastic, cohesive, well sorted, moist (CL). Changing at 27.7 feet to: Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).	26.3' SAND (SP) CLAY & SILT (CL) 27.7'		
27									
28	15	24/23	28-30	4-10 8-13		Yellowish-brown, CLAY & SILT, little Sand, slightly plastic, cohesive, well sorted, moist (CL). Changing at 28.9 feet to: Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 29.1 feet: Yellowish-brown, CLAY & SILT, little Sand, slightly plastic, cohesive, well sorted, moist (CL). Changing at 29.3 feet to: Yellowish-brown, SILT, cohesive, well sorted, moist (ML). Changing at 29.9 feet to: Yellowish-brown, CLAY & SILT, little Sand, slightly plastic, cohesive, well sorted, moist (CL).	28' SAND (SP) CLAY & SILT (CL) 28.9' 29.1' SAND (SP) 29.3' CLAY & SILT (CL) SILT (ML) 29.9'		
29									
30	16	24/22	30-32	9-12 16-15			CLAY & SILT (CL) 30.6'		
31							SAND (SP) 31' CLAY & SILT (CL)		
32	17	24/22	32-34	4-10 8-13		Yellowish-brown, CLAY & SILT, little Sand, slightly plastic, cohesive, well sorted, moist (CL). Changing at 30.6 feet to: Light yellowish-brown to pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 31.0 feet to: Yellowish-brown, CLAY & SILT, little Silt, slightly plastic, cohesive, well sorted, moist (CL).	32.5' SAND (SP)		
33									
34	18	24/23	34-36	7-13 20-25		Yellowish-brown, CLAY & SILT, little Silt, slightly plastic, cohesive, well sorted, moist (CL). Changing at 32.5 feet to: Light gray to light brownish-gray, fine grained SAND, trace Silt, very well sorted, moist (SP).			
35						Light gray to light brownish-gray, fine grained SAND, trace Silt, very well sorted, moist (SP).			
36	19	24/20	36-38	4-11 18-26		Light gray to light brownish-gray, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing 37.1 feet to: Light gray, fine to medium SAND, trace Silt, well sorted, moist (SP).			
37									
38	20	24/23	38-40	4-7 12-15		Very pale brown to light yellowish-brown, SILT, little Clay, slightly plastic, coheisve, well sorted, moist (ML). Changingn at 38.2 feet to: Yellowish-brown, CLAY & SILT, plastic, cohesive, moderately well sorted, moist (CL). Changing at 38.4 feet to: Very pale, brown to light yellowish-brown, SILT, little Clay, slightly plastic, cohesive,	38' 38.2' SILT (ML) 38.4' CLAY & SILT (CL) 38.7' SILT (ML) 38.9' CLAY & SILT (CL) SILT (ML) 40'		
39									

REMARKS

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Boring No.: SB-1/MW-1D

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	21	24/20	40-42	5-10 14-14		moderately well sorted, moist (ML). Changing at 38.7 feet to: Yellowish-brown, CLAY & SILT, plastic, cohesive, moderately well sorted, moist (CL). Changing at 38.9 feet to: Very pale brown to light yellowish-brown, SILT, little Clay, slightly plastic, cohesive, well sorted, moist (ML).	40.2' CLAY & SILT (CL) 40.5' SILT (ML) CLAY & SILT (CL) 41' SAND (SP)		
41									
42	22	24/18	42-44	5-5 11-13		Light yellowish-brown, CLAY & SILT, slight plastic, cohesive, very well sorted, moist (CL). Changing at 40.2 feet to: Very pale brown to yellowish-brown, SILT, little Clay, slightly plastic, coheisive, well sorted, moist (ML). Changing at 40.5 feet to: Light yellowish-brown, CLAY & SILT, slight plastic, cohesive, very well sorted, moist (CL). Changing at 41.0 feet to: Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).	42.2' 42.4' SILT (ML) SAND (SP)		
43									
44	23	24/20	44-46	10-10 15-22		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 42.2 feet to: Light yellowish-brown, SILT, trace Clay, slightly plastic, cohesive, well sorted, moist (ML).Changing at 42.4 feet to: Very pale, brown, fine grained SAND, trace Silt, very well sorted, moist (SP).			
45							45.3'		
46	24	24/20	46-48	4-13 16-21		Very pale, brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 45.3 feet to: Brown to yellowish-brown, CLAY & SILT, plastic, cohesive, very well sorted, moist (CL). Changing at 45.6 feet to: Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).	45.6' CLAY (CL) SAND (SP)		
47									
48	25	24/17	48-50	5-12 23-28		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).			
49									
50	26	24/20	50-52	4-6 15-17		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 51.2 feet to: Yellowish-brown, SILT, trace Clay, cohesive, non to slightly plastic, very well sorted (bedded), moist (ML).Changing at 51.7 feet to: Very pale brown, fine grained SAND, trace Silt, very well sorted, moist, with occasional very thin Silt seams (SP).			
51							51.2' SILT (ML) 51.7' SAND (SP)		
52	27	24/16	52-54	7-12 16-21		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist, with occasional very thin Silt seams (SP).			
53									

REMARKS

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
55	28	24/20	54-56	5-11 17-26		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist, with occasional very thin Silt seams (SP). Changing at 54.2 feet to: Very pale brown, fine grained SAND, little Silt, very well sorted, moist (SP).	54.2' SAND (SM)		
56	29	24/23	56-58	4-9 16-20		Light yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP). Changing at 56.3 feet to: Very pale brown, fine grained SAND, little Silt, very well sorted, moist (SM).	56' SAND (SP) 56.3' SAND (SM)		
57									
58	30	24/24	58-60	9-13 18-24		Very pale brown, fine grained SAND, little Silt, very well sorted, moist (SM). Changing at 59.0 feet to: Brown, fine grained SAND, some Silt, very well sorted, moist to wet (SM).			
59									
60	31	24/22	60-62	11-13 22-28		Brown, fine grained SAND, little Silt, non plastic, moderately cohesive, very well sorted, moist (SP).			
61									
62	32	24/22	62-64	6-6 11-14		Brown, fine grained SAND, little Silt, non plastic, moderately cohesive, very well sorted, moist (SM). Changing at 62.7 feet to: Brown, fine to medium grained SAND, trace Silt, grading fine with depth, well sorted, damp (SP). Changing at 63.0 feet to: Brown, fine grained SAND, trace Silt, very well sorted, damp (SP).	62.7' 63' SAND (SP) SAND (SM)		
63									
64	33	24/20	64-66	11-3 6-11		Brown, fine to medium grained SAND, trace Silt, grading fine with depth, well sorted, damp (SP). Changing at 65.0 feet to: Brown, fine grained SAND, some Silt, very well sorted, damp (SM). Changing at 65.1 feet to: Brown, fine to medium grained SAND, trace Silt, grading fine with depth, well sorted, wet (SP). Changing at 65.6 feet to:	64' SAND (SP) 65' 65.1' SAND (SM) SAND (SP) 65.6' CLAY & SILT		
65									
66	34	24/24	66-68	5-11 12-14		Brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 67.0 feet to: Yellowish-brown, fine to medium grained SAND, little Silt, very well sorted wet (SP).	66' (CL) SAND (SP) 67' SAND (SM)		
67									

REMARKS

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Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	35	24/13	68-70	2-4 7-13		Yellowish-brown, fine to medium grained SAND, little Silt, very well sorted wet (SP).	SAND (SM)		
69									
70	36	24/18	70-72	2-6 12-16		Yellowish-brown, fine to medium grained SAND, little Silt, very well sorted wet (SP).			
71									
72	37	24/23	72-74	3-3 5-9		Brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 73.1 feet to: Brown, CLAY & SILT, slightly plastic, moderately cohesive, well sorted, moist to wet (CL).	72' SAND (SP)		
73							73.1' CLAY & SILT (CL)		
74	38	24/20	74-76	2-1 2-2		Brown, CLAY & SILT, slightly plastic, moderately cohesive, well sorted, moist to wet (CL).			
75									
76	39	24/19	76-78	2-5 8-11		Brown, CLAY & SILT, slightly plastic, moderately cohesive, well sorted, moist to wet (CL).			
77									
78	40	24/23	78-80	2-4 5-10		Brown, CLAY & SILT, slightly plastic, moderately cohesive, well sorted, moist to wet (CL). Changing at 79.3 feet to: Yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Changing at 79.4 feet to: Yellowish-brown, medium to coarse grained SAND, trace Silt, moderately well sorted, wet (SW).			
79							79.4' SAND (SW)		
80	41	24/22	80-82	2-4 6-7		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).	80' SAND (SP)		
81									
							82'		

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	42	24/24	82-84	2-5 11-12		Yellowish-brown, medium to coarse grained SAND, trace Silt, well sorted, wet (SW). Changing at 82.4 feet to: Yellowish-brown, medium to coarse grained SAND, trace Silt, poorly sorted, wet (SW). Changing at 83.2 feet to: Yellowish-brown to gray, GRAVEL, some coarse grained Sand, trace Silt, poorly sorted, wet (GW). Changing at 83.4 feet to: Yellowish-brown, CLAY & SILT, plastic, coheisve, well sorted, moist (CL). Changing at 83.5 feet to: Yellowish-brown to gray, GRAVEL, some coarse grained Sand, trace Silt, poorly sorted, wet (GW). Changing at 83.7 feet to: Yellowish-brown, fine to medium SAND, trace Silt, trace Gravel, well sorted, wet (SP).	SAND (SW) 82.4' SAND (SW) 83.4' 83.5' CLAY & SILT (CL) 83.7' GRAVEL (GW) SAND (SP)		
83									
84	43	24/23	84-86	3-6 11-14			84.7' GRAVEL (GW)		Grout
85							85.2' SAND (SP)		
86	44	24/24	86-88	3-4 9-15		Yellowish-brown, fine to medium SAND, trace Silt, trace Gravel, well sorted, wet (SP). Changing at 84.7 feet to: Yellowish-brown to gray, GRAVEL, some coarse to medium grained Sand, trace Silt, poorly sorted, wet (GW). Changing at 85.2 feet to: Yellowish-brown, fine grained SAND, trace Silt, very well sorted, wet (SP).			
87							87.2' SAND (SW)		
88	45	24/16	88-90	3-5 8-12		Yellowish-brown, fine grained SAND, trace Silt, very well sorted, wet (SP). Changing at 87.2 feet to: Yellowish-brown, coarse grained SAND, some Gravel, trace Silt, very well sorted, wet (SW).			
89						Yellowish-brown, medium to coarse grained SAND, some Gravel, trace Silt, poorly sorted wet (SW).			
90	46	24/22	90-92	3-4 7-11		Yellowish-brown, fine to medium SAND, trace Silt, moderately sorted, wet (SP). Changing at 91.6 feet to: Dark grayish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Changing at 91.7 feet to: Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW).	90' SAND (SP)		
91							91.6' 91.7' CLAY & SILT (CL)		
92	47	24/1	92-94	5-7 12-13		Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW).	SAND (SW)	1	
93									
94	48	24/4	94-96	5-7 9-10		Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW).			
95									

REMARKS

1. Groundwater was encountered at approximately 91.7 feet below ground surface.

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
97	49	24/8	96-98	2-3 6-12		Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW).	SAND (SW)		
98	50	24/11	98-100	2-3 10-12		Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW).			
99									
100	51	24/23	100-102	3-4 9-13		Yellowish-brown, medium to coarse grained SAND, trace Silt, trace Gravel, grading finer with depth, well sorted, wet (SW). Changing at 101.8 feet to: Dark yellowish-brown to yellowish-brown, CLAY & SILT, moderately plastic, cohesive, well sorted, moist (CL).			
101							101.8'		
102	52	24/11	102-104	1-1 3-9		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).	102CLAY & SILT (CL) SAND (SP)		
103									
104	53	24/11	104-106	4-4 15-26		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
105									
106	54	24/11	106-108	1-5 15-30		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
107									
108	55	24/10	108-110	4-9 25-32		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
109									

REMARKS

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Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	56	24/10	110-112	4-9 20-31		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).	SAND (SP)		
111									
112	57	24/8	112-114	2-5 14-27		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
113									
114	58	24/11	114-116	2-4 10-28		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
115									
116	59	24/14	116-118	4-10 25-40		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
117									
118	60	24/10	118-120	3-7 21-25		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
119									
120	61	24/16	120-122	4-7 14-31		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
121									
122	62	24/14	122-124	3-6 22-32		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
123									

REMARKS

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Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	63	24/19	124-126	5-13 29-45		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).	SAND (SP)		
125									
126	64	24/1	126-128	1-5 18-34		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
127									
128	65	24/24	128-130	6-18 34-48		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
129									
130	66	24/23	130-132	5-10 28-46		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 131.5 feet to: Yellowish-brown, medium to coarse grained SAND, trace Silt, moderately sorted, wet (SW). Changing at 131.7 feet to: Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
131									
132	67	24/23	132-134	5-15 30-45		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
133									
134	68	24/24	134-136	3-5 21-31		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
135									
136	69	24/11	136-138	6-16 29-43		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
137									

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Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	70	24/6	138-140	2-3 13-33		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).	SAND (SP)		
139									
140	71	24/11	140-142	2-4 9-27		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
141									
142	72	24/14	142-144	3-10 25-42		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
143									
144	73	24/20	144-146	9-25-50/5"		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
145									
146	74	24/18	146-148	6-27 52-53		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
147									
148	75	24/12	148-150	9-34 48-50/3"		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
149									
150	76	24/0	150-152	6-11 26-29		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
151									

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Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	77	24/24	152-154	2-8 26-31		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).	SAND (SP)		
153									
154	78	24/20	154-156	5-12 28-43		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
155									
156	79	24/1	156-158	3-6 18-21		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
157									
158	80	24/24	158-160	7-8 19-25		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
159									
160	81	24/7	160-162	3-10 21-29		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
161									
162	82	24/0	162-164	4-11 25-32		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
163									
164	83	24/6	164-166	1-14 34-45		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
165									

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167	84	24/24	166-168	9-29 51-50/3"		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).	SAND (SP)		
168	85	24/13	168-170	3-6 18-34		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			
169									
170	86	24/1	170-172	5-6 19-44		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).			Top of Well Screen
171									Silica Sand Filter Pack
172	87	24/16	172-174	2-4 7-14		Yellowish-brown, fine to medium grained SAND, little Silt, trace Gravel, well sorted, wet (SP).	172' SAND (SM)		
173									2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
174	88	24/24	174-176	8-13 21-23		Yellowish-brown, fine to medium grained SAND, little Silt, very well sorted, wet (SP). Changing at 174.7 feet to: Yellowish-brown, SILT, trace Clay, non plastic, cohesive, very well sorted (bedded), moist (ML). Changing at 175.5 feet to: Yellowish-brown, SILT, trace Clay, moderately plastic, cohesive, very well sorted (bedded), wet (ML).	174.7' SILT (ML) 176'		
175									Bottom of Well Screen
176						Bottom of Borehole at 176.0 Feet		2	
177									
178									
179									

REMARKS

2. Monitoring well was installed in borehole upon completion. Well screen set from 170.1 to 174.7 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-1/MW-1D

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: MW-1S
Page: 1 **of** 6
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-5-17/9-5-17
Boring Location:
GS Elev.: 788.70' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0						See SB-1/MW-1D boring log for detailed soil descriptions.			PROTECTIVE CASING; Backfill/Cement Pad
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: MW-1S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: MW-18
Page: 2 **of** 6
File No.: 16.0062335.52
Check: J Cai

Elev. (Ft.)	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at limes and under conditions staled. Fluctuations of groundwater may occur due to other factors than those present at the lime measurements were made.

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Boring No.: MW-18
Page: 3 **of** 6
File No.: 16.0062335.52
Check: J Cai

Elev. (Ft.)	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at limes and under conditions staled. Fluctuations of groundwater may occur due to other factors than those present at the lime measurements were made.

Boring No.: MW-1S

BORING WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: MW-18
Page: 4 **of** 6
File No.: 16.0062335.52
Check: J Cai

Elev. (Ft.)	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at limes and under conditions staled. Fluctuations of groundwater may occur due to other factors than those present at the lime measurements were made.

Boring No.: MW-1S

BORING WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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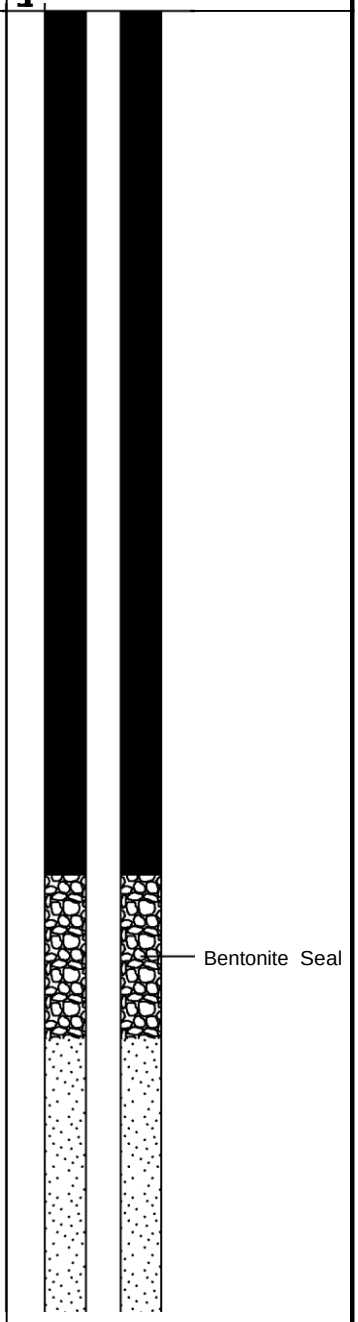
Boring No.: MW-18
Page: 5 **of** 6
File No.: 16.0062335.52
Check: J Cai

Elev. (Ft.)	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							



REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at limes and under conditions staled. Fluctuations of groundwater may occur due to other factors than those present at the lime measurements were made.

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Boring No.: MW-1S
Page: 6 **of** 6
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
69									Top of Well Screen
70									Silica Sand Filter Pack
71									2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
72									
73									
74									Bottom of Well Screen
75						Bottom of Borehole at 75.0 Feet		1	
76									
77									
78									
79									
80									
81									

REMARKS

1. Monitoring well was installed in borehole upon completion. Well screen set from 68.4 to 73.1 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Boring No.: SB-2/MW-2S
Page: 1 **of** 7
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-11-17/9-11-17
Boring Location:
GS Elev.: 797.60' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/18	0-2	7-8 8-10		Dark brown to yellowish-brown, SILT & CLAY, some Sand, plastic, cohesive, poorly sorted, moist (CL).	CLAY & SILT (CL)		PROTECTIVE CASING; Backfill/Cement Pad
2	2	24/23	2-4	8-8 9-9		Dark brown to yellowish-brown, SILT & CLAY, some Sand, plastic, cohesive, poorly sorted, moist (CL).			
4	3	24/22	4-6	5-6 7-7		Dark brown to yellowish-brown, CLAY & SILT, some Sand, plastic, cohesive, poorly sorted, moist (CL). Changing at 4.6 feet to: Brown to grayish-brown, SILT, some fine grained Sand, trace Clay, non to slightly plastic, slightly cohesive, moderately sorted moist (ML). Changing at 5.1 feet to: Yellowish-brown to brown, CLAY & SILT, some Sand, moderately plstic, cohesive, moderately sorted, moist (CL).	4.6' SILT (ML) 5.1' CLAY & SILT (CL)		
6	4	24/22	6-8	4-5 5-6		Yellowish-brown to brown, CLAY & SILT, some Sand, moderately plstic, cohesive, moderately sorted, moist (CL).			
8	5	24/17	8-10	2-4 6-6		Yellowish-brown to brown, CLAY & SILT, some Sand, moderately plastic, cohesive, moderately sorted, moist (CL). Changing at 9.0 feet to: Dark yellowish-brown, fine to medium SAND, trace Silt, moderately sorted moist (SP).	9' SAND (SP)		
10	6	24/17	10-12	3-4 4-4		Mottled dark yellowish-red to dark reddish-brown to dark brown to dark grayish-brown, SILT, some fine grained SAND, moderately sorted, moist (ML). Changing at 10.5 feet to: Yellowish-brown to pale brown, fine to medium SAND, trace Silt, well sorted, moist (SP).	10' SILT (ML) 10.5' SAND (SP)		

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-2/MW-2S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

GZA
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Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-2/MW-2S
Page: 2 **of** 7
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
13	7	24/17	12-14	2-2 3-4		Yellowish-brown to pale brown, fine to medium SAND, trace Silt, well sorted, moist (SP).	SAND (SP)		
14	8	24/22	14-16	2-2 3-5		Yellowish-brown to pale brown, fine to medium SAND, trace Silt, well sorted, moist (SP). Changing at 15.2 feet to: Soft, Dark brown, CLAY & SILT, plastic, cohesive, moderately sorted, moist (CL). Changing at 15.3 feet to: Yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP).	15.2' CLAY & SILT (CL) 15.3' SAND (SP)		
16	9	24/24	16-18	4-5 6-6		Yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP). Changing at 16.6 feet to: Yellowish-brown, CLAY & SILT, plastic, cohesive, moderately sorted, moist (CL).	16.6' CLAY & SILT (CL)		
18	10	24/14	18-20	4-5 8-10		Yellowish-brown, CLAY & SILT, plastic, cohesive, moderately sorted, moist (CL). Changing at 18.6 feet to: Yellowish-brown, fie to coarse grained SAND, some Gravel, trace Silt, poorly sorted, moist SW). Changing at 19.0 feet to: Yellowish-brown, CLAY & SILT, plastic, cohesive, moderately sorted, moist (CL). Changing at 19.3 feet to:	18.6' SAND (SW) 19' 19.3' CLAY & SILT (CL) SAND (SM)		
20	11	24/24	20-22	4-5 8-10		Yellowish-brown, fine grained SAND, some Silt, non plastic, moderately cohesive, well sorted, moist (SM). Dark yellowish-brown to yellowish-brown, SILT & CLAY, moderately plastic, cohesive, well sorted, moist (CL). Changing at 21.7 feet to: Light gray to light brownish-gray, fine grained SAND, trace Silt, very well sorted, moist (SP).	20' CLAY & SILT (CL) 21.7' SAND (SP)		
22	12	24/16	22-24	2-3 5-6		Dark yellowish-brown to yellowish-brown, SILT & CLAY, moderately plastic, cohesive, well sorted, moist (CL). Changing at 22.4 feet to: Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	22' CLAY & SILT (CL) 22.4' SAND (SP)		
24	13	24/16	24-26	4-6 6-6		Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
25									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-2/MW-2S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Engineers and Scientists

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1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-2/MW-2S
Page: 3 **of** 7
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
27	14	24/20	26-28	4-5 6-6		Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
28	15	24/18	28-30	6-7 12-12		Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
29									
30	16	24/22	30-32	7-9 11-13		Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP). Changing at 31.7 feet to: Light yellowish-brown, fine to medium grained SAND, trace Gravel, trace Silt, moderately well sorted, moist (SP).			
31									
32	17	24/18	32-34	7-7 7-8		Light yellowish-brown to yellowish-brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 32.2 feet to: Pale brown to very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, poorly sorted, moist (SW).	32.2' SAND (SW)		
33									
34	18	24/20	34-36	13-38 31-18		Pale brown, fine to coarse grained SAND, some Gravel, trace Silt, poorly sorted, moist (SW).			
35									
36	19	24/20	36-38	2-4 7-8		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).	36' SAND (SP)		
37									Grout
38	20	24/19	38-40	2-3 6-7		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
39									

REMARKS

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Boring No.: SB-2/MW-2S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-2/MW-2S
Page: 4 **of** 7
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
41	21	24/20	40-42	5-7 9-13		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).	SAND (SP)		
42	22	24/19	42-44	4-6 9-11		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
43									
44	23	24/22	44-46	5-8 10-13		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
45									
46	24	24/22	46-48	3-5 8-13		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
47									
48	25	24/23	48-50	5-7 9-10		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
49									
50	26	24/22	50-52	6-7 12-13		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
51									
52	27	24/20	52-54	5-9 11-13		Very pale brown, fine grained SAND, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP). Changing at 52.8 feet to: Yellowish-brown, CLAY & SILT, well sorted, moist (CL). Changing at 52.9 feet to: Very pale brown, fine grained SAND, trace Silt, very well sorted, moist (SP).	52.8' 52.9' CLAY & SILT (CL) SAND (SP) 54'		
53									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-2/MW-2S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-2/MW-2S
Page: 5 **of** 7
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
55	28	24/22	54-56	5-9 13-13		Yellowish-brown, fine to coarse grained SAND, trace Gravel, trace Silt, poorly sorted, moist (SW). Changing at 55.0 feet to: Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, grading to fine to medium grained Sand, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).	SAND (SW) 55' SAND (SM)		
56	29	24/22	56-58	3-5 11-14		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
58	30	24/20	58-60	8-12 15-20		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
60	31	24/20	60-62	5-9 10-11		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
62	32	24/22	62-64	8-11 14-15		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
64	33	24/18	64-66	2-4 8-14		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
66	34	24/18	66-68	6-14 17-18		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-2/MW-2S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Belmont,Michigan

Boring No.: SB-2/MW-2S
Page: 6 **of** 7
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	35	24/18	68-70	5-14 19-24		Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP). Changing at 69.3 feet to: Light yellowish-brown, fine to coarse grained SAND, trace Silt, moderately sorted, moist (SW). Changing at 69.4 feet to: Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, grading to fine to medium grained Sand, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).	SAND (SM)		
69							69.3'		
							69.4' SAND (SW)		
70	36	24/16	70-72	4-10 17-19			SAND (SP)		
71						Very pale brown grading to yellowish-brown, fine grained SAND, little Silt, grading to fine to medium grained Sand, trace Silt, very well sorted, moist with occasional trace Gravel, moist (SP).			
72	37	24/18	72-74	6-14 24-23		Brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
73									
74	38	24/23	74-76	2-3 5-10		Brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 75.5 feet to: Brown, fine to coarse grained SAND, trace Silt, trace Gravel, poorly sorted, wet (SW).			
75							75.5' SAND (SW)		
76	39	24/18	76-78	2-8 14-20		Brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).			
77									
78	40	24/18	78-80	3-7 10-18		Brown, fine to coarse grained SAND, trace Silt, trace Gravel, poorly sorted, wet (SW).			Top of Well Screen Silica Sand Filter Pack
79									
80	41	24/18	80-82	3-9 9-19		Brown, fine to coarse grained SAND, trace Silt, trace Gravel, poorly sorted, wet (SW). Changing at 80.7 feet to: Brown, fine to medium SAND, trace Silt, trace Gravel, moderately well sorted, wet (SW).			
81							80.7' SAND (SP)		2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
							82'		

REMARKS

1. Groundwater was not encountered during drilling or upon completion.
2. Monitoring well was installed in borehole upon completion. Well screen set from 78.5 to 83.1 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-2/MW-2S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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1855 House Street NE
Belmont. Michigan

Boring No.: SB-2/MW-28
Page: 7 **of** 7
File No.: 16.0062335.52
Check: J Cai

Elev.	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	E	Equipment Installed
						Bottom of Borehole at 82.0 Feet		1 2	Bottom of Well Screen
83									
84									
85									
86									
87									
88									
89									
90									
92									
93									
94									
95									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

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1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-3/MW-3S
Page: 1 **of** 6
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-12-17/9-12-17
Boring Location:
GS Elev.: 788.10' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

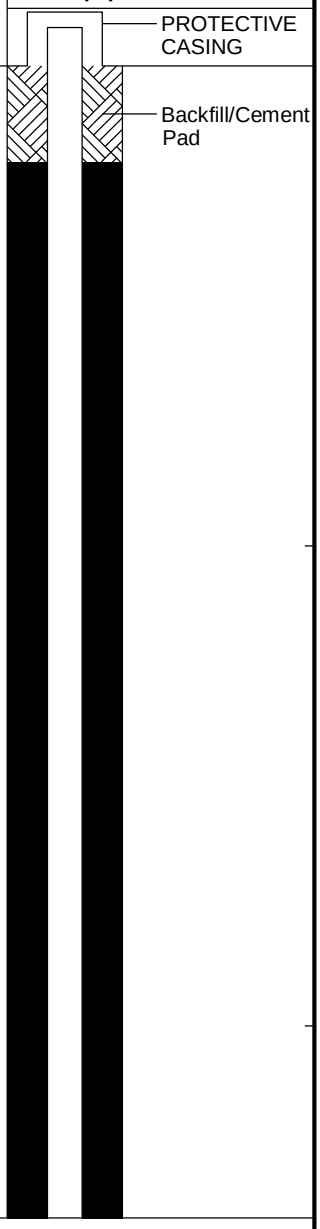
GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks
0	1	24/21	0-2	5-6 6-7	0.0 ppm >4.0 tsf	Hard, brown, CLAY, trace Silt, trace fine Sand, dry (CL).	CLAY (CL)	1 2
2	2	24/21	2-4	7-5 5-4	0.0 ppm	Loose, dark brown, yellowish brown, fine SAND, trace Silt, damp (SP).	2' SAND (SP)	
4	3	24/14	4-6	3-2 2-3	0.0 ppm	Loose, dark yellowish brown, fine SAND, trace Silt, damp (SP) Changing at 5.2 feet to: Loose, dark yellowish-brown, fine SAND, little Gravel, trace Silt, damp (SP).		
6	4	24/21	6-8	2-5 5-5		Loose, yellowish-brown, well sorted, fine SAND, damp (SP). Changing at 7.8 feet to: Loose, pale brown, fine SAND, damp (SP).		
8	5	24/21	8-10	1-4 5-7		Loose, pale brown, well sorted, fine SAND, trace Silt, damp (SP).		
10	6	24/20	10-12	4-5 6-7		Loose, pale brown, well sorted, fine SAND, trace Silt, damp (SP).		

Equipment Installed



REMARKS

1. Field screening of samples for organic vapors was performed with a MiniRae 2000 photoionization detector equipped with a 10.6 eV lamp. Readings above background levels are shown in parts per million (ppm) of isobutylene. Background was measured at 0.0 ppm.
2. Pocket penetrometer readings were measured in tons per square foot (tsf) and are used to evaluate consistency of cohesive soil.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-3/MW-3S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

WolverineWorldwide,Inc.
1855HouseStreetNE
Belmont,Michigan

Boring No.: SB-3/MW-3S
Page: 2 **of** 6
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	7	24/20	12-14	3-5 5-5		Loose, pale brown, well sorted, fine SAND, trace Silt, damp (SP).	SAND (SP)		
13									
14	8	24/20	14-16	4-5 5-5		Loose, pale brown, well sorted, fine SAND, trace Silt, damp (SP).			
15									
16	9	24/24	16-18	2-5 9-10	>4.0 tsf	Loose, pale brown, well sorted, fine SAND, trace Silt, damp (SP). Changing at 16.2 feet to: Hard, brown, CLAY, trace Silt, damp (CL). Changing at 17.8 feet to: Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).	16.2' CLAY (CL)		
17							17.8' SAND (SP)		
18	10	24/24	18-20	2-6 7-9		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP). Changing at 18.2 feet to: Brown, CLAY, trace Silt, damp (CL). Changing at 19.0 feet to: Medium dense, brown, well sorted, fine to medium SAND, trace Silt, moist (SP).	18.2' CLAY (CL)		
19							19' SAND (SP)		
20	11	24/24	20-22	5-6 7-10	>4.0 tsf	Hard, brown, CLAY, trace Silt, damp (CL). Changing at 20.5 feet to: Medium dense, brown, well sorted, fine to medium SAND, trace Silt, moist (SP). Changing at 21.5 feet to: Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).	20' CLAY (CL)		
21							20.5' SAND (SP)		
22	12	24/22	22-24	4-4 5-6		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP). Changing at 23.5 feet to: Medium dense, pale brown, well sorted, fine SAND, some Silt, wet (SM).			
23							23.5' SAND (SM)		
24	13	24/22	24-26	4-4 5-6		Medium dense, pale brown, well sorted, fine SAND, some Silt, wet (SM). Changing at 25.3 feet to: Hard, light gray and brown mottled, CLAY, trace Silt, moist (CL). Changing at 25.9 feet to: Loose, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
25							25.3' CLAY (CL)		
							25.9'		

REMARKS

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Boring No.: SB-3/MW-3S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	14	24/20	26-28	2-2 6-8	>4.0 tsf	Loose, pale brown, well sorted, fine SAND, trace Silt, moist (SP).	SAND (SP)		
27									
28	15	24/20	28-30	6-10 10-11		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
29									
30	16	24/20	30-32	2-4 9-10		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
31									
32	17	24/21	32-34	5-12 13-20		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
33									
34	18	24/19	34-36	8-16 28-40		Dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			Grout
35									
36	19	24/21	36-38	18-18 19-31		Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
37									
38	20	24	38-40			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
39									

REMARKS

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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	21	24	40-42			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
41									
42	22	24	42-44			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
43									
44	24	24	44-46			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
45									
46	26	24	46-48			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
47									
48	27	24	48-50			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
49									
50	28	24	50-52			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
51									
52	30	24	52-54			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
53									

REMARKS

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Boring No.: SB-3/MW-3S

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Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	31	24	54-56			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
55									
56	32	24	56-58			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
57									
58	33	24	58-60			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
59									
60	34	24	60-62			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
61									
62	35	24	62-64			Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP). Changing at 63.0 feet to: Light yellowish-brown to yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
63									
64	36	24	64-66			Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP).		3	
65									
66	37	24	66-68			Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP). Changing at 67.0 feet to: Yellowish-brown, fine to medium SAND, some Silt, very well sorted, wet (SM). Changing at 67.2 feet to: Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP).	67' 67.2'SAND (SM) SAND (SP)		
67									

REMARKS

3. Groundwater was encountered at approximately 64.0 feet below ground surface.

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Boring No.: SB-3/MW-3S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ_GZA_CORP.GDT 11/27/17

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Boring No.: SB-3/MW-3S
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Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
69	38	24	68-70			Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP).	SAND (SP)		
70	39	24	70-72			Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP).			Top of Well Screen
71									Silica Sand Filter Pack
72	40	24	72-74			Yellowish-brown, fine to medium SAND, trace Silt, very well sorted, wet (SP). Changing at 73.8 feet to: Yellowish-brown, fine to medium SAND, some Silt, well sorted, wet (SM).			2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
73							73.8' SAND (SM)		
74	41	24	74-76			Yellowish-brown, fine to medium SAND, some Silt, well sorted, wet (SM).			
75									Bottom of Well Screen
76							76'		
						Bottom of Borehole at 76.0 Feet		4	
77									
78									
79									
80									
81									

REMARKS

4. Monitoring well was installed in borehole upon completion. Well screen set from 69.7 to 74.6 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Boring No.: SB-3P/MW-3P
Page: 1 **of** 2
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-12-17/9-12-17
Boring Location:
GS Elev.: 787.50' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0						See SB-3/MW-3S boring log for detailed soil descriptions.			PROTECTIVE CASING
1									Backfill/Cement Pad
2									
3									
4									
5									
6									
7									
8									Bentonite/Grout
9									
10									
11									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Boring No.: SB-3P/MW-3P
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
13									
14									
15									
16									Bentonite Seal
17									
18									
19									Top of Well Screen
20									
21									Silica Sand Filter Pack
22									
23	1	24/24	23-25	3-4 7-9		Medium dense, brown, well sorted, fine SAND, trace Silt, wet (SP). Changing at 24.3 feet to: Hard, gray and brown mottled, CLAY, trace Silt, damp (CL).	SAND (SP)		2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
24					>4.0 tsf		24.3' CLAY (CL)	1	Bottom of Well Screen
25						Bottom of Borehole at 25.0 Feet	25'	2	

REMARKS

1. Pocket penetrometer readings were measured in tons per square foot (tsf) and are used to evaluate consistency of cohesive soil.
2. Monitoring well was installed in borehole upon completion. Well screen set from 19.0 to 24.0 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-3P/MW-3P

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Belmont,Michigan

Boring No.: SB-4/MW-4S
Page: 1 **of** 6
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-12-17/9-12-17
Boring Location:
GS Elev.: 782.30' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks
0	1	24/14	0-2	1-1 1-1	0.0 ppm	Very loose, yellowish- brown, well sorted, fine SAND, some Organic Matter (roots), trace Silt, dry (SP).	SAND	1
2	2	24/14	2-4	1-2 2-2	0.0 ppm	Loose, pale brown, well sorted, fine SAND, damp (SP).		
4	3	24/13	4-6	2-2 4-5	0.1 ppm	Loose, pale brown, well sorted, fine SAND, damp (SP).		
6	4	24/14	6-8	2-3 5-7	0.0 ppm	Loose, pale brown, well sorted, fine SAND, damp (SP).		
8	5	24/14	8-10	3-3 5-7	0.0 ppm	Loose, pale brown, well sorted, fine SAND, damp (SP).		
10	6	24/21	10-12	5-5 7-8	0.0 ppm >4.0 tsf	Loose, pale brown, well sorted, fine SAND, damp (SP). Changing at 11.0 feet to: Hard, gray and brown mottled, CLAY, trace Silt, damp (CL).	11' CLAY (CL)	2

Equipment Installed

PROTECTIVE CASING

Backfill/Cement Pad

REMARKS

1. Field screening of samples for organic vapors was performed with a MiniRae 2000 photoionization detector equipped with a 10.6 eV lamp. Readings above background levels are shown in parts per million (ppm) of isobutylene. Background was measured at 0.0 ppm.
2. Pocket penetrometer readings were measured in tons per square foot (tsf) and are used to evaluate consistency of cohesive soil.

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Boring No.: SB-4/MW-4S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	7	24	12-14	5-6 7-7	0.0 ppm >4.0 tsf	Hard, gray and brown mottled, CLAY, trace Silt, damp (CL). Changing at 13.0 feet to: Medium dense, pale brown and brown mottled, well sorted, fine SAND, trace Silt, damp (SP).	CLAY (CL) 13' SAND (SP)		
14	8	24/24	14-16	2-2 3-2	0.0 ppm	Loose, yellowish-brown, well sorted, fine SAND, trace Silt, damp (SP).			
16	9	24/18	16-18	1-1 1-3	0.0 ppm	Loose, yellowish-brown, well sorted, fine SAND, trace Silt, damp (SP). Changing at 17.8 feet to: Loose, yellowish-brown, well sorted, fine GRAVEL, trace Silt, damp (GW).	18'		
18	10	24/16	18-20	2-3 6-7	0.0 ppm	Loose, yellowish-brown, well sorted, fine GRAVEL, trace Silt, damp (GW). Changing at 19.0 feet to: Medium dense, yellowish-brown, well sorted, fine SAND, trace Silt, damp (SP).	GRAVEL (GW) 19' SAND (SP)		
20	11	24/15	20-22	6-7 9-9	0.0 ppm	Medium dense, yellowish-brown, well sorted, fine SAND, trace Silt, damp (SP).			
22	12	24/24	22-24	4-8 8-10	0.0 ppm	Medium dense, yellowish-brown, well sorted, fine SAND, trace Silt, moist (SP). Changing at 23.9 feet to: Hard, brown, CLAY, damp (CL).	23.9'		
24	13	24/24	24-26	6-7 9-10	0.0 ppm >4.0 tsf	Hard, brown, CLAY, damp (CL).	CLAY (CL) 26'		

REMARKS

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Boring No.: SB-4/MW-4S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-4/MW-4S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	14	24/0	26-28			NO RECOVERY.	NO RECOVERY		
27									
28	15	24/16	28-30	5-9 11-15	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, damp (SP).	28' SAND (SP)		
29									
30	16	24/15	30-32	6-12 13-21	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, damp (SP).			
31									
32	17	24/17	32-34	4-18 31-39	0.0 ppm	Dense, pale brown, well sorted, fine SAND, trace Silt, damp (SP).			
33									Bentonite/Grout
34	18	24/17	34-36	7-10 15-19	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, damp (SP).			
35									
36	19	24/17	36-38	4-10 15-22	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, trace Gravel, damp (SP).			
37									
38	20	24/20	38-40	10-12 21-24	0.0 ppm	Dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
39									

REMARKS

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Boring No.: SB-4/MW-4S
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Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	21	24/17	40-42	10-11 16-19	0.0 ppm	Dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP). Encountered Rock at 40.2 feet.	SAND (SP)		
41									
42	22	24/19	42-44	7-11 17-25	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
43									
44	23	24/19	44-46	7-12 23-26	0.0 ppm	Dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
45									
46	24	24/19	46-48	10-14 15-15	0.0 ppm	Medium dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
47									
48	25	24/20	48-50	8-14 36-49	0.0 ppm	Dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
49									
50	26	24/24	50-52	18-37 47-47	0.0 ppm	Very dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
51									
52	27	24/21	52-54	33-29 52-50/3"	0.0 ppm	Very dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).			
53									

REMARKS

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Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	28	24/16	54-56	19-58-50/4"	0.0 ppm	Very dense, pale brown, well sorted, fine SAND, trace Silt, moist (SP).	SAND (SP)		
55									
56	29	24	56-58			Light yellowish-brown to pale brown, very well sorted, fine to medium SAND, trace Silt, moist (SP).			
57									
58	30	24	58-60			Light yellowish-brown to pale brown, very well sorted, fine to medium SAND, trace Silt, moist (SP). Changing at 59.6 feet to: Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).		
59									
60	31	24	60-62			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).		3	
61									
62	32	24	62-64			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			
63									
64	33	24	64-66			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			
65									
66	34	24	66-68			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			Bentonite Seal
67									

REMARKS

3. Groundwater was encountered at approximately 59.6 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-4/MW-4S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Belmont,Michigan

Boring No.: SB-4/MW-4S
Page: 6 **of** 6
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	35	24	68-70			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).	SAND (SP)		
69									
70	36	24	70-72			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			
71									Top of Well Screen
72	37	24	72-74			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			Silica Sand Filter Pack
73									
74	38	24	74-76			Brown, very well sorted, fine to medium SAND, trace Silt, wet (SP).			2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
75									
76						Bottom of Borehole at 76.0 Feet	76'	4	Bottom of Well Screen
77									
78									
79									
80									
81									

REMARKS

4. Monitoring well was installed in borehole upon completion. Well screen set from 71.1 to 75.7 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Belmont,Michigan

Boring No.: SB-5/MW-5S
Page: 1 **of** 5
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-19-17/9-19-17
Boring Location:
GS Elev.: 778.80' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/19	0-2	6-5 8-9		Dark yellowish-brown, fine to coarse grained SAND, little Gravel, trace Silt, poorly sorted, dry to moist (FILL). Changing at 0.4 feet to: Light yellowish-brown, fine to coarse grained SAND, trace Silt, trace Gravel, moderately sorted, moist (FILL). Changing at 0.7 feet to: Very dark grayish-brown to dark yellowish-brown, fine grained SAND, some Silt, slightly cohesive, moderately sorted, moist (FILL). Changing at 1.2 feet to: Brownish-yellow grading to pale brown to very pale brown, fine grained SAND, trace Silt, well sorted, moist (SP). Brownish-yellow grading to pale brown to very pale brown, fine grained SAND, trace Silt, well sorted, moist (SP). Changing at 3.2 feet to: Dark yellowish-brown to brown, fine to medium grained SAND, little Clay, little Silt, trace Gravel, slightly plastic, moderately cohesive, poorly sorted, moist (SC). Changing at 3.5 feet to: Dark yellowish-brown, CLAY & SILT, plastic, cohesive, modereately well sorted, moist (CL).	SAND (FILL)		PROTECTIVE CASING
2	2	24/20	2-4	4-5 5-5			1.2' SAND (SP)		Backfill/Cement Pad
3									
4	3	24/18	4-6	2-3 3-4			3.5' CLAY & SILT (CL)		
5									
6	4	24/19	6-8	2-2 2-3		Dark yellowish-brown, CLAY & SILT, plastic, cohesive, modereately well sorted, moist (CL). Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	6' SAND (SP)		
7									
8	5	24/17	8-10	2-2 3-4		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
9									
10	6	24/18	10-12	3-4 4-6		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
11						Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-5/MW-5S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Belmont,Michigan

Boring No.: SB-5/MW-5S
Page: 2 **of** 5
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	7	24/23	12-14	2-3 5-9		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
13						Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
14	8	24/20	14-16	3-9 10-10		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
15									
16	9	24/20	16-18	2-4 4-4		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
17						Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
18	10	24/19	18-20	3-5 5-4		Light yellowish-brown, fine to medium SAND, trace Silt, very well sorted, moist (SP). Changing at 19.5 feet to: Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP). Changing at 19.3 feet to: Dark brown to dark yellowish-brown grading to black, fine to medium grained SAND, trace Silt, well sorted, moist to wet (SP).			
19									
20	11	24/18	20-22	3-3 4-3		Dark yellowish-brown, fine to medium grained SAND, trace Silt, wet sorted, moist to wet (SP). Changing at 20.2 feet to: Dark gray, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 20.3 feet to: Reddish-gray, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Changing at 20.7 feet to:			
21									
22	12	24/23	22-24	2-5 8-8		Yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Brown, Silty CLAY, plastic, cohesive, very well sorted, moist (CL).	22' Silty CLAY (CL)		
23									
24	13	24/20	24-26	4-6 6-7		Brown, Silty CLAY, plastic, cohesive, very well sorted, moist (CL).			
25							26'		

REMARKS

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Boring No.: SB-5/MW-5S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-5/MW-5S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
27	14	24/17	26-28	3-5 8-9		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
28	15	24/18	28-30	4-6 8-9		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			Bentonite/Grout
29									
30	16	24/24	30-32	5-6 9-10		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
31									
32	17	24/18	32-34	3-5 9-13		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
33									
34	18	24/18	34-36	3-7 13-16		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
35									
36	19	24/19	36-38	3-7 10-10		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
37									
38	20	24/24	38-40	3-5 8-12		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
39									

REMARKS

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Boring No.: SB-5/MW-5S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-5/MW-5S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	21	24/22	40-42	3-5 11-16		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
41									
42	22	24/24	42-44	3-11 18-21		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
43									
44	23	24/20	44-46	5-10 14-17		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
45									
46	24	24/24	46-48	4-7 9-9		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
47									
48	25	24/20	48-50	3-8 11-15		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
49									
50	26	24/24	50-52	3-10 17-18		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
51									
52	27	24/22	52-54	9-13 21-25		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
53									

REMARKS

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Boring No.: SB-5/MW-5S
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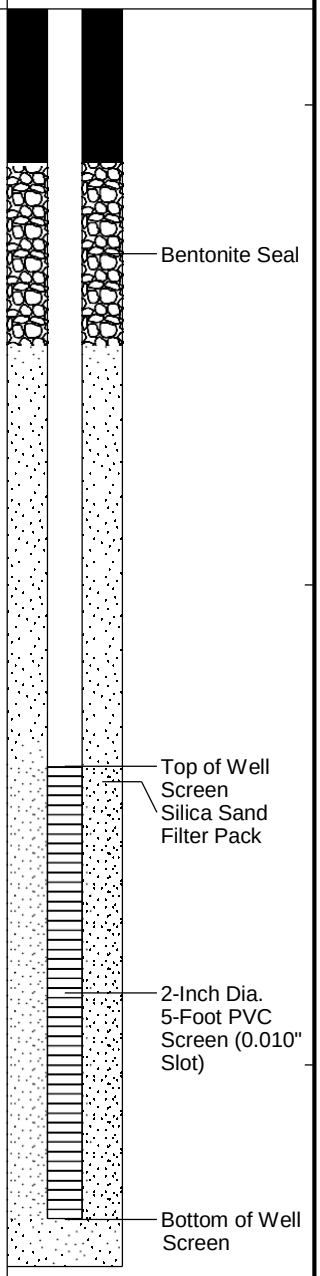
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks
55	28	24/24	54-56	4-5 8-10		Pale brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP). Changing at 54.5 feet to: Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).	SAND (SP)	1
56	29	24/24	56-58	3-4 5-6		Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).		
58	30	24/16	58-60	2-3 5-5		Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).		
60	31	24/16	60-62	1-1 2-2		Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP). Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).		
62	32	24/5	62-64	1-4 7-11		Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).		
64	33	24/11	64-66	2-6 10-10		Brown to yellowish-brown, fine to medium grained SAND, trace Silt, well sorted, wet (SP).		
66						Bottom of Borehole at 66.0 Feet	66'	2

Equipment Installed



REMARKS

1. Groundwater was encountered at approximately 54.5 feet below ground surface.
2. Monitoring well was installed in borehole upon completion. Well screen set from 61.9 to 66.6 feet below ground surface.

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Boring No.: SB-5/MW-5S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: MW-5P
Page: 1 **of** 2
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-19-17/9-19-17
Boring Location:
GS Elev.: 778.90' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0						See SB-5/MW-5S boring log for detailed soil descriptions.			PROTECTIVE CASING
1									Backfill/Cement Pad
2									
3									
4									
5									
6									
7									Bentonite/Grout
8									
9									
10									
11									

REMARKS

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Boring No.: MW-5P
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
13									
14									Bentonite Seal
15									
16									
17									Top of Well Screen
18									
19									Silica Sand Filter Pack
20									2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
21									
22									Bottom of Well Screen
22						Bottom of borehole at 22.3 Feet		1	
23									
24									
25									

REMARKS

1. Monitoring well was installed in borehole upon completion. Well screen set from 17.1 to 21.8 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: MW-5P

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-6/MW-6S
Page: 1 **of** 5
File No.: 16.0062335.52
Check: JCai

Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-13-17/9-14-17
Boring Location:
GS Elev.: 770.30' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/18	0-2	4-3 3-5		Very dark grayish-brown to dark brown, fine to medium grained SAND, some Silt, poorly sorted, dry (SM). Changing at 0.2 feet to: Dark brown, fine to medium grained SAND, some Silt, moderately sorted, dry (SM). Changing at 0.4 feet to: Dark yellowish-brown,fine to medium grained SAND, some Silt, trace Gravel, moderately sorted, dry (SM).	SAND (SM)		PROTECTIVE CASING
2	2	24/16	2-4	8-8 11-12		Dark yellowish-brown,fine to medium grained SAND, some Silt, trace Gravel, moderately sorted, dry (SM). Changing at 2.8 feet to: Dark yellowish-brown, fine to medium SAND, little Clay, little Silt, non to slightly plastic, moderately cohesive, poorly sorted, dry (SC). Changing at 3.0 feet to: Mottled dark yellowish-brown to pale brown, CLAY & SILT, some Sand, trace Gravel, plastic, cohesive, poorly sorted, dry to moist (CL).	2.8' 3' SAND (SC) CLAY & SILT (CL)		Backfill/Cement Pad
3									
4	3	24/19	4-6	8-9 13-15					
5						Mottled dark yellowish-brown to pale brown, CLAY & SILT, some Sand, trace Gravel, plastic, cohesive, poorly sorted, dry to moist (CL). Changing at 5.2 feet to: Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	5.2' SAND (SP)		
6	4	24/14	6-8	2-2 2-2		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
7									
8	5	24/20	8-10	1-3 3-4		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
9									
10	6	24/24	10-12	2-3 3-5		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
11									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-6/MW-6S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Belmont,Michigan

Boring No.: SB-6/MW-6S
Page: 2 **of** 5
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	7	24/22	12-14	3-4 5-5		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
13									
14	8	24/20	14-16	2-5 6-11		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist with some alternating beds of dark yellowish-brown, fine to medium grained SAND, trace Gravel at 14.6 feet.			
15									
16	9	24/22	16-18	4-8 9-10		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
17									
18	10	24/22	18-20	4-5 7-8		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
19									
20	11	24/19	20-22	6-9 14-15		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
21									
22	12	24/24	22-24	6-10 11-13		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
23									
24	13	24/20	24-26	5-8 13-18		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
25									

REMARKS

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Boring No.: SB-6/MW-6S
Page: 3 **of** 5
File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
	14	24/22	26-28	7-10 15-18		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		Bentonite/Grout
27									
28	15	24/22	28-30	7-11 12-14		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
29									
30	16	24/20	30-32	7-14 15-17		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
31									
32	17	24/16	32-34	7-10 15-21		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
33									
34	18	24/22	34-36	6-10 18-20		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).			
35									
36	19	24/19	36-38	10-16 23-34		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP). Changing at 36.8 feet to: Light yellowish-brown, fine grained SAND, little Silt, very well sorted, moist (SM). Changing at 37.8 feet to: Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP).	36.8' SAND (SM) 37.8' SAND (SP)		
37									
38	20	24/19	38-40	9-22 22-20		Light yellowish-brown to pale brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP). Changing at 38.5 feet to: Light yellowish-brown, fine grained SAND, little Silt, very well sorted, moist (SM).	38.5' SAND (SM)		
39									

REMARKS

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Boring No.: SB-6/MW-6S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-6/MW-6S
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File No.: 16.0062335.52
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
41	21	24/24	40-42	4-6 7-3		Light yellowish-brown, fine grained SAND, little Silt, very well sorted, moist (SM). Changing at 40.9 feet to: Yellowish-brown, fine grained SAND, little Silt, well sorted, moist (SM).	SAND (SM)		
42	22	24/19	42-44	11-22 37-38		Yellowish-brown, fine grained SAND, little Silt, well sorted, moist (SM). Changing at 43.1 feet to: Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP).	43.1' SAND (SP)		
44	23	24/22	44-46	16-22 28-30		Very pale brown, fine to medium SAND, trace Silt, very well sorted, moist (SP). Changing at 44.8 feet to: Brown, fine to medium grained SAND, trace Silt, well sorted, moist (SP).			
46	24	24/22	46-48	6-8 10-11		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).		1	
48	25	24/18	48-50	4-11 18-21		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			
50	26	24/18	50-52	5-11 14-17		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			
52	27	24/11	52-54	3-9 18-21		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			Bentonite Seal

REMARKS

1. Groundwater was encountered at approximately 46.0 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-6/MW-6S

BORING_WELL_6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Boring No.: SB-6/MW-6S
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Check: J Cai

Depth	Sample Information					Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data				
55	28	24/20	54-56	3-8 14-15		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).	SAND (SP)		
56	29	24/8	56-58	2-4 12-12		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			
57									Top of Well Screen Silica Sand Filter Pack
58	30	24/12	58-60	3-7 12-11		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			
59									2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
60	31	24/7	60-62	1-1 3-7		Brown, fine to medium grained SAND, trace Silt, trace Gravel, well sorted, wet (SP).			
61									
62						Bottom of Borehole at 62.0 Feet	62'	2	Bottom of Well Screen
63									
64									
65									
66									
67									

REMARKS

2. Monitoring well was installed in borehole upon completion. Well screen set from 57.1 to 61.8 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Contractor: StearnsDrillingCompany
Foreman: JerryHuntoon
Logged by: JohnMorehouse
Date Start/Finish: 9-19-17/9-20-17
Boring Location:
GS Elev.: 788.90' **Datum:**

	Auger/ Casing	Sampler
Type:	HollowStemAuger	SplitSpoon
O.D. / I.D.:	8.0"/4.25"	2.0"/13/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: NA **Survey Date:**

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/18	0-2	2-1 2-1		Very loose, dark brown to yellowish-brown, fine grained SAND, some Silt, moderately sorted, dry (TOPSOIL). Changing at 0.5 feet to: Brownish-yellow, fine grained SAND, little Silt, well sorted, dry (SM).	SAND (TOPSOIL) 0.5' SAND (SM)		PROTECTIVE CASING Backfill/Cement Pad
2	2	24/12	2-4	2-3 3-4		Loose, yellowish-brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	2' SAND (SP)		
4	3	24/18	4-6	2-2 3-2		Loose, yellowish-brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
6	4	24/5	6-8	2-2 2-2		Loose, yellowish-brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP) with fractured rock at 6.1 feet. Changing at 6.3 feet to: Dark brown, CLAY & SILT, some Sand, trace Gravel, plastic, cohesive, mmoist (CL).	6.3' CLAY & SILT (CL)		
8	5	24/12	8-10	2-2 3-4		Loose dark grayish-brown to dark brown, coarse grained SAND, little Gravel, trace Silt, poorly sorted, moist (SP).	8' SAND (SP)		
10	6	24/11	10-12	4-6 4-4		Loose dark grayish-brown to dark brown, coarse grained SAND, little Gravel, trace Silt, poorly sorted, moist (SP).			

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-7/MW-7S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	7	24/19	12-14	4-7 5-5		Loose dark grayish-brown to dark brown, coarse grained SAND, little Gravel, trace Silt, poorly sorted, moist (SP). Changing at 12.6 feet to: Stiff, brown, CLAY & SILT, some Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL). Changing at 13.2 feet to: Stiff, dark brown, CLAY & SILT, some Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL).	SAND (SP) 12.6' CLAY & SILT (CL) 13' 13.2' SAND (SM) CLAY & SILT (CL)		
13									
14	8	24/0	14-16	8-8 9-10		NO RECOVERY.			
15									
16	9	24/17	16-18	3-4 3-5		Loose, brown, fine grained SAND, trace Silt, very well sorted, moist (SP). Changing at 16.4 feet to: Medium brown, CLAY & SILT, some Sand, trace Gravel, moderately plastic, cohesive, poorly sorted, moist (CL). Changing at 16.7 feet to: Loose, dark yellowish-brown, fine grained SAND, trace Silt, well sorted, moist (SP). Changing at	16' SAND (SP) 16.4' 16.7' CLAY & SILT (CL) 17' SAND (SP) CLAY & SILT (CL)		
17									
18	10	24/22	18-20	4-4 5-6		17.0 feet to: Medium mottled yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Medium mottled yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Changing at 18.6 feet to: Stiff mottled yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL). Changing			
19							18.9' 19' SAND (SP) CLAY & SILT (CL)		
20	11	24/14	20-22	3-3 4-5		at 18.9 feet to: Loose, light yellowish-brown to brownish-yellow, fine grained SAND, very well sorted, moist (SP). Changing at 19.0 feet to: Stiff, mottled yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL).	20.6' SAND (SP)		
21						Stiff, mottled yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted, moist (CL).			
22	12	24/16	22-24	1-1 2-3		Loose to medium dense, very pale brown, fine grained SAND, trace Silt, very well sorted (bedded), moist (SP).			
23									
24	13	24/22	24-26	2-3 3-2		Loose to medium dense, very pale brown, fine grained SAND, trace Silt, very well sorted (bedded), moist (SP).			
25									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
27	14	24/22	26-28	2-3 3-3		Loose to medium dense, very pale brown, fine grained SAND, trace Silt, very well sorted (bedded), moist (SP).	SAND (SP)		
28	15	24/22	28-30	2-3 4-3		Loose to medium dense, very pale brown, fine grained SAND, trace Silt, very well sorted (bedded), moist (SP).			
29									
30	16	24/20	30-32	1-3 6-8		Loose to medium dense, very pale brown, fine grained SAND, trace Silt, very well sorted (bedded), moist (SP). Changing at 30.3 feet to: Stiff, yellowish-brown, SILT, little Clay, plastic, cohesive, well sorted, moist to wet (ML). Changing at 30.7 feet to: Medium dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted (bedded), moist (SP).	30.3' SILT (ML) 30.7' SAND (SP)		
31									
32	17	24/23	32-34	5-5 7-8		Medium dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted (bedded), moist (SP). Changing at 32.7 feet to: Soft, dark yellowish-brown, CLAY & SILT, plastic, cohesive, moist (CL). Changing at 32.8 feet to: Medium dense, very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, poorly sorted, moist (SP).	32.7' 32.8' CLAY & SILT (CL) SAND (SP)		Bentonite/Grout
33									
34	18	24/20	34-36	4-8 9-8		Medium dense, very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, moderately sorted, moist (SP).			
35									
36	19	24/18	36-38	5-6 7-8		Medium dense, very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, moderately sorted, moist (SP). Changing at 36.1 feet to: Brown to yellowish-brown, CLAY & SILT, plastic, cohesive, well sorted (bedded), moist (CL). Changing at 36.2 feet to: Medium dense, very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, moderately sorted, moist (SP).	36.1' 36.2' CLAY & SILT (CL) SAND (SP)		
37									
38	20	24/18	38-40	3-5 5-7		Medium dense, very pale brown, fine to coarse grained SAND, some Gravel, trace Silt, moderately sorted, moist (SP). Changing at 38.5 feet to: Medium dense, light yellowish-brown to very pale brown, fine to medium grained SAND, trace Silt,			
39									

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

Boring No.: SB-7/MW-7S

BORING_WELL 6233550 WOLVERINE WORDWIDE HOUSE STREET NE.GPJ GZA_CORP.GDT 11/27/17

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Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
41	21	24/20	40-42	2-4 7-8		very well sorted, moist (SP). Medium dense, light yellowish-brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
42	22	24/16	42-44	4-4 6-10		Medium dense, light yellowish-brown to very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP). Changing at 42.9 feet to: Medium dense, light yellowish-brown, fine to coarse grained SAND, some Gravel, trace Silt, poorly sorted, moist (SP).			
44	23	24/20	44-46	3-5 6-9		Medium dense, light yellowish-brown, fine to coarse grained SAND, trace Silt, poorly sorted, moist (SP). Changing at 45.3 feet to: Stiff to very stiff yellowish-brown grading to dark gray, CLAY & SILT, little Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL).	45.3' CLAY & SILT (CL)		
46	24	24/12	46-48	3-6 7-10		Stiff to very stiff yellowish-brown grading to dark gray, CLAY & SILT, little Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL).			
48	25	24/18	48-50	10-11 29-17		Stiff to very stiff yellowish-brown grading to dark gray, CLAY & SILT, little Sand, trace Gravel, plastic, cohesive, poorly sorted, moist (CL). Changing 48.6 feet to: Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	48.6' SAND (SP)		
50	26	24/6	50-52	21-39 48-25		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
52	27	24/23	52-54	6-12 16-20		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			

REMARKS

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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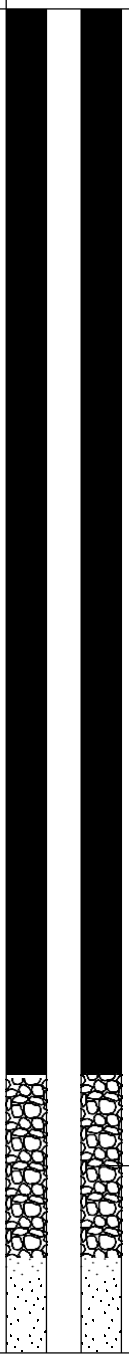
Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
55	28	24/20	54-56	6-16 17-23		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).	SAND (SP)		
56	29	24/23	56-58	6-13 17-21		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
57									
58	30	24/20	58-60	8-16 20-31		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
59									
60	31	24/24	60-62	9-17 18-24		Dense to very dense, very pale brown, fine to medium grained SAND, trace Silt, very well sorted, moist (SP).			
61									
62	32	24/18	62-64	4-8 10-11		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).		1	
63									
64	33	24/23	64-66	2-3 7-10		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).			
65									
66	34	24/1	66-68	1-3 5-9		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).			Bentonite Seal
67									



REMARKS

1. Groundwater was encountered at approximately 62.0 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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Check: J Cai

Depth	Sample Information: No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
69	35	24/23	68-70	1-4 7-7		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).	SAND (SP)		
70	36	24/8	70-72	2-7 11-11		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).			Top of Well Screen
71									Silica Sand Filter Pack
72	37	24/5	72-74	1-2 5-9		Medium dense, yellowish-brown, fine to medim grained SAND, trace Silt, well sorted, wet (SP).			2-Inch Dia. 5-Foot PVC Screen (0.010" Slot)
73									
74						Bottom of Borehole at 74.0 Feet	74'	2	Bottom of Well Screen
75									
76									
77									
78									
79									
80									
81									

REMARKS

2. Monitoring well was installed in borehole upon completion. Well screen set from 70.1 to 74.7 feet below ground surface.

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

APPENDIX B

STANDARD OPERATING PROCEDURES

SAMPLING EQUIPMENT DECONTAMINATION

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is established to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination.

2.0 SUMMARY OF METHODS

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances. The decontamination procedure may be summarized as follows:

1. Physical removal
2. Non-phosphate detergent wash
3. Tap water rinse
4. Distilled/deionized water rinse
5. Air dry
6. Distilled/deionized water rinse

The six-step process may be modified based on the chemicals of concern at the site. For example, an acid rinse using 10% nitric acid followed by a final rinse of distilled or de-ionized water may be added at a site where metals are a concern. A solvent rinse followed by a final rinse of distilled or de-ionized water may be added at sites where volatile organic compounds (VOCs) are a concern. The additional rinses will be specified in the Work Plan. Modifications to this standard operating procedure will be noted in the daily field report and in the final report.

3.0 POTENTIAL PROBLEMS

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

If the decontamination procedure is suspected to be incompatible with sampling equipment or other materials, consult with the manufacturer and discuss with the Project Manager alternative decontamination methods. Note any variations in the decontamination procedure in Daily Field Notes.

Impacted environmental media and decontamination solutions should be evaluated and may need to be treated as if they were hazardous materials. Contain and dispose of the materials according to the Site-specific Waste Management Plan, Work Plan, or proposed scope of work.

4.0 EQUIPMENT AND MATERIALS

Decontamination Tool/Supplies

- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized water sprayers
- Solvent sprayers
- Aluminum foil

Decontamination Solutions

- Non-phosphate detergent
- Selected solvents (acetone, hexane, nitric acid, etc.)
- Tap water
- Distilled or de-ionized water

Health and Safety Equipment

- Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

Waste Disposal

- Trash bags
- Trash containers
- 55-gallon drums
- Metal/plastic buckets/containers for storage and disposal of decontamination solutions

5.0 PROCEDURES

5.1 PREPARATION

Review the project Work Plan or proposed scope of work, and if applicable, Quality Assurance Plan. Discuss with the Project Manager the Site-specific contaminant hazards, decontamination methods, appropriate decontamination solutions, and waste disposal procedures.

5.2 DECONTAMINATION PROCEDURES

1. Wear Nitrile disposable gloves and other appropriate PPE whenever handling potentially impacted materials and decontamination equipment and solutions.

2. Employ work practices that minimize contact with hazardous substances.

3. Prepare decontamination solutions and set up rinseate containment with tanks, buckets, super sacks, or drums.

4. Label each decontamination solution and waste container with the name and identified chemical hazards.

5. Where applicable, begin decontamination with physical removal:

    a. Scrub equipment with brushes.

    b. Solutions should be circulated through the equipment with internal mechanisms that cannot be adequately cleaned with a brush.

    c. Bulk material that is strongly adhered may need to be chiseled off of the equipment.

    d. Large equipment may require the use of a pressurized water sprayer. A water supply, such as a tank, a power supply, such as a generator, a hose, and a spray nozzle are required to operate a pressurized water sprayer. Handle all rinseates as specified in the Work Plan or proposed scope of work.

    e. A damp cloth may be used on delicate or water-sensitive equipment.

6. Wash the equipment with a non-phosphate detergent and water solution. Handle all rinseates as specified in the Work Plan or proposed scope of work.

7. Rinse the equipment with potable tap water. Handle all rinseates as specified in the Work Plan or proposed scope of work.

8. Rinse the equipment with de-ionized or distilled water. Handle all rinseates as specified in the Work Plan or proposed scope of work.

9. If the equipment is used for sampling metals or has come into contact with elevated concentrations of metals, the equipment may need to be decontaminated using a 5-10% solution of nitric acid. If a nitric acid rinse is required it will be specified in the work plan.

    a. If necessary to prepare the acid solution, wear splash-guard goggles and protective clothing.

    b. Estimate the amount of solution needed and calculate the volume of nitric acid and volume of de-ionized or distilled water to make up the 5-10% solution.

    c. Add acid to water to prevent a severe exothermic reaction due to the dilution of acid in water.

    d. Label all solutions.

    e. Rinse the equipment with the acid solution. Contain the acid rinseate.

    f. Rinse the equipment with de-ionized or distilled water. Handle all rinseates as specified in the Work Plan or proposed scope of work.

10. If decontamination for organic contaminants is required, pesticide-grade solvents may be required (i.e. hexane). If a hexane rinse is required it will be specified in the work plan.

    a. Estimate the amount of solvent necessary and add to a spray bottle.

    b. Label all solvents.

    c. Spray the solvent all over the equipment and collect excess in a bucket.

    d. Allow the solvent to evaporate or wipe with a clean paper towel.

    e. Rinse the equipment with de-ionized or distilled water. Handle all rinseates as specified in the Work Plan or proposed scope of work.

11. If required, take an equipment blank sample after the decontamination process has been completed and the equipment is ready to sample again.

    a. Use water that has been verified by laboratory analysis to be analyte free.

    b. Run water over the portion of the equipment most likely to become impacted while sampling, and collect in a sample container at the bottom.

    c. Seal the container, label it, and place it upright in an iced cooler.

12. Clean up work area. Rinseates and wash water are to be handled as specified in the Work Plan or in the proposed scope of work. Handling may include containerizing rinseates in drums. Small amounts may be contained and mixed with soil in super sacks or drums.

13. Label all waste containers and arrange for their disposal.

14. Do NOT remove the waste from the Site without specific instructions and approval.

15. Do NOT sign waste manifests without specific instructions and approval.

16. Collect copies of any bills of lading or manifests for materials shipped off-Site. Make a note of the disposal destination and waste hauler in the daily field report.

17. Before leaving, perform a walk-around check to be sure that all equipment is packed.

18. Make a safety call to the Site supervisor or Project Manager when you leave the Site.

6.0 RECORDS AND DOCUMENTATION

The decontamination procedures, decontamination solutions, and waste disposal practices utilized in the field should be recorded in the daily field report.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

Collect equipment blank samples according to the project Work Plan or proposed scope of work and, if applicable, the Quality Assurance Plan. Whenever standard operating procedures are varied, it shall be recorded.

8.0 APPLICABLE STANDARDS AND REFERENCES

ASTM International, "Designation: D 5088-02, "Standard Practices for Decontamination of Field Equipment Used at Waste Sites." 2002.

Environmental Response Team (ERT), US EPA. "Sampling Equipment Decontamination," SOP No. 2006, Revision 0.0. August 11, 1994.

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SOIL SAMPLING

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative soil samples. Analysis of soil may be used to evaluate whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations present a risk to public health, welfare, or the environment.

The methodologies discussed in this procedure are applicable to the sampling of (dry) soil. Typically this term "soil" refers to samples which are not covered with an aqueous layer for more than 30% of the time. The descriptions and procedures are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by the sampling area. However, if modifications occur, they should be documented in the site logbook or report summarizing field activities.

2.0 SUMMARY OF METHODS

Soil samples may be recovered using a variety of methods and equipment, depending on the portion of the soil profile required (surface versus subsurface) and the project objectives. Soil is collected directly, using a hand-held device such as hand scoop, auger or a post hole digger, or indirectly using a power activated device such as power augers, back hoes, or drill rigs. Following collection, the soil can be homogenized, with the exception of samples for the analysis of volatile organic compounds, in a container constructed of inert material and transferred to the appropriate sample containers.

This SOP does not provide sufficient detail to describe the essential details for collecting samples for volatile organic compounds (VOCs); e.g., total petroleum hydrocarbons-gasoline, BTEX, etc. Refer to GZA SOP (#3.2.2) for specific sampling, sub-sampling, preservation and analytical preparations.

3.0 POTENTIAL PROBLEMS

There are two primary potential problems associated with soil sampling - cross contamination of samples and improper sample collection. Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary (Refer to GZA SOP #3.1.1 Sampling Equipment Decontamination). Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in loss of constituent concentration of the sample such as samples for VOC analysis, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

4.0 EQUIPMENT AND MATERIALS

Equipment needed for collection of soil samples includes:

- maps/plot plan
- safety equipment as specified in Health and Safety Plan, such as photo-ionization detector
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and/or film
- stainless steel, plastic, or other appropriate composition bucket
- 4-oz, 8-oz, and one-quart, wide-mouth jars w/Teflon-lined lids
- Ziploc plastic bags
- logbook
- sample jar labels
- chain of custody forms
- custody seals
- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- disposable Nitrile gloves
- sampling devices (depending on sampling methods)
    - spade or shovel
    - scoop
    - bucket auger
    - hand auger
    - extension rods
    - T-handle
    - Split spoon
    - power augers
    - backhoes
    - drill rigs

Decontamination solutions are specified in GZA SOP #3.1.1 Sampling Equipment Decontamination.

5.0 PROCEDURES

5.1 PREPARATION

1. Determine the extent of the sampling effort, the sampling methods to be employed and required equipment and supplies according to the sampling QA plans for the site.

2. Review the Site-Specific Health and Safety Plan.

3. Contact utility locator services (State/National One-Call system and/or private utility locators) to locate underground/overhead utilities. Contact appropriate site personnel for maps of underground utilities and structures.

4. Obtain necessary sampling and monitoring equipment.

5. Decontaminate or pre-clean equipment, and ensure that it is in working order.

6. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

7. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan. Make sure utility clearance is completed. Make site observations as to where electrical and gas lines run into buildings, where manholes are located, and where fire hydrants are located. Make sure utility clearance is completed.

8. Use stakes, flags, or buoys to identify and mark all sampling locations. Review the sampling locations and marked utilities/structures with the drilling contractor (if applicable). Make sure all the sample locations are clear of underground and overhead utilities. Specific site characteristics, including flow regime, basin morphometry, soil characteristics, depth of overlying aqueous layer, and extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, utility lines, property boundaries, and surface obstructions.

5.2 SAMPLE COLLECTION

Selection of a sampling device is most often contingent upon: (1) depth of sample at the sampling location, and (2) the physical characteristics of the medium to be sampled.

Use the following **Sample Collection** procedures after the desired depth has been reached by one of the methods outlined in Section 5.3.

- Wear new disposable Nitrile gloves for collecting and handling each sample.

- Collect samples for VOC analyses as described in GZA SOP # 3.2.2.
- For other analyses, select an appropriate precleaned sampling device and collect the sample.
- For composite sample, homogenize grab samples in a stainless steel or glass mixing container using the appropriate tool (stainless steel spoon, trowel, or pestle).
- Transfer the sample to the appropriate sample container.
- Secure the cap tightly. Chemical preservation of solids is generally not recommended.
- Clean the outside of the sample container to remove excess soil.
- Label and tag sample containers, and record appropriate data on soil sample data sheets (depth, location, color, other observations).
- Place glass sample containers in sealable plastic bags, if required, and place containers into an iced shipping container. Samples should be cooled to 4°C as soon as possible.
- Complete chain of custody forms and ship as soon as possible to minimize sample holding time. Scheduled arrival time at the analytical laboratory should give as much of a holding time as possible for scheduling of sample analysis.

5.3 VARIOUS BORING METHODS OF REACHING TARGET SAMPLE DEPTH

5.3.1 Sampling Surface Soils with a Trowel or Hand Scoop

Collection of surface soil can be accomplished with tools such as spades, shovels, and scoops. Surface soil can be removed to the required depth with a garden spade, then use a stainless steel or plastic scoop to collect the sample.

Representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect soil samples with a scoop or trowel:

1. Using a precleaned stainless steel scoop or trowel remove vegetation and top layer of soil, then loosen the desired volume of soil from the sampling area.

2. Transfer the discrete grab sample into an appropriate sample container. For samples requiring VOC analysis, collect the sample immediately and follow GZA SOP #3.2.2 for specific sampling, sub-sampling, preservation and analytical preparations.

3. Collect and handle the sample according the sample collection procedures in Section 5.2.

4. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

5.3.2 Sampling Surface Soils with a Hand Auger

This method uses an auger, a series of extension rods, a "T" handle, and a thin-wall tube sampler. The auger bores a hole to a desired sampling depth and then is withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil at the completion depth. The core is then withdrawn and the sample collected. Posthole augers have limited utility for sample collection, as they are designed more for their ability to cut through fibrous, rooted areas. Bucket augers are better for direct sample recovery, are fast, and provide a large volume of sample. Use the following procedure to collect soil samples with a hand auger:

1. Attach the auger bit to a drill extension rod, then attach the "T" handle to the drill extension rod.

2. Clear the area to be sampled of any surface debris.

3. Begin augering, periodically removing any accumulated soil from the auger bucket.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. (When sampling directly from the auger bucket, collect sample after the auger is removed from boring and proceed to Step 10.)

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower tube sampler down borehole. Gradually force tube sampler into soil. Care should be taken to avoid scraping the borehole sides. Also avoid hammering of the drill rods to facilitate coring, since the vibrations may cause the boring walls to collapse.

7. Remove tube sampler and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 1 inch), as this represents material collected by the tube sampler before penetration of the layer of concern.

10. Transfer the discrete grab sample into an appropriate sample container. For samples requiring VOC analysis, collect the sample immediately and follow GZA SOP #3.2.2 for specific sampling, sub-sampling, preservation and analytical preparations.

11. Collect and handle the sample according the sample collection procedures in Section 5.2.

12. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

5.3.3 Sampling Surface Soils with a Split-Spoon Sampler

This methodology will be utilized to collect soil samples down to a depth of approximately six feet (6') when soil conditions allow.

A split spoon sampler, useful for sampling unconsolidated soil, consists of two half cylinders (spoons) that fit together to form a tube approximately two feet in length and two inches in diameter. The cylindrical arrangement is maintained by a retaining head and bit rings that screw on at each end of the split spoon. The bit ring has beveled edges to facilitate sampling as the split spoon is forced into the ground.

The following procedures are used for collecting surface soil samples with a split-spoon sampler:

1. Clear away all surface debris (leaves, twigs, etc.) for a one-foot (1') radius around the sampling location.

2. Assemble a precleaned auger and auger a hole to the desired sampling depth. Carefully withdraw the auger to prevent cave-in of the borehole sidewalls.

3. Assemble a precleaned split-spoon sampler with appropriate extension rods and T-handle. Insert the sampler into the hole and force it into the soil with a twisting motion. Carefully withdraw the sampler and disassemble it.

4. Discard the upper one-inch (1") of the sample. Remove the remainder with a clean stainless steel laboratory spoon and transfer it directly to a suitable sample container.

5. Transfer the discrete grab sample into an appropriate sample container. For samples requiring VOC analysis, collect the sample immediately and follow GZA SOP #3.2.2 for specific sampling, sub-sampling, preservation and analytical preparations.

6. Collect and handle the sample according the sample collection procedures in Section 5.2.

7. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

5.3.4 Test Pit/Trench Excavation

A backhoe can be used to remove sections of soil, when detailed examination of soil characteristics are required. This is probably the most expensive sampling method because of the relatively high cost of backhoe operation.

The following procedures are used for collecting soil samples from test pits or trenches:

1. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities.

2. Review the site specific Health & Safety plan and ensure that all safety precautions including appropriate monitoring equipment are installed as required.

3. Using the backhoe, excavate a trench approximately three feet wide and approximately one foot deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.

4. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.

5. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.

6. Transfer the discrete grab sample into an appropriate sample container. For samples requiring VOC analysis, collect the sample immediately and follow GZA SOP #3.2.2 for specific sampling, sub-sampling, preservation and analytical preparations.

6. Collect and handle the sample according the sample collection procedures in Section 5.2.

7. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

8. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

5.3.5 Split Spoon Sampler with Hollow Stem Augering

Split spoon samplers are typically used with machine operated hollow stem auger boring technique. The method is suitable for reaching soils from approximately 12 inches to depths greater than 100 feet. Refer to GZA SOP #1.1.1 for operating procedures for the advancing of overburden earth borings employing the hollow-stem auger method for subsurface explorations.

The following procedures are used for collecting split spoon soil samples with hollow stem augering:

1. Advance hollow stem auger to the desired top sample depth;

2. Insert the split spoon sampler rod assembly and advance the sampler using the weight of the drilling stem and rods or a mechanical hammer.

3. Insert a catcher device in the head ring to prevent loss of unconsolidated sample during recovery.

4. After retrieving the split spoon sampler, expose the soil by unscrewing the bit and head rings and splitting the barrel.

5. If the recovery is enough to accommodate discarding a portion of the sample, discard the top and bottom two to three inches of the sample.

6. Transfer the discrete grab sample into an appropriate sample container. For samples requiring VOC analysis, collect the sample immediately and follow GZA SOP #3.2.2 for specific sampling, sub-sampling, preservation and analytical preparations.

7. Collect and handle the sample according the sample collection procedures in Section 5.2.

8. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

5.3.6 Direct Push Rigs

Direct push rigs, such as GeoProbe™ may be used for depths greater than 10 feet below ground surface.

Clear liners are typically used with direct push rigs. This method is appropriate only for unconsolidated materials. The sampling depth that can be achieved varies depending on the rig and the lithologies that are encountered.

The following procedures are used for collecting soil samples with direct push rigs:

1. Typically, the rig operator will:

    - Place the liner inside the metal probe rod;
    - Select a point holder with an opening appropriate for the site lithology and screw it on the probe rod;
    - Advance the rod a full rod length;
    - Retrieve the rod;
    - Remove the point holder;
    - Remove the liner, and.
    - Slice the liner to expose the soil.

2. After the liner has been sliced, follow the procedures outlined in GZA SOP # 3.2.2, collecting volatile organic samples (if needed) immediately after the liner is sliced.

3. For other analyses, slice the sample from the center portion of the split liner using a clean, decontaminated utensil.

4. Collect and handle the sample according the sample collection procedures in Section 5.2.

5. Follow required sampling equipment decontamination and disposal procedures (see GZA SOP #3.1.1 Sampling Equipment Decontamination).

6.0 RECORDS AND DOCUMENTATION

The details of the boring shall be recorded on the GZA boring log and the field activities should be recorded on the daily field report (copy attached).

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

Whenever standard operating procedures are varied, it shall be recorded. The drilling inspector should also record any detected odor from boring, and depth encountered.

8.0 APPLICABLE STANDARDS AND REFERENCES

ASTM D1452-80 Soil Investigation and Sampling by Auger Borings

ASTM D6282-98(2005) Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations

GZA SOP # 3.1.1 - Sampling Equipment Decontamination

GZA SOP # 3.2.2 - VOC Soil Sampling and Field Preservation Procedure

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VOC SOIL SAMPLING AND FIELD PRESERVATION

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods for field collection, handling, and preparation of soil samples for analysis of volatile organic compounds (VOCs) in solid material (e.g., soils, sediment and solid waste). This SOP is based on procedures described in U.S. EPA SW-846 Method 5035A "Closed-System Purge-And-Trap and Extraction for Volatile Organics in Soil and Waste Samples", dated July 2002 (Method 5035A). The purpose of this SOP is to explain the sample collection and preservation options and techniques described in Method 5035A. This SOP is applicable for environmental site assessments and response activities.

Note individual state regulatory agencies may have more strict or conservative requirements and guidance. Some of the sample collection and preservation methods described in Method 5035A may not be acceptable to the state regulatory agencies. Field personnel must review the Work Plan and discuss with the project manager regarding the sample collection and preservation method. In addition, field personnel must coordinate with the receiving laboratory to ensure the selected sampling methodology matches the analytical procedures to be used in the lab.

Refer to GZA SOP # 3.2.1 for standard operating procedures to collect soil sample at target depth intervals using boring techniques with samplers (such as split-spoon samplers, and direct-push samplers), or using bulk sampling methods (such as backhoe bucket).

2.0 SUMMARY OF METHODS

After subsurface samples are collected at desired depth intervals, sub-samples are then collected from the freshly exposed subsurface sample using a hand-held coring device or a syringe for submitting to analytical laboratories for analysis. When collecting sub-samples, up to four types of samples may be required:

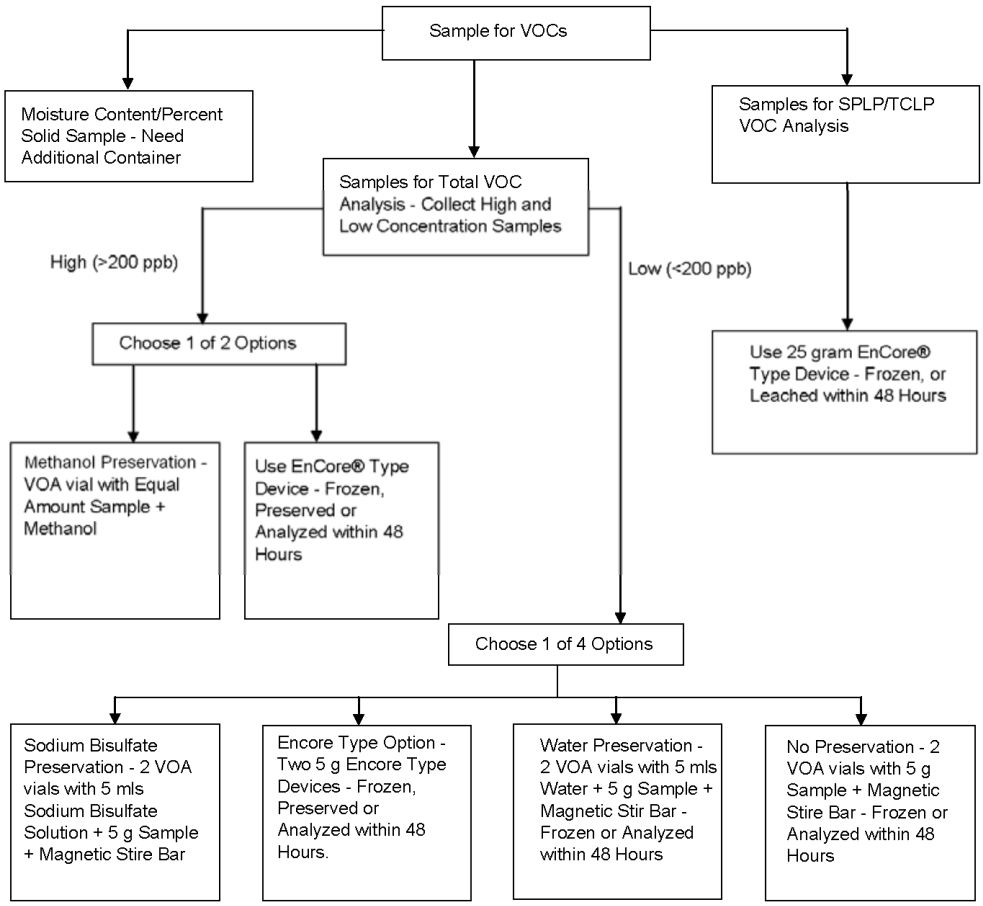
- A high-concentration-level sample, generally applicable to soils with VOC concentrations greater than 200 micrograms per kilogram (µg/Kg);
- A low-concentration –level sample, generally applicable to soils with VOC concentrations in the range of 0.5 to 200 µg/Kg;
- An SPLP/TCLP sample;
- A sample for percent solids/moisture content determination.

Approximately 5 to 10 grams of sample is obtained and preserved by one of the methods presented in Figure No. 1 below. Vials may be pre-weighed and pre-preserved in the laboratory or vials can be weighed and filled with preservatives in the field. After the sample aliquots are added to the vials, samples in vials are re-weighed to obtain the net sample weights. All weights must be recorded to within 0.2 g.

In addition to the samples collected for analysis, one co-located sample must be collected for a moisture content determination in order to report the VOC results on a dry-weight basis. Samples for moisture content determinations should not be chemically preserved and may be collected in conventional vials.

Additional samples may be necessary for matrix spikes and matrix spike duplicates. Field and trip blanks also may be required.

FIGURE NO. 1
VOC SAMPLE COLLECTION FLOW CHART



Selection of VOC Sample Methods

The selection of appropriate VOC sample methods listed in Figure No. 1 is an important part of project planning. The selection of high-level or low level VOC analyses depends on the identified contaminants of concern (COCs), expected soil concentrations and data quality objectives (DQOs) (typically the DQO is to demonstrate compliance with the applicable action levels for the COCs). Applicable action levels should be established once the contaminants of concern have been identified. If the expected soil COC concentrations are greater than 200 ug/kg, then field methanol preservation method is appropriate. If the expected soil COC concentrations are less than 200 ug/kg, and the applicable action levels for these COCs are greater than 200 ug/kg, then methanol preservation method is sufficient. If the expected soil COC concentrations are less than 200 ug/kg, and the applicable action levels for these COCs are less than 200 ug/kg, then low-concentration level methods should be used.

SW846 Method 3815 "Screening Solid Samples for Volatile Organics" can be used to determine whether a sample contains high or low concentrations of VOCs on site if the COCs at the site is known in advance and is detectable by a photoionization detector (PID).

If the expected concentrations cannot be estimated prior to sampling, and/or DQOs or other considerations indicate the need for both concentration levels, both low and high concentration aliquots must be collected.

For low-concentration level analysis, sodium bisulfate preservation method is only applicable to volatile aromatic hydrocarbons in soils known not to contain carbonates. It is not recommended as a primary preservation technique for all soil types and a broader VOC analyte list than aromatic VOCs.

Note that individual state regulatory agencies may have additional requirement regarding the selection of appropriate sample collection and preservation methods. For example, Michigan Department of Environmental Quality (MDEQ) generally does not accept samples without field methanol preservation for high concentration samples; and MDEQ discourages the use of soil coring devices for transporting total VOC analysis samples to the laboratory. See MDEQ's July 5, 2007, RRD Operational Memorandum No. 2, "Sampling and Analysis – Attachment 6, Sampling Methods for Volatile Organic Compounds in Soil" for details.

3.0 POTENTIAL PROBLEMS

Contamination of preservatives could result in a high bias of data. Personnel should optimize handling preservatives and sample vials in laboratory with controlled conditions. When samples are preserved in the field, it is especially critical to avoid the introduction of contamination from external sources. Consequently, personnel should work upwind of any possible source of VOCs (emissions from engines and backhoes, tobacco smoke, etc.) while adding preservatives to soil samples.

It is important to recognize that organic-free methanol can solubilize contaminants in ambient air. Forethought while sampling or handling vials is crucial to avoid possible contamination while using methanol preservation. Sodium sulfate solution also has the potential for absorbing contaminants from ambient air. Do not leave vials open and exposed to ambient air.

Equipment blanks and field blanks are expected to be included in the sampling plan. For example, when samples are preserved with methanol in the field, a methanol blank should be exposed to field conditions during the sample collection process.

The subsurface sampler used to collect samples from the subsurface should be removed as soon as possible from the subsurface; and most importantly the sub-samples that are submitted for laboratory analysis must be collected as soon as possible (ideally within five minutes of the collection of the subsurface sample) to reduce loss of VOCs due to volatilization. In addition, attempts must be made to further minimize loss of VOCs by managing the sample collection environment (i.e., limited direct sun, wind, heat, etc.).

4.0 EQUIPMENT AND MATERIALS

- maps/site sample plan
- safety equipment
- portable top-loading balance ±0.01g (for protocol# 3); balance weights for reference and calibration once per day
- zip-type plastic bags
- logbook
- sample labels
- chain of custody forms
- custody seals
- field data sheets
- cooler(s)
- ice
- stainless steel, plastic, or other appropriate composition bucket
- decontamination supplies/equipment
- glass vials, 40 mL, screw cap, Teflon® lined, septum sealed
- magnetic stir bars, Teflon® or glass-coated
- Methanol Kits (1 per sample)
    - 40 mL glass vial with 10 mL of purge-and-trap grade methanol
    - Disposable syringe-type samplers
    - 2- or 4-oz glass jars for percent moisture content
- Sub-sampling core samplers – core samplers must be constructed of non-reactive materials that will not absorb, leach or alter VOC concentrations in the sample. Examples of these materials are

stainless steel, glass and brass. Other materials, such as Viton®, Teflon® and some ridged plastics, which have demonstrated limited absorptive or diffusive passage of VOCs, can be used as long as the contact time between the sample and the sampler is minimized. It is important to note that syringes coated with glycerin should not be used. Syringe barrel should be smaller than neck of sample vial. Currently acceptable small diameter core samplers include a modified 10-milliliter (ml) disposable plastic syringe, a Purge and Trap Soil Sampler®, En Core® samplers, Terra Core samplers, Easy Draw Syringe® or other small-diameter tube/plunger sampler. One core sampler is needed for each sample aliquot to be collected

5.0 PROCEDURES

The soil sample collection procedure for determination of VOCs is a two-step process:

Step 1 – Collect an "undisturbed" subsurface soil sample, or expose the targeted area from where a sub-sample for laboratory analysis will be collected.

Step 2 – Collect a representative sub-sample from the "undisturbed" subsurface sample or directly from the exposed subsurface for submittal to a laboratory for VOC analysis.

5.1 COLLECTION OF SUBSURFACE SOIL SAMPLING

Refer to GZA SOP # 3.2.1 for standard operating procedures to collect soil sample at target depth intervals using boring techniques with samplers (such as split-spoon samplers, and direct-push samplers), or using bulk sampling methods (such as backhoe bucket). The following procedures should be followed to minimize loss of VOCs:

1.0 Upon collection of the subsurface soil sample, the samplers used to collect the "undisturbed" subsurface soil sample must be removed as soon as possible; and the sub-samples that are intended for VOC analysis must be collected as quickly as possible to reduce loss of VOC due to volatilization.

2.0 Attempt must be made to further minimize loss of VOCs by managing the sample collection environment (i.e. limiting direct sunlight, wind, head, etc.).

3.0 Subsurface soil samples to be collected for sub-sampling should be collected in a manner that controls the acquisition of the samples such that they do not "stack up" awaiting logging and sub-sampling;

4.0 Temporary storage of soil in the samplers (such as split spoons), capped liners, jars, or ziplock bags is not permitted.

5.0 "Undisturbed" subsurface soil samples should not be transferred from the samplers to a secondary container for future sub-sampling.

6.0 Under no circumstances should a sub-sample be collected from a disturbed sample that was previously used for field-screening purposes.

5.2 COLLECTION OF THE SOIL SUB-SAMPLE FOR VOC ANALYSIS

The purge and trap laboratory procedure used to determine volatile organic compounds requires approximately equal amounts of soil and liquid to be used in the analysis. If the ratio of soil to liquid is too high, the soil will not be adequately dispersed in the liquid, leading to poor results. If the amount of soil is too low, the detection limits will be increased, potentially rendering the results to be of limited use. It is better to use a slightly lower weight of soil than a higher weight of soil.

The small-diameter core sampler must be able to deliver a minimum of 5 grams of sample (≈ 3 cm3 of sample, assuming a density of 1.7 g/cm3) into a 40-ml VOA vial. While most small-diameter core samplers can only be used for sampling and placement into the appropriate sample containers, only the En Core®-type samplers can be used for sampling, storage, and transportation of the sample to the laboratory. Small-diameter core samplers should be selected based upon the properties of the matrix, the type of preservation method (field vs. lab), regulatory guidance and personal preferences.

The procedure for obtaining soil sub-samples is as follows:

1.0 Once the sampling interval has been selected, trim off the exposed surface of the matrix to expose a fresh surface. Removal of the unwanted surficial material can be accomplished by scraping the matrix surface with a decontaminated spatula or trowel. Soil sampling must commence immediately once a fresh surface has been exposed.

2.0 Push the small-diameter core sampler into the matrix to collect a volume of material that will yield the required mass of sample (wet weight) as determined by the analytical method. Depending upon the texture, depth or moisture content, insert the small-diameter core sampler straight into the matrix, on an angle. Multiple insertions can be made to obtain the required sample weight.

3.0 Wipe clean any soil adhering to the outside of the small-diameter core sampler before weighing.

4.0 If the weight is above the required amount, remove excessive soil by extruding a small portion of the core and cutting it away with a decontaminated trowel or spatula. If the weight is below the weight limit, obtain additional soil by reinserting the small-diameter core sampler into the soil core. Re-weigh after each addition or removal of sample from the small-diameter core sampler until the target weight is attained. Note the sample volume and amount in the small-diameter core sampler. Use the

volume of the sample as a guide in collecting the appropriately sized sub-sample of a similar matrix.

5.0 Immediately open the sample container and extrude the soil core into the sample container that will be submitted to the laboratory. Avoid splashing any preservative, if present, out of the sample container by holding the container at an angle while slowly extruding the soil core into the sample container. Do not immerse the small-diameter core sampler into the preservative. If an En Core®-type sampler is to be used for storage and shipment, prepare the sampler for shipment according to manufacturers instructions.

6.0 Collect the required number of sample containers or En Core®-type samplers based on the chosen preservation and analytical methods, as discussed in the subsequent section on soil preservation methods.

7.0 Include an additional sample for determination of soil moisture content and sample screening.

8.0 Ensure the threads and cap of the sample container or En Core®-type sampler are free of soil particles. Use a clean paper towel to remove soil particles from the threads and sealing surface of the sample container or En Core®-type sampler.

9.0 The presence of soil particles will compromise the container's seal and may result in loss of preservative or VOCs. This loss ultimately may invalidate the sample analysis. Always make sure the sample lid is firmly secure. The laboratory should flag samples that appear to have a poor seal so that the potentially low biased data can be evaluated relative to the project's data quality objectives.

10.0 The presence of soil particles will compromise the container's seal and may result in loss of preservative or VOCs. This loss ultimately may invalidate the sample analysis. Always make sure the sample lid is firmly secure. The laboratory should flag samples that appear to have a poor seal so that the potentially low biased data can be evaluated relative to the project's data quality objectives.

11.0 Record the laboratory and field identification numbers in the field notes and on the chain of custody. Record the sample identification information on the sample container using a suitable marker. Container labels with wire or rubber band attachments can be used, provided they can be removed easily for sample weighing. Do not attach any additional adhesive-backed labels or tape to the sample containers unless requested by laboratory or specified in manufacturer instructions. This will increase the weight of the sample container and the laboratory will not be able to determine the sample weight.

12.0 After sample collection, immediately return the containers to an iced cooler. Sample containers from different locations should be placed in separate ziplock bags to help avoid cross-contamination. The laboratory sample number or field sample identification number may be placed on the bag and cross-

referenced on the chain of custody. The laboratory performing the analysis will determine the sample weight.

5.3 PRESERVATION OF THE SOIL SAMPLE

1. Using a precleaned stainless steel scoop or trowel remove vegetation and top layer of soil, then loosen the desired volume of soil from the sampling area.

5.3.1 Methanol Preservation Sampling Procedure

1. Check that methanol sampling kits provided by the laboratory are 40 milliliter vials with 10 milliliters of methanol preservative. A disposable syringe-type sampler should be available for each vial.
2. Press the open end of the disposable syringe and fill with approximately 10 grams of soil. The syringe should be marked to hold a volume of soil with that approximate weight.
3. Make sure that the syringe is full of soil and that the soil is flush with the end of the syringe.
4. Expel the soil from the syringe into the 40-mL methanol-preserved vial and seal the vial.
5. Do not add an additional label to the vial, as it has been pre-weighed by laboratory. Fill out the information on the vial's label.
6. Place the sample upright in a cooler with ice.
7. Collect a replicate soil sample in a 2- or 4-ounce jar for the determination of percent moisture. Seal, label, and store the replicate sample in the cooler on ice.

5.3.2 En Core Sampling Procedure

1. Check that all of the components of the En Core sampler are available, including the two stainless steel reusable attachments, the coring body/storage chamber, and the protective moisture-proof bag.
2. Position the plunger rod so that the plunger can be moved freely from the top to the bottom of the coring body/storage chamber.

3. Attach the T-handle to the sampler.

4. Using the T-handle, push the En Core sampler into the soil until the coring body/storage chamber is completely full.

5. Look at the viewing hole while the device is in the soil to check if the coring body/storage chamber is completely full.

6. If the coring body/storage chamber is not completely full, quickly insert the device back into the same sampling spot and push harder to fill the coring body/storage chamber.

7. Scrape a spatula across the bottom of the coring body/storage chamber so the surface of the soil in the sampler is flush with the opening of the coring body/storage chamber.

8. Wipe the external surface of the coring body/storage chamber with a clean tissue or cloth.

9. Cap the coring body/storage chamber while it is still on the T-handle. Gently slide the cap onto the coring body/storage chamber with a twisting motion.

10. If cap is difficult to lock into position, use a new cap to seal the device.

11. Remove the T-handle from the device.

12. Lock the plunger into position by rotating the plunger rod.

13. If the relative concentration of analytes in the soil is unknown, take two additional soil samples in this manner.

14. Collect a replicate soil sample in a 2- or 4- ounce jar for the determination of percent moisture. Seal, label, and store the replicate sample in the cooler on ice.

15. Attach a sample label showing the sample number attached to the cap of the En Core sampler.

16. Place the sampler in its protective moisture-proof shipping bag. On the bag, record the sample label in waterproof pen,

17. Sample labels should include the following:

    i. Station Name
    ii. Date

iii. Time
iv. Sampler
v. Sample Identification
vi. Parameters
vii. Preservatives
viii. Remarks (if any)

18. Store the sealed sample storage chamber in a cooler with ice or in a freezer compartment regulated at a temperature between -7°C and -21°C.

19. Clean up work area and dispose of exhausted tubing, gloves, and filters. Pack non-essential equipment. Close and lock the well. Handle purge water as specified in the Work Plan.

20. Before leaving, perform a walk-around check to be sure that all equipment is packed.

21. Make a safety call to the Site supervisor or Project Manager when you leave the Site.

6.0 RECORDS AND DOCUMENTATION

The details of the boring shall be recorded on the GZA boring log or a field sampling form and the field activities should be recorded on the daily field report (copy attached). The time sampled, depth of the sample, and sample number must be noted on the log or form. The boring number, hand auger or unique sample location number must appear on the log or form.

Complete Field Notes, Health and Safety Plans, Tailgate Safety Forms, Field Sampling Form (ie. Boring Log or Test Pit Log), Chains of Custody, and Equipment Recovery Forms are required for VOC soil sampling.

Field Notes should include the following information:

- Method of VOC soil sampling.
- Soil sampling depth and time of collection.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

Whenever standard operating procedures are varied, it shall be recorded. The drilling inspector should also record any detected odor from boring, and depth encountered.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

Field Duplicates or replicate samples are collected at the same time and in the same manner as the sample intending to be duplicated or replicated. The name of a Duplicate sample will not be the same as the original sample but instead will be called a duplicate. The identity of the sample will be recorded in field notes.

Field Blanks are collected during the sampling procedure and in the same general area as samples are collected. To acquire a Field Blank sample when using a methanol sample kit, open the methanol-containing vial to the air for approximately the same time it takes for a soil sample to be collected. The name of these samples will include the Field Blank designation.

8.0 APPLICABLE STANDARDS AND REFERENCES

ASTM International. "D1452-80, Standard Practice for Soil Investigation and Sampling by Auger Borings," 2000.

ASTM International. "D6418-04, Standard Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis," 2004.

Michigan Department of Environmental Quality Remediation and Redevelopment Division. "Standard Operating Procedure for Methanol Preservation in the Field." Operational Memorandum Number 2, Attachment 6. October 22, 2004.

LOW-FLOW GROUNDWATER SAMPLING

1.0 SCOPE AND APPLICATION

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the standard method for collecting low stress (low flow) groundwater samples from monitoring wells. Low stress Purging and Sampling results in collection of groundwater samples from monitoring wells that are representative of groundwater conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of groundwater samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants.

This procedure does not address the collection of light or dense non- aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only.

2.0 SUMMARY OF METHODS

The purpose of the low stress purging and sampling procedure is to collect groundwater samples from monitoring wells that are representative of groundwater conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing. Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure minimizes aeration of the groundwater during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of groundwater purged from a well and the costs associated with its proper treatment and disposal.

3.0 POTENTIAL PROBLEMS

Problems that may be encountered using this technique include:

a) difficulty in sampling wells with insufficient yield;
b) failure of one or more key indicator parameters to stabilize;
c) cascading of water and/or formation of air bubbles in the tubing; and
d) cross- contamination between wells.

3.1 INSUFFICIENT YIELD

Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump. Purging should be interrupted before the water level in the well drops below the top of the well screen, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples.

3.2 FAILURE TO STABILIZE KEY INDICATOR PARAMETERS

If one or more key indicator parameters fails to stabilize after 4 hours, one of four options should be considered: a) continue purging in an attempt to achieve stabilization; b) discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book; c) discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or d) Secure the well, purge and collect samples the next day (preferred). The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter for all other samples is turbidity.

3.3 CASCADING

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4 or 3/8 inch ID) to ensure that the tubing remains filled with groundwater during sampling.

3.4 CROSS CONTAMINATION

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough "daily" decontamination procedures between sampling of each well in addition to the start of each sampling day.

3.5 EQUIPMENT FAILURE

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

4.0 PLANNING DOCUMENTATION, EQUIPMENT AND MATERIALS

- Approved site-specific Field Sampling Plan (FSP) /Quality Assurance Project Plan (QAPP). The FSP/QAPP must specify the type of pump and other equipment to be used. The FSP/QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval.

Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake.

- Well construction data, location map, field data from last sampling event.
- Polyethylene sheeting.
- Adjustable rate, positive displacement groundwater sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.
- Interface probe or equivalent device for determining the presence or absence of NAPL.
- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.
- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).
- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.
- Logbook (see Section VIII, below).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Inline groundwater sample filters with appropirate sizes, as required by the FSP/QAPP.
- Sample tags or labels, chain of custody.

- Tool/Supplies: Keys for wells, gates, and truck; Tubing cutter; Measuring cup; Socket wrench (5/16" is standard); Hose clamps; Paint pen; Stopwatch; Waterproof pens; Ice; Disposable Nitrile gloves; Potable water; De-ionized water (~0.5 gallons per well, distilled water may substitute).

- Decontamination Solutions

    - Reagent-grade denatured Ethyl Alcohol and MSDS
    - Spray bottle with appropriate chemical label
    - Non-phosphate anionic detergent (Liquinox or Alconox) and MSDS

- Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

- Waste Disposal

    - Trash bags
    - Trash containers
    - Metal/plastic buckets/containers for storage and disposal of decontamination solutions

5.0 PROCEDURES

5.1 PREPARATION

Review project FSP and/or QAPP. Discuss with the Project Manager the Site-specific contaminant hazards, decontamination methods, appropriate decontamination solutions, and waste disposal procedures.

5.2 PRE-SAMPLING PROCEDURE

1. Start at the well known or believed to have the least contaminated groundwater and proceed systematically to the well with the most contaminated groundwater. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Remove well cap.

4. If the well casing does not have a reference point (usually a V- cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of groundwater elevations to the mean geodesic datum (MSL).

5. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

6. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the groundwater.

5.3 PROCEDURE

1. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the FSP and/or QAPP or a depth otherwise approved by the project manager. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

2. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

3. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

4. Monitor Indicator Parameters: During purging of the well, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water quality indicator parameters. Then monitor and record the field indicator parameters including turbidity, temperature, specific conductance, pH, redox-potential (Eh), and dissolved oxygen (DO), approximately every three to five minutes. Redox-potential may not always be an appropriate stabilization parameters, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as shown in the following table (Puls and Barcelona, 1996). Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

Parameter	Stabilization Criteria	Reference
pH	± 0.1 pH units	Puls and Barcelona, 1996; Wilde et al., 1998
Specific electrical conductance (SEC)	± 3% s/cm	Puls and Barcelona, 1996
Oxidation-Reduction Potential (ORP)	±10 millivolts	Puls and Barcelona, 1996
Turbidity	± 10% NTUs (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996; Wilde et al., 1998
Dissolved Oxygen (DO)	± 0.3 milligrams per liter	Wilde et al., 1998

5. If a stabilized drawdown in the well can't be maintained at 0.3 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Under no circumstances should the well be pumped dry. Begin pumping at a lower flow rate, if the water draws-down to the top of the screened interval again turn pump off and allow for recovery. If two tubing volumes including the volume of water in the pump and flow cell have been removed during purging then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or groundwater sampling log with a recommendation for a different purging and sampling procedure.

6. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. Volatile organic compounds (VOCs) samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. Groundwater samples to be analyzed for VOCs may require pH adjustment. Consult the project manager, appropriate regulatory guidance, and analytical laboratory to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Groundwater purged from the well prior to sampling can be used for this purpose.

7. If the FSP and/or QAPP require filtered groundwater samples for metals, attach the inline filter with appropriate filter size to the end of the tubing. The inline filter must be pre-rinsed following manufacturer's recommendations, and if there are no recommendations for rinsing, a minimum of 500 mL of groundwater must pass through the filter before sampling. Do not filter groundwater samples for parameters that do not explicitly require it.

8. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

9. Measure and record well depth.

10. Close and lock the well.

5.4 DECONTAMINATION

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use ("daily decontamination") and after each well is sampled ("between-well decontamination"). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decontamination" procedures prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use ("daily decontamination").

Water level indicator meter and water quality field parameter meters will be decontaminated by the following procedures:

1. The water level meter will be hand washed with phosphate free detergent and a scrubber, then thoroughly rinsed with distilled water.

2. Water quality field parameter sensors and flow-through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer's requirements.

Decontamination of the sampling pump should be performed as follows:

3. Prepare four separate containers for decontamination. Each should hold enough fluid to completely submerge the pump.

4. The first container should contain a solution of reagent-grade denatured Ethyl Alcohol and potable water to a dilution scheme of 1 cup of alcohol to 2 gallons of water. Circulate this solution through the operation of the pump for no less than 3 minutes.

5. The second container should contain a solution of detergent and potable water. Circulate this solution through the operation of the pump for no less than 5 minutes.

6. The third container should contain potable water. Circulate this water through the operation of the pump for no less than 3 minutes.

7. The third container should contain de-ionized water. Circulate this water through the operation of the pump for no less than 3 minutes.

8. Decontaminate the pump electric cable and anything else that came in contact with the well using alcohol solution.

6.0 RECORDS AND DOCUMENTATION

Complete Field Notes, Health and Safety Plans, Tailgate Safety Forms, Groundwater Sampling Datasheets, Bailer Sheets, Chains of Custody, and Equipment Recovery Forms are required for groundwater sampling.

Field Notes should include the following information:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Pump placement.
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Equipment decontamination.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

Several kinds of Quality Assurance and Quality Control (QA/QC) samples may be collected. The amount may vary by Site and sampling objectives. The project specific FSP and/or QAPP or appropriate regulatory guidance should be consulted. In general, the following guidelines apply:

- Field duplicate/replicate – Collect 1 per 10 to 20 samples for all parameters.
- Matrix Spike and Matrix Spike Duplicated (if required)
- Equipment blank – Collect 1 per 10 to 20 samples for all parameters.
- Trip blank – 1 per sample cooler containing volatile organic compound (VOC) samples.

- Temperature blank – 1 per sample cooler.

As noted above, groundwater samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation.

- Field duplicates or replicate samples are collected at the same time and in the same way as the sample intending to be duplicated or replicated. The name of a duplicate sample will not be the same as the original sample but instead will be called a duplicate. The identity of the sample will be recorded in field notes.

- Matrix Spike and Matrix Spike Duplicate samples are collected at the same time and in the same way as the sample intending to be spiked. The name of these samples will include the MS or MSD abbreviation and the identity of the sample.

- Equipment blanks are sampled from the sample pump and are collected from a clean container, used exclusively for equipment blank samples, filled with de-ionized water. Equipment blanks should be taken after having sampled the most impacted monitoring well. Exhausted tubing should be removed from the pump, and new tubing attached. Circulate the de-ionized water through the pump for at least one minute before sampling the equipment blank from the pump. The name of these samples will include the equipment blank designation.

- Trip blanks are prepared by the laboratory and shipped with sample containers. These samples should be included in each sample cooler containing samples for VOCs. The name of these samples will include the trip blank designation.

- Temperature blanks are prepared by the laboratory and shipped with sample containers. These samples should be included in each sample cooler. The name of these samples will include the temperature blank designation.

8.0 APPLICABLE STANDARDS AND REFERENCES

ASTM International's, "Designation: D 6771-02, "Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations" dated February 10, 2002.

EPA's "Groundwater Sampling EPA Region I "Low Stress Purging and Sampling Procedure For the Collection of Groundwater Samples From Monitoring Wells", dated July 30, 1996.

EPA's "Groundwater Sampling EPA Region II "Groundwater Sampling Procedure Low Stress Purging and Sampling", dated March 16, 1998.

Puls, R.W. and M.J. Barcelona, 1996, "Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures", EPA/540/S-95/504.

Wilde, F.D., D.B. Radtke, J. Gibs and R.T. Iwatsubo, eds., 1998, "National Field Manual for the Collection of Water-Quality Data", U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, variously paginated.

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GROUNDWATER SAMPLING – MONITORING WELL (STANDING-WATER VOLUME BASED PURGING)

1.0 SCOPE AND APPLICATION

To obtain liquid samples for analysis to determine general quality of the groundwater at the sampling location or as part of a program to define a contaminant plume.

2.0 EQUIPMENT AND MATERIALS

- Appropriate sample containers
- Laboratory-cleaned stainless steel bailers
- Sampling cable
- One hundred-foot (100') steel tape with weighted end
- Rags or paper towels
- Cooler and ice

Additional equipment and materials such as field screening equipment, filtering equipment, etc., may be needed for particular sampling rounds.

3.0 PROCEDURES

1. Measure depth to groundwater to the nearest one-hundredth of a foot (0.01') using one hundred-foot (100') tape or electric water level indicator.

2. Prior to sample collection, a minimum of three (3) times the volume of standing water in the well will be removed using the following method:

    a. Measure depth to groundwater to the nearest one-hundredth of a foot (0.01') from the top of the riser pipe using the one hundred-foot (100') steel tape.

    b. If reliable information on well construction is not available, measure total well depth to the nearest one-hundredth of a foot (0.01') from the top of the riser pipe using the one hundred-foot (100') steel tape.

    c. Calculate the volume of standing water in the well using the above measurements and the inside diameter of the well.

    d. Using a laboratory-cleaned stainless steel bailer of known volume, bail three (3) times the volume of water calculated in three (3) from the well.

    e. Allow sufficient time for well to recharge before initiating sampling.

f. At locations where the well is deep, static water level is within twenty-five feet (25') of top of casing, and recharge is sufficiently rapid to prevent drawdown below twenty-five feet (25'), the calculated volume may be evacuated with the assistance of a portable centrifugal pump.

i. To accommodate this process, each well to be pumped will be equipped with a dedicated three-quarter-inch (3/4") polyethylene tubing of appropriate length. The tubing may be stored in the well, hung from a clip to accommodate easy retrieval, or it may be removed, labelled, and stored for the next sampling round.

ii. After attachment, the pump is started. It is then calibrated using a vessel of known volume and a watch second hand.

iii. After completion of the required volume evacuation, with the pump still running, the suction line is removed from the well and coiled and the required samples are collected with clean stainless steel bailers.

g. Where required purge volumes are large and centrifugal pumping is not feasible, alternate purging methods such as peristaltic, inertial, gas-driven or bladder pumps may be used.

3. Using a clean stainless steel or polyvinyl chloride bailer, withdraw a sample from the well.

4. Transfer the sample from the bailer directly into the sample container by depressing the check valve in the bottom of the bailer and allowing the sample to flow down the side of the sample container with minimum turbulence. This procedure is critical to minimize loss of volatile materials from the sample through aeration.

5. Cap and seal the sample container.

6. Wipe down the bailer with clean rags or paper towels to dry it and store the bailer in a plastic bag separate from any stock of clean bailers.

7. Label, preserve, and store the sample in accordance with appropriate protocols.

4.0 RECORDS AND DOCUMENTATION

Complete Field Notes, Health and Safety Plans, Tailgate Safety Forms, Groundwater Sampling Datasheets, Bailer Sheets, Chains of Custody, and Equipment Recovery Forms are required for groundwater sampling.

Field Notes should include the following information:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Well sampling sequence and time of sample collection.
- Equipment decontamination.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

5.0 SPECIAL NOTES

1. Separate laboratory-cleaned bailers will be used for each well sampled to preclude cross-contamination. As an alternative, dedicated bailers or bladder pumps which are left in the individual wells may be employed.

2. Either separate bailer cables will be employed or cables will be decontaminated between samples using a methanol wash followed by a distilled water rinse.

3. Purging equipment should be either dedicated or disposable and constructed of materials which will not influence sample quality. If purging or sampling equipment is to be reused, appropriate decontamination procedures must be used. Equipment or decontamination blanks should be collected between monitoring wells as required by the project QA/QC requirements.

6.0 APPLICABLE REFERENCES AND STANDARDS

Dunlap, N.J.; McNabb, J.F.; Scalf, M.R.; and Crosby, R.L., "Sampling for Organic Chemicals and Microorganisms in the Subsurface," EPA-600/2-77-16, August 1977.

